frontiers | Research Topics

Promoting healthy aging across the lifespan

Edited by
Elena Carrillo-Alvarez, Miriam Rodriguez-Monforte, Jordi Vilaró and Katherine Simone McGilton

Published in
Frontiers in Public Health



FRONTIERS EBOOK COPYRIGHT STATEMENT

The copyright in the text of individual articles in this ebook is the property of their respective authors or their respective institutions or funders. The copyright in graphics and images within each article may be subject to copyright of other parties. In both cases this is subject to a license granted to Frontiers.

The compilation of articles constituting this ebook is the property of Frontiers.

Each article within this ebook, and the ebook itself, are published under the most recent version of the Creative Commons CC-BY licence. The version current at the date of publication of this ebook is CC-BY 4.0. If the CC-BY licence is updated, the licence granted by Frontiers is automatically updated to the new version.

When exercising any right under the CC-BY licence, Frontiers must be attributed as the original publisher of the article or ebook, as applicable.

Authors have the responsibility of ensuring that any graphics or other materials which are the property of others may be included in the CC-BY licence, but this should be checked before relying on the CC-BY licence to reproduce those materials. Any copyright notices relating to those materials must be complied with.

Copyright and source acknowledgement notices may not be removed and must be displayed in any copy, derivative work or partial copy which includes the elements in question.

All copyright, and all rights therein, are protected by national and international copyright laws. The above represents a summary only. For further information please read Frontiers' Conditions for Website Use and Copyright Statement, and the applicable CC-BY licence.

ISSN 1664-8714
ISBN 978-2-8325-5806-5
DOI 10.3389/978-2-8325-5806-5

About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: frontiersin.org/about/contact

Promoting healthy aging across the lifespan

Topic editors

Elena Carrillo-Alvarez — Blanquerna Ramon Llull University, Spain
Miriam Rodriguez-Monforte — Ramon Llull University, Spain
Jordi Vilaró — Blanquerna Ramon Llull University, Spain
Katherine Simone McGilton — University Health Network, Canada

Citation

Carrillo-Alvarez, E., Rodriguez-Monforte, M., Vilaró, J., McGilton, K. S., eds. (2024). *Promoting healthy aging across the lifespan*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-5806-5

Table of contents

07 Cumulative health disadvantages: an empirical study of the health and mobility of the first cohort of migrant workers in China
Fengxian Qiu, Qingyang Kong and Dongjun Fan

25 Trends in behavioral and biological risk factors for non-communicable diseases among adults in Bhutan: results from cross-sectional surveys in 2007, 2014, and 2019
Supa Pengpid and Karl Peltzer

34 The impact of community care services on older people's psychological health: an empirical study in Liaoning Province, China
Qin Sen and Zhang Lei

44 Network analysis of cold cognition and depression in middle-aged and elder population: the moderation of grandparenting
Dongling Yuan, Jialing Wu, Shansi Li, Ruoyi Zhang, Xiao Zhou and Yi Zhang

56 Non-communicable disease multimorbidity among tribal older adults in India: evidence from Study on Global AGEing and adult health, 2015
Abhinav Sinha, Srikanta Kanungo, Debdutta Bhattacharya, Harpreet Kaur and Sanghamitra Pati

62 Prediction model of quality of life using the decision tree model in older adult single-person households: a secondary data analysis
Dajung Ryu and Sohyune Sok

72 Construction of healthy aging index from two different datasets
Madara Miķelsone, Ieva Reine, Signe Tomsone, Helgi Guðmundsson, Andrejs Ivanovs and Halldór S. Guðmundsson

83 Trajectories in physical functioning at older age in relation to childhood and adulthood SES and social mobility: a population-based cohort study
Andrzej Pająk, Maciej Polak, Magdalena Kozela, Agnieszka Doryńska and Martin Bobak

93 A situational analysis of ear and hearing care in South Korea using WHO ear and Hearing Care Situation Analysis tool
Juhyeong Lee, Chul Young Yoon, Junhun Lee, Tae Hoon Kong, Seung Ha Oh and Young Joon Seo

113 Community-based social healthcare practices in China for healthy aging: a social prescription perspective analysis
Rashid Menhas, Lili Yang and Rana Danish Nisar

126 Aging at home: factors associated with independence in activities of daily living among older adults in Norway—a HUNT study
Skender Redzovic, Beatrix Vereijken and Tore Bonsaksen

135 Self-care interventions of community-dwelling older adults: a systematic review and meta-analysis
Estela González-González and Carmen Requena

145 Barriers and facilitators for implementation of a combined lifestyle intervention in community-dwelling older adults: a scoping review
Patricia J. van der Laag, Berber G. Dorhout, Aaron A. Heeren, Cindy Veenhof, Di-Janne J. A. Barten and Lisette Schoonhoven

161 Variations in cognition by human capital characteristics: a cross-sectional analysis of Brazilian older adults
Paolo Miguel Manalang Vicerra

168 Health status of the population in Naqu, Tibet and its latent class analysis: a cross-sectional survey
Jiaxue Cui, Ouzhu Nima, Duoji Zhaxi, Chenxin Jin, Ruiqi Wang, Yizhuo Diao, Yongxing Chen, Xiaoguang Xu and Xiaofeng Li

181 Relationship of the SITLESS intervention on medication use in community-dwelling older adults: an exploratory study
Ruben Viegas, Filipa Alves da Costa, Romeu Mendes, Manuela Deidda, Emma McIntosh, Oriol Sansano-Nadal, Juan Carlos Magaña, Dietrich Rothenbacher, Michael Denkinger, Paolo Caserotti, Mark A. Tully, Marta Roqué-Figuls and Maria Giné-Garriga

189 *Idobata-Nagaya*: a community housing solution for socially isolated older adults following the great East Japan earthquake
Toshiki Abe, Hiroaki Saito, Nobuaki Moriyama, Naomi Ito, Morihito Takita, Yuri Kinoshita, Akihiko Ozaki, Yoshitaka Nishikawa, Chika Yamamoto, Tianchen Zhao, Mika Sato and Masaharu Tsubokura

196 Age-related change in muscle strength, muscle mass, and fat mass between the dominant and non-dominant upper limbs
Jing Pang, Fuyi Tu, Yiwen Han, Enyi Zhang, Yan Zhang and Tiemei Zhang

205 Association between the neutrophil-to-lymphocyte ratio and cognitive impairment: a meta-analysis of observational studies
Kuo-Chuan Hung, Chien-Cheng Liu, Jheng-Yan Wu, Chun-Ning Ho, Ming-Chung Lin, Chung-Hsi Hsing and I-Wen Chen

214 High prevalence of subjective cognitive decline in older Chinese adults: a systematic review and meta-analysis
Chao Xue, Juan Li, Mingqing Hao, Lihua Chen, Zuoxiu Chen, Zeli Tang, Huan Tang and Qian Fang

224 Acculturation and self-rated health among Chinese and Korean immigrants aged 49 to 75
Soomin Ryu, Brittany N. Morey, Yuxi Shi and Sunmin Lee

235 Decomposing differences in the chronic disease condition between rural and urban older adults in China: a cross-sectional analysis
Jian Zhang and Yuan Zhang

248 Effect of a lifestyle-integrated functional exercise (LiFE) group intervention (sLiFE) to falls prevention in non-institutionalized older adults. Protocol of a randomised clinical trial
Inés Llamas-Ramos, Rocío Llamas-Ramos, Cristina Lugones-Sánchez, Susana González-García, Olaya Tamayo-Morales, Jorge Juan Alvarado-Omenat, Carmen Pablos-Hernández, Manuel A. Gómez-Marcos, Luis García-Ortiz and Emiliano Rodríguez-Sánchez

256 Research on the healthy life expectancy of older adult individuals in China based on intrinsic capacity health standards and social stratification analysis
Mengya Liu, Meng Zhang, Jinglei Zhou, Nannan Song and Li Zhang

269 Associations of lower-limb muscle strength performance with static and dynamic balance control among older adults in Taiwan
Ping-Chun Yeh, De-Kai Syu, Chien-Chang Ho and Tian-Shyug Lee

276 Rethinking immunization programs through the life course approach
Evelyn Balsells, Margherita Ghiselli, Carolina Hommes, Beatriz Nascimento Lins de Oliveira, Ana Lucía Rosado-Valenzuela and Enrique Vega

281 e-VITA study protocol: EU-Japan virtual coach for smart aging
Roberta Bevilacqua, Vera Stara, Giulio Amabili, Arianna Margaritini, Marco Benadduci, Federico Barbarossa, Elvira Maranesi, Anne-Sophie Rigaud, Sébastien Dacunha, Cecilia Palmier, Johanna Moller, Ryan Browne, Toshimi Ogawa and Rainer Wieching

299 Sexual attitudes and utilization of sexual and reproductive health services among older women in southern China: a qualitative study
Xin Peng, Bingyi Wang, Qianyun Wang, Yuwei Li, Yinghui Sun, Xinyi Li, Joseph D. Tucker, Longtao He, Weiming Tang, Dan Wu and Huachun Zou

307 Trait-anxiety, depressive symptoms, family support and life satisfaction as determinants conditioning the degree of adherence of people in pre-older adults and older adults
Mariola Głowacka, Anna Polak-Szabela, Zofia Sienkiewicz and Maciej Kornatowski

315 The moderating effect of care time on care-related characteristics and caregiver burden: differences between formal and informal caregivers of dependent older adults
Eunmi Oh, SeolHwa Moon, Daum Chung, Rina Choi and Gwi-Ryung Son Hong

326 Effects of active exergames on physical performance in older people: an overview of systematic reviews and meta-analysis
Jordan Hernandez-Martinez, Francisco Ramos-Espinoza, Cristopher Muñoz-Vásquez, Eduardo Guzman-Muñoz, Tomas Herrera-Valenzuela, Braulio Henrique Magnani Branco, Maria Castillo-Cerda and Pablo Valdés-Badilla

347 Association between residential environment and emotional wellbeing among older adults in China: the mediating effect of health lifestyle
Zhu Huijie, Jiang Haojun, Zhu Zhiping and Yao Zhaoyu

356 Unraveling the dynamics of loneliness in the Baltic-Nordic region: a comparative analysis in the wake of COVID-19
Ieva Reine, Madara Miķelsone, Signe Tomsone, Helgi Guðmundsson, Andrejs Ivanovs, Halldór S. Guðmundsson and Ilze Koroļeva

368 A blended face-to-face and eHealth lifestyle intervention on physical activity, diet, and health outcomes in Hong Kong community-dwelling older adults: a study protocol for a randomized controlled trial
Min Yang, Yanping Duan, Sonia Lippke, Wei Liang and Ning Su

379 Traditional Chinese medicine health literacy among rural older adults: a cross-sectional study
Huizhong Zhang, Yan Zhang, Yuwen Yan, Xizheng Li and Yutong Tian

387 Influencing factors of home hospice care needs of the older adults with chronic diseases at the end of life in China: a cross-sectional study
Lei Wang, Yaru Li, Rui Zhao, Jiangxu Li, Xiangru Gong, Hongyu Li and Yuan Chi

399 Analysis of the life course effects of the disability dilemma among rural older adults in China
Fen Li, Xiangdong Gao and Yahui Meng

406 The effects of cultural engagement on health and well-being: a systematic review
Erica Viola, Marco Martorana, Daniele Ceriotti, Marta De Vito, Damiano De Ambrosi and Fabrizio Faggiano

420 Childhood and adult socioeconomic status influence on late-life healthy longevity: evidence from the Chinese longitudinal healthy longevity survey
Yuanyan Chen

frontiers | Frontiers in Public Health

TYPE Hypothesis and Theory
PUBLISHED 31 July 2023
DOI 10.3389/fpubh.2023.1221082

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Oscar A. Martínez-Martínez,
Universidad Iberoamericana, Mexico
Gigi Lam,
Hong Kong Shue Yan University, Hong Kong SAR, China

*CORRESPONDENCE
Qingyang Kong
✉ kongqingyang@163.com

RECEIVED 11 May 2023
ACCEPTED 17 July 2023
PUBLISHED 31 July 2023

CITATION
Qiu F, Kong Q and Fan D (2023) Cumulative health disadvantages: an empirical study of the health and mobility of the first cohort of migrant workers in China.
Front. Public Health 11:1221082.
doi: 10.3389/fpubh.2023.1221082

COPYRIGHT
© 2023 Qiu, Kong and Fan. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Cumulative health disadvantages: an empirical study of the health and mobility of the first cohort of migrant workers in China

Fengxian Qiu[1], Qingyang Kong[2]* and Dongjun Fan[2]

[1]Department of Social Work, School of Law, Anhui Normal University, Wuhu, China, [2]School of Economics and Management, Anhui Normal University, Wuhu, China

Background: The study aimed to understand the factors affecting the health and healthcare of the first cohort of migrant workers in China using the concept of the cumulative disadvantage framework.

Methods: Data from the China Migrants Dynamic Survey (2017) were used to analyze the process of cumulative disadvantage of health and healthcare among migrant workers. The study also analyzed the spatial lag problem between localized medical insurance policies and healthcare accessibility.

Results: The results revealed a significant negative association between the mobility of the first cohort of migrant workers and their health status. Long-term exposure to hazardous work had a greater negative impact on their health. Chinese migrant workers faced significant obstacles in accessing healthcare due to the lack of portability in health insurance.

Conclusion: The study emphasizes the urgent need for addressing the structural barriers hindering healthcare access and outcomes for migrant workers. It is crucial to promote a more equitable and sustainable healthcare system in China to ensure migrant workers' health and well-being.

KEYWORDS

the first cohort of migrant workers, cumulative disadvantage, life course, mobility, health

1. Introduction

Migrant workers have made significant contributions to China's economic and social development, improving their families' overall living conditions and alleviating rural poverty, while effectively restraining the rapid development of urban/rural disparities in the economy (1). However, as a socially vulnerable group (2), migrant workers face difficulties arising from lagging social policies and a lack of social rights (3), particularly in terms of health issues (4). As of the end of 2021, there were approximately 292 million migrant workers in China, accounting for 39% of China's total employed population (5). The average age of migrant workers is 41.7 years old, with those aged 40 and below accounting for 48.2%, and those aged 40–50 accounting for 27.3% of all migrant workers (6). The concept of the first cohort of migrant workers refers to the rural population who were born before 1980 and started to work outside around 1985 (7). In the 1980s, the number of floating population in China rapidly increased as a result of accelerated industrialization and urbanization processes, leading to the largest-scale

influx of rural migrant workers in Chinese history, often referred to as the "migrant worker wave." (8) These mobile populations were the first group of rural farmers to enter cities in search of employment opportunities following China's reform and opening-up policy. They migrated to urban areas with the aim of improving their family's living conditions and made significant contributions to China's economic development (1). However, due to household registration restrictions, they rarely obtained urban residency status or enjoyed the social welfare benefits provided by the urban social welfare system (3). They remained registered as rural residents, solely working in urban areas, and would return home when there were no job opportunities available (4). While working in cities, they saved as much as possible, minimizing their own expenses, and accumulated income to support their children's education, schooling, and marriage. They primarily focused on their family's needs and neglected their own well-being. This distinctive characteristic of the first-cohort migrant workers in China represents their commitment to sacrificing personal expenses for the sake of their family's welfare (9).

On the other hand, the second cohort of migrant workers refers to those born after 1980 and who entered urban areas for work after 2,000 year. Their motivation for migrating to cities is more driven by personal development and the pursuit of an urban lifestyle, with economic gains no longer being their primary objective (10).

Thus, the trend of migrant workers toward aging is apparent, and as a 4D (dirty, dangerous, damaging, and difficult) employment group (11), they face greater health risks and challenges than the general population and have a lower capacity to cope with health risks (12).

This study was based on the unique life experiences of the first cohort of migrant workers. Using the data of CMDS (2017), with migrant workers' self-rated health as the dependent variable and spatial and temporal dimensions as analytical perspectives, this study adopted a life course approach to construct a theoretical framework for analyzing the first cohort of migrant workers' health.

Can existing health care policies protect their health? What factors influence their health? This paper uses quantitative method to examine factors influencing the first cohort of migrant workers health, specifically, we inquire what will they rely on? In the process, we shed light on the social rights, social stratification systems, and cumulative disadvantage in health as well as the access and management of healthcare in China.

1.1. The accumulation of disadvantages and life course

Flaskerud and Winslow defined the concept of vulnerable groups as groups that lack sufficient resources and have higher rates of illness and death. They mainly considered the health status of a particular group in a specific social structure, emphasizing the influence of society on individual health maintenance and social rights (13). In the definition of the concept, the core indicators of vulnerable groups are their ability to access resources, their health status, and the risks they face. This concept has been applied to research on the health statuses of various groups, and discussed regarding the relationship between health status and its effects. One theory of cumulative disadvantage is closely related to the concept of vulnerable groups; this theory posits that vulnerable groups acquire typical cumulative disadvantages throughout their life course (14). The focus of the theory of cumulative disadvantage is to identify the process by which opportunities for inequality lead to the continuous accumulation of a disadvantaged status throughout an individual's life (15). O'Rand believes that a person's social status and related benefits widen the differences between individuals or groups over time and with age, leading to the accumulation of disadvantages. Currently, the theory of cumulative disadvantage is often used in conjunction with life course theory (16). Many researchers have focused on the accumulation of disadvantages when exploring individuals' life courses (17). In essence, an important potential theme in life course analysis is the concept of accumulating advantages (or disadvantages), which means that individuals obtain privileges (or disadvantages) based on their social status in early life (18). People in different groups occupy different positions in occupational development and hierarchical structures, so their vulnerability to social order or livelihood opportunities resulting from large-scale social changes is also different (15). Social system changes have different effects on individuals in different life stages, and thus, different age groups are significantly affected by the unique impact of this social change process, which is, at least in part, determined by their advantageous (or disadvantageous) status in the social structure (19). Therefore, the life course can be used as a unique age-stratified indicator of risks and a sign of a unique and cohort-related social position in the opportunity structure, forming a "risk chain" (20). At the same time, childhood experiences affect individuals' adult physical and mental health (21, 22). In adulthood, there is a high correlation between social and economic status, lifestyle, and health status (23, 24). The life course is a carrier that indicates different roles, responsibilities, and expectations at different ages (25, 26). An individual's life course is shaped by the interaction between social mechanisms and individual traits, among which "turning point events" (27), such as migration and retirement, are the markers that can change the direction of an individual's life trajectory (28). Therefore, poverty in older individuals is the result of the accumulation of disadvantages throughout their life course (29, 30). This perspective links individuals' temporary states at different stages of life and different observation points to form a continuous life course (31). In recent years, the life course perspective has shown significant advantages in explaining the poverty status of older people (32, 33), indicating that older people's poverty can be attributed not only to current conditions, but also to the accumulation of disadvantages throughout their lives, especially in those with sustained negative life experiences (34). This perspective attempts to bridge a gap between individuals at the micro level and at the macro level, integrating accumulated and constructed life courses.

1.2. Migrant workers' economic income and health maintenance ability

Research on the relationship between health and income has primarily focused on industrialized countries, with most findings strongly supporting the impact of health on employment or income (35, 36). From a micro perspective, a possible mechanism by which health affects income is that healthy individuals can directly increase labor productivity (37), whereas changes in work habits during illness may lead to a suboptimal income function and result in income loss (38). There is a positive correlation between health and economic income, wherein a good health status promotes income, and a

significant deterioration in health reduces household income (39). Income, in turn, affects health development through living standards and medical conditions (40), thus forming a cyclical system between the health and income of migrant workers (41, 42). Compared with those in good health, migrant workers with poor health earn only 63.43% of their average annual income from migrant work (43). In terms of the use of medical resources by migrant workers (44), research has found that the probability of low-income groups using the healthcare system is much lower than that of high-income groups (45, 46). Feng and Yu found that the effect of income inequality on health has a lagging effect and can be described as a "U-shaped" relationship (47), where the impact of income inequality on health is mainly negative when income inequality is high (48).

1.3. The accumulation of healthy weaknesses in of migrant workers

The Grossman health capital theory suggests that health is not only an investment; it is also a consumption good. While each person's initial endowment of health may differ, their personal choices can affect their subsequent level of health, and their socio-economic status and educational level can also cause differences in health production (49).

Due to their lack of innate education, rural migrant workers who enter the secondary labor market face obvious environmental injustice issues, as their living and working conditions are often affected by severe pollution (50). The health risks associated with the hazardous environment to which they are exposed include infectious diseases, production accidents, and occupational hazards, all of which threaten the health and life of rural migrant workers (51). Furthermore, long working hours and engagement in high-intensity physical labor negatively impact their health (52, 53). Research shows that the overall health levels of rural migrant workers declined during the period of 1997–2006. As a result of this health decline, rural migrant workers often chose to return to their hometowns for economic reasons (54). However, compared to rural medical conditions, urban medical conditions have a greater effect on promoting the health of rural migrant workers. Therefore, this choice further exacerbates the health vulnerability of rural migrant workers (55).

1.4. Medical insurance and utilization of medical services for migrant workers

The medical insurance system in China shows a relationship with social identity, with regional and identity differences being noted, which leads to differences in the effectiveness of medical services among different populations and regions (56). Research by Ye Minghua using macro-level data from China showed that, from 1991 to 2000, medical services in both urban and rural areas were considered luxury goods. It was not until the establishment of the new rural cooperative medical care system in rural areas that medical services became a necessity for rural residents in 2004, allowing them to enjoy medical service benefits with very low incomes (57). The new rural cooperative medical care system has increased farmers' utilization of medical services and significantly improved the health of high-income populations, while the impact on middle- and low-income participating farmers has not been significant (58). In a study of healthcare resource utilization among rural migrant workers, Wang et al. found that 11% of migrant workers had never sought medical services when they fell ill, 65% chose self-medication, and although 24% chose to seek medical attention, 48% of them went to unlicensed private clinics or grassroots health organizations. Only when faced with serious illnesses were these rural migrant workers forced to seek medical services. Among those who needed hospitalization, 30% refused treatment, and 23% chose to return to their hometown or elsewhere for medical treatment (59). In academic research, scholars have paid more attention to and primarily discussed the relationship between migrant workers' insurance participation and health. There has been less discussion about the spatial separation and health relationships associated with the first cohort of rural migrant workers' health maintenance.

1.5. Movement and health of migrant workers

In studies on immigrant health and duration of stay, there is a phenomenon known as the "salmon bias effect" or "healthy migrant effect," which refers to the inverse health selection effect that exists among immigrants during the process of migration (60). This effect suggests that the health status of migrants is selectively better than that of other residents in their place of origin and the general population (61), due to the selective migration of healthier individuals during the migration process However, due to the influence of factors such as lifestyle, health behaviors, and socioeconomic status at the destination, this health advantage gradually diminishes over time (62). Therefore, immigrants whose health conditions significantly deteriorate are often unable to stay in their destination countries for a long time. Some studies have also pointed out that the link between migration and health is mainly due to the pressure associated with migration.

In the research on the migration behavior and health of Chinese rural migrant workers, Liu Juanjuan studied the impact of health risks on rural labor migration and found that, the greater the health risk, the less willing rural laborers are to migrate outwards. Those who perceive themselves to be in better health are more likely to seek work opportunities outside their hometowns (63).

According to survey data on rural migrant workers in the eight districts of Beijing collected by Yuan Huina, approximately one-quarter of the migrant workers experienced a decline in their health status after migration. The study also found a cyclical relationship between health and income among migrant workers (39). Specifically, those who initially had better health statuses had a higher unit earnings rate, but declines in their health statuses led to a decrease in their unit earnings rate (37). Moreover, rural migrant workers with lower socioeconomic statuses were more likely to experience a declines in health (42).

A similar cyclical effect was also found in a study by Yin Qing (64) on the relationship between health and income among rural residents in China. The present study discusses the relationship between the mobility of migrant workers in China and their health. It is noted that migrant workers in China have high mobility, in terms of both geographic and occupational mobility. While this mobility can be seen as upward and self-selected, it also comes with instability, risk, and stress, which can affect the health of migrants. Measures of

cross-provincial migration and job changes are used to reflect migrant workers' mobility, as well as the length of time spent away from their hometowns.

It should be noted that research has shown that the deterioration of migrant workers' health can place a heavy burden on both the individual and their families. In addition, we suggest that the burden of ill health can be transferred to rural areas when sick migrant workers return home, exacerbating the urban/rural health gap. Existing research has focused on various factors related to migrant workers' health, such as healthcare systems, social capital, income, occupational diseases, and work-related injuries. However, there is a lack of theoretical frameworks that comprehensively examine migrant workers' health issues.

The current study suggests that analyzing the health of migrant workers from a generational perspective may be useful, as there are differences between the health of the first cohort of migrant workers and that of second-generation migrant workers. The unique life experiences of the first cohort of migrant workers and their environment mean that their health statuses and the factors that affect it are different from those of second-generation migrant workers.

This research aimed to fill gaps in the existing literature by focusing on the health of the first cohort of migrant workers and introducing the concept of "health vulnerability accumulation." We aimed analyze the health status of the first cohort of migrant workers in detail, focusing on several dimensions, such as the accumulation of health vulnerability over time, and spatial lags in healthcare insurance, occupational differences, and work duration.

Based on the above analysis, this study proposes the following hypotheses:

> *Hypothesis 1:* The spatial lag effect of medical insurance affects the ability of migrant workers to maintain their health.
>
> *Hypothesis 2:* The cumulative disadvantages of the first cohort of migrant workers in terms of health are related to their length of employment.
>
> *Hypothesis 3:* Sacrificing health for income is an unavoidable choice for migrant workers.

2. Study design and data description

2.1. Construction of the model of cumulative disadvantages for the first cohort of migrant workers

This study, which is based on an individual life course perspective, discusses the influence of social factors on personal life opportunities. Given the unique life course of the first cohort of migrant workers, especially their disadvantaged position as social outsiders and weak actors in the labor market, they have become a vulnerable group in society due to the accumulation of factors such as age, skills, health, and social exclusion, exhibiting typical characteristics of the accumulation of disadvantages in health. We attempted to analyze the uniqueness and related factors of the health problems of the first cohort of migrant workers using a disadvantaged accumulation model that is highly compatible with their life course, and by exploring the factors that affect their health maintenance during the process of migration for work.

Due to the lack of long-term tracking survey data, this study selected cross-sectional data to establish a targeted explanatory framework for the factors that influence the health of the first cohort of migrant workers based on relevant indicators and data. Although the first cohort of migrant workers is highly suited to the conceptual model of vulnerable groups in terms of livelihood, resource accessibility, health status, and risk risk-coping ability, due to limitations in length and research topics, this study mainly discussed the process of health disadvantage accumulation among the first cohort of migrant workers, temporarily leaving the issues of livelihood resource accessibility and risk-coping ability for further specialized research.

Disadvantage accumulation is the process by which the disadvantaged status that results from unequal opportunities accumulates over the course of a person's life (65). As a person's social status and related interests change over time and with age, differences between individuals or groups become more pronounced (13). The key factor in the accumulation of disadvantages in the migrant worker group in this study is the time-based disadvantage accumulation of the first cohort of migrant workers. These workers face policies of exclusion, occupational hazards, and economic disadvantage during their continuous migration, which accumulate over their life course and make them more likely to fall into poverty and accumulate higher health risks as they age.

From a specific analytical perspective, their work time was used as the longitudinal accumulation line, and their health care accessibility was used as the spatial lag zone to further clarify the factors that contribute to their health disadvantage accumulation process in both the longitudinal and horizontal boundaries. The process by which health disadvantages accumulate in the first cohort of migrant workers also involves constant interaction between individuals and their social environments, existing social policies, and economic incomes (see Figure 1).

2.2. Data sources and variables

The data for this study came from the China Migrants Dynamic Survey (2017), and we focused on rural migrant workers aged 40 and above. The specific definition used for inclusion in our study was those over 40 years old with a rural household registration. Jin Xiaoyi et al. defined the first cohort migrant workers in terms of their physical health, job type, and social security. They found that migrant workers over the age of 45 face significant pressures in employment, medical care, and income. In the working life of migrant workers, their income reaches its peak at the age of 35, after which it stabilizes and then declines (66). This decline happens earlier than for urban residents, who maintain their peak income until the age of 45, indicating that migrant workers lose job opportunities and earning capacity too early in the job market. The first cohort of migrant workers who are over 50 years of age faced amplified health risks and market livelihood risks, and their ability to resist risks is weakened as a result. Their opportunities to

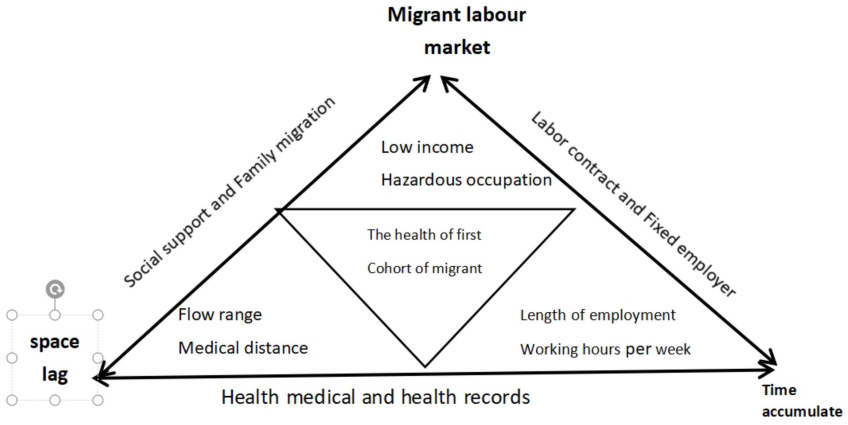


FIGURE 1
The conceptual model of migrant workers' cumulative disadvantage in health.

continue working in urban areas decreased, and their livelihood risks increased. For the purposes of this study, rural migrant workers over 40 years old were selected. After processing the variables, the resulting sample contained 36,668 observations. The basic characteristics of the sample were as follows: the average age of the respondents was 47.19 years; their average duration of education was 8.04 years; on average, they worked 60.10 h weekly; they had moved to an average of 2 cities; their logarithmic average income was CNY 8.024; 38% of the respondents were engaged in hazardous occupations; 46.1% had had an illness in the past year; 87.4% had insurance; 70.3% had received health education; 28.2% had created a health file; 32.6% had moved for economic reasons; 50.5% had moved together with their family; 35.8% reported having social exchanges locally; and 25.5% had signed labor contracts. Among them, male migrant workers accounted for 62.5% of all the respondents, and married migrant workers accounted for 94.5% of all the respondents.

2.3. Variable setting and measurement

2.3.1. Dependent variable

In the research design of this study, the health status of migrant workers was considered the dependent variable, and self-assessment by the workers was used to obtain the data (67). Although there may have been some measurement error in self-reported health status, previous studies have suggested that it is a better indicator for predicting health status and is more robust than objective health measures (68). In the 2017 National Dynamic Monitoring Survey of the Health and Family Planning of the Floating Population questionnaire, the health status of migrant workers was divided into four categories: healthy, basically healthy, unhealthy but able to live independently, and unable to live independently. In this study, migrant workers who were classified as "basically healthy" were considered to have potential health risks or suboptimal health status (69), Disease is often regarded as a deviation from the normal standards of physical and mental well-being, based on common sense and everyday experience. Conversely, good health is defined as the absence of illness (70) and those classified as "unhealthy but able to live independently" and "unable to live independently" were combined into the category of "unhealthy status" and assigned a value of 0. Those classified as "healthy" were defined as having a "healthy status" and assigned a value of 1.

2.3.2. Explanatory variables

We measured the explanatory variables considering three aspects.

Firstly, with respect to time indicators, this study examined the cumulative relationship between the health status of the first cohort of migrant workers and the duration of migration and weekly working hours. The duration of migrant workers' migration and weekly working hours were used as indicators to measure the dimensions of their work time and weekly working hours. The time when they first left their registered household was used as an indicator to measure the duration of their migration. The duration of migration was calculated as 2017 minus the answer to question 302. The data from question 201 in the questionnaire were used as a variable to measure weekly working hours.[1]

Secondly, the relationship between health and medical service accessibility was examined considering the dimension of spatial differences in medical services for migrant workers. This study used the floating range of the first cohort of migrant workers and the distance to medical and nearby medical service points as variables. These two variables represented the accessibility of medical services for migrant workers.

Since the survey data were collected from our sample in 2017, considering that the medical insurance available to farmers was the new rural cooperative medical insurance or the urban resident medical insurance, this study did not use where migrant workers participated in medical insurance as a variable. Instead, the floating range of the first cohort of migrant workers was taken as a spatial variable to examine the distance from their home to their place of insurance, which was used as an indicator of the impact of health

1 When was the first time you left your domicile (county level)? Have you ever done more than 1h of paid work in the week before the May Day holiday this year?

and medical service accessibility on the health of the first cohort of migrant workers. For this variable, out-of-province migration was assigned a value of 1, while non-provincial migration was assigned a value of 0.

The second spatial indicator reflects the impact of medical service accessibility on the health of rural migrant workers. In theory, the longer it takes for rural migrant workers to travel from their place of residence to the nearest medical service institution, the worse the accessibility of public services and basic health conditions are, and the lower the health maintenance level of rural migrant workers becomes, which affects their health. The distance from a respondent's place of residence to their nearest medical service institution was coded as follows: within 15 min = 1; 15–30 min (inclusive) = 2; 30 min (exclusive)–1 h (inclusive) = 3; more than 1 h = 4.

Thirdly, the relationship between the accumulation of disadvantages in the first cohort of migrant workers and their health was examined considering the dimensions of their occupational characteristics and monthly income. The monthly income indicator was measured by the question, "How much was your wage income/pure income in the previous month (or previous employment)?" To avoid errors in the questionnaire and data, we performed a logarithmic transformation of the data. The respondents' main occupations were measured by the question, "What is your current main occupation?." We divided the occupations of the first cohort of migrant workers into hazardous and non-hazardous occupations based on the occupation's degree of harm to the body. Where hazardous occupations = 1 and non-hazardous occupations = 0. Our occupational classification is primarily based on the theory of "skill segmentation" in the vertical labor market (71). In the labor market, employment situations can be categorized into non-routine cognitive, non-routine manual, routine cognitive, and routine manual occupations (72, 73). Building upon this framework and considering the Chinese labor market context, as well as the employment realities of migrant workers, this study further subdivides the employment of migrant workers into routine cognitive work and routine manual work. Following the design of previous relevant studies, occupations involving high pollution, high damage, high risk, and intense physical labor in industries such as processing, manufacturing, and construction are classified as hazardous work that poses significant health risks. Other occupations are classified as routine cognitive work, which is considered non-hazardous (72, 74).

2.3.3. Control variables

To more accurately analyze the lagging and cumulative factors of the first cohort of migrant workers' health in time and space, this study introduced three sets of control variables and gradually incorporated them to observe the factors affecting the health of the first cohort of migrant workers.

The first set of control variables includes the personal characteristics of the migrant workers, such as their age, years of education, marital status, and occupation, in order to reflect the individual factors that affect the health of the first cohort of migrant workers.

The second set of control variables reflects the family and social support factors of the first cohort of migrant workers, including mobility patterns, whether they moved with their families, and social communication, to reflect the influence of social support and family conditions on the health of the first cohort of migrant workers.

The third set of control variables reflects the personal medical accessibility of the first cohort of migrant workers, including whether they had established resident medical health records, whether they had received medical health education, etc., to reflect the relationship between medical accessibility for the first cohort of migrant workers and their health (Table 1).

2.4. Data analysis methods

In order to test our hypothesis, a logit probability model was employed, with the health variable as a dummy variable, two levels as healthy and unhealthy. $Health_i$ values are 1 and 0, where 1 represents a healthy status and 0 represents an unhealthy status.

The probability of being in a healthy state:

$$P(health_i = 1) = F(\alpha + \beta X_i) = \frac{1}{1 + \exp\left[-(\alpha + \beta X_i)\right]},$$

and

$$\ln \frac{P(health_i = 1)}{P(health_i = 0)} = \alpha + \beta X_i.$$

The logit probability model was set up as follows:

$$\log ithealth_i = \ln \pi_i = \alpha + \beta X_i + \mu_i, \pi_i = \frac{P(health_i = 1)}{P(health_i = 0)} \quad (1)$$

Here, π_i is the odds ratio or probability ratio. X_i represents the set formed by various explanatory variables, β represents the set formed by the coefficients of the various explanatory variables, and u_i represents the random disturbance term.

The logistic regression model, compared to the tobit and probit models, is the most widely used model in current applications. The cumulative probability function of the logistic model is continuously differentiable, and it has better out-of-sample predictive performance. Due to its non-linear and explicit probability characteristics, the logistic model can be solved quickly. When there are no changes in the choice set of the model but only changes in the levels of variables, it is convenient to calculate the probabilities of being healthy or unhealthy in the new environment. The logistic model has the property of Independence of Irrelevant Alternatives (IIA), which assumes that the odds ratios of unrelated alternatives are independent. Therefore, when the health status of migrant workers can have multiple possibilities, the inclusion of additional health conditions does not affect the odds ratios of other health conditions. Thus, Model (1) can be easily extended to accommodate multiple health conditions. In light of this, in the robustness tests of Hypotheses 1 and 2 in Section 4, we will classify the health conditions as follows: $Health_i$ are set as follows: 1 – unable to perform daily activities, 2 – unhealthy but able to perform daily activities, 3 – basic health, and 4 – healthy.

TABLE 1 Statistical description of the variables (N = 36,668).

Variable	Assignment or definition	Observed value	Mean (ratio)	Standard deviation
Dependent variable				
Self-rated health	Healthy = 1, unhealthy = 0	36,668	0.756	0.429
Independent variables				
Working hours per week	Migrant workers work hours per week	36,665	60.104	18.990
Length of employment	The time when migrant workers leave their hometown	36,668	15.130	8.942
Mobility outside the province	Out-of-province = 1, non-provincial =0	36,668	0.592	0.492
Distance from medical institutions	Within 15 min = 1, for the 15–30 min = 2, for 30 min–1 h = 3, over 1 h = 4	36,668	1.190 (83.5, 14.9, 1.75, 0.26)	0.457
Hazardous occupation	Yes = 1, no = 0	36,668	0.380	0.485
Monthly income	Migrant worker wage income takes logarithmic treatment	36,060	8.024	0.608
Control variables				
Married	Yes = 1, no = 0	36,668	0.945	0.227
Gender	Male = 1, female = 0	36,668	0.625	0.484
Age	Actual age of migrant workers	36,668	47.185	5.621
Level of education	Illiteracy = 0, elementary school = 6, middle school = 9, senior middle school = 12; junior college = 15, undergraduate college = 16, graduate student = 20	36,668	8.040 (2.84, 14.30, 43.66, 21.9, 10.46, 6.42, 0.52)	2.830
The number of floatings	Number of cities where migrant workers have worked	36,665	2.134	2.530
Illness within a year	Yes = 1, no = 0	36,668	0.461	0.498
Health education	Yes = 1, no = 0	33,867	0.703	0.457
Health records	Yes = 1, no = 0	33,867	0.282	0.450
The floating of reason	Economic reasons = 1, social reasons = 0	36,668	0.326	0.469
Family migration	Yes = 1, no = 0	36,668	0.505	0.500
Sign a labor contract	Yes = 1, no = 0	36,668	0.255	0.436
Fixed employer	Yes = 1, no = 0	36,668	0.383	0.487

The percentages of each category are shown in parentheses for the multi-category variables. For the binary variables, the mean represents the percentage of the first category, while the proportion of the second category is omitted.

In order to accurately estimate the parameter β, this study used a stepwise approach to add variables and observe changes in coefficients after each regression to assess the robustness of parameter estimates, drawing on Acemoglu et al. (75). Additionally, the study employed Baron and Kenny's framework for analyzing moderation effects by gradually adding control variables and observing changes in the regression coefficients and their significance for both the main and moderator variables (interaction terms), to explore the reasons for the formation of the vulnerability of migrant workers (76). Similarly, based on a regression equation with the first cohort of migrant workers' self-assessed health status as the dependent variable and variables with spatiotemporal characteristics, such as migration duration and medical insurance participation location, as independent variables, we constructed a regression equation by successively adding control variables, such as M1 and M2. We then compared the changes in coefficients between the latter and former equations, thereby analyzing the explanatory power of each set of variables, including differences in self-assessed health status among the first cohort of migrant workers. The OLS method used for obtaining the regression coefficients may have suffered from omitted variable bias, but since the omitted variables were mostly the same for the two regression equations compared (except for the addition of variable M in the latter equation), the impact of omitted variable bias would have been limited (77).

3. Analysis of data results

3.1. Descriptive statistics of health of first cohort of migrant workers

In this study, the definition of the first cohort of migrant workers referred to 36,668 individuals who were over 40 years old, had a rural household registration, and worked as employees. Among them, 31,344 individuals self-reported their physical health as good, accounting for 70.37% of the sample.[2] This indicated that the physical health of the first cohort of migrant workers was relatively good, but

2 Data source: Data of 2017 China Migrants Dynamic Survey.

their self-reported health was lower than that of the new generation of migrant workers. This is partly due to the aging of the first cohort leading to a higher degree of health loss. On the other hand, the logic behind the migration of the first cohort of migrant workers was different from that of second-generation migrant workers. The former aimed to obtain economic benefits, while the latter aimed to gain developmental opportunities. Therefore, their family responsibilities and ethical obligations were different. The first cohort of migrant workers adhered to the traditional culture of filial piety and had intergenerational family support and development responsibilities. Therefore, they rarely used their income for personal consumption, especially for health expenses, and delayed their health needs as much as possible in order to obtain maximum income, which led to greater health problems for themselves.

Furthermore, in terms of working hours, only 17.05% of the first cohort of migrant workers worked 40 h or less per week, which was lower than the average of 21.05% for all migrant workers in this period of time. The percentage of first-generation workers who worked between 40 and 60 h per week was 38.11%, which was also lower than the average of 40.91% for all migrant workers. The percentage of first-generation workers who worked more than 60 h per week was 44.74%, which was higher than the average of 38.04% for all migrant workers (77). From the statistical data, it can be seen that the average time that the first cohort of migrant workers spent working was lower than the average for migrant workers during standard working hours, or slightly higher working hours per week. However, their average working time was much higher than that of all migrant workers when they worked more than 60 h per week. Overall, 80% of migrant workers worked overtime, with almost no rest time. If calculated based on 1 day of rest on the weekend, their daily working time was more than 10 h. Excessive working hours seriously eroded the physical health of the first cohort of migrant workers.

3.2. Spatiotemporal extrusion regression analysis of the first cohort of migrant workers under the accumulation of disadvantages

The health issues of the first cohort of migrant workers included the long-term accumulation of disadvantages and the result of pressures on health caused by spatial and temporal lag from a policy perspective. The essential process by which these disadvantages accumulated lay in the economic and occupational vulnerabilities of these migrant workers – namely, the health disadvantages caused by engaging in heavy physical labor while working outside of their rural homes. Therefore, this accumulation process was not only a time-based accumulation; it was also affected by multidimensional factors. To ensure the robustness of the estimation results and to avoid the interference of multicollinearity, four models were produced by gradually introducing explanatory variables and control variables. All four models showed a significant negative correlation between the duration and range of migration and health. The estimation results are presented in Table 2.

Model 1 is a basic regression model that used external working time, engagement in hazardous occupations, out-of-province mobility, weekly working hours and distance from the hospital as core explanatory variables to verify Hypotheses 1–3.[3] The regression results showed that the weekly working hours and external working time (duration away from home) were significantly negatively correlated with health status at the 1% and 0.1% levels, respectively. This indicated that, the longer the weekly working hours and the duration away from home, the lower the probability of good health. The regression results supported Hypothesis 1. Out-of-province mobility and distance from the hospital were both significantly negative at the 1% level, supporting Hypothesis 2. Engagement in hazardous occupations was significantly negative at the 1% level, also supporting Hypothesis 2. Monthly income was significantly positive at the 1% level, indicating that, the higher the income, the greater the probability of good health. This suggested that individuals with higher incomes had stronger health maintenance abilities, helping to alleviate the accumulation of health disadvantages. The regression results of Model 1 fully supported the hypothesis of the health disadvantage accumulation of migrant workers. Although scholars have conducted related research on the health status and working time of migrant workers, there is a lack of empirical research with large-sample survey data. Our sample, taken from the first cohort of migrant workers in China, generally had an external working time of more than 20 years, and they engaged in more 4D-type work, with overtime as a common phenomenon. This study further clarified the process by which the health disadvantages of the first cohort of migrant workers accumulated by selecting specific research objects from nationwide data.

Considering the working life history of the first cohort of migrant workers, they were a typical "low-skilled, low-educated, low-income, and high-risk" population. They are known as "second-class citizens" in the job market (78). Due to the special history of the earliest group of migrant workers, the first cohort of migrant workers experienced a "process of recognition" when entering the city, which means they gradually moved from being excluded to being recognized (79). In the low-income and high-loss labor environments, the longer the first cohort of migrant workers' external mobility time, the greater their health losses, and the lower their health self-evaluation (9). From this perspective, the external mobility time of migrant workers is essentially a process of health disadvantage accumulation. That is, their investment in health maintenance was minimal, while their health losses increased day by day. Under such an accumulation of health disadvantages, the health outcomes of the first cohort of migrant workers were obviously not optimal.

Model 2 added medical education, health records, gender, age, marital status, and other first-type control variables of our first designated category to control for the individual characteristics.[4] The

3 Due to the primary goal of income for the first-generation migrant workers in their migration, income is a critical control variable related to the core explanatory variable. Omitting this variable would result in significant estimation bias. Therefore, Model 1 includes income as a control variable.

4 These control variables not only influence the health level of migrant workers but also have correlations with the core explanatory variables. For instance, in cases where families do not migrate, migrant workers face challenges in taking care of their children when they relocate to distant provinces, and in such situations, left-behind family members are responsible

10.3389/fpubh.2023.1221082

TABLE 2 Regression analysis of the health and mobility of the first cohort of migrant workers.

	Model 1	Model 2	Model 3	Model 4
	Health	Health	Health	Health
	b/se	b/se	b/se	b/se
Health				
Hazardous occupation	−0.079**	−0.147***	−0.096**	−0.088**
	(0.026)	(0.028)	(0.030)	(0.030)
Floating outside the province	−0.108***	−0.119***	−0.130***	−0.124***
	(0.017)	(0.018)	(0.018)	(0.018)
Distance from medical institutions	−0.198***	−0.185***	−0.177***	−0.174***
	(0.026)	(0.028)	(0.028)	(0.028)
Length of employment	−0.018***	−0.019***	−0.018***	−0.018***
	(0.001)	(0.001)	(0.002)	(0.002)
Working hours per week	−0.002**	−0.002**	−0.003***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Monthly income	0.516***	0.353***	0.343***	0.332***
	(0.021)	(0.022)	(0.022)	(0.022)
Income change	0.053**	0.093***	0.113***	0.090***
	(0.020)	(0.021)	(0.022)	(0.022)
Medical education		0.056	0.056	0.010
		(0.029)	(0.029)	(0.031)
Health records		0.111***	0.112***	0.043
		(0.031)	(0.031)	(0.033)
Gender		0.224***	0.228***	0.243***
		(0.029)	(0.029)	(0.029)
Age		−0.052***	−0.053***	−0.052***
		(0.002)	(0.002)	(0.002)
Level of education		0.029***	0.027***	0.021***
		(0.005)	(0.005)	(0.005)
Married		0.098	0.092	0.090
		(0.057)	(0.058)	(0.058)
Family migration			−0.245***	−0.244***
			(0.033)	(0.033)
The floating of reason			−0.068*	−0.271***
			(0.031)	(0.042)
The number of floating			0.017**	0.017**
			(0.006)	(0.006)
Fixed employers				0.166***
				(0.045)
Sign labor contract				0.207***
				(0.041)
_cons	−2.236***	0.982***	1.143***	1.213***
	(0.177)	(0.240)	(0.242)	(0.242)
N	36,057	33,307	33,307	33,307
r3				
p	2.08e-190	6.14e-303	1.29e-310	8.40e-323

t statistics in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

regression results showed that the signs and significance of the core variables in Model 1 did not differ significantly from those in Model 2, and the conclusions of Hypotheses 1–2 remained robust. In Model 2, the estimates of the mobility range (out-of-province mobility) and mobility time (working time) variables were negative and significant at the 0.1% level. We can therefore conclude that, the longer the external mobility time of migrant workers, the worse their health self-evaluation. That is, the larger the mobility ranges and the longer the durations of time away from home, the greater the time and economic costs of medical expense reimbursement, thus exacerbating the accumulation of health disadvantages for migrant workers.

To further control the influence of the selection characteristics of the first cohort of migrant workers, the second- and third-category control variables, such as family migration, reasons for migration, the number of migrations, and the signing of labor contracts, were added to Models 3 and 4. After these control variables were added, there were no significant changes in the parameter symbols and significance levels of the core explanatory variables in the models, and the estimation results were robust. The mobility range and mobility time variables remained significantly negative at the 1% level.

According to the various models in Table 2, the parameter symbols of the income variables and income change variables were significantly positive at the 5% level, indicating that income plays a crucial role in health maintenance. However, the income of the first cohort of migrant workers was generally lower than that of urban residents, and the role of income in health maintenance was not strong enough to offset the cumulative damage to health caused by the weak position of migrant workers. Data showed that medical services only became a necessity for rural residents as late as 2004. This transformation was critical in the establishment of the new rural cooperative medical insurance, which allowed rural residents to enjoy corresponding medical service benefits even on extremely low incomes. The income level of migrant workers peaked at the age of 35 and then showed a stable decline, falling earlier than urban residents' income, indicating that migrant workers lose employment opportunities and income capacity too early in the job market. Their lower income, coupled with their low health maintenance capacity, further exacerbates the accumulated health disadvantages of the first cohort of migrant workers. At the same time, in terms of the age dimension, there was also a significant negative correlation between age and health within the first cohort of migrant workers, showing that health declines with increasing age. Of course, even if occupational and economic factors are excluded, a negative correlation between age and health problems regarding individual physiological functions also exists. However, for the first cohort of migrant workers, due to their unique life course, their occupations and low economic status undoubtedly exacerbate the health disadvantages caused by the correlation between age and health beyond what is due to natural factors.

According to Models 3 and 4, their reason for migration is significantly related to health, which also verified that the critical factors for the first cohort of migrant workers' mobility were economic rather than social. Migrant workers only choose areas and industries with higher incomes, and do not consider other impact of other factors on health.[5] This is the rational strategy of "survival first" for migrant workers, and it is almost their only choice, indicating that migrant workers may sacrifice health for income. In terms of the number of migrations, health status was significantly positively correlated with the number of migrations these workers made, indicating that, the more they migrated, the higher their self-rated health, which partially validated the "salmon bias" explanation; that is, the healthier the migrant workers are, the more they will chase better opportunities by constantly moving. Because they have better physical health, they are more willing to invest time and other costs in searching for jobs. Those who are unhealthy can only lower their expectations, go with the floating, reduce the number of migrations they make, and pursue short-term benefits, thus becoming unable to change their weak position and likely to fall into a predicament as they age and their physical condition declines, increasing the possibility of a vicious cycle.

According to Models 3 and 4, the health level of migrant workers was significantly negatively associated with family migration at the 0.1% level. The self-rated health of the first cohort of migrant workers undertaking migrations with their the families was significantly lower than that of non-family migration migrant workers who did not migrate with their families. Whether family migration affects health is the result of comprehensive family dynamic decision making, which is related not only to health but also to income. Insufficient income cannot meet the expenses of a family, including those for children's education.

Due to the collinearity between the family migration mode and income, adding the family migration variable increases the variance of parameter estimation and reduces the precision of our estimate of the effect of the income variable due to collinearity. The standard error relative to the parameter's estimated value thus increases in this situation.[6]

The results obtained regarding family migration also raised some questions for the existing research in the academic community. In the existing research, rural-to-urban migration is seen as an important way to improve the health and mental health of migrant workers (80, 81). However, the results of this study showed that, for the first cohort of migrant workers, migrating with their family had a negative impact on their health. The family stress theory may better explain the impact of family migration on the health of the first cohort of migrant

for farming the land. Being in close proximity to home during busy farming seasons allows for immediate support. Furthermore, migrant workers who have established health records and received health education have a better understanding of their health issues and are aware of the occupational requirements and hazards. They can choose to avoid certain positions or reduce their time spent in such occupations. For instance, individuals with respiratory conditions tend to avoid jobs with high levels of dust.

5 Due to the correlation between household migration patterns and income, adding household migration variables can increase the variance of parameter estimates due to collinearity, thus reducing the accuracy of parameter estimates. The inclusion of household migration variables also decreases the estimated value of income variables affected by collinearity and increases the relative standard error. As a result, the actual contract signing rate may be even lower.

6 The actual contract signing rate may be lower.

workers. The first cohort of migrant workers were in the low-end job market with low incomes, and they tried to maximize the comparative benefits between rural and urban areas by squeezing their own consumption. However, regarding home-based migration, a family's living expenses in the city are obviously higher than those in the countryside. Single migrant workers can be more frugal in terms of accommodation, food, and daily life. However, when they migrate with their family, their offspring need to study close to where the parents work, incurring more expenses. Therefore, the first cohort of migrant workers had to further compress their health expenditures, seek more dangerous or worse jobs to strive for higher incomes, and provide more economic support for their offspring's development in the city. Family stress, therefore, further strengthened the health vulnerability of the first cohort of migrant workers.

Model 4 added labor contracts and fixed employers as control variables to on the basis of the previous model to further examine the health status and job stability of the first cohort of migrant workers. The regression results were significant, such that having a formal contract and a fixed employer could significantly improve health at the 0.1% level. In general, having a formal labor contract may increase income. A formal contract and a fixed employer also mean a safe working environment and good social relationships, which can increase confidence and a sense of security, and improve health. Migrant workers with higher incomes can live in more convenient environments, including locations that are closer to medical institutions. The presence of a labor contract and a fixed employer has a key impact on the health of migrant workers. The benefit of labor contracts and fixed employers for migrant workers lies in whether they can provide relatively stable health security and future job expectations for migrant workers. Existing studies also show that the health status of migrant workers is positively correlated with the signing of labor contracts. In signed labor contracts, the medical insurance of migrant workers can be reimbursed locally and can be included in the employee's medical insurance, thereby solving the problems of the spatial lag and non-portability of medical insurance. However, the low actual contract signing rate among migrant workers may hinder the realization of these benefits.

4. Tests of the robustness of the accumulation of health disadvantages and spatio temporal lag in the first cohort of migrant workers

The regression model results above demonstrate that there are significant spatial differences in the health status of the first cohort of migrant workers, which can be observed with the gradual addition of other factors. In essence, these differences relate to the current medical insurance system, suggesting that the New Rural Cooperative Medical Scheme (NRCMS) exhibits a spatial lag effect in maintaining the health of migrant workers. Additionally, the health of the first cohort of migrant workers is subject to the cumulative effect of time vulnerability. More loss-intensive and longer jobs result in greater health losses for migrant workers and poorer self-evaluations of health. To further test the robustness of the baseline regression results, this study changed the setting of the dependent variable and conducted a robustness test by replacing the dependent variable and re-regressing it. The results of the robustness test shown in Table 3 indicated that changing the setting of the dependent variable did not affect the baseline regression results. Specifically, even when controlling for other factors, the health of the first cohort of migrant workers is still affected by the spatiotemporal lag represented by the typical variables of migration range and duration, and there is also a time vulnerability accumulation mechanism in terms of health. The robustness test supported Hypotheses 1, 2.

Model 5 re-categorized the health status of migrant workers and redefined the health variables as follows: 1 = unable to take care of oneself, 2 = unhealthy but able to take care of oneself, 3 = basically healthy, and 4 = healthy. To distinguish the health variables in Model 5 from those in Table 2, the health variable in Model 5 was named Health 1. The results showed that the insurance location, migration duration, social interactions, and income from family migration are significantly related to health status. The parameter symbols did not change from Model 2.

Model 6 experienced a slight increase in the standard error, resulting in the t-value just falling below the critical threshold of 5%. In Model 7, an illness was used as an indicator of health, with 1 = no illness and 0 = having an illness. The health variable was named Health3. After adding various control variables and regressing the dependent variable of Health3, the results showed that mobility duration, mobility range, income, and other factors were significantly correlated with having an illness, and medical education and medical records significantly influenced the illness status of migrant workers. Consistent with many models in Table 2, income status also affected the health maintenance ability of the first cohort of migrant workers, with lower income being associated with poorer health status.

5. Further discussion of income and health

Tables 2, 3 show that the variables regarding the reasons for migration are significantly negative, revealing that migrant workers who move for economic and income reasons may harm their health. However, this does not necessarily mean that increasing income will harm health; instead, it indicates that the relationship between income and health is conditional. Of course, most people in the labor market meet this condition, leading to its neglect in the health domain, but the first cohort of migrant workers is an exception.

Income, as a key variable, plays a significant role in the health evaluation of migrant workers in the context of their accumulated health vulnerabilities. In academic research on the relationship between migrant workers' health and income, most studies have indicated that lower income has a greater impact on health (63, 66). However, there are also some workers who sacrifice their health to obtain a higher income by extending working hours or engaging in dangerous 4D work (37, 39). The bidirectional relationship between health and income has always been a focus of discussion in research on the relationship between the two factors.

In this study, to test Hypothesis 3, to further reduce the bidirectional influence between working hours, income, and health, two methods were adopted. One was the analysis of moderating effects, using income as a moderating variable to analyze whether income has a detrimental effect on health when working hours are extended. The other method was to find proxy variables for sacrificing health to obtain income. Income is obtained by labor under the

10.3389/fpubh.2023.1221082

TABLE 3 Tests of the robustness of the accumulation of health disadvantages and spatio temporal lag in the first cohort of migrant workers.

	Model 5	Model 6	Model 7
	Health 1	Health 2	Health 3
	b/se	b/se	b/se
Main			
Floating outside the province	−0.071***	−0.101***	−0.130***
	(0.016)	(0.015)	(0.018)
Distance from medical institutions	0.033	−0.068**	−0.193***
	(0.025)	(0.024)	(0.028)
Length of employment	−0.019***	−0.022***	−0.018***
	(0.001)	(0.001)	(0.002)
Working hours per week	−0.007***	−0.005***	−0.002**
	(0.001)	(0.001)	(0.001)
Monthly income.	0.167***	0.286***	0.362***
	(0.020)	(0.019)	(0.023)
Income change	0.046*	0.072***	0.102***
	(0.018)	(0.017)	(0.022)
Hazardous occupation	−0.152***	−0.134***	−0.090**
	(0.025)	(0.023)	(0.030)
Medical education	−0.068**	−0.029	−0.056
	(0.025)	(0.024)	(0.029)
Health records	0.137***	0.124***	0.107***
	(0.026)	(0.024)	(0.031)
Gender	0.148***	0.194***	0.231***
	(0.025)	(0.023)	(0.029)
Age	−0.002	−0.027***	−0.052***
	(0.002)	(0.002)	(0.002)
Level of education	0.008	0.021***	0.028***
	(0.004)	(0.004)	(0.005)
Married	−0.264***	−0.124*	−0.096
	(0.051)	(0.048)	(0.058)
Family migration	−0.369***	−0.350***	−0.246***
	(0.029)	(0.026)	(0.033)
The floating of reason	−0.251***	−0.242***	−0.179***
	(0.030)	(0.029)	(0.035)
The number of floating	0.017**	0.001	0.018**
	(0.006)	(0.005)	(0.006)
Sign labor contract	0.076*	0.059*	0.269***
	(0.032)	(0.029)	(0.037)
cut1	−0.018	−0.490*	0.959***
	(0.215)	(0.206)	(0.245)
cut2		1.186***	3.248***
		(0.206)	(0.248)
cut3		2.840***	8.965***
		(0.208)	(0.560)
cut4		4.681***	
		(0.217)	
N	33,307	33,307	33,307
r3			
p	5.30e-200	4.94e-324	0

t statistics in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Models 5 and 6 were estimated using the ordinal selection model.

condition of unchanged health status. Labor input is represented by working hours, and income obtained by labor input is income obtained by sacrificing health. The residual obtained by regressing income on variables such as working hours represented the income obtained by sacrificing health. This residual method has been widely used in related studies (82–84). The specific equation is as follows:

$$\ln income_i = \beta_1 + \beta_2 worktiome_i + \sum \delta_j z_j + u_i \quad (2)$$

Other variables influencing income are included in Eq. 2. The estimated residuals from Eq. 1 can serve as a proxy for the portion of income obtained at the cost of sacrificing health. Subsequently, using the residuals as the explanatory variable for health, we analyzed the factors contributing to the vulnerability of the health of the first cohort of migrant workers from the perspectives of policy-induced spatial lag and the duration of migrant workers' out floating. The regression results are shown in Table 4.

According to Table 4, the income equation of Model 9 included a series of variables that influence income, such as working hours, mobility range, occupational characteristics, human capital (education, health), social capital (whether workers experience social interactions in the local area), production capital (whether there is insurance coverage and whether there are dividends), and social security level (whether workers are enrolled in social security). Therefore, other factors influencing income are hidden in the residuals, including income obtained at the cost of sacrificing health. Thus, the residuals obtained from Model 9 can be used as a proxy for income obtained at the cost of sacrificing health. In order to accurately characterize the vulnerable position of the first cohort of migrant workers who sacrificed their health for income out of necessity, Model 9 excluded variables related to hazardous industries or occupations (hazardous occupations) that may be detrimental to health and included these detrimental factors in the residuals. Model 10 did not include the variable of income obtained at the cost of sacrificing health, while Model 11 included this variable. Model 12 included the interaction term between income obtained at the cost of sacrificing health and weekly working hours, to reflect the dual effect of engaging in hazardous occupations such as 4D works and damaging health by increasing working hours. Model 13 included both the variable of income obtained at the cost of sacrificing health and the interaction term between this variable and weekly working hours.

The estimation results of Models 10–13 showed that income obtained at the cost of sacrificing health was significantly negative at the 1% significance level after controlling for wage income and other variables, verifying the fact that migrant workers generally exchange health for income, and confirming the accumulation of vulnerabilities among migrant workers. Hypothesis 3 has been validated. The interaction term between income obtained at the cost of sacrificing health and weekly working hours in Models 12 and 13 was also significantly negative at the 0.1% level, indicating that the working environment of migrant workers (e.g., 4D work) is correlated with weekly working hours, and the combination of the two further reduces health levels, or that the detrimental working environment worsens the health levels of migrant workers by prolonging working hours. The estimation results of the interaction term also suggested that migrant workers do not receive sufficient income compensation for their poor working environment. If the compensation were high enough, migrant workers would choose to reduce working hours to restore their health and maintain labor force levels. However, in reality, the detrimental working environment and long working hours have a cumulative effect, and migrant workers do not choose to substitute working environment for working hours, but rather continue to increase working hours and choose poorer working environments to ensure necessary income. Furthermore, for these individuals, it also shows that income does not significantly increase with working hours, working environment, or work intensity. In terms of the employment sector, the first cohort of migrant workers were mainly concentrated in labor-intensive, low-income industries, engaging in high-intensity, high-risk, low-wage jobs. In some construction sites, about 90% of the workers were the first cohort of migrant workers. These characteristics of the first cohort of migrant workers make them typical representatives of excessive labor and low income in the job market (85).

Tables 2, 3 respectively validate the hypotheses presented earlier through regression models and robustness tests, respectively. Specifically, we found that the health of the first cohort of migrant workers is subject to spatial lag and vulnerable accumulation mechanisms. The spatial lag was reflected in a significant negative correlation between the range of mobility and self-rated health of the first cohort of migrant workers. Vulnerability accumulation was primarily shaped by factors such as low income, hours of overtime worked per week, 4D-type jobs, and time spent away from home, which cumulatively contributed to the health vulnerability of the first cohort of migrant workers. Furthermore, this vulnerability became increasingly apparent as this cohort aged. Throughout their working lives, the market disadvantage and excessive labor involved in their jobs contributed to the process of the accumulation of health vulnerabilities.

6. Discussion and conclusion

6.1. Discussion

Our study is the first to utilize nationwide large-scale data to demonstrate the phenomenon of accumulated vulnerability in the health status of first-cohort migrant workers. Previous studies have primarily focused on the social relationships and economic income of migrant workers (2, 3), without considering the unique health issues faced by first cohort of migrant workers, the issue of accumulating health vulnerabilities. For migrant workers, the accumulation of vulnerabilities poses a harm to their health that is greater than the sum of its parts ($1 + 1 > 2$). Previous research has only considered the issue of individual vulnerabilities (4, 86), while the combination of various disadvantages can lead them to actively choose work environments that are detrimental to their health in order to earn income. This short-term behavior and the lack of consideration for their future well-being result in a pessimistic outlook for their later years in life. Additionally, our study discusses the relationship between the familial migration of migrant workers and their health, we found that when migrant workers migrate with their families, it has an impact on their health. Our study expand the research perspective on family-based migration of migrant workers. Internationally, scholars have often discussed the health issues of cross-border migration and have also shown concern for

10.3389/fpubh.2023.1221082

TABLE 4 Testing the sacrifice of health for economic income among the first cohort of migrant workers.

	Model 8	Model 9	Model 10	Model 11	Model 12
Variables	Lincome	Health	Health	Health	Health
Monthly income		0.123***	0.666***	0.601***	0.681***
		(4.953)	(15.72)	(15.17)	(16.07)
Sacrifice the income earned from your health			−0.968***		−0.616***
			(−15.06)		(−5.620)
Interaction term between sacrificing health and weekly work hours				−0.0135***	−0.00601***
				(−14.88)	(−3.841)
Working hours per week	0.00156***	−0.00178**			
	(7.889)	(−2.076)			
Floating outside the province	0.116***	0.171***	0.0632*	0.0736**	0.0595*
	(17.34)	(5.386)	(1.907)	(2.235)	(1.797)
New rural cooperative location	0.0413***	0.151***	0.129***	0.123**	0.124**
	(4.067)	(3.178)	(2.655)	(2.521)	(2.549)
Length of employment		−0.216***	−0.240***	−0.234***	−0.239***
		(−6.139)	(−6.668)	(−6.519)	(−6.647)
Distance from medical institutions	0.0205***	−0.155***	−0.176***	−0.171***	−0.175***
	(2.757)	(−4.639)	(−5.142)	(−4.988)	(−5.108)
Married	0.0516***	0.0228	−0.115	−0.105	−0.121
	(3.562)	(0.304)	(−1.492)	(−1.368)	(−1.573)
Gender	0.245***	0.205***	0.0203	0.0300	0.0105
	(35.32)	(5.942)	(0.549)	(0.821)	(0.285)
Age	−0.0905***	−0.349***	−0.274***	−0.283***	−0.272***
	(−21.71)	(−17.60)	(−13.04)	(−13.60)	(−12.95)
Level of education	0.0282***	0.0230***	0.00286	0.00410	0.00165
	(21.15)	(4.017)	(0.471)	(0.682)	(0.272)
Ill within a year	−0.0362***	−0.843***	−0.825***	−0.826***	−0.824***
	(−5.514)	(−26.57)	(−25.53)	(−25.55)	(−25.48)
Participate in the new rural insurance	−0.144***	−0.218***	−0.126**	−0.133**	−0.121**
	(−14.31)	(−3.838)	(−2.193)	(−2.319)	(−2.115)
Health education		0.0778**	0.103***	0.0989***	0.103***
		(2.231)	(2.900)	(2.778)	(2.885)
Health records	−0.0254***	0.0971***	0.119***	0.111***	0.117***
	(−3.574)	(2.706)	(3.251)	(3.050)	(3.202)
The floating of reason	0.0359***	0.128***	0.0233	0.00975	0.0109
	(4.565)	(3.517)	(0.661)	(0.276)	(0.308)
Family migration	0.0628***	−0.0181	−0.0656*	−0.0674*	−0.0700**
	(9.282)	(−0.534)	(−1.893)	(−1.947)	(−2.019)
Family economic status		0.284***	0.508***	0.475***	0.511***
		(8.427)	(13.15)	(12.60)	(13.22)
Family difficulties		0.608	0.469	0.510	0.476
		(1.074)	(0.804)	(0.872)	(0.813)
Local social interaction	0.0614***	0.0677**	0.0176	0.0215	0.0149
	(9.141)	(2.054)	(0.521)	(0.637)	(0.442)

(Continued)

TABLE 4 (Continued)

	Model 8	Model 9	Model 10	Model 11	Model 12
Engaged in the industry		−0.0284			
		(−0.658)			
The health of migrant workers	0.119***				
	(15.23)				
Whether there is contracted land	−0.0318***				
	(−4.609)				
Are there any dividends	0.105***				
	(4.862)				
Constant	7.555***	−1.020	−3.523***	−3.163***	−3.553***
	(271.3)	(−1.612)	(−5.240)	(−4.740)	(−5.270)
Observations	31,299	22,472	22,029	22,029	22,029
R-squared	0.14	0.0644	0.0024	0.7646	0.1172

t statistics in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

the health and occupational issues of immigrants (9, 58). However, they have not conducted data-driven comparative analyses on the relationship between immigrants' occupations and health Furthermore, there has been limited discussion on the portability of policies related to Chinese immigrant health issues and the influence of traditional Chinese culture, such as filial piety culture, on their health factors. Specifically, first-cohort migrant workers primarily allocate their income to sustaining their family's income, often allocating fewer funds for their own health issues.

6.2. Policy implications

From a policy perspective, the tension between the high mobility of migrant workers and the regional limitations of the medical insurance system creates a rigid situation in which the use of medical insurance by migrant workers is limited by their mobility. This rigidity significantly inhibits the health maintenance ability of migrant workers, resulting in the inclusion of spatial lag in the typical characteristics of health maintenance for migrant workers. Additionally, the limitations imposed by the New Cooperative Medical Scheme (NCMS) on the place of residence and household registration further exacerbate the dilemma between the mobility of rural residents and their access to medical resources, leading to significant difficulties for migrant workers in obtaining medical care. In reality, many individuals in the first cohort of migrant workers faced a difficult decision between maintaining their health and sustaining their livelihood. For them, giving up their mobility was equivalent to giving up their only means of accessing economic resources. Thus, many migrant workers chose to sacrifice their medical benefits to ensure the sustainability of their livelihood (87).

In the context of China's aging society, it is crucial to further stimulate the labor capacity of middle-aged and older adult groups, and break the non-benign cycle of health, mobility, and employment among the first cohort of migrant workers. It is necessary to reduce the impact of health problems on China's labor supply market, and enhance the medical security system and health maintenance ability of the first cohort of migrant workers. Therefore, the following policy recommendations are proposed:

First, at the level of the overall planning of urban and rural residents' social medical insurance, efforts should be made to achieve provincial-level or large regional-level coordination. Anhui Province's migrant worker floating is mainly concentrated in the Yangtze River Delta region, where the cross-regional coordination of residents' social medical insurance can be achieved. The Bohai Economic Rim could also address the mobility and medical needs of migrant workers in the north, making medical insurance more adaptable to the high-mobility characteristics of migrant workers, and eliminating the binary tension between their native residence home and their need for high mobility. This will provide convenience in the health maintenance of migrant workers and eliminate the effect of lag in the treatment of health issues.

Second, a special medical initiative action for migrant workers should be launched to enhance the health maintenance ability of the first cohort of migrant workers. Research has shown that establishing health records and receiving relevant health education in the workplace could significantly enhance the health maintenance ability of the first cohort of migrant workers. Establishing nearby community medical locations could also significantly improve their health status. It is necessary to enforce a health examination system for the first cohort of migrant workers, with their workplaces as the first responsible party. Special projects for the health maintenance of migrant workers should be established, and enterprises and social forces should be mobilized to participate.

Third, health knowledge and routine medical care for the first cohort of migrant workers should be promoted to enhance their medical literacy. Improving the health literacy of migrant workers can help achieve the early diagnosis and treatment of health problems and eliminate the accumulation of health vulnerabilities. Following the concept of promoting health education and health literacy for the "whole population" and "full life cycle," targeted

screening for health risks and activities to improve health risk awareness should be conducted for older migrant workers.

6.3. Study limitations and contributions

6.3.1. Study limitations

This study was based China Migrants Dynamic Survey (2017). This study has some limitations.

First, this is a cross-sectional study, which to some extent has limited our chance to explore the comparison of health status among migrant workers before and after migration due to the lack of respondents health information before 2017.

Meanwhile, interpretation of the findings implying causality should take caution. A longitudinal study may yield a better understanding of the relationship between migrant workers' mobility and their health.

Second, the existing data mainly focuses on the health of migrant workers, and lacks the health data of urban populations during the same period, which limits our opportunity to make comparisons between the health status of migrant workers and urban populations.

Third, there may be other factors that affect the health of the first cohort of migrant workers, but our study is limited to the questionnaire items, which also affects our study of the specificity of the health status of the first cohort of migrant workers.

6.3.2. Contributions

Despite of its limitations, this study contributes to the existing literature by providing a more comprehensive understanding of the factors that contribute to the poor health outcomes of Chinese migrant workers. Specifically, the study highlights the unequal access to social rights, particularly healthcare, as a major underlying cause of migrant workers' poor health beyond the limitations of China's universal healthcare system. By shedding light on this issue, the study underscores the need for systemic changes to address the structural barriers that hinder healthcare access for migrant workers and promote greater equity in healthcare delivery in China.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

FQ and QK made the conceptualization, designed methodology, wrote the main manuscript text and reviewed and edited. FQ, QK, and DF prepared Tables 1–4. FQ was responsible for funding acquisition. All authors contributed to the article and approved the submitted version.

Funding

This research was funded by Social Science Fund of Anhui Province, grant number: AHSKY2022D172.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Cai Z, Wang D. Sustainability and labor contribution of China's economic growth. *Econ Res*. (1999) 10:62–8.

2. Wang XZ. From 'survival' to 'recognition': the problem of migrant workers from the perspective of citizenship rights. *Soc Stud*. (2009) 1:121–38.

3. Chen YF. Migrant workers: institutional arrangements and identity recognition. *Soc Stud*. (2005) 3:119–32.

4. Zhou XG, Lu M. Health of migrants: China's achievement or regret? *Econ Res J*. (2016) 3:79–98.

5. National Bureau of Statistics. "Statistical communique of the People's Republic of China on the 2021 National Economic and Social Development." (2022) Available at: http://www.stats.gov.cn/tjsj/zxfb/202202/t20220227_1827960.html

6. National Bureau of Statistics. Monitoring Survey Report on Migrant Workers. (2022) Available at: http://www.gov.cn/xinwen/2022-04/29/content_5688043.htm

7. Wang CG. The relationship between social identity of New generation rural floating population and urban-rural integration. *Soc Stud*. (2001) 3:63–76.

8. Song LF. The formation, trend and countermeasures of the "migrant workers wave". *Chinese Soc Sci*. (1995) 4:78–91.

9. Liu CJ, Cheng JL. The intergenerational differences and citizenization of migrant workers in China. *Econ Netw*. (2007) 4:18–21. doi: 10.3969/j.issn.1007-7685.2007.04.006

10. Xu CX. Ways of migrating into the city and 0ccupational mobility of migrant workers: comparative analysis of two generations of migrant workers. *Youth Stud*. (2010) 3:1–12.

11. Lee K, McGuinness C, Kawakami T. *Research on occupational safety and health for migrant workers in five Asia and the Pacific countries: Australia, Republic of Korea, Malaysia, Singapore and Thailand*. Geneva: International Labour Organization (2011).

12. Qiu FX. Analysis of the accessibility of health services for the first generation of migrant workers from the perspective of building a healthy China. *J Anhui Normal Univ (Soc Sci Ed)*. (2023) 2:81–92. doi: 10.14182/j.cnki.j.anu.2023.02.009

13. Jacquelyn Flaskerud H, Winslow BJ. Conceptualizing vulnerable populations health-related research. *Nurs Res*. (1998) 47:69–78. doi: 10.1097/00006199-199803000-00005

14. Dale D. Cumulative advantage/disadvantage and the life course: cross-fertilizing age and social science theory. *J Gerontol*. (2003) 6:S327–37. doi: 10.1093/geronb/58.6.S327

15. Bauman LJ, Silver EJ, Stein REK. Cumulative social disadvantage and child health. *Pediatrics*. (2006) 117:1321–8. doi: 10.1542/peds.2005-1647

16. O'Rand AM. The precious and the precocious: understanding cumulative disadvantage and cumulative advantage over the life course. *Gerontologist*. (1996) 36:230–8. doi: 10.1093/geront/36.2.230

17. Falci CD, Mortimer JT, Noel HJ. Parental timing and depressive symptoms in early adulthood. *Adv Life Course Res*. (2010) 15:1–10. doi: 10.1016/j.alcr.2010.05.001

18. Merton RK. *Social theory and social structure*. New York: Free Press, a division of Macmillan Pub (1967).

19. Leight SB. The application of a vulnerable populations conceptual model to rural health. *Public Health Nurs*. (2003) 20:440–8. doi: 10.1046/j.1525-1446.2003.20604.x

20. England P, Garcia-Beaulieu C, Ross M. Women's employment among blacks, whites, and three groups of Latinas: do more privileged women have higher employment? *Gend Soc*. (2004) 18:494–509. doi: 10.1177/0891243204265632

21. Guralnik JM, Butterworth S, Wadsworth MEJ, Kuh D. Childhood socioeconomic status predicts physical functioning a half century later. *J Gerontol Ser A Biol Med Sci*. (2006) 61:694–701. doi: 10.1093/gerona/61.7.694

22. Hamil-Luker J, O'Rand AM. Gender differences in the link between childhood socioeconomic conditions and heart attack risk in adulthood. *Demography*. (2007) 44:137–58. doi: 10.1353/dem.2007.0004

23. O'Rand AM, Jenifer HL. Processes of cumulative adversity: childhood disadvantage and increased risk of heart attack across the life course. *J Gerontol Ser B Psychol Sci Soc Sci*. (2005) 2:S117–24. doi: 10.1093/geronb/60.Special_Issue_2.S117

24. Galobardes B, John WL, Smith GD. Childhood socioeconomic circumstances and cause-specific mortality in adulthood: systematic review and interpretation. *Epidemiol Rev*. (2004) 26:7–21. doi: 10.1093/epirev/mxh008

25. Riley MW, Foner A, Waring J. *Aging and society: a sociology of age stratification*. Manhattan, NY: Russell Sage Foundation (1972).

26. Clausen J. The continuing problem of defining mental deficiency. *J Spec Educ*. (1972) 6:97–106. doi: 10.1177/002246697200600113

27. Li Q, Deng JW. Social change and personal development: paradigms and methods of life course research. *Soc Stud*. (1999) 6:1–18.

28. Dannefer D. Cumulative advantage /disadvantage and the life course: cross-fertilizing age and social science theory. *J Gerontol Ser B Psychol Sci Soc Sci*. (2003) 58:S327–37. doi: 10.1093/geronb/58.6.S327

29. Guo YH, Chang AS. Life course and social security: a sociological exploration of the life course of laid-off and unemployed workers. *Chinese Soc Sci*. (2005) 5:93–107.

30. Bao LP. Analysis of time perception in life course theory. *Soc Stud*. (2005) 4:120–33. doi: 10.19934/j.cnki.shxyj.2005.04.005

31. Jiao KS, Bao ZM. Social change, life course, and elderly health. *Soc Stud*. (2020) 35:149–69. doi: 10.19934/j.cnki.shxyj.2005.04.005

32. Elder J, Glen H, Avshalom C. Human development and social change: an emerging perspective on the life course In: N Bolger, A Caspi, G Downey and M Moorehouse, editors. *Persons in context: developmental processes*. New York: Cambridge University Press (1988). 77–113.

33. Elman C, Angela MO. The effects of social origins, life events, and institutional sorting on adults' school transitions. *J Soc Sci Res*. (2007) 36:1276–99. doi: 10.1016/j.ssresearch.2006.11.001

34. Glasgow N, Brown DL. Older, rural and poo In: RT Coward and JA Krout, editors. *Aging in rural settings: life circumstances and distinctive features*. New York: Springer Publishing (1998). 187–205.

35. Lee LF. Health and wage: a simultaneous equation model with multiple discrete indicators. *Int Econ Rev*. (1982):199–221.

36. Stern S. Semiparametric estimates of the supply and demands effects of the disability on labor force participation. *J Econ*. (1996) 71:49–70. doi: 10.1016/0304-4076(94)01694-1

37. Liu GE, William H, Dow Fu AZ, Akin JS. Health human capital and income growth in China. *China Econ Q*. (2004) 4:101–18.

38. Strauss J, Thomas D. Human resources: empirical modeling of household and family decisions In: JR Behrman and TN Srinivasan, editors. *Handbook of development economics*, vol. *3*. Amsterdam: North-Holland (1995). 1883–2023. doi: 10.1016/S1573-4471(05)80006-3

39. Wei Z. The role of health on off-farm employment and wage decision. *Econ Res J*. (2004) 2:64–74.

40. Zhang CC. Empirical analysis on impact of health change on labor supply and income. *Econ Rev*. (2011) 4:79–88.

41. Zhou F. Income and health of urban migrant workers: effects of occupational status. *Econ Forum*. (2009) 22:49–52. doi: 10.3969/j.issn.1003-3580.2009.22.016

42. Yuan HN. Health and income of migrant workers in cities – evidence from a survey of migrant workers in Beijing. *J Manag World*. (2009) 5:56–66.

43. Qin LJ, Chen B, Qin XZ. Analysis of the impact of health on the income of migrant workers going out to work. *World Econ Papers*. (2013) 6:110–20.

44. Qian L, Chen J. Rely on education or health: the influence of the two kinds of human capitals on migrant workers' income and its differentiation effect. *Xinjiang State Farms Econ*. (2018) 2:11–9.

45. Ren H, Ren QQ. Demand intensity and participation behavior of migrant workers' medical insurance: an explanation for the deviation phenomenon. *Study Pract*. (2020) 3:61–75.

46. Fu DY, Li NX, Gao B. Factors influencing migrant workers' health insurance selection in the process of urbanization: based on the date of Chengdu. *J Sichuan Univ (Philos Soc Sci Edn)*. (2018) 3:63–8. doi: 10.3969/j.issn.1006-0766.2018.03.010

47. Feng J, Yu YY. Income inequality and health in rural China. *Econ Res J*. (2007) 1:79–88.

48. Christopher B, Stern N. Productivity, wages and nutrition, part I, the theory. *J Dev Econ*. (1978) 5:331–62. doi: 10.1016/0304-3878(78)90016-0

49. Grossman M. On the concept of health capital and the demand for health. *J Polit Econ*. (1972) 80:223–55. doi: 10.1086/259880

50. Lu WC, Li YL. Theoretical reasoning on health rights of migrant workers: a perspective of environmental justice. *Chinese J Popul Sci*. (2009) 3:13–20.

51. Xiong GL, Wu J, Wang F, Cheng MJ. Pay attention to the health risks of migrant workers. *Med Soc*. (2006) 2:1–5.

52. Huang QB, Sa ZH. The association between working hours and physical and mental health among rural – urban migrant workers in China. *Chin J Health Psychol*. (2015) 3:358–62. doi: 10.13342/j.cnki.cjhp.2015.03.012

53. Zhou XG, Lu M. The rural migrant workers' health: China's success or regret? *China J Econ*. (2016) 3:79–98.

54. Liu Y. The dynamic change of Chinese migrant workers' health – evidence from CHNS (1997-2006) survey data. *J Xinjiang Univ (Philos Soc Sci)*. (2011) 6:33–37. doi: 10.3969/j.issn.1000-2820.2011.06.007

55. Mi SH, Li BZ, Zhu QB. The impact of social capital on the health status of rural – urban migrant workers. *Issues Agric Econ*. (2016) 9:42–53.

56. Feng J. *Health needs and medical security system construction: a study of rural China, Shanghai*. Shanghai People's Publishing House. (2009) 79–176.

57. Ye MH. Is the medical service to rural residents luxury or necessity? Based on rural and urban comparison of medical demand income elasticity:1990—2009. *Issues Agric*. (2011) 6:30–5.

58. Li XJ, Wang ZH, Lin ZP. The impact of new rural cooperative medical care on farmers' medical treatment behavior and health – based on the analysis of different income levels. *World Econ Papers*. (2012) 3:58–75.

59. Wang J, Zheng J, Wang P, Qi L. Migration and health in China: bridging the gaps in policy aims and the reality of medical services to migrants. *J Public Adm*. (2014) 4:29–45.

60. McDonald JT, Kennedy S. Insights into the healthy immigrant effect: health status and health service use of immigrants to Canada. *Soc Sci Med*. (2004) 59:1613–27. doi: 10.1016/j.socscimed.2004.02.004

61. Marmot MG, Adelstein AM, Bulusu L. Lessons from the study of immigrant mortality. *Lancet*. (1984) 323:1455–7. doi: 10.1016/S0140-6736(84)91943-3

62. Arifin E.N., Ananta A., Punpuing S. Impact of migration on health in Kanchanaburi, Thailand. *International Population Conference* 2005, 18–23.

63. Liu JJ. An empirical analysis of the impact of health risks on rural labor migration. *J Hulunbuir Univ*. (2013) 5:10–4. doi: 10.3969/j.issn.1009-4601.2013.05.005

64. Yin QS, Wang W, Wang P. Circular effect analysis of income and health status of rural residents in China: An empirical analysis based on CHNS data. *Economist*. (2011) 11:43–51.

65. Crystal S, Shea D. Cumulative advantage, cumulative disadvantage, and inequality among elderly people. *Gerontologist*. (1990) 30:437–43. doi: 10.1093/geront/30.4.437

66. Jin XY, Hu ZY, Gu DD. Who are the elderly migrant workers: data analysis based on the monitoring survey of floating population. *Manag Rev*. (2018) 7:271–80.

67. Alpert PT. Self-perception of social isolation and loneliness in older adults. *Home Health Care Manag Pract*. (2017) 29:249–52. doi: 10.1177/1084822317728265

68. Poortinga W. Social relations or social capital? Individual and community health effects of bonding social capita. *Soc Sci Med*. (2006) 1:255–70. doi: 10.1016/j.socscimed.2005.11.039

69. Yi YY, Song XW. Study on the importance of factors affecting the health of floating population in China: empirical analysis based on random forest model. *Northwest Popul J*. (2020) 4:15–26. doi: 10.15884/j.cnki.issn.1007-0672.2020.04.002

70. Calnan M. The health locus of control: an empirical test. *Health Promot Int*. (1987) 4:323–30. doi: 10.1093/heapro/2.4.323

71. Ehrenberg RG, Smith RS. *Modern labor economics, theory and public policy*. Boston: Addison-Wesley Educational Publishers Inc. (1997).

72. Cortes GM, Jaimovich N, Siu HE. Disappearing routine jobs: who, how, and why. *J Monet Econ*. (2017) 91:69–87. doi: 10.1016/j.jmoneco.2017.09.006

73. Cain GG. The challenge of segmented labor market theories to orthodox theory: a survey. *J Econ Lit*. (1976) 14:1215–1257.

74. Zhang S, Shi X. Market segmentation, capital deepening, and education deepening: further thoughts on employment issues. *J Yunnan Univ (Soc Sci)*. (2003) 5:70–76. doi: 10.3969/j.issn.1671-7511.2003.05.010

75. Acemoglu D, Johnson S, Robinson J, Thaicharoen Y. Institutional causes, macroeconomic symptoms: volatility, crises and growth. *J Monet Econ*. (2003) 50:49–123. doi: 10.3386/w9124

76. Baron R.M., Kenny D. A. *The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations*. London: Chapman and Hall (1986), *51*, 173–1182.

77. Qi MZ, Wang Y. Research on the socio-economic stratification of floating population in China. *Chinese J Popul Sci*. (2021) 6:110–123+128.

78. Démurger S, Gurgnd M, Li A, Yue X. Migrants as second-class workers in urban China? A decomposition analysis. *J Comp Econ*. (2009) 37:610–28. doi: 10.1016/j.jce.2009.04.008

79. Wang XZ. From "survival" to "recognition": the problem of migrant workers in the field of citizenship. *Sociol Res*. (2009) 1:21–138.

80. Liang H. The mental health status of migrant workers from the perspective of intergenerational differences. *Popul Res*. (2014) 4:87–100.

81. Yu L, Zhu Y. The impact of residential segregation on the health of migrant population: an analysis based on the 2014 dynamic monitoring data of migrants. *Shandong Soc Sci*. (2018) 6:120–8.

82. Richardson S. Over-investment of free cash flow. *Rev Acc Stud*. (2020) 11:159–89.

83. Hribar P, Melessa SJ, Small RC. Does managerial sentiment affects accrual estimates? Evidence from the banking industry. *J Account Econ*. (2017) 63:26–50. doi: 10.1016/j.jacceco.2016.10.001

84. Xin BH, Dou YZ, Tao J. Confucian culture affects the stability of commercial banks. *J Anhui Normal Univ (Hun Soc Sci)*. (2023) 1:129–143. doi: 10.14182/j.cnki.j.anu.2023.01.013

85. Guo F.M., Zhang S.W. (2021). Does signing labor contracts help alleviate migrant workers? *World Economic* Conference 2021, 6, 1-16.

86. Li DP, Lu HY, Wen XL. Labor time, social interaction, and the physical and mental health of migrant workers: an empirical analysis based on CGSS2013 data. *Survey World*. (2018) 3:40–5. doi: 10.13778/j.cnki.11-3705/c.2018.03.007

87. Qiu FX, Liu J, Zhan HJ. Migration and health—freedom of movement and social benefits for Chinese migrant workers. *Sustainability*. (2021) 13:1–26. doi: 10.3390/su132212371

frontiers | Frontiers in Public Health

TYPE Perspective
PUBLISHED 01 August 2023
DOI 10.3389/fpubh.2023.1192183

Check for updates

OPEN ACCESS

EDITED BY
Palash Chandra Banik,
Bangladesh University of Health Sciences, Bangladesh

REVIEWED BY
Gemma Bridge,
Independent Researcher, Leeds, United Kingdom

*CORRESPONDENCE
Karl Peltzer
✉ kfpeltzer@gmail.com

RECEIVED 23 March 2023
ACCEPTED 03 July 2023
PUBLISHED 01 August 2023

CITATION
Pengpid S and Peltzer K (2023) Trends in behavioral and biological risk factors for non-communicable diseases among adults in Bhutan: results from cross-sectional surveys in 2007, 2014, and 2019.
Front. Public Health 11:1192183.
doi: 10.3389/fpubh.2023.1192183

COPYRIGHT
© 2023 Pengpid and Peltzer. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Trends in behavioral and biological risk factors for non-communicable diseases among adults in Bhutan: results from cross-sectional surveys in 2007, 2014, and 2019

Supa Pengpid[1,2,3] and Karl Peltzer[1,4,5]*

[1]Department of Health Education and Behavioral Sciences, Faculty of Public Health, Mahidol University, Bangkok, Thailand, [2]Department of Public Health, Sefako Makgatho Health Sciences University, Pretoria, South Africa, [3]Department of Healthcare Administration, College of Medical and Health Science, Asia University, Taichung, Taiwan, [4]Department of Psychology, University of the Free State, Bloemfontein, South Africa, [5]Department of Psychology, College of Medical and Health Science, Asia University, Taichung, Taiwan

Background: The study aimed to evaluate trends in the prevalence and correlates of risk factors for non-communicable diseases (NCDs; low physical activity, insufficient fruit/vegetable intake, current tobacco use, problem alcohol use, diabetes, hypertension, increased total cholesterol, and obesity) in Bhutan.

Methods: Three repeat cross-sectional Bhutan STEPS surveys ($N = 9,281$) in 2007, 2014, and 2019 were analyzed.

Results: The proportion of people with 3–8 NCD risk factors significantly decreased from 62.8% in 2007 to 32.6% in 2019 ($p < 0.001$), and the mean number of NCD risk factors significantly decreased from 3.0 in 2007 to 2.1 in 2019 ($p < 0.001$). In linear regression analyses by study year, older age ($p < 0.001$) was positively associated with eight NCD risk factors across all study years. Furthermore, male subjects were negatively ($p < 0.01$) and positively ($p < 0.001$) associated with eight NCD risk factors, respectively. Higher education levels ($p < 0.05$) were positively associated with eight NCD risk factors in 2007 and negatively associated with eight NCD risk factors in 2019 ($p < 0.05$). Employment ($p < 0.001$) and urban residence ($p < 0.001$) were positively associated with eight risk factors for NCD in 2019, while urban residence ($p < 0.001$) was negatively associated with eight NCD risk factors in 2014.

Conclusion: The prevalence of eight NCD risk factors decreased in Bhutan over the past 13 years. Inadequate fruit and vegetable intake, problem alcohol use, and hypertension increased, current tobacco use, low physical activity, obesity, diabetes, and elevated total cholesterol decreased from 2007 to 2019. Several factors associated for eight and each individual NCD risk factor were identified, which can help guide interventions.

KEYWORDS

trends, risk factors, non-communicable diseases, Bhutan, behavior

Introduction

The majority (>85%) of deaths from non-communicable diseases (NCDs) occur in low-resource countries (1). In Bhutan, for example, 69% of all deaths in 2016 were caused by NCDs (2). Cardiovascular disease, cancer, respiratory disease, and diabetes contribute to more than 80% of all premature NCD deaths (1). Poor diet, tobacco use, harmful alcohol use, and low physical activity all increase the risk of dying from an NCD (1). In the Southeast Asia region, NCDs caused 7.9 million deaths in 2008 and are expected to increase by 21% over the next decade (3). Between 1990 and 2010, nearly all NCDs, in particular diabetes and coronary heart disease, increased at a higher rate in South Asia than globally (4). Considering the increase in NCDs in lower-resource countries in the East and Southeast Asian region, it is important to gain insight into the trends and local determinants of NCDs (3–6). In this context, national community-based trend data on NCD risk factors in Bhutan is needed.

A 2014 population-based study of adults in Bhutan ($N = 2,822$) found that 67% had inadequate fruit and vegetable intake (<5 servings/day), 6% did low physical activity, 7% were heavy alcohol users (>40 g for men/>20 g for women), 13% had elevated total cholesterol (≥190 mg/dL/or on anti-lipid medication), 36% had hypertension, 11% had elevated impaired fasting glucose, 33% were overweight/obese (≥25 kg/m^2), and 24.8% were current tobacco users (7, 8). In Nepal in 2013, 27.7% of the population (15–69 years) had 3–8 NCD risk factors (98.9% inadequate fruit/vegetable intake, 25.7% elevated blood pressure, 22.6% elevated total cholesterol, 21.4% overweight or obesity, 18.5% current smoking, 3.6% elevated blood glucose, 3.4% low physical activity, and 2.0% harmful alcohol use) (9).

In a population (35–64 years) in the urban region of Delhi, India, the prevalence of overweight increased from 42.2% in 1991–1994 to 56.0% in 2010–2012, hypertension went from 23.0 to 42.2%, elevated fasting blood glucose went from 12.7 to 20.2%, smoking went from 16.1 to 17.4%, and total elevated cholesterol decreased from 38.1% in 1991–1994 to 32.9% in 2010–2012 (10). In studies of individual risk factors for NCDs in Mongolia, low physical activity increased by 16.3% from 2005 to 2013 (11), and the prevalence of hypertension among adults in China increased by 11.9% from 1991 to 2015 (12). In Myanmar (Yangon region), the prevalence of diabetes increased from 8.3% in 2004 to 10.2% in 2014 (13), and in Iran, the prevalence of daily smoking decreased from 31.1% in 1990 to 19.5% in 2016 among men and decreased from 5.4 to 1.0% among women in the same period (14).

Several sociodemographic factors, such as older age (5, 9, 15–17), being a male subject, educational level (9, 16), and urban residence (5, 16), have been found to increase the odds of multiple biological and behavioral risk factors for NCDs. The aim of the study was to assess trends (from 2007 to 2019) in NCD risk factors (low physical activity, insufficient fruit/vegetable intake, current tobacco use, problem alcohol use, diabetes, hypertension, elevated total cholesterol, and obesity) in Bhutan.

Methods

Three cross-sectional Bhutan STEPS surveys (limited to the capital city of Thimphu in 2007, countrywide in 2014 and 2019) (18) with complete NCD risk factor measurements were analyzed; the overall response rate was >93% in 2014 > 96% in 2019 (19–21). Participants were randomly selected using a multi-stage stratified sampling procedure. One person per household within the age range of the survey (25–74 years in 2007, 18–69 years in 2014, and 15–69 years in 2019) was included (19–21). The study was approved by the Research Ethics Board for Health (REBH), Bhutan, and participants provided written informed consent.

Data collection followed the WHO 3-STEPS method: step 1—questionnaire administration (demographic, medical, and health risk behavioral information); step 2—blood pressure and anthropometric measurements; and step 3—biochemical tests (blood glucose and lipids) (18–21). Of the three blood pressure measurements, an Omron BP automatic blood pressure monitor apparatus was used (19–21); the last two readings were averaged (18). Blood glucose and elevated total cholesterol were measured in "peripheral (capillary) blood at the data collection site using dry chemical methods and biochemical analysis with a Hitachi 912 bio-analyzer" (19–21).

Measures

Outcome variables

NCD risk factors were included based on previous studies (8, 15, 22, 23) as follows.

Behavioral NCD risk factors

Fruit/vegetable consumption (<5 servings/day), low physical activity according to the "Global Physical Activity Questionnaire" (24), current tobacco use, and problem alcohol use (eight or more standard drinks for women and 15 or more standard drinks for men/week) (11–21, 25).

Biological risk factors for NCDs

Diabetes was defined as "fasting plasma glucose levels ≥126 mg/dL, and/or currently taking insulin or oral hypoglycemic drugs" (18). Hypertension was assessed "based on measured blood pressure (BP; mean of the last two of three readings) defined as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg or currently on antihypertensive medication" (26); elevated total cholesterol (TC) was defined as plasma venous value ≥190 mg/dl; body mass index was measured as ≥25 kg/m^2 obesity (27).

Sociodemographics

Adult household members, residential and employment status, sex, age, and education (19–21).

Data analysis

The study sample was "weighted considering the probability of selection at three levels and accounted for participant weight/ individual weight, non-response weight, and adjustment for participant's age/sex group (population weight)" (19–21). The proportion of NCD risk factors was grouped based on previous studies (7, 15), 3–8 NCD risk factors (versus 0–2 risk factors), and the description of the NCD risk factors by

study year is shown in bar graphs. Adjusted logistic regression was used to assess the predictors of each of the eight NCD risk factors, and linear regression was used to estimate the determinants of the number of NCD risk factors by study year. Only complete cases were included in the analysis. $p<0.05$ was considered significant. Statistical procedures to account for the complex study design were performed using Stata SE 15.0 (College Station, TX, United States).

Results

The sample consisted of 9,281 (≥15 years) participants (M = 41.7 years; SD = 13.7 years), 647 in 2005, 1,897 in 2009, 2,380 in 2013, and 5,004 in 2019. From 2007 to 2019, the proportion of older and urban residents decreased, and the proportion of those with higher education increased (Table 1).

Distribution of NCD risk factors from 2007 to 2019

The prevalence of individual NCD risk factors increased significantly for inadequate fruit and vegetable intake from 64.3% in 2007 to 86.6% in 2019 ($p<0.001$), for problem alcohol use from 3.1% in 2007 to 8.1% in 2019 ($p<0.001$), and decreased significantly for low physical activity from 58.4% in 2007 to 11.4% in 2019 ($p<0.001$), current tobacco use from 43.2% in 2007 to 23.4% in 2019 ($p<0.001$), obesity (≥25 kg/m^2) from 52.4% in 2007 to 43.1% in 2019 ($p<0.001$), diabetes from 8.4% in 2007 to 2.6% in 2019 ($p<0.001$), and total cholesterol from 42.2% in 2007 to 9.9% in 2019 ($p<0.001$), while the prevalence of hypertension remained unchanged from 2007 to 2019. The proportion of people having 3–8 NCD risk factors decreased significantly from 62.8% in 2007 to 32.6% in 2019 ($p<0.001$), and the mean number of NCD risk factors decreased significantly from 3.0 in 2007 to 2.1 in 2019 ($p<0.001$). Similar results were found in the stratified analysis by sex (Table 2).

Across the study years, the prevalence of having zero NCD risk factors was 5.0%, 1 = 29.5%, 2 = 33.7%, 3 = 20.8%, 4 = 7.8%, 5 = 2.6%, 6 = 0.6%, and 7 = 0.1%, and eight risk factors were 0%; the distribution of the study year is shown in Figure 1.

TABLE 1 Sociodemographic characteristics of individuals aged 15 years and older in Bhutan, 2007, 2014, and 2019 (unweighted %).

Variable	Study year		
	2007	2014	2019
	N = 1897	*N* = 2,380	*N* = 5,004
	N (%)	*N* (%)	*N* (%)
Age (years)			
15–34	402 (21.2)	874 (36.7)	1,986 (39.7)
35–49	630 (33.2)	921 (38.7)	1,795 (34.7)
50–74	865 (45.6)	585 (24.6)	1,283 (25.6)
Sex			
Female subjects	1,042 (54.9)	1,466 (61.6)	3,095 (61.9)
Male subjects	855 (45.1)	914 (38.4)	1,909 (38.1)
Education (in years)			
0	1,303 (68.8)	1,455 (61.1)	2,492 (49.8)
1–10	386 (20.4)	656 (27.6)	1,529 (30.6)
≥11	206 (10.9)	269 (11.3)	983 (18.6)
Employment			
Non-employed	1,149 (61.2)	692 (29.2)	3,782 (75.6)
Employed	729 (38.8)	1,684 (70.8)	1,223 (24.4)
Adult household members			
0–2	573 (30.4)	1,642 (69.0)	1,416 (28.3)
3	500 (26.6)	427 (17.9)	1,230 (24.6)
4 or more	810 (43.0)	310 (13.0)	2,356 (47.1)
Residence			
Rural	0 (0.0)	747 (31.4)	1,881 (37.6)
Urban	1,897 (100)	1,633 (68.6)	3,123 (62.4)

Sociodemographic determinants of individual behavioral NCD risk factors

Compared to the study year 2007, the study year 2019 had a significantly higher prevalence of inadequate fruit and vegetable intake ($p<0.001$), and problem alcohol use ($p<0.001$), and a significantly lower prevalence of low physical activity ($p<0.001$) and current tobacco use ($p<0.001$). The middle and/or older age groups had an increased probability of problem alcohol use ($p<0.001$). Being a male subject decreased the odds of low physical activity ($p<0.001$) and increased the odds of current tobacco use ($p<0.001$) and problem alcohol use ($p<0.001$). Higher levels of education were positively associated with low physical activity ($p<0.001$) and inversely associated with problem alcohol use ($p<0.05$). Being employed decreased the odds of inadequate fruit and vegetable intake ($p<0.001$) and increased the odds of current tobacco use ($p<0.05$) and problem alcohol use ($p<0.01$; Table 3).

Sociodemographic determinants of individual biological risk factors for NCDs

Compared to the study year 2007, the study year 2019 had a significantly higher prevalence of hypertension ($p<0.001$) and lower prevalence of obesity ($p<0.01$), lower diabetes ($p<0.001$), and lower elevated total cholesterol ($p<0.001$). Older age was associated with overweight/obesity ($p<0.001$), hypertension ($p<0.001$), diabetes ($p<0.001$), and elevated total cholesterol ($p<0.001$). Being a male subject was positively associated with hypertension ($p<0.05$) and negatively associated with overweight/obesity ($p<0.001$) and elevated total cholesterol ($p<0.05$). Higher levels of education were associated with overweight/obesity ($p<0.05$) and diabetes ($p<0.01$) and being employed was associated with general obesity ($p<0.001$) and hypertension ($p<0.001$; Table 4).

Associations with eight NCD risk factors

In linear regression analyses by study year, older age ($p<0.001$) was positively associated with eight NCD risk factors. Furthermore,

TABLE 2 Distribution of risk factors for non-communicable diseases among individuals aged 15 years and older in Bhutan, 2007, 2014, and 2019 (weighted %).

	Study year			*p* value
Non-communicable disease (NCD) risk factors	2007	2014	2019	
	N (%)	*N* (%)	*N* (%)	
All				
Fruit and vegetable intake (<5 servings/day)	1,262 (64.3)	1,619 (66.9)	4,317 (86.6)	<0.001
Low physical activity	1,178 (58.4)	325 (11.9)	597 (11.4)	<0.001
Current tobacco use	711 (43.2)	480 (24.8)	979 (23.4)	<0.001
Problem alcohol use	66 (3.1)	305 (12.8)	422 (8.1)	<0.001
General obesity (≥25 kg/m^2)	1,029 (52.4)	903 (32.9)	2,562 (43.1)	<0.001
Hypertension	603 (26.0)	909 (35.7)	1,620 (27.0)	0.139
Diabetes	197 (8.4)	66 (2.3)	163 (2.6)	<0.001
Elevated total cholesterol	863 (44.2)	307 (12.5)	635 (9.9)	<0.001
3–8 NCD risk factors	1,275 (62.8)	780 (30.4)	1914 (32.6)	<0.001
	M (SD)	M (SD)	M (SD)	
Total NCD risk factors	3.0 (1.4)	2.0 (1.2)	2.1 (1.2)	<0.001
Male subjects				
Fruit/vegetable intake (<5 servings/day)	543 (62.1)	605 (66.0)	1,629 (86.6)	<0.001
Low physical activity	450 (50.8)	85 (8.2)	219 (10.9)	<0.001
Current tobacco use	324 (39.9)	286 (32.4)	587 (32.2)	<0.001
Problem alcohol use	37 (3.5)	166 (5.6)	239 (10.9)	<0.001
General overweight/obesity (≥25 kg/m^2)	470 (52.4)	269 (26.7)	860 (38.9)	<0.001
Hypertension	27 (28.0)	353 (35.1)	73 (30.3)	0.108
Diabetes	89 (8.3)	25 (2.2)	62 (2.7)	<0.001
Elevated total cholesterol	382 (44.3)	120 (11.9)	203 (9.2)	<0.001
3–8 NCD risk factors	543 (59.8)	304 (30.8)	807 (35.3)	<0.001
	M (SD)	M (SD)	M (SD)	
Total NCD risk factors	2.9 (1.4)	2.0 (1.2)	2.2 (1.2)	<0.001
Female subjects				
Fruit/vegetable intake (<5 servings/day)	719 (67.3)	1,014 (70.4)	2,688 (86.8)	<0.001
Low physical activity	728 (69.8)	240 (16.8)	378 (12.3)	<0.001
Current tobacco use	387 (38.2)	194 (14.3)	392 (11.3)	<0.001
Problem alcohol use	29 (2.1)	139 (9.5)	183 (4.4)	<0.001
General overweight/obesity (≥25 kg/m^2)	559 (53.6)	634 (39.8)	1702 (49.3)	<0.001
Hypertension	316 (22.9)	556 (35.2)	882 (23.1)	0.002
Diabetes	108 (8.5)	41 (2.3)	101 (2.6)	<0.001
Elevated total cholesterol	481 (41.1)	187 (11.9)	432 (11.0)	<0.001
3–8 NCD risk factors	732 (66.4)	476 (29.9)	1,107 (29.3)	<0.001
	M (SD)	M (SD)	M (SD)	
Total NCD risk factors	2.9 (1.4)	2.0 (1.2)	2.2 (1.2)	<0.001

being a male subject ($p < 0.01$) was negatively and positively ($p < 0.001$) associated with eight NCD risk factors in 2007 and 2019, respectively. Higher levels of education ($p < 0.05$) were positively associated with eight NCD risk factors in 2007 and negatively associated ($p < 0.05$) with eight NCD risk factors in 2019. Employment ($p < 0.001$) and urban residence ($p < 0.001$) were positively associated with eight NCD risk factors in 2019, while urban residence ($p < 0.001$) was negatively associated with eight NCD risk factors in 2014 (Table 5).

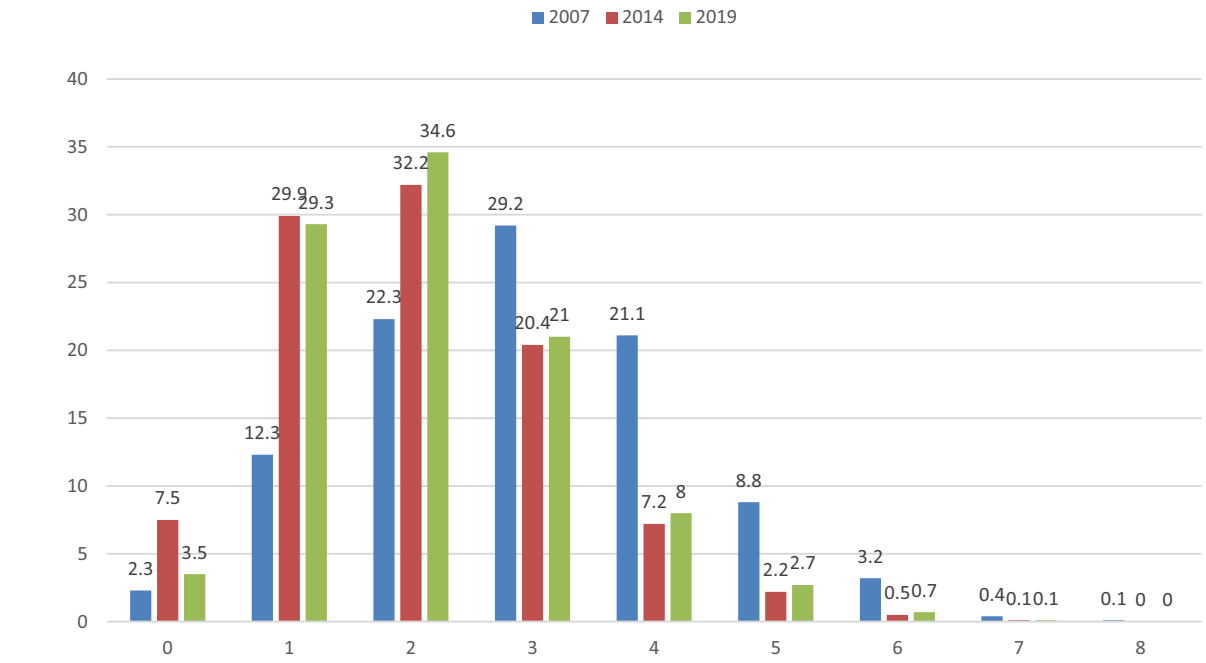


FIGURE 1
Prevalence of risk factors for non-communicable diseases among adults in Bhutan from 2007 to 2019 (%).

TABLE 3 Determinants of behavioral risk factors for non-communicable diseases.

Variable	Inadequate fruit/ vegetable intake	Low physical activity	Current tobacco use	Problem alcohol use
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Study year				
2007	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
2014	1.37 (1.04, 1.82)*	0.10 (0.07, 0.12)***	0.37 (0.28, 0.48)***	4.41 (3.06, 6.37)***
2019	3.54 (2.63, 4.77)***	0.09 (0.06, 0.12)***	0.39 (0.30, 0.52)***	4.10 (2.96, 5.69)***
Age (years)				
15–34	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
35–49	0.88 (0.73, 1.06)	0.95 (0.75, 1.20)	0.87 (0.72, 1.06)	1.70 (1.29, 2.25)***
50–74	1.00 (0.79, 1.27)	1.22 (0.95, 1.55)	0.82 (0.65, 1.02)	1.90 (1.50, 2.50)***
Sex				
Female subjects	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Male subjects	0.98 (0.82, 1.18)	0.60 (0.48, 0.70)***	3.31 (2.83, 3.89)***	2.06 (1.65, 2.55)***
Education (in years)				
0	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
1–10	0.91 (0.73, 1.13)	1.39 (1.13. 1.71)**	1.21 (0.99, 1.48)	0.74 (0.56, 0.99)*
≥11	0.82 (0.61, 1.11)	1.90 (1.31, 2.74)***	0.97 (0.74, 1.28)	0.64 (0.44, 0.92)*
Employment				
Non-employed	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Employed	0.67 (0.56, 0.80)***	1.07 (0.84, 1.37)	1.31 (1.01, 1.69)*	1.52 (1.15, 2.01)**
Adult household members				
0–2	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
3	1.15 (0.91, 1.96)	0.77 (0.58, 1.02)	0.93 (0.75, 1.14)	0.76 (0.58, 0.99)*
4 or more	1.24 (0.94, 1.64)	0.96 (0.78, 1.19)	1.00 (0.80, 1.24)	0.84 (0.67, 1.07)
Residence				
Rural	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Urban	1.13 (0.82, 1.57)	1.17 (0.83, 1.64)	1.12 (0.85, 1.47)	1.20 (0.92, 1.56)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

TABLE 4 Determinants of biological risk factors for non-communicable diseases.

Variable	General obesity	Hypertension	Diabetes	Elevated total cholesterol
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Study year				
2007	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
2014	0.37 (0.30, 0.46)***	1.72 (1.42, 2.09)***	0.28 (0.19, 0.41)***	0.17 (0.14, 0.21)***
2019	0.77 (0.65, 0.90)**	1.48 (1.24, 1.76)***	0.39 (0.25, 0.62)***	0.14 (0.11, 0.17)***
Age (years)				
15–34	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
35–49	2.32 (1.98, 2.73)***	3.16 (2.69, 3.71)***	5.76 (2.85, 11.65)***	2.02 (1.51, 2.70)***
50–74	2.09 (1.72, 2.56)***	5.62 (4.51, 7.01)***	14.34 (6.71, 30.65)***	2.92 (2.13, 3.99)***
Sex				
Female subjects	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Male subjects	0.54 (0.47, 0.61)***	1.18 (1.01, 1.38)*	0.73 (0.52, 1.04)	0.78 (0.63, 0.96)*
Education (in years)				
0	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
1–10	1.08 (0.93, 1.25)	0.91 (0.75, 1.10)	1.88 (1.23, 2.88)**	1.17 (0.94, 1.45)
≥11	1.25 (1.01, 1.54)*	0.85 (0.70, 1.03)	1.82 (0.92, 3.60)	0.93 (0.65, 1.34)
Employment				
Non-employed	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Employed	1.52 (1.26, 1.83)***	1.37 (1.14, 1.64)***	1.19 (0.76, 1.87)	1.10 (0.86, 1.40)
Adult household members				
0–2	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
3	0.89 (0.75, 106)	0.97 (0.81, 1.16)	0.97 (0.69, 1.37)	1.02 (0.81, 1.21)
4 or more	0.86 (0.72, 1.02)	0.95 (0.79, 1.13)	0.82 (0.56, 1.19)	1.02 (0.80. 1.31)
Residence				
Rural	1 (Reference)	1 (Reference)	1 (Reference)	1 (Reference)
Urban	0.86 (0.73, 1.01)	0.93 (0.79, 1.10)	1.09 (0.61, 1.94)	0.83 (0.64, 1.07)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

Discussion

The study aimed to assess, for the first time, the trends (from 2007 to 2019) in NCD risk factors in Bhutan. We found that the prevalence of eight NCD risk factors decreased among Bhutanese adults from 2007 to 2019. Inadequate fruit and vegetable intake, problem alcohol use, and hypertension increased, and current tobacco use, low physical activity, obesity, diabetes, and elevated total cholesterol decreased from 2007 to 2019.

Consistent with studies in urban India (10) and China (12), the prevalence of hypertension increased over time in this study. The prevalence of diabetes increased over time in urban India (10) and Myanmar (13), but decreased in our study. Similar to a study in urban India (10), the prevalence of total elevated cholesterol decreased over time in our study. While a previous trend study in Mongolia (11) found an increase in low physical activity, our study found a decrease in low physical activity. Similar to a study in Iran (14), we observed a decrease in current tobacco use over time. In our study, the prevalence of obesity decreased over time, whereas it increased over time in urban India (10) and Mongolia (28).

In Bhutan, the decrease in current tobacco use may be attributed to tobacco demand reduction measures (total ban on tobacco sales, ban on tobacco advertising, and sponsorship) (29, 30), high compliance with health protection measures for non-smokers (29), and possibly changes in social norms (perception that tobacco use is a sin) (31). Decreases in low physical activity values may be attributed to the "implementation of community-wide public education and awareness campaigns for physical activity" (3, 29), the creation of open-air gyms, bicycle and hiking pathways, pedestrian days, and annual physical activity activities (32). Early diagnosis and better management of diabetes and elevated total cholesterol may have contributed to their reduction (3).

However, we found an increase in the prevalence of problem drinking despite having several measures in place to reduce harmful alcohol use (restrictions on physical availability, bans on alcohol advertising except in containers, and taxes on alcoholic beverages

TABLE 5 Associations with risk factors for non-communicable diseases among individuals aged 15 years and older in Bhutan, 2007–2019.

Variable	Study year		
	2007	2014	2019
	Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)
All			
Age (years)			
15–34	Reference	Reference	Reference
35–49	0.36 (0.18 to 0.53)***	0.41 (0.27 to 0.55)***	0.57 (0.46 to 0.69)***
50–74	0.86 (0.67 to 1.04)***	0.78 (0.61 to 0.95)***	0.80 (0.65 to 0.94)***
Sex			
Female subjects	Reference	Reference	Reference
Male subjects	−0.24 (−0.39 to −0.09)**	−0.05 (−0.10 to 0.09)	0.16 (0.08 to 0.25)***
Education (in years)			
0	Reference	Reference	Reference
1–10	0.05 (−0.12 to 0.22)	0.15 (−0.02 to 0.31)	−0.12 (−0.20 to −0.03)*
≥11	0.26 (0.02 to 0.51)*	−0.04 (−0.29 to 0.21)	−0.18 (−0.31 to −0.04)*
Employment			
Non-employed	Reference	Reference	Reference
Employed	0.14 (−0.02 to 0.29)	0.04 (−0.11 to 0.19)	0.27 (0.16 to 0.38)***
Adult household members			
0–2	Reference	Reference	Reference
3	0.13 (−0.16 to 0.31)	−0.11 (−0.26 to 0.04)	−0.02 (−0.12 to 0.07)
4 or more	0.09 (−0.08 to 0.26)	0.01 (−0.18 to 0.21)	−0.01 (−0.12 to 0.10)
Residence			
Rural	---	Reference	Reference
Urban		−0.33 (−0.51 to −0.15)***	0.22 (0.09 to 0.36)***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

except spirits) (29). However, better enforcement of alcohol policies is needed in addition to public health promotion (33). Furthermore, since the main source of alcohol is home-brewed *Ara*, "intervention targeting a reduction in the production of the local alcohol *Ara* should be undertaken urgently" [*SIC*] (34). We also found an increase in the prevalence of inadequate fruit and vegetable consumption, which may be due to seasonal availability, dietary habits (8), and the decline in fruit production (35). The government can increase interventions in terms of body weight control, tobacco use cessation, reduction of alcohol use, healthy eating, and screening and control of high levels of blood glucose, cholesterol, and blood pressure.

In comparison to other low- and middle-income countries, the proportion of 3–8 NCD risk factors (62.8% in 2007 and 32.6% in 2019) in this study was higher than in Nepal (3–8 NCD risk factors, 27.7%) (9), Malawi (3–7 NCD risk factors, 16.5%) (22), and Uganda (3–5 NCD risk factors, 17.3%) (23). A high proportion of multiple NCD risk factors were found, as in a previous study in Bhutan (7), which increases the odds of developing NCDs in this country.

In line with previous research (7, 9, 15–17), this study shows that increasing age, being a male subject, being employed and living in an urban area in 2019, and having higher education in 2007 were associated with higher odds of having multiple NCD risk factors. Early screening targeting men, urban dwellers, and those with higher education should be promoted to prevent risk factors for NCDs in Bhutan. Compared to the 2013 Nepal paper, this study showed a higher rate of current tobacco use (24.8% in 2014) than in Nepal (18.5%), low physical activity (11.9% in 2014) than Nepal (3.4%), higher obesity (≥25 kg/m^2, 32.9% in 2014) than Nepal (≥25 kg/m^2, 21.4%), elevated blood pressure (35.7% in 2014) than Nepal (25.7%), and a lower rate of inadequate fruit and vegetable intake (66.9% in 2014) than Nepal (98.9%) (8), lower elevated blood glucose (2.3% in 2014) than Nepal (3.6%), and lower elevated total cholesterol (12.5% in 2014) than Nepal (22.7%) (9).

Current tobacco use, problem alcohol use, and hypertension were significantly higher in men than in women, while general obesity, low physical activity, and raised total cholesterol were significantly higher in women than in men. The higher prevalence of substance use in men than in women and the higher rate of overweight/obesity in women than in men have been observed in previous studies (15, 22). Higher levels of education were positively associated with low physical activity, obesity, and diabetes and inversely associated with problem alcohol use. Employment decreased the odds of inadequate fruit and vegetable intake and increased the odds of current tobacco use, problem alcohol use, general obesity, and hypertension. These results show how the eight specific NCD risk factors can be targeted differently according to sex, educational level, and employment status.

Study limitations include the cross-sectional, repeated survey design, and self-reporting of some indicators. The Bhutan 2007 STEPS survey was limited because it was subnational. The household income variable was collected in the three surveys, but there were missing cases, so this variable was excluded from the analysis.

Conclusion

Based on three surveys of people aged 15 years or older, we found that the prevalence of eight NCD risk factors decreased in Bhutan from 2007 to 2019. Inadequate fruit and vegetable intake, problem alcohol use, and hypertension increased, and current tobacco use, low physical activity, obesity, diabetes, and elevated total cholesterol decreased from 2007 to 2019. Several factors associated with NCD risk factors were identified, including older age, sex, education level, and residence status, which may guide interventions. Future research may include a comparison of four surveys once the fourth Bhutan STEPS survey becomes available.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: World Health Organization NCD Microdata Repository: Available at: https://extranet.who.int/ncdsmicrodata/index.php/catalog.

Ethics statement

The studies involving human participants were reviewed and approved by the "Research Ethics Board for Health (REBH)." The patients/participants provided their written informed consent to participate in this study.

Author contributions

SP and KP meet the criteria for authorship, conceived and designed the study, performed the statistical analysis, drafted the manuscript, and made critical revisions to key intellectual content. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgments

The data source, the World Health Organization NCD Microdata Repository (URL: https://extranet.who.int/ncdsmicrodata/index.php/catalog), is hereby acknowledged.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. World Health Organization (WHO) Noncommunicable diseases. (2018). Available at: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases (Accessed August 2, 2021).

2. World Health Organization (WHO) Bhutan: Noncommunicable Diseases (NCD) Country Profiles. (2018). Available at: https://cdn.who.int/media/docs/default-source/country-profiles/ncds/btn_en.pdf?sfvrsn=54d291b3_35&download=true (accessed August 2, 2021)

3. Narain JP, Garg R, Fric A. Non-communicable diseases in the South-East Asia region: burden, strategies and opportunities. *Natl Med J India*. (2011) 24:280–7.

4. Siegel KR, Patel SA, Ali MK. Non-communicable diseases in South Asia: contemporary perspectives. *Br Med Bull*. (2014) 111:31–44. doi: 10.1093/bmb/ldu018

5. United Nations Interagency Task Force on the Prevention and Control of Noncommunicable Diseases Joint Mission, Bhutan, 6–10 February 2017. Geneva: World Health Organization. (2017) (WHO/NMH/NMA/17.57). Licence: CC BY-NC-SA 3.0 IGO.

6. Kontis V, Mathers CD, Bonita R, Stevens GA, Rehm J, Shield KD, et al. Regional contributions of six preventable risk factors to achieving the 25 × 25 non-communicable disease mortality reduction target: a modelling study. *Lancet Glob Health*. (2015) 3:e746–57. doi: 10.1016/S2214-109X(15)00179-5

7. Pelzom D, Isaakidis P, Oo MM, Gurung MS, Yangchen P. Alarming prevalence and clustering of modifiable noncommunicable disease risk factors among adults in Bhutan: a nationwide cross-sectional community survey. *BMC Public Health*. (2017) 17:975. doi: 10.1186/s12889-017-4989-x

8. Sithey G, Wen LM, Dzed L, Li M. Noncommunicable diseases risk factors in Bhutan: A secondary analysis of data from Bhutan's nationwide STEPS survey 2014. *PLoS One*. (2021) 16:e0257385. doi: 10.1371/journal.pone.0257385

9. Aryal KK, Mehata S, Neupane S, Vaidya A, Dhimal M, Dhakal P, et al. The Burden and Determinants of Non Communicable Diseases Risk Factors in Nepal: Findings from a Nationwide STEPS Survey. *PLoS One*. (2015) 10:e0134834. doi: 10.1371/journal.pone.0134834

10. Prabhakaran D, Roy A, Praveen PA, Ramakrishnan L, Gupta R, Amarchand R, et al. 20-Year Trend of CVD Risk Factors: Urban and Rural National Capital Region of India. *Glob Heart*. (2017) 12:209–17. doi: 10.1016/j.gheart.2016.11.004

11. Dashzeveg D, Nakamura K, Seino K, Al-Sobaihi S, Palam E. Changes in the configuration and patterns of physical activity among Mongolian adults, 2005-2013. *J Rural Med*. (2018) 13:151–9. doi: 10.2185/jrm.2977

12. Ma S, Yang L, Zhao M, Magnussen CG, Xi B. Trends in hypertension prevalence, awareness, treatment and control rates among Chinese adults, 1991-2015. *J Hypertens*. (2021) 39:740–8. doi: 10.1097/HJH.0000000000002698

13. Aung WP, Bjertness E, Htet AS, Stigum H, Kjøllesdal MKR. Trends in Diabetes Prevalence, Awareness, Treatment and Control in Yangon Region, Myanmar, Between 2004 and 2014, Two Cross-Sectional Studies. *Int J Environ Res Public Health*. (2019) 16:3461. doi: 10.3390/ijerph16183461

14. Ghelichkhani P, Baikpour M, Mohammad K, Rahim Fattah FH, Rezaei N, Ahmadi N, et al. Age, Period and Cohort Analysis of Smoking Prevalence in Iranian Population over a 25-Year Period. *Arch Iran Med*. (2021) 24:7–14. doi: 10.34172/aim.2021.02

15. Wekesah FM, Nyanjau L, Kibachio J, Mutua MK, Mohamed SF, Grobbee DE, et al. Individual and household level factors associated with presence of multiple non-communicable disease risk factors in Kenyan adults. *BMC Public Health*. (2018) 18:1220. doi: 10.1186/s12889-018-6055-8

16. Zaman MM, Bhuiyan MR, Karim MN, MoniruzZaman , Rahman MM, Akanda AW, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: An analysis of STEPS survey 2013. *BMC Public Health*. (2015) 15:659. doi: 10.1186/s12889-015-1938-4

17. Rafique I, Saqib MAN, Munir MA, Qureshi H, Rizwanullah , Khan SA, et al. Prevalence of risk factors for noncommunicable diseases in adults: key findings from

the Pakistan STEPS survey. *East Mediterr Health J*. (2018) 24:33–41. doi: 10.26719/2018.24.1.33

18. World Health Organization (WHO) (2018). STEPwise approach to surveillance (STEPS). Available at: https://www.who.int/ncds/surveillance/steps/en/ (Accessed August 22, 2021).

19. Ministry of Health (2009). Report on 2007 Steps Survey for Risk Factors and Prevalence of Noncommunicable Diseases in Thimphu. Available at: https://extranet.who.int/ncdsmicrodata/index.php/catalog/738/related-materials (Accessed August 5, 2021)

20. World Health Organization Regional Office for South-East Asia. National survey for noncommunicable disease risk factors and mental health using WHO STEPS approach in Bhutan. (2014). Available at: https://extranet.who.int/ncdsmicrodata/index.php/catalog/427/related-materials (Accessed August 5, 2021).

21. Department of Public Health, Ministry of Health (2020). Non-communicable disease Risk Factors: Bhutan STEPS Survey 2019, Thimphu. Available at: https://extranet.who.int/ncdsmicrodata/index.php/catalog/855/related-materials (Accessed August 5, 2021).

22. Msyamboza KP, Ngwira B, Dzowela T, Mvula C, Kathyola D, Harries AD, et al. The burden of selected chronic non-communicable diseases and their risk factors in Malawi: nationwide STEPS survey. *PLoS One*. (2011) 6:e20316. doi: 10.1371/journal.pone.0020316

23. Wesonga R, Guwatudde D, Bahendeka SK, Mutungi G, Nabugoomu F, Muwonge J. Burden of cumulative risk factors associated with non-communicable diseases among adults in Uganda: evidence from a national baseline survey. *Int J Equity Health*. (2016) 15:195. doi: 10.1186/s12939-016-0486-6

24. Armstrong T, Bull F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). *J Public Health*. (2006) 14:66–70. doi: 10.1007/s10389-006-0024-x

25. Centers for Disease Control and Prevention (CDC). Dietary Guidelines for Alcohol. (2020). Available at: https://www.cdc.gov/alcohol/fact-sheets/moderate-drinking.htm (Accessed August 2, 2021).

26. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, et al. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. (2003) 42:1206–52. doi: 10.1161/01.HYP.0000107251.49515.c2

27. Wen CP, David Cheng TY, Tsai SP, Chan HT, Hsu HL, Hsu CC, et al. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. *Public Health Nutr*. (2009) 12:497–506. doi: 10.1017/S1368980008002802

28. Chimeddamba O, Gearon E, Brilleman SL, Tumenjargal E, Peeters A. Increases in waist circumference independent of weight in Mongolia over the last decade: the Mongolian STEPS surveys. *BMC Obes*. (2017) 4:19. doi: 10.1186/s40608-017-0155-3

29. Tuangratananon T, Wangmo S, Widanapathirana N, Pongutta S, Viriyathorn S, Patcharanarumol W, et al. Implementation of national action plans on noncommunicable diseases, Bhutan, Cambodia, Indonesia, Philippines, Sri Lanka, Thailand and Viet Nam. *Bull World Health Organ*. (2019) 97:129–41. doi: 10.2471/BLT.18.220483

30. Gurung MS, Pelzom D, Dorji T, Drukpa W, Wangdi C, Chinnakali P, et al. Current tobacco use and its associated factors among adults in a country with comprehensive ban on tobacco: findings from the nationally representative STEPS survey, Bhutan, 2014. *Popul Health Metrics*. (2016) 14:28. doi: 10.1186/s12963-016-0098-9

31. Kyaing NN, Islam MA, Sinha DN, Rinchen S. Social, economic and legal dimensions of tobacco and its control in South-East Asia region. *Indian J Public Health*. (2011) 55:161–8. doi: 10.4103/0019-557X.89944

32. Tamang M, Dahal BP, Dorji T, Tamang ST, Lucero-Prisno DE 3rd. Situation of physical activity in the prevention of non-communicable diseases in Bhutan: challenges and the way forward. *BMJ Open Sport Exerc Med*. (2022) 8:e001448. doi: 10.1136/bmjsem-2022-001448

33. Gyeltshen T, Penjor T, Dorji L, Tshering L, Dorji K, Subedi BN, et al. Alcohol policy compliance among retailers in Bhutan: a multisite community intervention study. *BMC Public Health*. (2021) 21:1893. doi: 10.1186/s12889-021-11932-0

34. Wangdi K, Jamtsho T. Prevalence and correlates of current alcohol use among bhutanese adults: a nationally representative survey data analysis. *Indian J Psychol Med*. (2019) 41:38–45. doi: 10.4103/IJPSYM.IJPSYM_412_18

35. Dizon F, Jackson C, Adubi A, Taffesse S. Harnessing spatial opportunities in agriculture for economic transformation. (2019). World Bank. Available at: https://documents1.worldbank.org/curated/en/568371553841727531/pdf/Bhutan-Policy-Note-Harnessing-Spatial-Opportunities-in-Agriculture-for-Economic-Transformation.pdf (Accessed October 10, 2021).

frontiers | Frontiers in Public Health

TYPE Community Case Study
PUBLISHED 04 August 2023
DOI 10.3389/fpubh.2023.1199830

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Barcelona, Spain

REVIEWED BY
Sup Amornpinyo,
Khon Kaen University, Thailand
Dai Su,
Capital Medical University, Beijing, China

*CORRESPONDENCE
Qin Sen
✉ 1052952319@qq.com

RECEIVED 04 April 2023
ACCEPTED 19 July 2023
PUBLISHED 04 August 2023

CITATION
Sen Q and Lei Z (2023) The impact of community care services on older people's psychological health: an empirical study in Liaoning Province, China.
Front. Public Health 11:1199830.
doi: 10.3389/fpubh.2023.1199830

COPYRIGHT
© 2023 Sen and Lei. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

The impact of community care services on older people's psychological health: an empirical study in Liaoning Province, China

Qin Sen* and Zhang Lei

School of Humanity and Law, Northeastern University, Shenyang, China

Background: Rapid population aging in China means it is imperative to establish a comprehensive care service system for older people. Currently, China is vigorously promoting the development of community care services for older people which should, ideally, focus on psychological health in addition to physical health. This study examined the impact of community care services on older people's psychological health.

Methods: Survey data ($n = 741$) were collected from people aged 60 years and older in Liaoning Province, China, in which various community care services for older people were provided. Information was collected regarding the types of services provided (e.g., meal services, medical and social care), participants' demographic details (age, gender, economic circumstances, etc.), and their psychological health (e.g., loneliness, life satisfaction). The impact of the various care services on older people's psychological health was subsequently examined through the construction of a structural equation model.

Results: Community care services for older people had a significant positive impact on their psychological health, with the most significant positive impact on cultural and sports activities, visiting and chat services, and emotional counseling. The impact of community care services on sub-groups of older people (e.g., those who were disabled, socially isolated and/or poor) was different.

Conclusion: It is necessary to provide comprehensive and high-quality community care services, organize diverse cultural, sports, and recreational activities, provide differentiated and specific services for older people, and formulate corresponding service guidelines.

KEYWORDS

community care service, psychological health, population aging, structural equation model, heterogeneity analysis

1. Introduction

Since 2000 China has experienced rapid aging of its population and is a trend that is predicted to continue well into the future (1). According to the seventh national population census data, by the end of 2020, 18.70% of the population in China will be aged 60 years and older. The "Fourteenth Five-Year Plan" of the National Plan for the Development of the Aged Cause and the Care Service System clearly emphasizes the need to continue to expand the "balanced, reasonable, high-quality, efficient, urban and rural coverage of care services,

benefiting the entire population." At present, family pensions, community pensions and institutional pensions are the three main types of urban pension models in China, and a "9,064" pension service model has been formed (90% of the older adults live at home, 6% live in community, and 4% live in institutions). This shows that community care services play a crucial role in China's pension system (2). As an old industrial base province in Northeast China, Liaoning Province ranks first in terms of population aging due to the influences of industrial structures, economic levels, social culture and other factors. Since 2020, Liaoning Province has taken the lead in carrying out reform pilot work of community care services for older people in China. A series of policies and regulations have been promulgated, including the Regulations of Shenyang Municipality on Home-based Care Services. It has carried out reform pilot work of community care services for older people in 200 communities in nine cities, including Shenyang and Dalian, and formed a series of working models with demonstration effects.

With the trend of aging, the health of the older population is of concern. Older people tend to suffer from more physical and mental diseases and are prone to psychological problems, inducing the risk of suicide (3). According to 2018 Report on Older Adults' Psychological Health in China, 95% of older people have different degrees of psychological disorders, and they are prone to emotional problems. In June 2019, the National Health Commission also pointed out that changes in living conditions, social relations and physical conditions associated with older age, such as the weakening of the body and the death of a partner, bring negative feelings of inferiority and worthlessness. If these feelings are not appropriately managed, psychological problems such as depression and/or anxiety may result. According to the World Health Organization, "health is not only the absence of disease or weakness in the body but also the physical, psychological and social integrity of a person." The psychological health of older people is not only a medical and health problem but also a public problem affecting social stability and development (4). At present, child support, institutional care and community care services focus on meeting the survival and physiological needs of older people, while overlooking or neglecting their spiritual needs and psychological problems (5).

Recently, the Chinese government has placed greater importance on the issue of the care of older people in policies, focusing on their living conditions, and demanding the improvement of the quality of care services to meet their diverse needs. However, while most policies tend to guarantee basic living needs, such as food, housing, and basic medical care, and emphasis on resource support for service institutions, there is a lack of support for psychological services.

Similarly, current research on community care services mainly focuses on which service items should be established (6), how processes and quality can be improved (7), and how older people's satisfaction with services can be enhanced (8). However, there is limited research on the impact of community care services on older people's health, especially their psychological health, and there is a lack of investigation into the demand for services and service effectiveness, which directly affects the improvement and development of community care services. From this point of view, the psychological health of older people in China receives little attention but requires consideration.

Given this, this study is committed to studying, within the context of actively promoting community care services for older people in China, whether the community can become the real spiritual home for older people, provide them with high-quality and convenient services, and thus positively impact their psychological health. An additional question was whether this impact differs for sub-groups of the population. This is an important issue affecting the construction and improvement of the community care service system for older people in China. This study explored the impact of community care services on the psychological health of older people using the research results of 200 community care pilots for older people in Liaoning Province.

2. Literature review

2.1. Community care services for older people

Population aging and the care of older people are social issues faced by all countries globally. Welfare countries have implemented models of community care for older people since the 1960s. In the UK, the Department of Health and Social Security (DHSS) proposed that "use community facilities and resources to provide long-term care and assistance for people in need of care in the community, especially the very vulnerable older adults ", and an important objective of community care services is to reduce loneliness and abandonment experienced by older people. Ayers and Lyman (9) emphasized the critical role of psychological counseling and emotional assistance in caring for older people. Connelly (10) divides the content of community care into four types, the first is life care (including home services, apartments, etc.), the second is material support (including providing food, tax relief, etc.), the third is medical support (including disease treatment, health care, etc.), and the fourth is overall care (including improving the living environment, promoting social participation, etc.).

2.2. Definition of psychological health

The World Federation for Mental Health (WFMH) defines psychological health as "developing one's mood into the best state within the range of physical intelligence and emotion that is not inconsistent with other people's mental health." The World Health Organization (WHO) (2014) summarizes three characteristics of psychological health: "good personality, good ability to handle affairs, and good interpersonal relationship (11)." Wu (12) reported that as older people experience physical aging and social role changes, their psychological health also presents different characteristics, and attention should be paid to their cognitive abilities and adaptability.

2.3. Measurement of psychological health

In terms of psychological health measurement, early researchers mainly analyzed older people's psychological health from a single perspective of subjective psychological feelings. Siebert et al. (13) reported that loneliness, depression, subjective well-being and life satisfaction are sensitive indicators that can be used to quantify older people's mental health. Kozma and Stones (14) developed the

Memorial University Newfoundland Scale of Happiness (MUNSH), which is based on the theory of emotional balance and studies the mental health of older people from the dimensions of loneliness, depression and subjective well-being. The Geriatric Depression Scale GDS and the Center for Epidemiological Studies Depression Scale CES-D are also common tools for measuring the degree of depression and mental health of older people (15, 16). In China, Li et al. (17) from the Institute of Psychology of the Chinese Academy of Sciences compiled the "Mental Health Scale for the Older People (Urban Version)," and identified five dimensions of psychological health: cognitive efficacy, emotional experience, self-awareness, interpersonal communication and adaptability. Based on literature research, consulting case analysis, expert interviews and discussions, and open-ended questionnaires, Deng and Zheng (18) developed the "Mental Health Scale for the Urban Middle-aged and older Adults," which involves loneliness, depression, cognition, and interpersonal relations, etc.

Based on the research results of scholars from China and other countries, the measurement of the psychological health of older people using subjective emotional indicators only is limited. A comprehensive evaluation index system including loneliness, cognitive ability, life satisfaction and interpersonal activity participation as the main dimensions should be established.

2.4. Interfering factors of psychological health of older people

In order to fully understand the root causes of psychological problems and diseases of older people and improve their psychological health, scholars from all countries are committed to analyzing the factors that influence their psychological health, which can be roughly summarized into three aspects: physiological condition (sleep quality, illness, etc.), social relationships (family relationships, interpersonal relationships, etc.), and economic conditions (income levels, social security). Regarding physiological factors, Jorunn (19) studied the relationship between the ability to perform Activities of Daily Living (ADL) and loneliness in older people through structured interviews in a rehabilitation center, and concluded that ADL functions could reduce loneliness. Jacobs et al. (20) analyzed the relationship between physical health and loneliness in older people and found that those with physical dysfunction were more likely to feel lonely. In terms of social relationships, Wu (21) found that the social support of family, neighbors and friends affects the subjective well-being and mental health of older people by affecting their self-esteem, and reducing loneliness. Regarding economic conditions, Saber (22) reported that the level of economic income significantly impacts older people's happiness index.

3. Methods

3.1. Sample data sources

The data for this study were derived from the results of a survey conducted by the Institute of Urban and Rural Community Construction of Northeast University in 200 community care service pilot communities in Liaoning Province from 2021 to 2023. The survey adopted a multi-stage stratified cluster sampling method and was aimed at people aged 60 years and older. Step 1: The sample size was determined to be 800 people by calculation; Step 2: The sample size for each city was determined on the basis of the size of the population in each of the 14 cities in Liaoning Province; Step 3: Sampling communities were identified using a systematic random sampling method; Step 4: Using cluster sampling method, six samples of older people in each community were randomly selected and asked to complete a survey. A total of 852 questionnaires were distributed, and 741 valid questionnaires were returned, yielding a response rate of 87%. The data have strong universality and representativeness.

3.2. Variable selection and measurement

Independent variables: community care services for older people. According to the relevant regulations of the Ministry of Civil Affairs and other departments, community care services for older people include eight elements: living care services, meal and cleaning services, medical and health services, visiting and chat services, emotional counseling services, emergency rescue services, cultural and sports activities services, and legal aid services. Values were assigned to each of service item for the purpose of analysis, with a value of '1' assigned if the community provided this social service, while a value of '0' was assigned if the service was not provided.

Dependent variables: older people's psychological health. According to the measurements of psychological health in the literature review, this paper aimed to build a comprehensive and objective measurement index of older people's psychological health. Therefore, the four indicators of loneliness, cognitive ability, life satisfaction and participation in activities were selected to measure older people's psychological health. "Loneliness" is a sensitive indicator of psychological health with which it is significantly negatively correlated, and the higher an individual's psychological health, the lower the perceived loneliness (23). The question "Do you often feel lonely?" was included in the questionnaire which was answered using a 1–5 scale where "1 = always, 2 = often, 3 = sometimes, 4 = rarely, and 5 = never." "Cognitive ability" refers to the ability of the human brain to process, store and extract information. Based on the Mental Health Scale for the Older Adults (Urban Version), this study designed seven questions that reflected seven aspects: memory, spatial recognition, learning ability, understanding ability, expression ability, calculation ability and reaction speed. Each answer was assigned the value of "1 = correct, 0 = wrong or unknown," and the scores of the seven questions were added to compute a total score. "Life satisfaction" is a key indicator of older people's subjective well-being and Song et al. (24, 25) showed that the life satisfaction index of older people could be used to reflect their psychological health status. Life satisfaction was measured by the question "Are you satisfied with your current life?" which was answered using a 1–5 scale where: "1 = very dissatisfied, 2 = dissatisfied, 3 = average, 4 = satisfied, and 5 = very satisfied." "Participation in activities" belongs to the dimension of interpersonal communication, which is measured by the frequency of engagement in social activities. Scholars from all countries regard interpersonal activities as a measure of older people's psychological health. "Participating in activities" was assessed by the question "Do

you participate in the following activities now?" including "music or dance, sports, playing cards or mahjong, communicating with friends, voluntary activities, and other outdoor activities." The question was answered using a 1–5 scale where: "1 = not participating, 2 = not every month but at least once a year, 3 = not every week but at least once a month, 4 = not every day but at least once a week, and 5 = participating almost every day." The answers to the six items were summated to compute a total score.

Control variables: referring to the existing research about the factors that influence older peoples' mental health, data were collected regarding the participant's personal characteristics, behavior habits, economic status and family status, including age (1 = 60–65 years old, 2 = 65–70 years old, 3 = 70–75 years old, 4 = 75–80 years old, 5 = 80 and over), gender (0 = female, 1 = male), living conditions (1 = family, 2 = living alone, 3 = nursing home), marital status (1 = married and living with a spouse, 2 = married but not living with spouse, 3 = divorced, 4 = widowed, 5 = unmarried), physical exercise (0 = no physical exercise in the past, 1 = physical exercise in the past), disability (1 = no disability, 2 = mild disability, 3 = moderate disability, 4 = severe disability) and economic situation (1 = very poor, 2 = relatively poor, 3 = average, 4 = relatively wealthy, 5 = very wealthy).

3.3. Empirical models

3.3.1. Confirmatory factor analysis

In this study, four variables: loneliness, cognitive ability, life satisfaction and participation activities were used as indicators of "older people's psychological health." In contrast "older people's psychological health" was a latent variable, which is the common part of the four measurement indicators – a common factor. In order to test whether the whole factor model was significant, confirmatory factor analysis (CFA) was conducted on the four indicators of loneliness, cognitive ability, life satisfaction and participation in activities to verify whether the factor load coefficient of "older people's mental health" was significant, and to verify whether the measurement of "older people's mental health" was valid.

3.3.2. Structural equation model (SEM)

As a confirmatory method, the structural equation model can explore the structural relationship between variables, and is widely used in psychology, sociology and other fields (26, 27). In this study, the explanatory variable "community care service" was an explicit variable, and the explanatory variable "older people's psychological health" was a latent variable measured by four indicator variables: loneliness, cognitive ability, life satisfaction, and social activities. The structural model equation of community care services and older people's psychological health is shown by the formula (1):

$$\eta = \alpha + \Gamma X + \zeta \quad (1)$$

The measurement model is shown in formula (2):

$$y = \gamma\eta + \mu \quad (2)$$

In formula (1), η Is a latent variable, indicating older people's mental health; Γ Indicates the change of the latent variable after each unit change of the indicator variable; X refers to community care services that affect older people's psychological health, which are composed of living care services, meal and cleaning services, medical and health services, visiting and chat services, emotional counseling services, emergency rescue services, cultural and sports activities services and legal aid services; ζ Represents a random perturbation term. In the formula (2), y = (y1, y2, y3, y4) is a group of indicator variables for older people's psychological health. This study used four indicators: loneliness, cognitive ability, life satisfaction, and social activities; ε indicates the measurement error item (Table 1).

4. Analysis of empirical results

4.1. Descriptive statistical results

Descriptive data and participants' characteristics are summarized in Table 2 which shows that the average score for loneliness was 4.03, indicating that respondents had a low sense of loneliness as a whole and do not feel particularly lonely. Cognitive ability is composed of memory, spatial recognition, learning ability, understanding ability, expression ability, calculation ability and reaction speed, and the average score was 6.52, indicating that respondents had high overall cognitive ability and normal intelligence. The average life satisfaction score was 3.88, indicating that participants were relatively satisfied with their current life as a whole and had a positive and optimistic attitude toward life. However, the average number of people participating in activities was 9.63, which indicates that participants had less contact with people and were not fully involved in various social activities. According to the social withdrawal theory, people's abilities will inevitably decline with increasing age, and they gradually lose their social roles, thus reducing social interaction and participation in activities. This view is consistent with the results of this research.

TABLE 1 Sample size allocation.

City	Amount of sample communities per city	Amount of samples per community	Sample size
Shenyang	30	6	78
Dalian	20	6	72
Anshan	11	6	60
Chaoyang	10	6	60
Jinzhou	10	6	60
Huludao	9	6	60
Tieling	9	6	60
Yingkou	8	6	54
Dandong	7	6	60
Fushun	6	6	60
Fuxin	6	6	54
Liaoyang	6	6	60
Panjin	5	6	60
Benxi	5	6	54
Sum	142		842

TABLE 2 Characteristics of the participants and availability of support services.

	Variables	*N*	Means	Standard deviation	Minimum values	Maximum values
Control variable	Age	738	2.12	1.037	1	5
	Gender	736	0.42	0.303	0	1
	Living conditions	723	1.22	0.455	1	3
	Marital status	707	2.77	1.476	1	5
	Physical exercise	728	0.69	0.454	0	1
	Disability	719	1.38	0.762	1	4
	Economic situation	711	1.96	0.629	1	5
Dependent variables	Loneliness	717	4.03	0.996	1	5
	Cognitive ability	689	6.52	1.084	0	7
	Life satisfaction	718	3.88	0.796	1	5
	Participation activities	723	9.63	3.830	6	30
Independent variables	Living care services	702	0.12	0.303	0	1
	Meal and cleaning services	726	0.83	0.317	0	1
	Medical and health services	714	0.57	0.475	0	1
	Visit and chat services	722	0.15	0.353	0	1
	Emotional counseling services	706	0.17	0.287	0	1
	Emergency rescue services	715	0.28	0.464	0	1
	Cultural and sports activities services	710	0.37	0.412	0	1
	Legal aid services	721	0.21	0.493	0	1

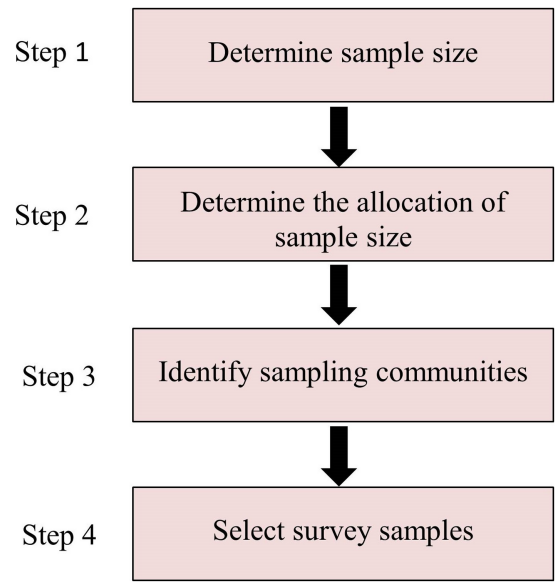


FIGURE 1
Chart of sample selection.

In terms of community care services, the average value of each service is ranked from high to low as follows: meal and cleaning services, medical and health services, cultural and sports activities services, emergency rescue services, legal aid services, emotional counseling services, visit and chat services, and living care services, with the average value of 0.83, 0.57, 0.37, 0.28, 0.21, 0.17, 0.15, and 0.12, respectively. Overall, the service items and supply coverage of the existing community care services are seriously insufficient, with the focus on physical health and basic living needs while social and spiritual needs are overlooked. According to Maslow's hierarchy of needs theory, community care services should not only focus on the first level of physical needs and the second level of safety needs, but also focus on the third and fourth levels of social and respect needs.

4.2. Model estimation results

Before running the model, the data in this study were first tested for reliability using SPSS software. The results showed that the Cronbach's α of each study variable was above 0.6, indicating that the data had high reliability. Subsequently, AMOS software was used to draw a model path map and perform data operations, and after debugging, the model was optimized. The final output is shown in Figure 1. The fitting index RMSEA = 0.067 and SRMR = 0.039 indicates that the model fitness of the constructed factor model was good.

According to the model estimation results in Figure 1, community care services have a significant impact on older people's psychological

health with an impact coefficient of 0.72. The three services with the most significant impact were cultural and sports activity services, visiting and chat services, and emotional counseling services, with coefficients of 0.38, 0.26, and 0.22, respectively. This result indicates that within the community, the involvement of professional social workers and psychological counselors, carrying out diverse cultural and sports activities to enhance the social participation and communication circle of older people can enrich their leisure life, provide a sense of collective belonging and existence, and maintain a positive and healthy mentality. Visiting and chat services are a direct way to comfort people. Service personnel can play the role of relatives or friends of empty nesters to a certain extent and alleviate older people's loneliness through communicating with them. At the same time, due to personal, family, or neighborhood factors, older people are prone to suffer from depression and anxiety. Counseling services provided by professional psychological consultants can help older people reduce internal misunderstandings and distress and lower their risk of mental illness.

In addition to these three items, the service items that ranked fourth to fifth in terms of impact were: meal and cleaning services and living care services. These service categories can improve the quality of life of older people, ensure that they live with dignity in their familiar community environment, thereby making them feel the meaning and value of life, and enhancing their life satisfaction. While the other three service elements - medical and health services, emergency rescue services and legal aid services were found to have no significant effects, and may even have a negative impact on older people's mental health. This is mainly due to the relatively short development time of the three services, which are still in the initial stage of development, insufficient experience of practitioners, high service costs, and insufficient coverage, resulting in a lower overall service level (Figure 2).

4.3. Robustness check

Considering that older people's psychological health is also affected by other factors, this study also added control variables to the following models (1) and (2), including age, gender, living conditions, and whether participants undertook physical exercise. The regression coefficients and significant changes in the models were evaluated to assess the robustness of the empirical models.

In Table 3, Part A shows the estimated results of the structural model for various factors affecting older people's mental health, and Part B shows the estimated results of the measurement model, which is essentially consistent with the estimated results of the structural equation model. Part C shows the fitting indicators for the entire model, and of them, RMSEA<0.08, SRMR<0.05, and $R^2 \approx 0.7312$, indicating that the overall fit of the model is good, and the empirical results are robust and acceptable.

4.4. Heterogeneity analysis

The data were further analyzed to assess heterogeneity and whether the impact of community care services on older people's psychological health varied according to whether they live alone, whether they are disabled, and their economic level.

Table 4 shows the results of the heterogeneity analysis. Results showed that living care services have a differential impact on disabled versus non-disabled older people, and have a significant positive impact on the psychological health of disabled older people, but no significant impact on non-disabled older people. The reason is that disabled people are unable to complete daily life independently due to physical impairments, and need the help of professional service personnel (28). Meal and cleaning services were also found to have a differential impact on the psychological health of solitary older people, disabled older people, and poor older people. This is likely due to the greater vulnerability of these groups who have a greater need for these services. In addition, the coverage and quality of this service are currently high, and older people can obtain it in a convenient and low-cost manner, thereby improving their life satisfaction. Furthermore, older people can benefit from the opportunity of interacting and communicating with others during meals which is likely to reduce their sense of loneliness (29). Medical and health services were found to have a positive impact on the psychological health of non-solitary older people, disabled older people, and wealthy older people. By comparison, the impact on other groups of older people was negative. This may be due to disabled older people having a stronger demand for medical services, requiring family support to a certain extent, and relatively high cost (30). Visiting and chat services have a differential impact on those who live alone and have a significant positive impact on their psychological health. This is most likely because solitary older people lack the care of their families and children and are eager to communicate with others (31). Emotional counseling services have a positive impact on the psychological health of different groups of older people, particularly the solitary and the disabled, who are more vulnerable to psychological problems due to life stresses. Emergency rescue services have a positive impact on the psychological health of the solitary and disabled older people, while their impact on other groups of older people was negative. This may be because solitary and disabled older people have impaired physical functioning and may be more likely to face the risk of sudden illness and/or accidental injury. Emergency rescue services provide protection for older people through remote monitoring, improving their sense of security. Cultural and sports activities services have a significant positive impact on the psychological health of all groups of older people, indicating that regardless of residential, physical, and economic status, older people have a clear need to participate in various social interaction activities to reduce loneliness, improve life satisfaction, social skills, and maintain their cognitive abilities. Legal aid service has a negative impact on the psychological health of non-solitary and poor older people, while it has a positive impact on other groups of older people. This may be because, when faced with legal disputes, the non-solitary group typically has children to assist them, while those who are poor may have limited understanding of the legal system, and generally resolve disputes through other means.

Overall, community care services significantly impact the psychological health of the solitary, disabled and poor older people, proving that these vulnerable groups have a greater need for community care services. At the same time, different types of services have different effects on different groups of older people. Those who are solitary need more spiritual services, the disabled need more life support services, and the poor need more cultural

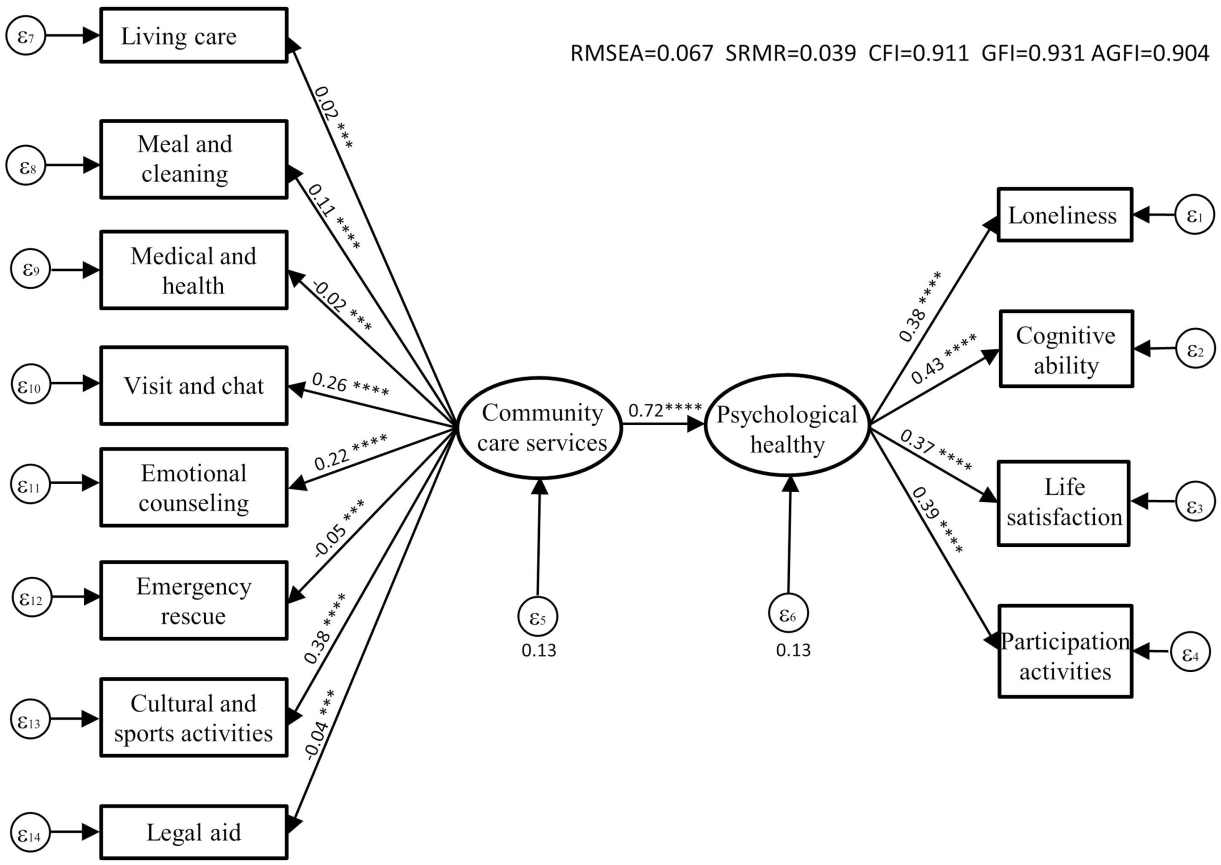


FIGURE 2
Path model of the impact of community care services on older people's psychological health.

and entertainment services. This analysis result is consistent with other Chinese scholars' research reports. For example, Wu (21) reported that solitary older people lack the support and care of their families regarding life and spirituality and need social interventions to improve their psychological health. Huang (32) also reported that disabled older people need customized and specific services based on daily living and care services, but the current supply is still significantly insufficient. Wang (33) reported that poor older people have fewer opportunities to participate in social activities and created the phenomenon of "conceptual poverty" and "spiritual poverty." It is necessary to encourage and support poor older people to participate in community activities and improve their quality of life.

5. Discussion

This study examined the impact of community care services on older people's psychological health in Liaoning Province. Overall, community care services have a significant positive impact on older people's psychological health, which is consistent with previous research (34).

This study further indicates that only five of the eight service items have a positive impact, while the remaining three have a negative impact, including medical and health services, emergency rescue services, and legal aid services. Previous studies have not found this phenomenon, but some Chinese scholars have pointed out that these three services have obvious shortcomings such as insufficient supply and poor professionalism, and thus cannot meet the needs of older people (35), which confirms the conclusion of this study.

In addition, this study indicates that living conditions, disability, and older people's economic circumstances have a differential impact on the results. Community care services have a greater impact on the psychological health of older people living alone, the disabled, and the poor. This indicates that vulnerable groups need more customized and high-quality community services which has also been confirmed by other relevant studies.

In China, the "Healthy Aging" policy is committed to improving the comprehensive health of older people, especially their psychological health and social adaptability. This study is based on the policy background of "healthy aging," and differs from other studies that only focus on physical health. Instead, it focuses on multidimensional psychological health, to test the effectiveness of different community care services. This study fills the research gap in this field and suggests directions for Chinese community care services to address issues associated with population aging.

At the same time, however, this study is limited to Liaoning Province, which has a very large aging population, and does not cover the whole country, which may result in the research results not being widely representative. In the future, with further research, more comprehensive conclusions may be drawn.

TABLE 3 Estimation results of extended SEM Model.

Model	Equation	(1)	(2)
	Estimation method	ML	ML
A structural model	Living care	0.018**	0.015**
		(1.30)	(0.72)
	Meal and cleaning	0.153***	0.148***
		(3.08)	(3.21)
	Medical and health	−0.025**	−0.019**
		(−2.26)	(−2.34)
	Visit and chat	0.027**	0.034**
		(2.21)	(2.58)
	Emotional counseling	0.045***	0.076**
		(3.77)	(3.30)
	Emergency rescue	−0.023**	−0.031**
		(−1.32)	(−0.72)
	Cultural and sports activities	0.421****	0.395****
		(3.30)	(3.43)
	Legal aid	0.018**	0.019**
		(1.45)	(1.37)
	Age	−0.009****	−0.009****
		(−15.01)	(−16.31)
	Gender	0.036****	0.036****
		(4.64)	(4.60)
	Living conditions		−0.012**
			(−1.54)
	Physical exercise		0.189****
			(15.80)
B measurement model	Loneliness	0.355****	0.412****
		(2.738)	(2.145)
	Cognitive ability	1.569****	1.450****
		(6.099)	(5.730)
	Life satisfaction	0.996****	0.610****
		(3.194)	(3.935)
	Participation activities	8.326****	7.689****
		(11.124)	(10.517)
	N	734	721
C fit indices	RMSEA	0.072	0.072
	SRMR	0.036	0.034
	R^2	0.814	0.772

****indicates p is significant at 0.1%, ***indicates p is significant at 1%, and **indicates p is significant at 5%.

6. Conclusion

This study was based on survey data from pilot programs of community care services in Liaoning Province, to explore the impact of community care services on the psychological health of older people. The empirical results show that, of the eight service elements stipulated by policy, the implementation of five types of services had a significant positive impact on older people's psychological health, namely, cultural and sports activities services, visiting and chat services, emotional counseling services, meal and cleaning services, and living care services, while the other three service elements - medical and health services, emergency rescue services and legal aid services were found to have no significant effects, and may even have a negative impact on older people's mental health. This is mainly due to the relatively short development time of the three services, which are still in the initial stage of development, insufficient experience of practitioners, high service costs, and insufficient coverage, resulting in a lower overall service level. In addition, there are differences in the results of community care services under different living conditions, disability conditions, and economic conditions. It is necessary to focus on the psychological health of older people living alone, the disabled, and the poor, and provide specific community care services for these groups.

In response to these conclusions and to the policy spirit of "healthy aging" and "active aging" in China, the following suggestions are proposed to improve the community-based elder care model, and improve the psychological health status of the older population:

First, provide comprehensive and high-quality community care services for older people, focusing on improving the quality and coverage of spiritual services. Research shows that with the development of China's economy and society, older people's needs are characterized by diversity. After basic physiological and survival needs are met, emotional satisfaction, the acquisition of dignity, and the establishment of social interaction are equally important. From the perspective of the supply side of care services, existing care services for older people are characterized by "emphasizing physiology but neglecting psychology." The coverage of spiritual services is relatively low, and the service level is relatively poor. It is recommended that the development of spiritual services for older people in the community be strengthened through fund allocation, talent cultivation, facility construction, team cooperation, and project introduction.

Second, build a social activity platform for older people, and organize diverse cultural, sports, and other entertainment activities for them. Of the eight community care service elements, cultural and sports activities had the most significant impact on older people's psychological health, which requires lower capital costs in comparison to other services. In the case of limited community resources, priority could be given to the implementation of recreational activities and services. Communities should establish activity centers for older people, fully mobilize their human resources, and regularly organize activities for them, thereby connecting them to the community and enriching their lives.

Third, it is important to focus on the psychological health of the most vulnerable and disadvantaged groups of older people, i.e., those who are solitary, disabled and/or poor, and give them more respect and care. Generally speaking, while impairments in physical functioning are obvious and receive attention, loneliness and lack of social interaction are more difficult to detect but are likely to

TABLE 4 Heterogeneity analysis results.

Variables	Items	Solitary older adults	Non solitary older adults	Disabled older adults	Non disabled older adults	Wealthy older adults	Poor older adults
Living care	SE	0.037	0.016	0.051	0.016	0.027	0.019
	Z	3.14	1.79	2.35	1.96	2.79	5.06
	Significance	0.024	0.007	0.029****	0.011	0.013	0.026***
Meal and cleaning	SE	0.032	0.021	0.056	0.018	0.049	0.018
	Z	4.32	1.44	3.23	1.84	2.79	0.58
	Significance	0.075****	0.026**	0.142****	0.058**	0.024	0.028***
Medical and health	SE	0.044	0.013	0.05	0.018	0.039	0.011
	Z	−1.08	2.14	1.75	−0.38	1.82	−0.33
	Significance	−0.012	0.073**	0.052**	−0.027	0.013***	−0.006
Visit and chat	SE	0.061	0.017	0.052	0.025	0.041	0.028
	Z	1.5	1.3	1.48	3.34	3.41	1.5
	significance	0.079****	0.034**	0.077**	0.084**	0.142**	0.042
Emotional counseling	SE	0.042	0.073	0.125	0.048	0.325	0.198
	Z	5.23	2.75	4.96	1.77	3.28	2.66
	Significance	0.275****	0.112***	0.189***	0.063**	0.137***	0.158***
Emergency rescue	SE	0.048	0.022	0.046	0.019	0.051	0.013
	Z	3.24	−1.86	1.09	−1.27	−2.78	−1.03
	Significance	0.074**	−0.029	0.035**	−0.093	−0.034	−0.012
Cultural and sports activities	SE	0.058	0.015	0.045	0.022	0.04	0.024
	Z	2.86	6.73	0.8	6.58	0.15	3.36
	Significance	0.166***	0.103****	0.036	0.146****	0.012	0.082****
Legal aid	SE	0.047	0.012	0.041	0.018	0.037	0.019
	Z	1.48	−1.05	0.21	0.59	2.78	−1.04
	Significance	0.07	−0.034	0.008	0.048**	0.054	−0.039
N		126	597	96	623	226	485

****indicates *p* is significant at 0.1%, ***indicates *p* is significant at 1%, and **indicates *p* is significant at 5%.

result in loneliness, depression and an increased risk of mental illness. Therefore, when providing care services for older people, it is important to provide targeted services based on the particular circumstances of those who are particularly vulnerable, and develop corresponding service guidelines.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Northeastern University Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Wu M, Li S, Zhang N, Zhu Y, Ning B, Thomas W, et al. Investigation on the life and psychological health status of the solitary older adults in China. *Chin J Public Health*. (2011) 07:849–51.

2. Xiang L. Analysis on the mode of community care service in China. *Qinghai Soc Sci*. (2007) 05:31–3. doi: 10.14154/j.cnki.qss.2007.05.002

3. Cheng X, Bu H, Duan W, He A, Zhang Y. Measuring character strengths as possible protective factors against suicidal ideation in older Chinese adults: a cross-sectional study. *BMC Public Health*. (2020) 20:439. doi: 10.1186/s12889-020-8457-7

4. Ashley N, AlKandari Y, Znidarsic K, Douglas E. Individual measures of social support may have limited impact on physiological parameters among older adults in Kuwaitis. *Am J Hum Biol*. (2021) 34:e23655. doi: 10.1002/AJHB.23655

5. Yin H, Liu S, Song G. Research status and prospect of psychological health of the older adults in China. *Chin J Health Psychol*. (2014) 22:1566–9. doi: 10.13342/j.cnki.cjhp.2014.10.052

6. Kendig H, Mealing N, Carr R, Lujic S, Byles J, Jorm L. Assessing patterns of home and community care service use and client profiles in Australia: a cluster analysis approach using linked data. *Health Soc Care Com*. (2012) 20:375–87. doi: 10.1111/j.1365-2524.2011.01040.x

7. Janne R, Mona M, Knut E, Sverre B, Anja B, Manuel GP, et al. Development of best practice recommendations to enhance access to and use of formal community care services for people with dementia in Europe: a Delphi process conducted by the Actifcare project. *Aging Ment Health*. (2020) 25:2298–309. doi: 10.1080/13607863.2020.1822286

8. Xie F, Deng A, Chen J, Xiong R. Factors associated with willingness to receive a novel community care service for older people in Foshan, China: a cross-sectional study. *BMC Health Serv Res*. (2022) 22:1–8. doi: 10.1186/S12913-022-08004-3

9. Ayers SC, Lyman DR. The development of a community-based system of care. *Handbook Comm Clin Pract*. (2005) 5:221–42. doi: 10.1093/acprof:oso/9780195159226.003.0016

10. Connelly N. Balancing pluralism: new welfare mixes in care for the older adults. *J Soc Policy*. (1994) 23:446–8. doi: 10.1017/S0047279400022066

11. World Health Organization. (2002). E. coli. Available at: https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/06/WHO-Active-Ageing-Framework.pdf (Accessed April 3, 2023).

12. Wu Z. The connotation, evaluation, and research survey of mental health in the older adults. *Chin J Gerontol*. (2003) 12:799–801.

13. Siebert DC, Mutran EJ, Reitzes DC. Friendship and social support: the importance of role identity to aging adults. *Soc Work*. (1999) 44:522–33. doi: 10.1093/sw/44.6.522

14. Kozma A, Stones M. The measurement of happiness: development of the Memorial University of Newfoundland scale of happiness (MUNSH). *J Gerontol*. (1980) 35:906–12. doi: 10.1093/geronj/35.6.906

15. Alfred CC. Clinical validation of the geriatric depression scale (GDS). *J Aging Health*. (1996) 8:238–53. doi: 10.1177/089826439600800205

16. Hertzog C, Van A, Judith U, Paul D, Hultsch D, Dixon R. Measurement properties of the Center for Epidemiological Studies Depression Scale (CES-D) in older populations. *Psychol Assess*. (1990) 2:64–72. doi: 10.1037/1040-3590.2.1.64

17. Li J, Wu Z, Han B. Mental health scale for the older adults (urban version). *Chin Ment Health J*. (2009) 23:656–60.

18. Deng L, Zheng R. Development of a mental health scale for middle-aged and older people in cities. *Chin J Appl Psychol*. (2005) 1:45–51.

19. Jorunn D, Birgitte E, Marit K. The impact of depression and sense of coherence on emotional and social loneliness among nursing home residents without cognitive impairment - a questionnaire survey. *J Clin Nurs*. (2012) 21:965–74. doi: 10.1111/j.1365-2702.2011.03932.x

20. Jacobs JM, Hammerman-Rozenberg R, Maaravi Y, Cohen A, Stessman J. The impact of visual impairment on health, function and mortality. *Aging Clin Exp Res*. (2005) 17:281–6. doi: 10.1007/bf03324611

21. Wu Y. Can the social loneliness of the older adults be alleviated through social participation with the support of the community and stakeholders? A sustainable activity design study. *With Design*. (2022) 7:3481–90. doi: 10.1007/978-981-19-4472-7_229

22. Saber M, Rashedi V, Fadakar DM, Borhaninejad V. Social support, happiness, and self-rated health among elder adults: a population-based study. *Adv Gerontol*. (2021) 11:22–8. doi: 10.1134/S2079057021010471

23. Hutten E, Jongen E, Anique E, Hout C, Lankveld M. Loneliness and mental health: the mediating effect of perceived social support. *Int J Environ Res Public Health*. (2021) 18:11963. doi: 10.3390/IJERPH182211963

24. Song J, Yang L, Han M, Wu Y. Study on the mental health of the older adults under different pension models. *J Healthc Eng*. (2022) 2022. doi: 10.1155/2022/2367406

25. Zhai X. The influence mechanism of social support on life satisfaction of the older adults: an analysis based on the intermediary effects of physical health and mental health. *Popul J*. (2016) 38:49–60. doi: 10.16405/j.cnki.1004-129X.2016.02.005

26. Gerino E, Rollè L, Sechi C, Brustia P. Loneliness, resilience, mental health, and quality of life in old age: a structural equation model. *Front Psychol*. (2017) 8:2003. doi: 10.3389/fpsyg.2017.02003

27. Herbert W, Kit-Tai H, Roche L, Craven R, John B, McInerney V. Problems in the application of structural equation modeling: comment on Randhawa, beamer, and Lundberg (1993). *J Educ Psychol*. (1994) 86:457–62. doi: 10.1037/0022-0663.86.3.457

28. Barron CR, Foxall MJ, Dollen K, Jones PA, Shull KA. Marital status, social support, and loneliness in visually impaired older people. *J Adv Nurs*. (1994) 19:272–80. doi: 10.1111/j.1365-2648.1994.tb01081

29. Berg S, Mellstrom D, Persson G, Svanborg A. Loneliness in the Swedish aged. *J Gerontol*. (1981) 36:342–9. doi: 10.1093/geronj/36.3.342

30. Eran S, David J, Tamar Y. The strength of family ties: a meta-analysis and meta-regression of self-reported social support and mortality. *Soc Networks*. (2013) 35:626–38. doi: 10.1016/j.socnet.2013.08.004

31. Barnay T, Juin S. Does home care for dependent older people improve their mental health? *J Health Econ*. (2016) 45:149–60. doi: 10.1016/j.jhealeco.2015.10.008

32. Huang Z, Xu T, Huang Y, Yang Q, Gui J, Fu Y, et al. Analysis of spatiotemporal differences in the provision of community services for the disabled older adults in China: based on CLHLS (2008-2018) tracking data. *Mod Prev Med*. (2022) 19:3535–41. doi: 10.20043/j.cnki.MPM.202202386

33. Wang S. Active aging and a new exploration of the governance path of poverty among the older people in China. *Jiang-huai Tribune*. (2016) 01:132–7. doi: 10.16064/j.cnki.cn34-1003/g0.2016.01.022

34. Su Q, Wang H, Fan L. The impact of home and community care services pilot program on healthy aging: a difference-in-difference with propensity score matching analysis from China. *Arch Gerontol Geriatr*. (2023) 110:104970. doi: 10.1016/J.ARCHGER.2023.104970

35. Jiang H, Liu Z. Community home care services, multidimensional health and social participation of chronically ill older adults -empirical analysis based on propensity score matching and multiple mediation analysis. *Front Public Health*. (2023) 11:114–118. doi: 10.3389/FPUBH.2023.1121909

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 22 August 2023
DOI 10.3389/fpubh.2023.1204977

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Taolin Chen,
Sichuan University, China
Max Jacob Owens,
University of South Florida St. Petersburg, United States

*CORRESPONDENCE
Yi Zhang
✉ zhangyipsy@csu.edu.cn

RECEIVED 13 April 2023
ACCEPTED 27 July 2023
PUBLISHED 22 August 2023

CITATION
Yuan D, Wu J, Li S, Zhang R, Zhou X and Zhang Y (2023) Network analysis of cold cognition and depression in middle-aged and elder population: the moderation of grandparenting.
Front. Public Health 11:1204977.
doi: 10.3389/fpubh.2023.1204977

COPYRIGHT
© 2023 Yuan, Wu, Li, Zhang, Zhou and Zhang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Network analysis of cold cognition and depression in middle-aged and elder population: the moderation of grandparenting

Dongling Yuan[1], Jialing Wu[1], Shansi Li[1], Ruoyi Zhang[1], Xiao Zhou[1] and Yi Zhang[1,2,3]*

[1]Medical Psychological Center, The Second Xiangya Hospital, Central South University, Changsha, China, [2]Medical Psychological Institute of Central South University, Central South University, Changsha, China, [3]National Clinical Research Center on Mental Disorders (Xiangya), Changsha, China

Background: Cognitive decline and negative emotions are common in aging, especially decline in cold cognition which often co-occurred with depression in middle-aged and older adults. This study analyzed the interactions between cold cognition and depression in the middle-aged and elder populations using network analysis and explored the effects of grandparenting on the cold cognition-depression network.

Methods: The data of 6,900 individuals (≥ 45 years) from the China Health and Retirement Longitudinal Study (CHARLS) were used. The Minimum Mental State Examination (MMSE) and the Epidemiology Research Center Depression Scale-10 (CESD-10) were used to assess cold cognition and depressive symptoms, respectively. Centrality indices and bridge centrality indices were used to identify central nodes and bridge nodes, respectively.

Results: Network analysis showed that nodes "language ability" and "depressed mood" were more central nodes in the network of cold cognition and depression in all participants. Meantime, nodes "attention," "language ability" and "hopeless" were three key bridge nodes connecting cold cognition and depressive symptoms. Additionally, the global connectivity of the cold cognition and depression network was stronger in the non-grandparenting than the grandparenting.

Conclusion: The findings shed a light on the complex interactions between cold cognition and depression in the middle-aged and elder populations. Decline in language ability and depressed mood can serve as predictors for the emergence of cold cognitive dysfunction and depression in individuals during aging. Attention, language ability and hopelessness are potential targets for psychosocial interventions. Furthermore, grandparenting is effective in alleviating cold cognitive dysfunction and depression that occur during individual aging.

KEYWORDS

network analysis, cold cognition, depression, grandparenting, the middle-aged and elder population

Introduction

Aging is increasing seriously globally as the decline in birth rate and increases in life expectancy (1). The statistical data from the National Bureau of Statistics of China show that the number of populations aged 60 and older was 253 million in 2019 (2). Moreover, it is estimated that the number of middle-aged and older adults will reach 400 million in China by 2050, which will bring significant challenges in healthcare and socio-economic (3).

Previous studies have demonstrated that cognitive decline and negative emotions are common in aging, especially decline in cold cognition which often co-occurred with depression in middle-aged and older adults (4, 5). Cold cognition refers to the process of information with less emotional influence, such as working memory, attention, executive function and language (6). Studies have demonstrated that cold cognitive dysfunction is a risk factor for emotional disorders including depression (7, 8). Individuals with cold cognition decline are more vulnerable to suffering from depression than health ones (9). Meanwhile, the meta-analysis has also revealed that some cold cognition dysfunctions are present in the first episode and persist after the depression having been remitted (10–12). These findings suggest that cold cognition dysfunction can be used as a good marker for depression susceptibility (13), prognosis (14) and functional recovery (15). Moreover, a previous study reported that the co-occurrence of cold cognition dysfunction with depression has a negative impact on daily life significantly (16). Although it is well documented that cold cognition impairment and depression often co-exist, they only focused on the relationship between cold cognition and depression at the overall level, ignoring the effects of specific cold cognitive functions on different depressive symptoms. Furthermore, the study on the connection between specific cold cognition dysfunctions and depressive symptoms in middle-aged and older adults is rare.

Recently, increasing numbers of research have found that traditional conceptualization studies of psychopathology obscured meaningful associations between symptoms (17). With the development of cybermetrics, Borsboom (18) has proposed the network theory of psychiatric disorders based on the network analysis approach, which suggests that psychiatric disorders are conceptualized as representations of a symptom network. In the network, nodes are symptoms, the connectivity between nodes represents inter-symptomatic relationships, and the dynamic changes in the symptom network triggered by the interaction of symptoms represent the occurrence and development of psychiatric disorders. Network analysis has emerged as a new approach to investigate complex, dynamic relationships between individual psychiatric symptoms (19). In contrast to traditional perspectives, network analysis treats a particular psychiatric disorder as an interacting cluster of symptoms (18, 20), whereas the emergence and development of disorders are thought to be caused by strong causal interactions between symptoms (18, 21). Thus, an important aim of the network analysis approach is to identify the core symptoms (high centrality nodes) and the bridging symptoms that connect the symptom networks between different psychiatric disorders in the symptom network. Furthermore, core and key bridge symptoms can be more likely to activate other symptoms in the network, thereby driving the development of psychiatric disorders (20, 22). Clinically, core symptoms of psychiatric disorders identified by network analysis can be used as a target of interventions, which may be more effective in preventing the occurrence and promoting regression of psychiatric disorder. Recently, several studies have been conducted to explore psychiatric disorders based on network analysis. For example, Briganti et al. (23) proposed network analysis is a useful tool to explore depression symptoms and offers new insight as to how they interact. A symptom network analysis of PTSD found that fear circuitry and dysphoric PTSD symptoms appear to emerge as connected networks as time elapses after trauma, while intrusive memories and reactivity are centrally associated with other symptoms in the acute phase (22). These findings not only indicate that the relationship between psychiatric symptoms is a network of direct interactions, but also reveal that the clinical symptoms network of psychiatric disorders prominently highlights meaningful associations of symptoms within and between disorders (24). However, network analysis of cold cognition dysfunction and depressive symptoms in middle-aged and older adults is still lack.

In addition, previous studies have also shown that the heterogeneity of depressive symptoms and cold cognitive impairment are largely influenced by individual differences. For example, Sneed and Schulz (25) study in adults found a non-linear decline in cold cognition function with age, while older adults with grandparenting had a slower rate of cognition deterioration than the non-grandparenting. Grandparenting refers to grandparents living with their grandchildren assuming some or all of the responsibility for raising and educating their grandchildren (26), and is very common in China. There is evidence to support the benefits of grandparenting on human well-being and mental health. For example, it was found that older adults who lived with grandchildren had lower levels of depression compared to those without (27). Arpino and Bordone (28) study also found that grandparenting positively affects the cognition function in older adults. Collectively, grandparenting may have important effects on cold cognition and emotion in older adults. However, whether grandparenting plays an important role in cognitive function-depressive networks in middle-aged and older adults needs further confirmation.

In this study, network analysis was used to clarify the complex relationship between cold cognition and depression to identify the core symptoms and the mechanisms of co-occurrence between cold cognition and depression in middle-aged and older adults. Furthermore, we also compared cold cognition-depression networks between the grandparenting and non-grandparenting to explore the effect of grandparenting on the cold cognition-depression network. These may help to explain the negative impacts of cold cognition decline on the emotions of the middle-aged and elder populations, even facilitating timely treatments of core symptoms to prevent and alleviate depression for them.

Methods

Participants and procedure

The present study used the China Health and Retirement Longitudinal Survey (CHARLS) in 2018 follow-up data to explore the network structure of cold cognition and depression among middle-aged and older adults in China. The CHARLS is a nationally representative data with a large sample and high data quality regarding

basic information, mental health and physical health of Chinese aged 45 years or older.

The inclusion and exclusion criteria for the subjects in this study were (1) having demographic information such as age, gender, whether or not they were raised in intergenerational relationships, and years of education and being older than 45 years old (2); completing the Center for Epidemiologic Studies Depression Scale (CESD-10) and having no missing values; and (3) completing Mini-Mental State Examination (MMSE) assessment with no missing values. There are a total of 19,816 subjects in the 2018 survey. According to the inclusion criteria, 1,107 cases with missing age, gender or age less than 45 years old, and 2,819 cases missing grandparenting status and years of education, 3,109 cases with incomplete CESD scores, and 5,881 cases with incomplete MMSE assessments were excluded, and a final valid sample of 6,900 cases was obtained in present study.

Measures

Cold cognition

The cold cognitive function was calculated by a Minimum Mental State Examination (MMSE) questionnaire in the CHARLS (29). The MMSE scale contains 30 items to cover time and place orientation, immediate memory, attention and calculation, recall, and language ability. The correct answer for each item is recorded as one score. High scores are associated with better cognitive function. While scores below the cut-off values can be considered as an impaired cognition. Specifically, the MMSE cutoff was set at 16/17 for uneducated persons (0 years of education), 19/20 for those with 1–6 years of education, and 23/24 for those with 7 or more years of education (30). The Cronbach's α coefficient of the MMSE in this study was 0.813.

Depression

Center for Epidemiologic Studies Depression-10 (CESD-10) was used to assess depressive symptoms and levels in middle-aged and elder persons (31, 32). The CESD-10 is a self-reported questionnaire to assess depressive symptoms in the past week on a 4-point scale with a total score range of 0 to 30, more severe depression is indicated by a higher score, i.e., the CESD score $\geq$ 20 was regarded as depressed, $\geq$ 10 considered to have depressive symptoms and $<$ 10 means no significant depressive symptoms (33). The scale Cronbach's α coefficient in this study was 0.809.

Statistical analysis

The data analysis was performed with SPSS and R version 4.1.2.

Network estimation

The network model of 15 indicators was estimated using the EBIC glasso function in the q graph package of network tools R package (34). Specifically, a Gaussian graphical model was first estimated, which estimated the pairwise correlation parameters among all nodes. Meanwhile, the LASSO regularization technique was employed to cautiously identify correlated edges, and accurately identify the underlying network structure (35). Epskamp and Fried (34) study reported a detailed information on the estimation of such regularized biased correlation networks, and how to estimate such models in R.

For the network with 15 nodes, 105 parameters [15 × (15-1)/2] need to be estimated (34). According to at least 3–5 individuals per parameter, the sample size in this study is sufficient for conducting network analysis (N = 6,900). In the network, 15 indicators were depicted as nodes, while the correlations between symptoms were described as edges. The mgm package was used to assess the predictability of each node. A node with a high value of predictability indicated that it is explained by its neighboring nodes (36). Additionally, edges can be positive (green lines) or negative (red lines) and stronger connections were represented by thicker and more saturated edges.

Centrality and bridge centrality estimation

Three indices of centrality were calculated to assess the importance of each node in the network via the centrality Plot function in the graph package (37) (1). The overall importance of a symptom in the network is indicated by the strength centrality (38) (2); The closeness centrality indicated that the impact of one symptom rapidly spreads to other symptoms (39) (3), The betweenness centrality indicated a bridge symptom connecting with other symptoms and potential target symptoms for interventions (21). Given that the stability of closeness and betweenness centrality are usually low (40), the standardized strength centrality (z scores) was mainly reported in this study, and the results of closeness and betweenness centrality were presented in the Supplementary material.

The network tools R package was used to calculate bridge centrality statistics, including bridge strength, bridge betweenness, and bridge closeness. Similarly, only strength bridge centrality was mainly reported and the top 20% scoring nodes were selected as predicted bridge nodes based on the bridge strength values of the network (41).

Network accuracy and stability estimation

The accuracy and stability of the network were calculated using bootstrapping methods in the 'bootnet' package (34). First, the 95% confidence intervals (CIs) of edge-weights accuracy were computed *via* bootstrapping procedures (bootstrapped samples = 1,000). Secondly, the subset program (subsetting bootstrap; i.e., removing a certain percentage of the participants and re-estimating the network) was used to test the stability of the node centrality estimates. The centrality estimate was considered stable if the centrality order of the network constructed after removing many samples was the same as the centrality order of the original network, the centrality order of the original network was the same as that of the original network. The stability of the centrality indices was then summarized using CS-coefficients (correlation stability). The CS-coefficient should be ideally above 0.5 but at least above 0.25 (42).

Network comparison test

The comparison of networks between grandparenting and non-grandparenting was calculated using a permutation-based test

with the 'Network Comparison Test' package (43), which tests differences between two networks based on global strength, network structure, and edge strength. The thresholds to the results of the two networks comparison were adjusted by applying False Discovery Rate (FDR) correction. In addition, centrality estimates were computed using the "test centrality" command, which statistically assesses the centrality of symptoms across the two networks. The magnitude of the node difference was compared using standardized data (z-scores) and evaluated using the effect size (Cohen's d). Small, medium and high effects are represented by Cohen's d values of 0.2, 0.4 and 0.8, respectively (44).

Results

Participant characteristics

The valid sample size was 6,900 including 3,360 grandparenting (48.70%) and 3,540 non-grandparenting (51.30%), 3,309 males (48.00%) and 3,591 females (52.00%), with the mean age of (63.31 ± 7.07) years and (6.64 ± 3.81) years of education. 1,192 participants did not receive education, 3,024 participants received 1–6 years of education and 2,681 participants received 7 or more years of education; 5,214 participants lived with a spouse (75.57%) and 1,686 participants lived without a spouse (24.43%); 1876 participants were urban residence (27.32%) while 4,991 participants were rural residence (72.68%). Meanwhile, 448 participants had no significant depressive symptoms (6.50%, the score of <10 on the CESD-10), 3,524 participants reported the presence of significant depressive symptoms (51.07%, with a score of ≥10 on the CESD-10). Of these, 2,928 participants were depressed (42.43%, with a score of ≥20 on the CESD-10). 968 paticipants with illiterats showed cognitive impairment (81.21%). 2,205 participants (72.92%) with 1–6 years and 2,360 participants (88.03%) with seven or more years of education exhibited cognition decline, see Appendix 1 for details.

Moreover, Table 1 showed the basic characteristics of the grandparenting and non-grandparenting samples. No significant difference in age, education years and gender between the two groups. The middle-aged and older adults in the grandparenting group had significantly higher levels of cold cognitive function and lower levels of depression than those in the non-grandparenting group. Moreover, scores of five cold cognitive functions (orientation, immediate memory, attention and calculation, recall, language ability) of the grandparenting group were all significantly higher than that of the non-grandparenting group. The grandparenting group also scored significantly lower on all depressive symptoms than the non-grandparenting group. The mean scores, standard deviations, predictability and abbreviation for each node of the MMSE and CESD-10 were presented in Table 2.

Network estimation for total samples

Network structure

The network structure of cold cognition and depression in middle-aged and older adults was depicted in Figure 1. The ring-shaped pie charts of the network were used to indicate the predictability of nodes, i.e., the mean predictability was 0.35 (range from 0.05 to 0.72, Table 2). Within the cold cognition community, node "memory" had the most directly positive connection with node "language ability," followed by the positive connection between nodes "memory" and "recall." Moreover, "memory," "recall" and "language ability" were more closely linked to each other in the cold cognitive function cluster. Among the depressive symptom community, node "unhappy" had the most directly positive with node "hopeless," followed by the positive connection between nodes "lonely" and "cannot continue." Furthermore, "upset," "mind distraction," "depressed mood" and "exhaust" were more closely linked to each other, followed by the degree of the closeness among "fear," "lonely" and "cannot continue." Additionally, there were many associations among the items across the communities. For example, node "hopeless" was most strongly negatively associated with node "attention," followed by connections between nodes "attention," "exhaust," and "cannot continue." Simultaneously, not all nodes in the two sub-networks of cold cognition and depression were directly connected, e.g., nodes "lonely" and "depressed mood" were not significantly directly connected to the cluster of cold cognition nodes.

Centrality and bridge centrality

The centrality and bridge strength of each node among middle-aged and older adults were presented in Figure 2 (results of other centrality indicators and the estimation of node strength difference are

TABLE 1 Sample characteristics.

Variables	Total (n = 6,900)	Grandparenting (n = 3,360)	Non-grandparenting (n = 3,540)	χ^2/t (GP *vs* NGP)	p
Gender, n (%)	/	/	/	0.44[a]	0.83
Male	3,309 (48.00%)	1,607 (47.82%)	1702 (48.08%)	/	/
Female	3,591 (52.00%)	1753 (52.18%)	1838 (51.92%)	/	/
Age, mean (SD)	63.31 (7.07)	63.46 (6.42)	63.17 (7.63)	1.68[b]	0.09
Education years, mean (SD)	6.64 (3.81)	6.63 (3.69)	6.65 (3.91)	-0.25[b]	0.80
Cognition function, mean (SD)	14.16 (6.71)	15.21 (6.73)	13.17 (6.53)	12.73 [b]	<0.001
Depression, mean (SD)	19.19 (6.51)	17.71 (5.63)	20.60 (6.9)	−19.03 [b]	<0.001

Total, total sample; GP, Grandparenting sample; NGP, Non-grandparenting sample; a, the test statistic from the Chi-Squared test; b, the test statistic from the independent samples t-test.

TABLE 2 Each node of the MMSE and CESD-10 in total, grandparenting and non-grandparenting sample.

Nodes	Abbreviation	*M* (SD)			Pre		
		Total	GP	NGP	Total	GP	NGP
Cognitive functions (The MMSE)							
Orientation	Orientation	6.12 (2.65)	6.13 (2.69)	5.77 (2.55)	0.05	0.03	0.08
Memory	Memory	1.25 (1.34)	1.45 (1.37)	1.16 (1.31)	0.72	0.74	0.69
Attention	Attention	2.26 (2.30)	2.47 (1.96)	2.12 (1.96)	0.10	0.07	0.12
Recall	Recall	2.02 (1.04)	1.22 (1.29)	0.97 (1.22)	0.61	0.62	0.58
Language ability	Language ability	3.67 (3.04)	3.93 (3.07)	3.16 (2.73)	0.72	0.75	0.68
Depressive symptoms (CESD-10)							
I was bothered by things that usually do not bother me.	Upset	1.96 (1.09)	1.79 (1.00)	2.16 (1.13)	0.38	0.31	0.41
I had trouble keeping my mind on what I was doing.	Mind distraction	1.97 (1.08)	1.85 (1.01)	2.13 (1.12)	0.35	0.30	0.37
I felt depressed.	Depressed mood	1.96 (1.08)	1.79 (0.98)	2.14 (1.37)	0.48	0.44	0.49
I felt that everything I did was an effort.	Exhaust	2.03 (1.15)	1.87 (1.07)	2.20 (1.19)	0.38	0.32	0.41
I felt hopeful about the future.	Hopeless	2.35 (1.23)	2.20 (1.18)	2.38 (1.22)	0.16	0.18	0.14
I felt fearful.	Fear	1.42 (0.84)	1.29 (0.67)	1.51 (0.93)	0.24	0.17	0.27
My sleep was restless.	Sleeplessness	2.18 (1.22)	2.07 (1.18)	2.35 (1.24)	0.18	0.13	0.21
I was happy.	Unhappy	2.09 (1.18)	1.97 (1.14)	2.22 (1.20)	0.25	0.22	0.27
I felt lonely.	Lonely	1.69 (1.05)	1.50 (0.90)	1.86 (1.14)	0.32	0.25	0.34
I could not "get going".	Cannot continue	1.49 (0.92)	1.34 (0.76)	1.60 (1.01)	0.35	0.28	0.38

M, mean; SD, Standard deviation; Pre, Predictability; Total, total sample; GP, Grandparenting sample; NGP, Non-grandparenting sample.

in Appendix S2). Node "language ability" had the highest strength. Nodes "depressed mood," "memory," and "upset" were also statistically stronger than most other nodes in the network. The bridge strength in nodes "attention," "language ability" and "hopeless" were stronger than most other nodes.

Network accuracy and stability

The edge stability estimation showed moderate stability of the estimated networks: although there were considerable overlaps among the 95% CIs of edge weights, nonoverlapped CIs also existed (Appendix S3) and estimation of edge weight difference indicated edges of higher stability were significantly different with other edges in the network (Appendix S4). Meanwhile, stability estimates of the centrality index showed that the centrality strength stability coefficient (CS-coefficients) was 0.750 (Appendix S5).

Cold cognition-depression networks in grandparenting and non-grandparenting

Network structure

The network structure of cold cognition and depression among middle-aged and older adults with and without grandparenting was depicted in Figure 3. Although the overall structure is similar, there were significant differences in the pattern of nodes' connections and the strength of the edges between the two networks. Additionally, the ring-shaped pie charts of the grandparenting and non-grandparenting networks were used to indicate the predictability of nodes, i.e., the mean predictability was 0.32 (range from 0.03 to 0.75) and 0.36 (range from 0.08 to 0.69), respectively (Table 2).

Centrality and bridge centrality

The centrality and bridge strength of each node in grandparenting and non-grandparenting networks were shown in Figure 4 (results of other centrality indicators and the estimation of node strength difference were presented in Appendix S6). Node "language ability" had the highest strength, while nodes "depressed mood," "memory," and "upset" were also statistically stronger than most other nodes in the grandparenting network. In the non-grandparenting network, the strength of node "depressed mood" was highest, followed by nodes "language ability," "memory," and "upset." In addition, nodes "attention," "hopeless" and "language ability" were stronger than most other nodes for the bridge strength of the two networks, which is consistent with the bridge nodes of the cold cognition and depression network in the total sample.

Network accuracy and stability

The edge stability estimation showed moderate stability of the grandparenting and non-grandparenting networks (Appendix S7) and the estimation of edge weight difference showed that edges of

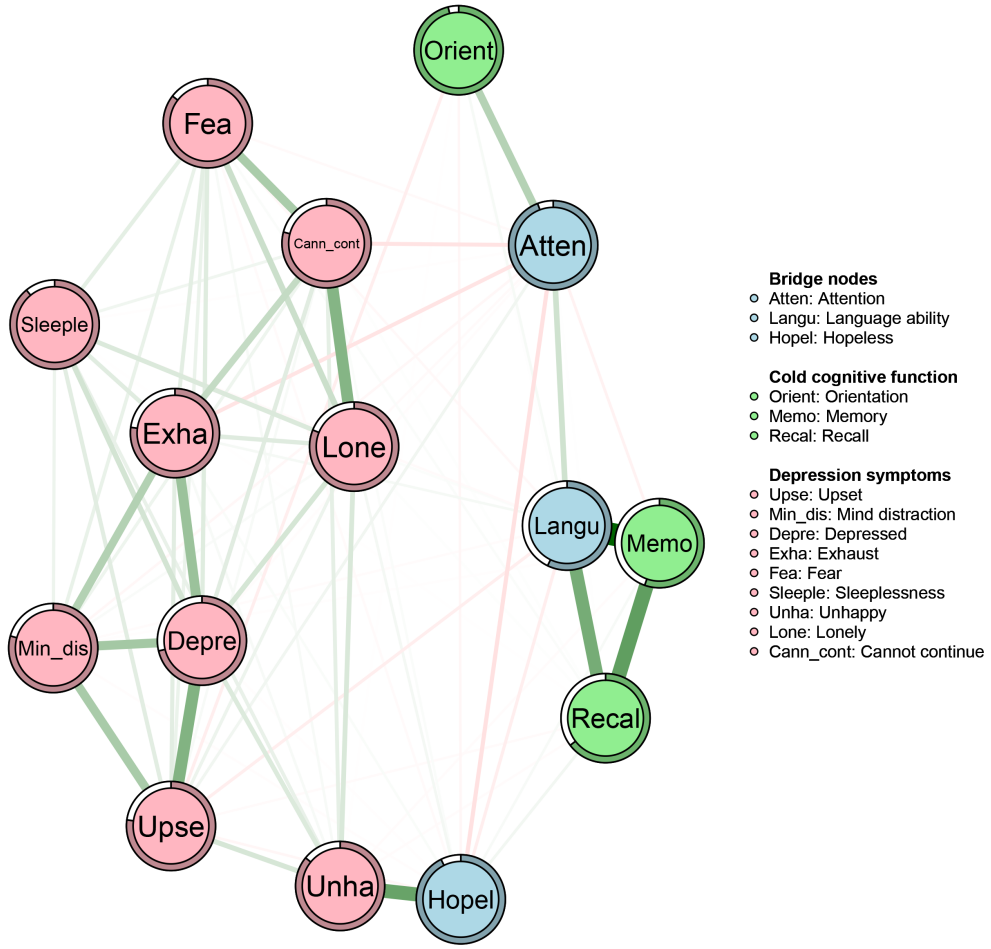


FIGURE 1
Networks of cold cognition and depressive symptoms in middle-aged and elder population. Nodes represent cold cognition and depressive symptoms and edges represent partial correlations between symptoms. Edge thickness and darkness indicate the association strength (minimum and maximum edge values were set to be equal across networks), and edge color indicates the correlation valence (green = positive; red = negative). Bridge nodes indicated the connection of cold cognition and depressive symptoms. Orient, Orientation; Memo, Memory; Atten, Attention; Recal, Recall; Langu, Language ability; Upse, Upset; Min_dis, Mind distraction; Depre, Depressed mood; Exha, Exhaust; Hopel, Hopeless; Fea, Fear; Sleeple, Sleeplessness; Unha, Unhappy; Lone, Lonely; Cann_cont, Cannot continue.

higher stability of these two networks were significantly different from other edges (Appendix S8). Meanwhile, stability estimates of the centrality index showed that the centrality strength stability coefficients (CS-coefficients) were 0.75 in the two networks (Appendix S9).

Network comparison

The results of the network comparison showed that the grandparenting and non-grandparenting networks differed significantly in overall structure ($M = 0.09$, $p = 0.02$) and connectivity ($S = 0.61$, $p < 0.01$). The non-grandparenting network had higher global connectivity than the grandparenting network (6.03 vs. 5.41). The comparison of mean node strength centrality was presented in Table 3. The nodes in the non-grandparenting network had significantly higher centrality indices than nodes in other networks on "orientation," "attention," "recall," "upset," "exhaust," "sleeplessness," "unhappy," "lonely" and "cannot continue" with Cohen's d values above 0.8 (Table 3).

Discussion

The present study used network analysis to construct the network of cold cognition and depression in middle-aged and elder adults. The key findings are that (1): the cold cognitive cluster and depressive symptoms cluster are relatively independent in the middle-aged and elder adults (2); language ability and depressed mood are the most central nodes in the cold cognitive cluster and depressive symptoms cluster, respectively, as well as in the cold cognition-depression network; while attention, language ability, and hopeless are the top-three key bridge nodes connecting cold cognition and depressive symptoms in the network (3); There are significant effects of grandparenting on the global structure and connectivity of the network, specifically, the connectivity of the cold cognition-depression network is significantly stronger in the non-grandparenting than that in the grandparenting; the non-grandparenting network nodes have higher centrality indices on orientation, attention, recall, upset, exhaust, sleeplessness, unhappy and lonely.

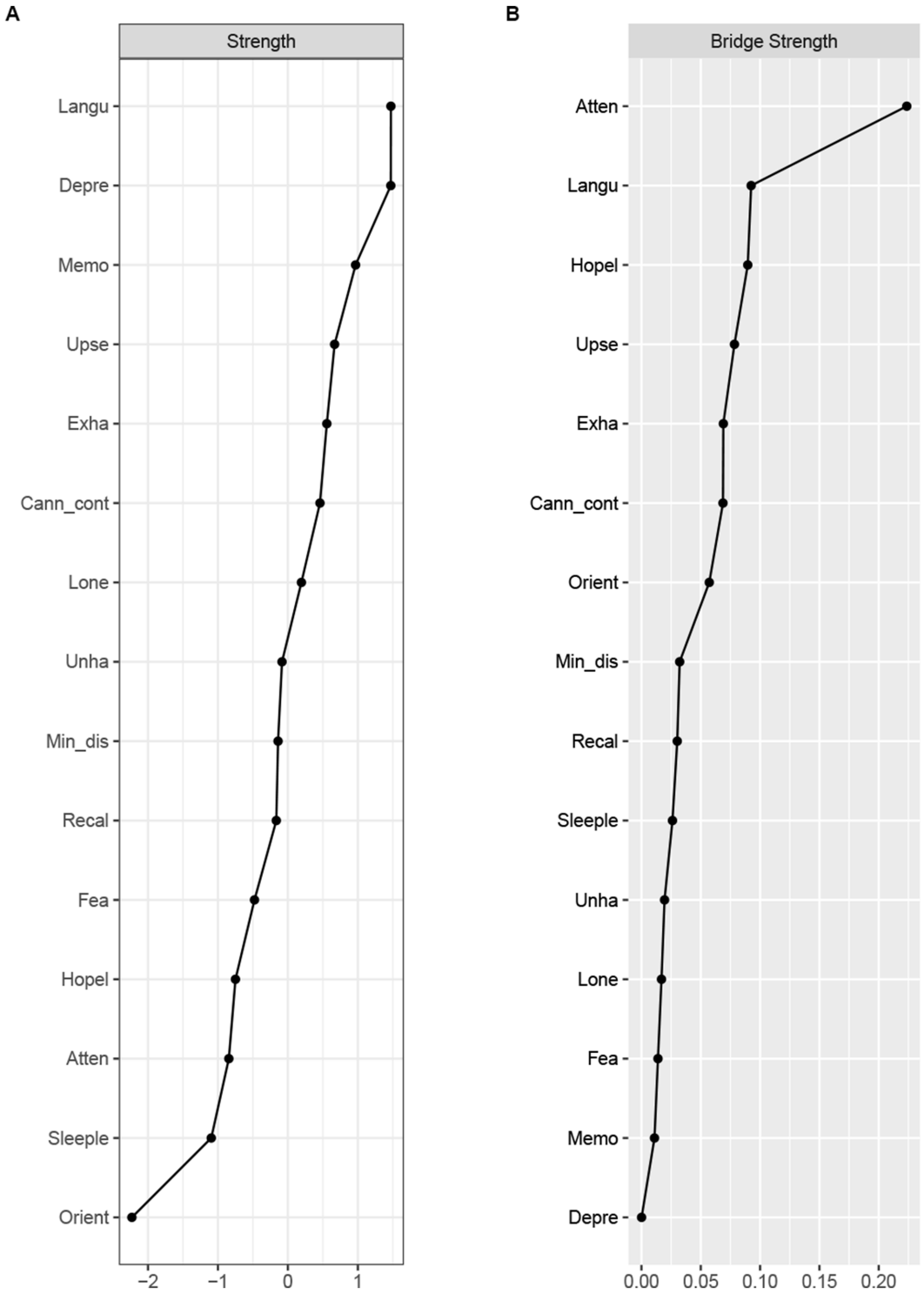


FIGURE 2
Node strength **(A)** and bridge strength **(B)** centrality estimates for the cold cognition and depressive symptoms network in middle-aged and elder population. Standardized z-scores are plotted for ease of interpretation. Higher scores represent higher centrality estimates (i.e., the symptom has greater influence in the network). Orient, Orientation; Memo, Memory; Atten, Attention; Recal, Recall; Langu, Language ability; Upse, Upset; Min_dis, Mind distraction; Depre, Depressed mood; Exha, Exhaust; Hopel, Hopeless; Fea, Fear; Sleeple, Sleeplessness; Unha, Unhappy; Lone, Lonely; Cann_cont, Cannot continue.

Brain organs gradually degenerate with aging, which leads to the decline of cognitive function, especially cold cognitive functions such as attention, working memory, and language ability. In this study, the language ability, assessed by the MMSE, is a comprehensive cold cognitive ability. Depressed mood, as a core symptom of depression (45), covers a series of negative emotional experiences, such as sadness and low mood

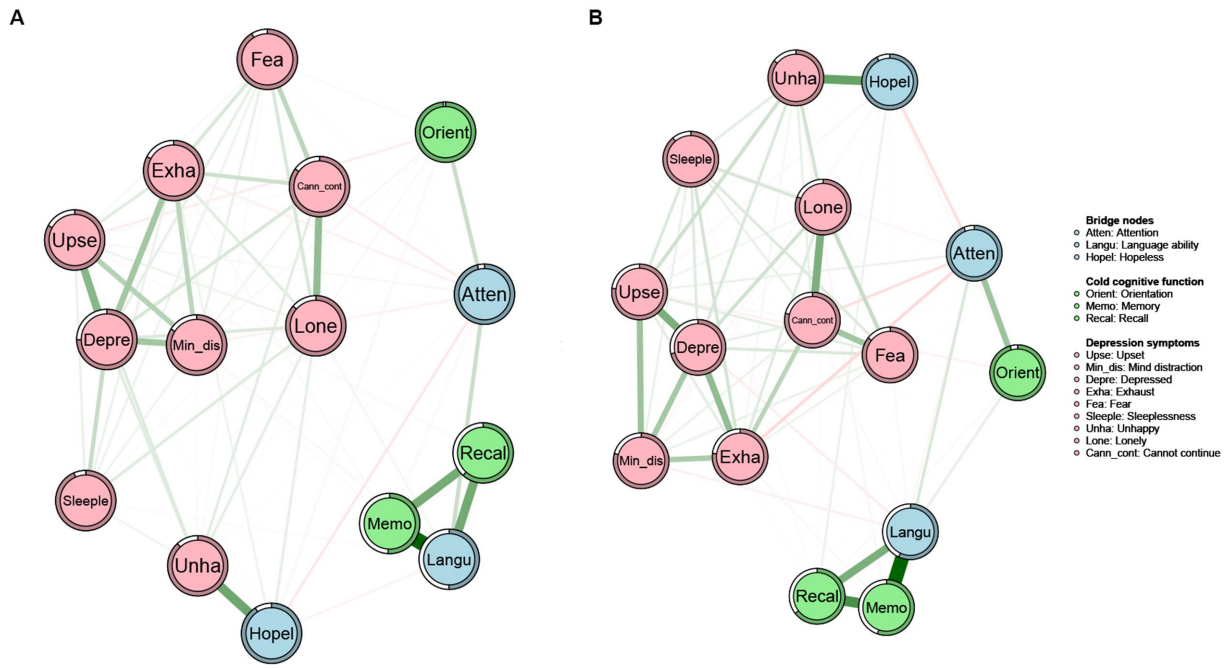


FIGURE 3
Networks of cold cognition and depressive symptoms in the grandparenting **(A)** and non-grandparenting **(B)**. Nodes represent cold cognition and depressive symptoms and edges represent partial correlations between symptoms. Edge thickness and darkness indicate the association strength (minimum and maximum edge values were set to be equal across networks), and edge color indicates the correlation valence (green = positive; red = negative). Bridge nodes indicated the connection of cold cognition and depressive symptoms. Orient, Orientation; Memo, Memory; Atten, Attention; Recal, Recall; Langu, Language ability; Upse, Upset; Min_dis, Mind distraction; Depre, Depressed mood; Exha, Exhaust; Hopel, Hopeless; Fea, Fear; Sleeple, Sleeplessness; Unha, Unhappy; Lone, Lonely; Cann_cont, Cannot continue.

(46). Due to the gradual decline of physical functions (including brain functions) and faded social roles, middle-aged and elder persons are prone to develop a depressed mood, even leading to depressive episodes (47). In this study, language ability is the core node in both the cold cognitive clusters and the cold cognition-depression network, while the cold cognitive ability shows an overall decline in middle-aged and elder population. Consistent with previous reports (36, 48), the depressed mood is another core symptom in both the depressive symptom cluster and cold cognition-depression network in middle-aged and older adults. In consideration of the vital roles of the highest centrality nodes in a network (48, 49), the language ability decline and depressed mood are the most likely candidates for triggering and maintaining the decline in cold cognition and depressive symptoms. According to the network theory of mental disorder (18), targeting central symptoms with biological or psychosocial interventions, rather than peripheral symptoms, can be highly effective. In present study, interventions for the two core symptoms (depressed mood and language skills) would alleviate depressed mood and slow down the decline of language skills in middle-aged and older adults, as well as facilitate the improvement of peripheral symptoms, such as decreased attention and hopelessness, which in turn would have a greater impact on the cold cognitive-depression network (20). However, we also found the lack of a significantly direct connection between depressed mood and cold cognition node clusters, which not only supports the hot and cold cognition model (50), but also hints that reducing core symptoms, such as depressed mood or enhancing language ability, alone only improves the internal symptom network of depression or cold cognition, respectively.

According to the network theory of psychiatric disorders (18), finding and targeting key bridge-connecting symptoms (nodes) is needed to treat with cold cognitive-depressive co-morbidities in middle-aged and older adults. In the present study, attention, language ability and hopelessness are the top-three key bridge nodes connecting cold cognition to depressive symptoms in the network, suggesting that bridge nodes contribute to comorbidity of cold cognitive dysfunction and depression. In clinically, targeting the three bridge nodes of attention, language skills, and hopelessness for interventions may be effective for both cold cognitive dysfunction and depressive symptoms (51). The hopelessness theory of depression (52) proposes that adverse life events are prone to induce despair, helplessness, and uselessness in individuals, resulting in depressed mood and thoughts. In this study, hopelessness is a stronger symptom linking cold cognition and depressive symptoms. In middle-aged and elder individuals, cold cognitions (such as working memory and attention) are markedly declined, and their social roles are gradually becoming less important until retirement, which may be a series of adverse stressors and lead to senses of uselessness and hopelessness, and in turn hopelessness trigger the most core symptoms of depression - depressed mood and eventually develop into depressive disorder. Thus, hopelessness in middle-aged and older adults is not only a symptom of depression but may also be a risk factor for developing into depressive disorder. The findings of this study combined with previous studies may have utility in tailoring and testing interventions to reduce the co-occurrence of cold cognitive dysfunctions and depression in the mild-aged and elder population. For example, it is recommended to maintain healthy lifestyle to slow down physiological aging (including cold cognition), while communication with good friends and family members is thought to alleviate negative mood symptoms (53).

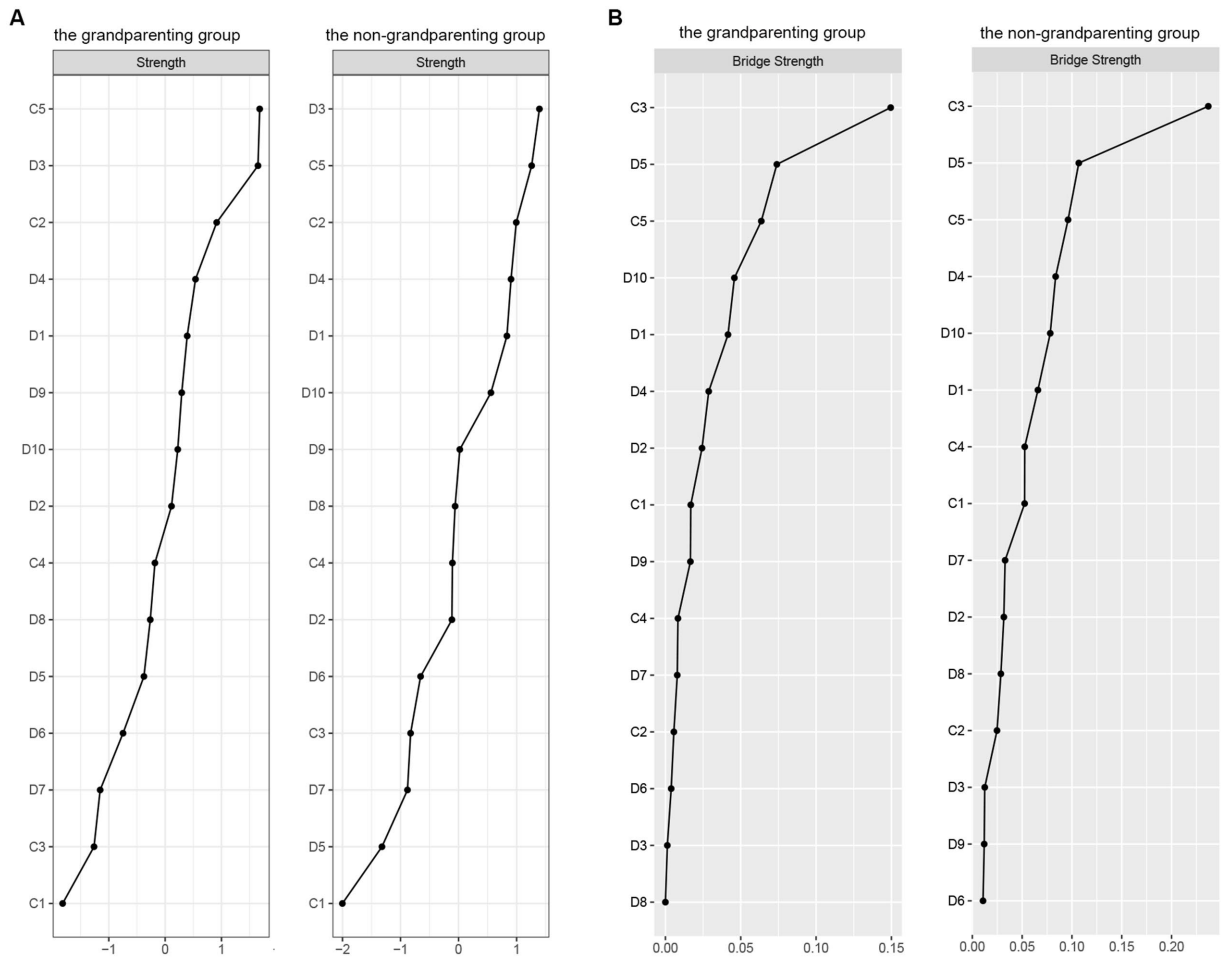


FIGURE 4
Node strength **(A)** and bridge strength **(B)** centrality estimates for the cold cognition and depressive symptoms network in the grandparenting and non-grandparenting. Standardized z-scores are plotted for ease of interpretation. Higher scores represent higher centrality estimates (i.e., the symptom has greater influence in the network). Orient, Orientation; Memo, Memory; Atten, Attention; Recal, Recall; Langu, Language ability; Upse, Upset; Min_dis, Mind distraction; Depre, Depressed mood; Exha, Exhaust; Hopel, Hopeless; Fea, Fear; Sleeple, Sleeplessness; Unha, Unhappy; Lone, Lonely; Cann_cont, Cannot continue.

In China, middle-aged and older adults often regard parenting their grandchildren as a responsibility and obligation. Previous studies suggested that intergenerational parenting may be a protective factor in cognitive impairment and depression (27, 28). This study also showed that the global connectivity of the cold cognition-depression network in the non-grandparenting is stronger than that in the grandparenting. Also, grandparenting failed to change the effect of cold cognition on depressive symptoms but had a moderating effect on the strength of the connection in the cold cognition – depressive symptom network. In addition, non-grandparenting group is more strongly connected to this network, which suggested that it is at higher risk for depression as cold cognitive functioning declines in mild-aged and elder adults without grandparenting.

Borsboom et al. (20) believed that high centrality symptoms increasingly activate other symptoms in the network and improve the development of psychiatric disorders. In this study, three-fifths of centrality nodes in the cold cognitive-depressive symptom network were much higher in the non-grandparenting group than in the grandparenting group, suggesting a protective effect of grandparenting on comorbidity of cold cognitive dysfunction and depression. Additionally, non-emotional cold cognitive impairment contributes to the development of hot cognition, and subsequently lead to psychiatric symptoms and further worsening cold cognitive impairment (12). Specifically, cold cognition decline such as attention and recall are prone to activate other emotional and somatic symptoms in the network among middle-aged and older adults without grandparenting, which would promote the development of co-occurrence in cold cognitive disorder and depression.

Finally, the present study also has some limitations: (1) although the effect of cold cognition on depression has received increasing attention from clinical studies, the role of hot cognition on depression should not be neglected. (2) The present study explored the relationship between cold cognition and depressive symptoms from a perspective network analysis, which has some clinical implications for improving cold cognition impairment and depression in the middle-aged and older adults. However, future studies should analyze their dynamic relationships based on longitudinal data to guide clinical practice with more robust and rigorous findings; (3) although the MMSE is a broad measure of cognitive ability and cold cognition is a complex ability, more precise and comprehensive neurofunctional tests are needed in the future

TABLE 3 Comparison of mean node strength centrality between the grandparenting and non-grandparenting.

	M (SD)			
Nodes	Grandparenting	Non-grandparenting	*p*	Cohen's d
Orientation	0.225 (0.053)	0.362 (0.031)	0.009	−3.155
Memory	0.989 (0.032)	1.020 (0.037)	0.336	/
Attention	0.392 (0.043)	0.545 (0.051)	0.009	−3.243
Recall	0.721 (0.030)	0.802 (0.038)	0.019	−2.366
Language ability	1.120 (0.035)	1.070 (0.035)	0.138	/
Upset	0.808 (0.043)	0.956 (0.043)	0.009	−3.441
Mind distraction	0.760 (0.038)	0.823 (0.031)	0.168	/
Depressed mood	1.200 (0.038)	1.150 (0.031)	0.267	/
Exhaust	0.893 (0.041)	0.982 (0.036)	0.039	−2.306
Hopeless	0.563 (0.050)	0.510 (0.049)	0.475	/
Fear	0.579 (0.038)	0.707 (0.040)	0.019	−0.579
Sleeplessness	0.470 (0.035)	0.623 (0.030)	0.009	−4.693
Unhappy	0.707 (0.036)	0.819 (0.031)	0.009	−3.334
Lonely	0.813 (0.043)	0.854 (0.034)	0.445	/
Cannot continue	0.841 (0.038)	0.960 (0.034)	0.009	−3.300

to assess cold cognition and depressive network structure in middle-aged and older adults; (4) excepting for grandparenting, future research also needs to study the effects of other factors, such as socioeconomic status, physical and mental health status, on the association between cold cognitive and depressive symptoms in middle-aged and older adults.

In conclusion, there are complex interactions between cold cognition and depression in middle-aged and older adults. Grandparenting has effect on the cold cognitive-depression networks. Systemic multi-level interventions targeting central nodes and bridge nodes may be effective in alleviating the co-occurrence of cold cognitive cline and depressive symptoms in the mild-aged and older adult population.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

YZ and DY: conception and design. DY, JW, and SL: provision of study materials. DY, JW, RZ, and XZ: collection and assembly of data. DY and YZ: data analysis, interpretation, and manuscript writing. All authors contributed to the article and approved the submitted version.

Funding

This work was supported by Hunan Provincial Natural Science Foundation China (No. 2022JJ70146), the Hunan Provincial Innovation Foundation for Postgraduate (No. CX20230299) and the Fundamental Research Funds for the Central Universities of Central South University (No. 2023ZZTS0224).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1204977/full#supplementary-material

References

1. Naja S, Din Makhlouf MME, Chehab MAH. An ageing world of the 21st century: a literature review. *Int J Community Med Public Health*. (2017) 4:4363. doi: 10.18203/2394-6040.ijcmph20175306

2. Jing Z, Wang Y, Ding L, Tang X, Feng Y, Zhou C. Effect of social integration on the establishment of health records among elderly migrants in China: a nationwide cross-sectional study. *BMJ Open*. (2019) 9:e034255. doi: 10.1136/bmjopen-2019-034255

3. Fang EF, Scheibye-Knudsen M, Jahn HJ, Li J, Ling L, Guo H, et al. A research agenda for aging in China in the 21st century. *Ageing Res Rev*. (2015) 24:197–205. doi: 10.1016/j.arr.2015.08.003

4. Mac Aulay RK, Calamia MR, Cohen AS, Daigle K, Foil H, Brouillette R, et al. Understanding heterogeneity in older adults: latent growth curve modeling of cognitive functioning. *J Clin Exp Neuropsychol*. (2018) 40:292–302. doi: 10.1080/13803395.2017.1342772

5. Sun Z, Wang Z, Xu L, Lv X, Li Q, Wang H, et al. Characteristics of cognitive deficit in amnestic mild cognitive impairment with subthreshold depression. *J Geriatr Psychiatry Neurol*. (2019) 32:344–53. doi: 10.1177/0891988719865943

6. Roiser JP, Sahakian BJ. Hot and cold cognition in depression. *CNS Spectr*. (2013) 18:139–49. doi: 10.1017/S1092852913000072

7. Stern Y. The concept of cognitive reserve: a catalyst for research. *J Clin Exp Neuropsychol*. (2003) 25:589–93. doi: 10.1076/jcen.25.5.589.14571

8. Hugo J, Ganguli M. Dementia and cognitive impairment: epidemiology, diagnosis, and treatment. *Clin Geriatr Med*. (2014) 30:421–42. doi: 10.1016/j.cger.2014.04.001

9. Mirza SS, Ikram MA, Bos D, Mihaescu R, Hofman A, Tiemeier H. Mild cognitive impairment and risk of depression and anxiety: a population-based study. *Alzheimers Dement*. (2017) 13:130–9. doi: 10.1016/j.jalz.2016.06.2361

10. Bora E, Harrison BJ, Yücel M, Pantelis C. Cognitive impairment in euthymic major depressive disorder: a meta-analysis. *Psychol Med*. (2013) 43:2017–26. doi: 10.1017/S0033291712002085

11. Rock PL, Roiser JP, Riedel WJ, Blackwell AD. Cognitive impairment in depression: a systematic review and meta-analysis. *Psychol Med*. (2014) 44:2029–40. doi: 10.1017/S0033291713002535

12. Ahern E, Semkovska M. Cognitive functioning in the first-episode of major depressive disorder: a systematic review and meta-analysis. *Neuropsychology*. (2017) 31:52–72. doi: 10.1037/neu0000319

13. Allott K, Fisher CA, Amminger GP, Goodall J, Hetrick S. Characterizing neurocognitive impairment in young people with major depression: state, trait, or scar? *Brain Behav*. (2016) 6:e00527. doi: 10.1002/brb3.527

14. Groves SJ, Douglas KM, Porter RJ. A systematic review of cognitive predictors of treatment outcome in major depression. *Front Psych*. (2018) 9:382. doi: 10.3389/fpsyt.2018.00382

15. Bortolato B, Miskowiak KW, Köhler CA, Maes M, Fernandes BS, Berk M, et al. Cognitive remission: a novel objective for the treatment of major depression? *BMC Med*. (2016) 14:9. doi: 10.1186/s12916-016-0560-3

16. Buist-Bouwman MA, Ormel J, de Graaf R, de Jonge P, van Sonderen E, Alonso J, et al. ESEMeD/MHEDEA 2000 investigators. Mediators of the association between depression and role functioning. *Acta Psychiatr Scand*. (2008) 118:451–8. doi: 10.1111/j.1600-0447.2008.01285.x

17. Fried EI, Nesse RM. The impact of individual depressive symptoms on impairment of psychosocial functioning. *PLoS One*. (2014) 9:e90311. doi: 10.1371/journal.pone.0090311

18. Borsboom D. A network theory of mental disorders. *World Psychiatry*. (2017) 16:5–13. doi: 10.1002/wps.20375

19. Fisher ML, Loukola A, Kaprio J, Turner JR. Role of the Neuregulin signaling pathway in nicotine dependence and co-morbid disorders. *Int Rev Neurobiol*. (2015) 124:113–31. doi: 10.1016/bs.irn.2015.07.006

20. Borsboom D, Cramer AOJ. Network analysis: an integrative approach to the structure of psychopathology. *Annu Rev Clin Psychol*. (2013) 9:91–121. doi: 10.1146/annurev-clinpsy-050212-185608

21. McNally RJ. Can network analysis transform psychopathology? *Behav Res Ther*. (2016) 86:95–104. doi: 10.1016/j.brat.2016.06.006

22. Bryant RA, Creamer M, O'Donnell M, Forbes D, McFarlane AC, Silove D, et al. Acute and chronic posttraumatic stress symptoms in the emergence of posttraumatic stress disorder: a network analysis. *JAMA Psychiat*. (2017) 74:135. doi: 10.1001/jamapsychiatry.2016.3470

23. Briganti G, Scutari M, Linkowski P. Network structures of symptoms from the Zung depression scale. *Psychol Rep*. (2021) 124:1897–911. doi: 10.1177/0033294120942116

24. Epskamp S, Kruis J, Marsman M. Estimating psychopathological networks: be careful what you wish for. *PLoS One*. (2017) 12:e0179891. doi: 10.1371/journal.pone.0179891

25. Sneed RS, Schulz R. Grandparent caregiving, race, and cognitive functioning in a population-based sample of older adults. *J Aging Health*. (2019) 31:415–38. doi: 10.1177/0898264317733362

26. Muller Z, Litwin H. Grandparenting and psychological well-being: how important is grandparent role centrality? *Eur J Ageing*. (2011) 8:109–18. doi: 10.1007/s10433-011-0185-5

27. Tsai F-J. The maintaining and improving effect of grandchild care provision on elders' mental health-evidence from longitudinal study in Taiwan. *Arch Gerontol Geriatr*. (2016) 64:59–65. doi: 10.1016/j.archger.2016.01.009

28. Arpino B, Bordone V. Does Grandparenting pay off? The effect of child care on grandparents' cognitive functioning. *J Marriage Fam*. (2014) 76:337–51. doi: 10.1111/jomf.12096

29. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. (1975) 12:189–98. doi: 10.1016/0022-3956(75)90026-6

30. Li H, Jia J, Yang Z. Mini-mental state examination in elderly Chinese: a population-based normative study. *J Alzheimers Dis*. (2016) 53:487–96. doi: 10.3233/JAD-160119

31. Cheng HG, Chen S, McBride O, Phillips MR. Prospective relationship of depressive symptoms, drinking, and tobacco smoking among middle-aged and elderly community-dwelling adults: results from the China health and retirement longitudinal study (CHARLS). *J Affect Disord*. (2016) 195:136–43. doi: 10.1016/j.jad.2016.02.023

32. Boey KW. Cross-validation of a short form of the CES-D in Chinese elderly. *Int J Geriatr Psychiatry*. (1999) 14:608–17. doi: 10.1002/(SICI)1099-1166(199908)14:8<608::AID-GPS991>3.0.CO;2-Z

33. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med*. (1994) 10:77–84. doi: 10.1016/S0749-3797(18)30622-6

34. Epskamp S, Borsboom D, Fried EI. Estimating psychological networks and their accuracy: a tutorial paper. *Behav Res Methods*. (2018) 50:195–212. doi: 10.3758/s13428-017-0862-1

35. van Borkulo CD, Borsboom D, Epskamp S, Blanken TF, Boschloo L, Schoevers RA, et al. A new method for constructing networks from binary data. *Sci Rep*. (2014) 4:5918. doi: 10.1038/srep05918

36. Liu R, Chen X, Qi H, Feng Y, Su Z, Cheung T, et al. Network analysis of depressive and anxiety symptoms in adolescents during and after the COVID-19 outbreak peak. *J Affect Disord*. (2022) 301:463–71. doi: 10.1016/j.jad.2021.12.137

37. Opsahl T, Agneessens F, Skvoretz J. Node centrality in weighted networks: generalizing degree and shortest paths. *Soc Netw*. (2010) 32:245–51. doi: 10.1016/j.socnet.2010.03.006

38. McNally RJ, Robinaugh DJ, Wu GWY, Wang L, Deserno MK, Borsboom D. Mental disorders as causal systems: a network approach to posttraumatic stress disorder. *Clin Psychol Sci*. (2015) 3:836–49. doi: 10.1177/2167702614553230

39. Borgatti SP, Mehra A, Brass DJ, Labianca G. Network analysis in the social sciences. *Science*. (2009) 323:892–5. doi: 10.1126/science.1165821

40. Birkeland MS, Greene T, Spiller TR. The network approach to posttraumatic stress disorder: a systematic review. *Eur J Psychotraumatol*. (2020) 11:1700614. doi: 10.1080/20008198.2019.1700614

41. Jones PJ, Ma R, McNally RJ. Bridge centrality: a network approach to understanding comorbidity. *Multivar Behav Res*. (2021) 56:353–67. doi: 10.1080/00273171.2019.1614898

42. Armour C, Fried EI, Deserno MK, Tsai J, Pietrzak RH. A network analysis of DSM-5 posttraumatic stress disorder symptoms and correlates in U.S. military veterans. *J Anxiety Disord*. (2017) 45:49–59. doi: 10.1016/j.janxdis.2016.11.008

43. van Borkulo CD, van Bork R, Boschloo L, Kossakowski JJ, Tio P, Schoevers RA, et al. Comparing network structures on three aspects: a permutation test. *Psychol Methods*. (2022) 2022:476. doi: 10.1037/met0000476

44. Cohen J. Statistical power analysis. *Curr Dir Psychol Sci*. (1992) 1:98–101. doi: 10.1111/1467-8721.ep10768783

45. Beard C, Millner AJ, Forgeard MJC, Fried EI, Hsu KJ, Treadway MT, et al. Network analysis of depression and anxiety symptom relationships in a psychiatric sample. *Psychol Med*. (2016) 46:3359–69. doi: 10.1017/S0033291716002300

46. Danhauer SC, Legault C, Bandos H, Kidwell K, Costantino J, Vaughan L, et al. Positive and negative affect, depression, and cognitive processes in the cognition in the study of tamoxifen and Raloxifene (co-STAR) trial. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn*. (2013) 20:532–52. doi: 10.1080/13825585.2012.747671

47. Alexopoulos GS. Depression in the elderly. *Lancet Lond Engl*. (2005) 365:1961–70. doi: 10.1016/S0140-6736(05)66665-2

48. Hayes AM, Yasinski C, Ben Barnes J, Bockting CLH. Network destabilization and transition in depression: new methods for studying the dynamics of therapeutic change. *Clin Psychol Rev*. (2015) 41:27–39. doi: 10.1016/j.cpr.2015.06.007

49. Levinson CA, Zerwas S, Calebs B, Forbush K, Kordy H, Watson H, et al. The core symptoms of bulimia nervosa, anxiety, and depression: a network analysis. *J Abnorm Psychol*. (2017) 126:340–54. doi: 10.1037/abn0000254

50. Stange JP, Jenkins LM, Hamlat EJ, Bessette KL, DelDonno SR, Kling LR, et al. Disrupted engagement of networks supporting hot and cold cognition in remitted major depressive disorder. *J Affect Disord*. (2018) 227:183–91. doi: 10.1016/j.jad.2017.10.018

51. Kaiser T, Herzog P, Voderholzer U, Brakemeier E-L. Unraveling the comorbidity of depression and anxiety in a large inpatient sample: network analysis to examine bridge symptoms. *Depress Anxiety*. (2021) 38:307–17. doi: 10.1002/da.23136

52. Abramson LY, Metalsky GI, Alloy LB. Hopelessness depression: a theory-based subtype of depression. *Psychol Rev*. (1989) 96:358–72. doi: 10.1037/0033-295X.96.2.358

53. Hammami S, Zarrouk A, Piron C, Almas I, Sakly N, Latteur V. Prevalence and factors associated with frailty in hospitalized older patients. *BMC Geriatr*. (2020) 20:144. doi: 10.1186/s12877-020-01545-4

frontiers | Frontiers in Public Health

TYPE Brief Research Report
PUBLISHED 24 August 2023
DOI 10.3389/fpubh.2023.1217753

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Parul Puri,
George Institute for Global Health, India
Rama Shankar Rath,
All India Institute of Medical Sciences, Gorakhpur, India

*CORRESPONDENCE
Sanghamitra Pati
drsanghamitra12@gmail.com

RECEIVED 05 May 2023
ACCEPTED 27 July 2023
PUBLISHED 24 August 2023

CITATION
Sinha A, Kanungo S, Bhattacharya D, Kaur H and Pati S (2023) Non-communicable disease multimorbidity among tribal older adults in India: evidence from Study on Global AGEing and adult health, 2015.
Front. Public Health 11:1217753.
doi: 10.3389/fpubh.2023.1217753

COPYRIGHT
© 2023 Sinha, Kanungo, Bhattacharya, Kaur and Pati. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Non-communicable disease multimorbidity among tribal older adults in India: evidence from Study on Global AGEing and adult health, 2015

Abhinav Sinha [1], Srikanta Kanungo[1], Debdutta Bhattacharya[1], Harpreet Kaur[2] and Sanghamitra Pati [1]*

[1]ICMR-Regional Medical Research Centre, Bhubaneswar, Odisha, India, [2]Indian Council of Medical Research, New Delhi, India

Introduction: Multimorbidity defined as the simultaneous presence of two or more chronic conditions in an individual is on the rise in low- and middle-income countries such as India. With India aiming to achieve universal health coverage, it is imperative to address the inequalities in accessing healthcare, especially among vulnerable groups such as tribal. Moreover, changing lifestyle has led to the emergence of multimorbidity among tribals in India. We aimed to estimate the prevalence and assess the correlates of multimorbidity among tribal older adults in India.

Methods: We employed nationally representative data from the World Health Organization's Study on Global AGEing and Adult Health conducted in 2015. We included 522 participants aged ≥50 years who reported their caste to be 'Scheduled Tribe' in the survey. A multivariable regression model assessed the association between multimorbidity and various attributes.

Results: Arthritis, cataract, and hypertension were the most common chronic conditions. The overall prevalence of multimorbidity was ~22.61%. We observed a higher likelihood of having multimorbidity among respondents aged ≥80 years [AOR: 4.08 (1.17–14.18)] than the younger age groups, and among the most affluent group [AOR: 2.64 (1.06–6.56)] than the most deprived class.

Conclusion: The prevalence of multimorbidity among tribal older adults is emerging which cannot be overlooked. Health and wellness centers may be a window of opportunity to provide egalitarian and quality preventive and curative services to achieve universal health coverage. Future studies should explore the outcomes of multimorbidity in terms of healthcare utilization, expenditure, and quality of life in this group.

KEYWORDS

multimorbidity, tribal, older adults, India, SAGE

Introduction

The escalating burden of non-communicable diseases (NCDs) vis-à-vis prevailing infectious diseases has led to a rise in multimorbidity among low- and middle-income countries (LMICs) such as India (1). Multimorbidity defined as two or more co-occurring long-term conditions may encompass NCDs, a chronic infectious disease, or any mental health condition (2). The growing burden of multimorbidity in India is evident in our

recent study which estimated its prevalence to be ∼50% among participants aged ≥45 years (3). Multimorbidity is associated with poorer patient-reported outcome measures such as functional ability, psycho-social wellbeing, and health-related quality of life (4–6). Furthermore, the complex care needs in multimorbidity lead to polypharmacy and increased healthcare utilization and expenditure (7–9). Multimorbidity management requires frequent visits to physicians, routine investigations, and long-term use of medicines posing a difficulty in the continuity of care (10).

Social determinants of health are equally relevant for chronic conditions (11). Evidence suggests socioeconomic marginalization increases the health risk of an individual (12). Indigenous people commonly referred to as 'tribal' are one such vulnerable group that faces disparity in healthcare access (13). Tribal people comprise nearly 8.6% of the total Indian population, most of them live in rural areas with subsistence-based economy (14). Tribal people have distinct socio-cultural beliefs and traditions which include a higher use of alcohol and tobacco making them more prone to several NCDs (15). Additionally, changing lifestyle multimorbidity is emerging as an important public health challenge in this community (16). Most of the data on NCDs among the tribal population are either based on evidence from a single tribe or region, with limited nation-wide studies. However, to achieve universal health coverage, it is pertinent to generate national evidence on NCD multimorbidity among tribal that could help in guiding the existing programs and policies to reduce healthcare inequality in this group. Hence, we aimed to estimate the prevalence of multimorbidity and assess its correlates among tribal older adults in India. This study will generate national evidence on the multimorbidity profile among tribal older adults, which could help the base for designing future policies and interventions.

Methods

Overview of data

We employed data from the second round of the World Health Organization's Study on Global AGEing and adult health (SAGE) conducted in 2015. SAGE is a nation-wide survey conducted among a representative sample of older adults aged ≥50 years and a smaller cohort of adults aged 18–49 years. SAGE compiles comprehensive longitudinal data on the health and wellbeing of adults and documents the aging process in six countries: India, China, Russia, Ghana, Mexico, and South Africa. In India, data were collected from six states: Assam, West Bengal, Karnataka, Rajasthan, Uttar Pradesh, and Maharashtra, by adopting a multistage stratified cluster random sampling design to reach the ultimate unit of observation. SAGE utilized community-based face-to-face interviews to collect data through standardized survey instruments. Uniform data collection procedures were followed after training the staff to collect and assimilate the data. The detailed description of methods adopted during the SAGE survey has been documented in the Indian National Report of SAGE, wave-2 (17).

Study participants

A total of 9116 individuals were surveyed during SAGE, wave-2 (India), out of which 721 individuals reported their caste to be 'Scheduled Tribe.' Furthermore, in congruence with our objective, we dropped the data of 199 participants aged <50 years, as SAGE provides a representative sample of respondents aged ≥50 years only, whereas participants <50 are a smaller cohort. Thus, a total of 522 participants aged ≥50 years were included in the analysis.

Outcome variable

The main outcome of interest was multimorbidity (two or more chronic conditions in an individual) generated by a simple sum of all chronic conditions present in an individual, i.e., a chronic disease score. We included a total of ten chronic conditions with nine self-reported chronic conditions: arthritis, stroke, diabetes, chronic lung disease, asthma, depression, hypertension, cataract, and edentulism. Additionally, obesity was calculated by considering weight in kg divided by height in m^2 using a cutoff for WHO's body mass index (BMI) for South Asian adults (25 kg/m^2) (18).

Independent variables

Age was categorized as 50–59 years, 60–69 years, 70–79 years, and ≥80 years. Sex of the participants was reported as male and female. Residence was classified as urban and rural. Education was grouped as "no formal education" and "been to school" on the basis of the question "Have you ever been to school?" Occupation was assessed on the basis of "Have you ever in your life done any type of work (not including housework)?" with the responses as yes or no. Those who responded "yes" were classified as "worked," while those who said "no" were grouped as 'never worked.' Partner status was assessed on the basis of "What is your current marital status?" with currently married and cohabiting grouped as 'have a partner' and never married, separated/divorced, and widowed classified as "no partner." The wealth index was categorized into five quintiles grouped as the most deprived, 2, 3, 4 and the most affluent. Alcohol consumption was classified as yes or no on the basis of the question "Have you ever consumed a drink that contains alcohol?"

Statistical analysis

We presented continuous data such as age in mean and standard deviation. Descriptive statistics such as frequency and proportion were used to report the characteristics of the study population and prevalence. All analyses were done utilizing survey weights to compensate for complex survey designs. In the study, a 95% confidence interval (CI) was reported for all weighted proportions as a measure of uncertainty. Bivariate logistic regression assessed the association between multimorbidity and various socio-demographic characteristics, reported as odds ratio (OR) with 95% CI. A multivariable logistic regression model was

executed to assess the correlates presented as an adjusted odds ratio (AOR) with 95% CI.

Ethical considerations

We analyzed anonymous secondary data obtained from IIPS, Mumbai. We requested the data by filling data request form available at: https://iipsindia.ac.in/content/SAGE-data. The data are available after attaching a valid identity proof and data request form. Data set access/downloads are only granted for legitimate academic research purposes. The original SAGE study was approved by WHO's Ethics Review Committee. In India, ethics clearance was also obtained from the International Institute of Population Sciences, Mumbai, which is the partner organization for conducting this study in India.

Results

The mean age of the participants was observed to be 61.29 ± 8.13 years ranging from 50 to 92 years. Most of the participants (46.17%) were aged between 50 and 59 years. More than half of the respondents were women. In total, 90.8% of the respondents belonged to urban areas (Table 1). Almost two-thirds of the participants had no formal education while nearly one-third of the respondents belonged to the most deprived class.

Arthritis was the most (18.44%) prevalent chronic condition followed by cataract (16.82%) and hypertension (11.80%). The prevalence of obesity was observed to be ∼13.28% (Table 2). The overall prevalence of multimorbidity was observed to be 22.61%. A higher prevalence (49.24%) of multimorbidity was observed among respondents aged ≥80 years. Female respondents had a higher prevalence (23.29%) of multimorbidity than their male counterparts. Urban residents (33.19) and participants belonging to the most affluent group (36.89%) had a higher prevalence of multimorbidity (Table 3).

The bivariate association showed a significant association of multimorbidity with participants aged ≥80 years and the most affluent class. The multivariable regression model suggested a higher likelihood of having multimorbidity among respondents aged ≥80 years [AOR: 4.08 (1.17–14.18)] than the younger age groups. We observed a higher chance of having multimorbidity among the most affluent group [AOR: 2.64 (1.06–6.56)] than the most deprived class (Table 3).

TABLE 1 Socio-demographic characteristics of the study population, Study on Global AGEing and adult health, 2015 (17).

Socio-demographic characteristics	(*N* = 522)	
	n (%)	
Age (years) (*N* = 522)	50–59	241 (46.17)
	60–69	188 (36.02)
	70–79	79 (15.13)
	≥80	14 (2.68)
Sex (*N* = 522)	Male	237 (45.40)
	Female	285 (54.60)
Residence (*N* = 522)	Rural	474 (90.80)
	Urban	48 (9.20)
Education (*N* = 522)	No formal education	325 (62.26)
	Been to school	197 (37.74)
Occupation (*N* = 522)	Never worked	119 (22.80)
	Worked	403 (77.20)
Partner status (*N* = 522)	Have partner	369 (70.69)
	No partner	153 (29.31)
Wealth index (*N* = 522)	Most deprived	157 (30.08)
	2	131 (25.10)
	3	110 (21.07)
	4	63 (12.07)
	Most affluent	61 (11.69)
Alcohol (*N* = 521)	Yes	132 (25.34)
	No	389 (74.66)

TABLE 2 Profile of chronic conditions, Study on Global AGEing and adult health, 2015 (17).

Chronic condition	Prevalence *n*, % (95% CI)
Arthritis (*N* = 521)	96, 18.44 (15.18–22.02)
Stroke (*N* = 521)	10, 1.83 (0.09–3.50)
Diabetes (*N* = 520)	32, 6.09 (4.24–8.57)
Chronic lung diseases (*N* = 521)	14, 2.68 (1.47–4.47)
Asthma (*N* = 521)	29, 5.56 (3.75–7.89)
Depression (*N* = 520)	10, 1.84 (0.09–3.51)
Hypertension (*N* = 520)	61, 11.80 (9.09–14.81)
Cataract (*N* = 520)	87, 16.82 (13.62–20.22)
Edentulism (*N* = 521)	61, 11.72 (9.07–14.78)
Obesity (*N* = 488)	65, 13.28 (10.43–16.66)
Multimorbidity (*N* = 522)	118, 22.61 (19.08–26.44)

Discussion

Although substantial improvement in the healthcare system is being made, the tribal population still remains vulnerable in India (18). The socio-cultural beliefs of tribal groups not only make them distinct from the general population but also expose them to risky health behaviors. NCD multimorbidity is equally relevant for tribal health as the general population since the former group is also witnessing a significant lifestyle change making them more prone to NCD multimorbidity (19). Addressing the healthcare needs of tribal is important to achieve universal health coverage (20); hence, we garnered nationally representative evidence on multimorbidity in this population.

We observed arthritis to be the most commonly prevalent chronic condition followed by cataract and hypertension which

TABLE 3 Association between multimorbidity and various socio-demographic characteristics, Study on Global AGEing and adult health, 2015 (17).

Socio-demographic characteristics		Multimorbidity present		
		n, % (95% CI)	Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Age (Years)	50–59	47, 19.50 (14.75–25.17)	Reference	Reference
	60–69	43, 22.81 (17.17–29.70)	1.22 (0.72–2.07)	1.29 (0.73–2.30)
	70–79	21, 26.43 (17.04–37.28)	1.48 (0.76–2.89)	1.61 (0.79–3.27)
	≥80	7, 49.24 (21.26–73.41)	4.00 (1.01–15.96)	4.08 (1.17–14.18)
Sex	Male	50, 21.75 (16.44–27.41)	Reference	Reference
	Female	68, 23.29 (18.69–28.75)	1.09 (0.67–1.76)	1.35 (0.70–2.58)
Residence	Rural	92, 20.71 (17.08–24.85)	Reference	Reference
	Urban	26, 33.19 (22.75–44.39)	1.90 (0.86–4.17)	1.20 (0.49–2.92)
Education	No formal education	63, 19.92 (15.52–24.55)	Reference	Reference
	Been to school	54, 26.84 (20.65–33.24)	1.47 (0.91–2.39)	1.37 (0.81–2.35)
Occupation	Never worked	93, 23.14 (19.05–27.50)	Reference	Reference
	Worked	25, 20.82 (14.08–29.43)	1.14 (0.64–2.03)	1.30 (0.71–2.38)
Partner status	Have partner	75, 21.02 (16.89–25.61)	Reference	Reference
	No partner	43, 26.03 (19.54–33.45)	1.32 (0.79–2.21)	1.16 (0.65–2.06)
Wealth index	Most deprived	24, 15.60 (10.11–22.02)	Reference	Reference
	2	24, 19.52 (13.03–27.84)	1.31 (0.67–2.55)	1.27 (0.65–2.46)
	3	29, 25.56 (17.91–34.73)	1.86 (0.91–3.77)	1.69 (0.85–3.36)
	4	16, 25.29 (15.26–37.94)	1.83 (0.84–3.98)	1.63 (0.73–3.64)
	Most affluent	25, 36.89 (25.39–49.33)	3.16 (1.41–7.07)	2.64 (1.06–6.56)
Alcohol	Yes	22, 18.65 (12.17–27.07)	0.73 (0.42–1.28)	0.81 (0.43–1.52)
	No	96, 23.80 (19.69–28.22)	Reference	Reference

is consistent with the findings of a study based on nationally representative data among older adults in India that reported hypertension, gastrointestinal defects, and arthritis to be the most prevalent long-term conditions (6). Nonetheless, a study conducted among *Mishing* tribes of Assam reported that 11% of the respondents had obesity which is in congruence with our findings (21). We observed the prevalence of multimorbidity to be 22.61%, which is higher than the prevalence (14.5%) reported by a previous study based on nationally representative data among older adults (22). A probable reason for this could be that our study included higher-aged participants (≥50 years), whereas Puri et al. considered lower-age group respondents (≥45 years). Moreover, it is well known that multimorbidity increases with an increase in age. However, it is worth noting that the prevalence of multimorbidity among tribal people is lesser than that of the general population as previous studies suggest that the prevalence of multimorbidity among the general population aged ≥45 years is ∼50% (3, 7, 8). This further emphasizes that early behavioral change communication (BCC) for lifestyle modification such as physical exercise, low salt intake, and abstaining from alcohol and tobacco may be crucial in preventing a further increase in the burden of NCD multimorbidity among tribal groups. Culturally appropriate and linguistically tailored health messages through each tribe's folklore, puppet show, dance, nukkad natika, etc. may be beneficial in reaching the masses. Nonetheless, rather than individuals, families should be the center of intervention.

We observed higher chances of having multimorbidity among older adults aged ≥80 years and above, which is in congruence with the findings of previous studies which suggest that multimorbidity increases with an increase in age (23). The chronic conditions start to appear in midlife at 40–45 years of age and tend to accumulate with an increase in age (6), which could have been one of the reasons for a significant association of multimorbidity among adults aged 80 years and above in the present study. Nonetheless, this age group requires special attention as they tend to be more socially and economically dependent on the younger age groups for treatment. Additionally, in deprived sections of society, the health of these individuals is often neglected as the priority shifts more toward the earning member of the family. Telemedicine services may provide a continuum of care and reduce physical visits to physicians.

We found a significant association between the most affluent class and multimorbidity which is consistent with the findings of a study conducted among 11,365 tribal older adults in India (22). Since our findings are based on self-reported chronic conditions, a probable reason for the affluent class to have more multimorbidity could be due to a better diagnosis of these conditions as compared to the deprived group. The affluent class

has a higher capacity to pay, and hence, they may easily avail of healthcare services leading to better diagnosis of conditions. Health and wellness centers envisioned with providing preventive and curative services for chronic conditions may act as a window of opportunity to provide egalitarian and accessible primary care services for all. Nonetheless, to make universal health coverage a reality, we need to especially focus on the marginalized sections of society. The findings of this study highlight two main points: (1) multimorbidity is equally prevalent among tribal older adults, (2) multimorbidity is associated with affluence which highlights that the affluent group might be able to afford healthcare services due to which they were better diagnosed and, hence, points toward equitable healthcare systems that could be accessible and affordable for all strata of society so as to achieve UHC. Additionally, in LMICs such as India which is witnessing an epidemiological transition, it is common for the affluent groups to have NCDs, which could be attributed to lifestyle-related factors such as sedentary habits and consumption of high-fat food. The newly formed cadre of community health officers may help in BCC activities which would help in lifestyle modifications.

Strengths and limitations

This study is based on a nationally representative sample; however, it is limited by the use of self-reported chronic conditions that may undermine the true population prevalence. Additionally, we used cross-sectional data that could not establish causality.

Conclusion

The prevalence of multimorbidity among tribal groups is rising and cannot be overlooked. Older age and affluent groups within the tribal population need to be kept at the center of behavioral change communication for lifestyle modifications. Health and wellness centers may be an opportunity to provide egalitarian, accessible, and quality preventive and curative services for this group. Future studies should explore the impact of multimorbidity on healthcare utilization and expenditure of tribal people.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://iipsindia.ac.in/content/SAGE-data.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements. No potentially identifiable images or data are presented in this study.

Author contributions

Concept, design, and drafting of the manuscript: AS and SP. Acquisition, analysis, or interpretation of data: AS, SK, DB, HK, and SP. Critical revision of the manuscript for important intellectual content: SK, DB, and HK. Statistical analysis: AS. Administrative and technical support: SK, DB, and SP. Supervision: SP. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Arokiasamy P. India's escalating burden of non-communicable diseases. *The Lancet global health.* (2018) 6:e1262–3. doi: 10.1016/S2214-109X(18)30448-0

2. MacMahon, S. *Multimorbidity: A Priority for Global Health Research.* London: The Academy of Medical Sciences (2018).

3. Kanungo S, Ghosal S, Kerketta S, Sinha A, Mercer SW, Lee JT, et al. Association of oral health with multimorbidity among older adults: findings from the longitudinal ageing study in India, wave-1, 2017–2019. *Int J Environ Res Public Health.* (2021) 18:12853. doi: 10.3390/ijerph182312853

4. Sinha A, Varanasi R, Pati S. Kaleidoscopic use of World Health Organization's Study on global ageing and adult health data set to explore multimorbidity and its outcomes in low and middle-income countries: an insider view. *J. Family Med. Prim. Care.* (2021) 10:4623. doi: 10.4103/jfmpc.jfmpc_1598_21

5. Pati S, Swain S, Knottnerus JA, Metsemakers JF, van den Akker M. Health related quality of life in multimorbidity: a primary-care based study from Odisha, India. *Health Qual Life Outcomes.* (2019) 17:1–1. doi: 10.1186/s12955-019-1180-3

6. Puri P, Sinha A, Mahapatra P, Pati S. Multimorbidity among midlife women in India: well-being beyond reproductive age. *BMC women's health.* (2022) 22:1–5. doi: 10.1186/s12905-022-01693-2

7. Sinha A, Kerketta S, Ghosal S, Kanungo S, Lee JT, Pati S. Multimorbidity and Complex Multimorbidity in India: findings from the 2017–2018 longitudinal ageing study in India (LASI). *Int J Environ Res Public Health.* (2022) 19:9091. doi: 10.3390/ijerph19159091

8. Sinha A, Kerketta S, Ghosal S, Kanungo S, Pati S. Multimorbidity among urban poor in India: findings from LASI, wave-1. *Front Public Health.* (2022) 10:881967. doi: 10.3389/fpubh.2022.881967

9. Pati S, Sinha A, Ghosal S, Kerketta S, Lee JT, Kanungo S. Family-level multimorbidity among older adults in India: looking through a syndemic lens. *Int J Environ Res Public Health.* (2022) 19:9850. doi: 10.3390/ijerph19169850

10. Skou ST, Mair FS, Fortin M, Guthrie B, Nunes BP, Miranda JJ, et al. Multimorbidity. *Nat Rev Dis Primers.* (2022) 8:1–22. doi: 10.1038/s41572-022-00376-4

11. Donkin A, Goldblatt P, Allen J, Nathanson V, Marmot M. Global action on the social determinants of health. *BMJ Global Health.* (2018) 3:e000603. doi: 10.1136/bmjgh-2017-000603

12. Baah FO, Teitelman AM, Riegel B. Marginalization: Conceptualizing patient vulnerabilities in the framework of social determinants of health—An integrative review. *Nurs INQ.* (2019) 26:e12268. doi: 10.1111/nin.12268

13. Marrone S. Understanding barriers to health care: a review of disparities in health care services among indigenous populations. *Int J Circumpolar Health.* (2007) 66:188–98. doi: 10.3402/ijch.v66i3.18254

14. SDG India Index and Dashboard 2019-20. (2019). Available online at: https://niti.gov.in/sites/default/files/2019-12/SDG-India-Index-2.0_27-Dec.pdf (accessed October 6, 2022).

15. Negi DP, Singh MM. Tribal health and health care beliefs in India: a systematic. *Int J Res Soc Sci.* (2018) 8:1.

16. Kumar MM, Pathak VK, Ruikar M. Tribal population in India: a public health challenge and road to future. *J Family Med Primary Care.* (2020) 9:508. doi: 10.4103/jfmpc.jfmpc_992_19

17. *SAGE Wave-2, India Report.* (2020). Available online at: https://www.iipsindia.ac.in/sites/default/files/other_files/WHO-SAGE_Wave-2_India_Report.pdf (accessed October 6, 2022).

18. Dhawan D, Sharma S. Abdominal obesity, adipokines and non-communicable diseases. *J Steroid Biochem Mol Biol.* (2020) 203:105737. doi: 10.1016/j.jsbmb.2020.105737

19. Barik D, Thorat A. Issues of unequal access to public health in India. *Front Pub Health.* (2015) 3:245. doi: 10.3389/fpubh.2015.00245

20. Sajeev P, Soman B. Prevalence of noncommunicable disease risk factors among the Kani tribe in Thiruvananthapuram district, Kerala. *Indian Heart J.* (2018) 70:598–603. doi: 10.1016/j.ihj.2018.01.022

21. Tangcharoensathien V, Mills A, Das MB, Patcharanarumol W, Buntan M, Johns J. Addressing the health of vulnerable populations: social inclusion and universal health coverage. *J Glob Health.* (2018) 8:2. doi: 10.7189/jogh.08.020304

22. Misra PJ, Mini GK, Thankappan KR. Risk factor profile for non-communicable diseases among Mishing tribes in Assam, India: Results from a WHO STEPs survey. *Indian J Med Res.* (2014) 140:370.

23. Puri P, Pati S. Exploring the linkages between non-communicable disease multimorbidity, health care utilization and expenditure among aboriginal older adult population in India. *Int J Pub Health.* (2022) 5:1–15. doi: 10.3389/ijph.2022.1604333

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 31 August 2023
DOI 10.3389/fpubh.2023.1224018

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Dolors Juvinya,
University of Girona, Spain
Dalin Yang,
Washington University in St. Louis,
United States

*CORRESPONDENCE
Sohyune Sok
✉ 5977sok@khu.ac.kr

Received 17 May 2023
ACCEPTED 14 August 2023
PUBLISHED 31 August 2023

CITATION
Ryu D and Sok S (2023) Prediction model of quality of life using the decision tree model in older adult single-person households: a secondary data analysis.
Front. Public Health 11:1224018.
doi: 10.3389/fpubh.2023.1224018

COPYRIGHT
© 2023 Ryu and Sok. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Prediction model of quality of life using the decision tree model in older adult single-person households: a secondary data analysis

Dajung Ryu[1] and Sohyune Sok[2]*

[1]Department of Nursing, Graduate School, Kyung Hee University, Seoul, Republic of Korea, [2]College of Nursing Science, Kyung Hee University, Seoul, Republic of Korea

Background: Attention is drawn to the subjective health status and quality of life of older adult single-person households, whose number is gradually increasing as factors including low fertility, increased life expectancy, aging, and household miniaturization interact.

Objective: The study was to identify predictors that affect the quality of life of single-person households aged 65 years or older and living in South Korea.

Methods: A secondary data analysis design was used. Data included physical, mental, social, and demographic characteristics, subjective health status, and quality of life parameters of 1,029 older adult single-person households surveyed by the Korea Health Panel in 2019. For analysis, the predictive model was evaluated using split-sample validation and the ROC curve. The area under the curve after the decision tree analysis was calculated. Final nodes predicting the quality of life of older adult single-person households were derived.

Results: Significant predictors were identified in this order: subjective health status, chronic disease, income, and age. Subjective health status was the most important factor influencing quality of life ($\triangle$ $p < 0.001$, $x^2 = 151.774$). The first combination that perceived high quality of life of older adult single-person households was the case of high subjective health status and no chronic disease, followed by the case of high subjective health status, presence of chronic disease, and high income.

Conclusion: This study confirmed that subjective health status and chronic disease are essential factors for quality of life among the four related indicators of quality of life presented by the OECD. In nursing practice, nurses need to pay attention the factors influencing quality of life of older adult single-person households. Especially, nursing practice for older adult single-person households needs to be focused on improving subjective health status and on relieving chronic disease.

KEYWORDS

aged, single-person households, health, quality of life, decision trees

Introduction

Life expectancy is increasing worldwide as the mortality rate improves owing to the expansion in the supply of medical resources, alleviation of problems in medical access, improvement in income level, and increased interest in improving quality of life. South Korea's life expectancy in 2020 is 82.8 years. The rate of increase from the previous year is the highest at 97.4% among OECD member countries, and the proportion of the older adults is expected to increase further in the future (1). South Korea entered an aged society in 2017, and the expected proportion of the older adult population in 2050 is 35.9%, which is expected to rank second among countries in the world (1–4). With the spread of individualistic ideology and the diversification of individual values, fertility rate is expected to continue to decrease, and the aging population will intensify. Moreover, the recent notable demographic change in South Korea involves the downsizing of households. The number of Korean single-person households aged 65 years or older increased by 36% from 1.06 million in 2010 to 1.44 million in 2018, accounting for 7.2% of the total number of households (1, 3). In the future, the number of older adult single-person households is expected to continue to increase due to the aging population and the deepening of trends in terms of low fertility, individual economic and health independence, enjoyment of personal life, and changes in parental support preferences (3, 5).

In South Korea, older adult single-person households have a high proportion of no economic activity, low asset sufficiency, and stability as well as a large gap in health (4, 6). Compared to multi-person households, they lack psychological and social stability, having poor health status, and poor access to medical care (7, 8). Emotional loneliness in older adults single-person households is associated with mortality, higher rates of depression, and lower quality of life (9). In other words, older adult single-person households comprise a group that needs special attention, and they need help when they have a disease or disability that require long-term care services. As this puts a burden on individual health and social welfare, it is necessary to study the health status and health outcomes of older adult single-person households. Exploring the health determinants of older adult single-person households is an essential task to improve the quality of life. It is also important to set and evaluate goals for the effectiveness and equity of health-related policies.

The health of the older adults refers to a state of complete physical, mental, and social well-being while maintaining autonomy, independence, and intergenerational solidarity (3, 10). Four indices of life expectancy, avoidable death, chronic disease, and subjective health status of the older adults are key factors for quality of life (4, 11). Understanding subjective health status has become essential to improving quality of life. Subjective health status refers to the overall evaluation or perception of an individual's health and is a good factor in evaluating health and quality of life (11, 12). Regardless of the diagnosis of a medical institution, the physical and mental health status felt by an individual is a predictor of objective indicators such as mortality rate (13, 14), even though it is a subjective characteristic, and comprehensively reflects the health status. Additionally, older people think their health is worse than younger people, which partially reflects the burden of chronic diseases (11). Chronic disease, which is an objective indicator, is a clinical diagnosis characterized by vulnerability and is known as an unfavorable predictor of health and quality of life. However, even in the case of taking medications for chronic diseases, the person can maintain a smooth daily life and think that his/her health is good. Even when one is not taking special medications, the person can underestimate his/her health status by worrying and being excessively concerned about his/her health.

Quality of life is another important concept to be considered in relation to subjective health status. Quality of life is multidimensional according to the content and measurement method (15), and it is abstract as it contains individual values and philosophies. The WHO defines quality of life as an individual's perception for one's place within the culture and value system related to the subject's goals, expectations and standards (10). Looking at the previous studies related to quality of life, there were many comparative studies between tools for measuring quality of life (16, 17). Most of the studies related to influencing factors were based on chronic diseases (16–18), and studies related to subjective health status were limited to some age groups or gender (19–22). There is lack of research on which predictor, either chronic disease or subjective health status, is a better predictor as an influencing factor on the quality of life of older adult single-person households (11).

Decision tree analysis is a method of classifying and predicting vast amounts of data. It is a useful tool in the health care field because it is easier to understand and facilitates prediction of characteristics by visualizing the predicted rule as a tree (23–25). Quality of life in the older adults is related to physical (26, 27), psychological (28), and socioeconomic (29, 30) factors. Therefore, we aimed to more intuitively and objectively identify the predictors of quality of life for older adults and single-person households through various combinations of variables related to quality of life. Decision tree analysis models that present a holistic picture of predictors of quality of life can aid in better clinical decision-making than individual predictors in regression models (23). Accordingly, this study intends to contribute to facilitating the development of community-based programs for improvement of quality of life by examining whether physical, mental, social, and demographic characteristics appear as significant influencing factors in older adult single-person households according to subjective health status. Focus is on the four OECD indicators that are related to or suggested as influencing factors.

The purpose of this study sought to determine the path for predicting the quality of life of older adult single-person households in South Korea using the decision tree analysis method. The specific aims were (1) to identify factors related to the quality of life of older adult single-person households; (2) to identify the good and poor quality of life groups in the older adult single-person households.

Methods

Study design

This study was a secondary data analysis study designed to build a predictive factor model that affects the quality of life of older adult single-person households using the Korea Health Panel 2019 Annual Data Version 2.0.1 (31) hosted by the Korea Institute for Health and Social Affairs and the National Health Insurance Service.

Study subjects and data collection

The Korea Health Panel Survey is a nationally approved statistic (Approval No. 920012). Sampling secured representativeness through

the standard sample design of the 2016 Population and Housing Census in Korea, which reflects changes in the demographic structure of the population, such as aging. Based on the data of the Population and Housing Census, it was conducted by a probability-proportional two-step stratified colony sampling method in which administrative districts were set as stratification variables, and this data is the most up-to-date data as the second-term panel data. The weight of the Korea Medical Panel data can statistically correct the bias of the data, and the representativeness and accuracy of the estimate can be improved by correcting the inclusion error, unequal sampling rate, and non-response error due to the difference in the number of households and population between the time of sample design and the time of survey. Among 1,440 single-person households out of a total of 6,689 households that responded to the 2019 Korea Health Panel Survey, 1,029 older adult people aged 65 years or older responded to all the survey variables in the study. This study was conducted from April to October 2022.

Measurements

This study included the physical, mental, and socioeconomic factors presented in previous studies, focusing on the four indicators (11) of the OECD, which were presented as factors influencing quality of life, to identify the path to predict the quality of life of single-person older adult households (26–30).

General and health-related characteristics list

General and health-related characteristics list included age, gender, income, educational level, chronic disease, disability, stress, suicide thoughts, need care, commercial treatment center, and self-rated health (SHR). This consisted of a total of 11 items.

Physical factors

For physical factors, chronic disease and presence of disability were used. In this study, only those diagnosed by a doctor were included for chronic disease, resulting in 28 types other than hypertension and diabetes (31). These include major chronic diseases affecting the older adults as suggested by the WHO and avoidable causes of death as suggested by the OECD: cardiovascular disease, hypertension, cerebrovascular disease, diabetes, cancer, respiratory disease, and musculoskeletal disease (10, 11). The question about disability was "Do you currently have a disability?'

Mental factors

For mental factors, the stress level and the presence of suicidal thoughts were used. Stress consisted of a 4-point Likert scale (1 = very much, 4 = hardly). In this study, the score was reverse-coded: the higher the score, the more severe the stress. The question about suicidal thoughts was on a nominal scale and "Have you ever had thoughts of wanting to die in the past 1 year?"

Social factors

For social factors, the need for care and the presence of the usual source of care were used to confirm the level of social support of the subject. The need for care was divided into cases in which social care was required due to physical and mental health problems and cases in which social care was not required. The presence of the usual source of care was a factor related to the existence of physical and human resources in the local community. The question about the presence of the usual source of care was whether the person had a medical institution and a doctor that he/she usually visited. When the person had both, it was determined that the person had the usual source of care.

Subjective health status

Subjective health status answered in the form of self-assessment was a comprehensive evaluation of the subject's overall health status. The question for this was 'How is your current health?' It consisted of a 5-point Likert scale (1 = very good, 5 = very bad). In this study, the score was reverse-coded: the higher the score, the better the subjective health status.

Quality of life

The quality of life scale used was the EQ-5D-3L developed by the EuroQoL group, consisting of the dimensions of exercise ability, self-management, activity of daily living, pain and discomfort, and anxiety and depression. Each dimension consisted of 3 levels (1 = no disturbance, 2 = somewhat disturbing, 3 = very disturbing). Therefore, a total of $3^5 = 243$ combinations was made to measure the quality of life according to different health status levels. A case in which all five dimensions were level 1 was regarded as a state of complete health, and the value at this time was set to "1". If the dimension was answered as level 2 or 3, the value was calculated using the weight formula. In this study, the quality-weighted correction score was used to calculate with the method suggested by the Korea Centers for Disease Control and Prevention (32). The range of the subject's quality of life score was −0.171 to 1, and the codes and calculation formulas for dimensions and levels are shown in Table 1.

Ethical considerations

Statistical data of the Korea Health Panel were obtained with prior consent from all subjects before data collection. Data were analyzed after the data access review was approved by submitting the consent form for data use before the start of the study. The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of the Korea Institute for Health and Social Affairs (Approval No. 2022-017 and April 15, 2022).

Data analysis

The data were analyzed using the SPSS 25.0 program. Descriptive statistics were performed on the subjects' characteristics and quality

TABLE 1 EQ-5D-3L index ($N = 1,029$).

	Level 1	Level 2	Level 3
Exercise ability		M2	M3
Self-management		SC2	SC3
ADL		UA2	UA3
Pain, discomfort		PD2	PD3
Anxiety, depression		AD2	AD3
Interaction			N3
EQ-5D index $=1-(0.05+0.096\times M2+0.418\times M3+0.046\times SC2+0.136\times SC3+0.051\times UA2+0.208\times UA3+0.037\times PD2+0.151\times PD3+0.043\times AD2+0.158\times AD3+0.05\times N3)$			

ADL, Activities of Daily Living.

of life, and independent samples t-test and x^2-test were carried out by dividing the subjects into two groups based on the mean quality of life calculated by the quality-weighted correction score to compare the subjects' characteristics. In order to predict factors related to the quality of life of single-person older adult households, a decision tree analysis method among data mining techniques was applied. Decision trees are composed of components called nodes, and the separation process of nodes occurs according to the frequency belonging to each category of the target variable (33). In this study, the x^2-test was used when the target variable was discrete, and the Chi-squared Automatic Interaction Detection (CHAID) algorithm was used to allow separation of two or more using F-test when the target variable was continuous (34). That is, the separation criterion for forming the structure of the decision tree is the chi-square test statistic, the significance level of the node split is set to.05, and the maximum number of iterations for model estimation is set to 100. The stopping rules of a decision tree refer to rules that make the current node become a terminal node, and these rules require the maximum tree depth and the minimum number of observations in a node (24). In this study, the maximum number of levels of CHAID was specified as 3, Parent node 100, and Child node 50, and a split sample validity test, ROC curve, and area under the curve were performed to examine whether the decision tree could be applied to the population.

Results

General and health-related characteristics of the study participants

The mean age of the subjects was 76.48 ±6.79 years, and there were more females (78.3%) than males. Most of the subjects (88.3%) had chronic diseases. In terms of stress, 41.6% hardly felt stress, 39.8% felt a little, 16.1% felt a lot, and 2.5% felt very much. 88.0% of the subjects answered that they had no suicidal thoughts, and 93.0% of the subjects answered that they did not need care. 55.0% of subjects had the usual source of care. The mean score of subjective health status was 2.91 ±0.89 points (range 1 ~ 5), and 33.5% was perceived as bad. Examination of the difference in the general characteristics according to the quality of life after dividing the subjects into two groups based on the mean quality of life of 0.862 ±0.14 showed that all variables differed between the two groups (Table 2).

Subjective health status and level of quality of life and relationship

The quality of life dimension of subjects was measured using a weight formula. The closer to 1 the value obtained is, the more positively they perceived their life. The mean quality of life of the subjects was 0.862 ±0.14. The mean of the self-management dimension was the highest at 0.867 ±0.33, and the mean of the pain and discomfort dimension was the lowest at 0.416 ±0.47. The subjects' quality of life had a moderate correlation with subjective health status ($r = 0.55$, $p < 0.001$), and it was confirmed that there was a significant correlation in the order of exercise ability ($r = 0.47$, $p < 0.001$), activity of daily living ($r = 0.47$, $p < 0.001$), pain and discomfort ($r = 0.43$, $p < 0.001$), self-management ($r = 0.34$, $p < 0.001$), and anxiety and depression ($r = 0.33$, $p < 0.001$) (Table 3).

Prediction model of factors influencing the quality of life of subjects

In order to build a model for predicting the quality of life of subjects, decision tree analysis was performed on the training data and test data by inputting all the variables used in the study. The variable of the parent node means the more important it is as an influencing factor, and the level of quality of life changes as the characteristics of the child node accumulate. In this study, the total number of nodes was 9, the final number of nodes was 5, and the number of levels was 3. The significant predictors were subjective health status, chronic disease, income, and age in this order. According to the decision tree analysis results, the most important factor influencing quality of life was subjective health status ($\triangle p < 0.001$, $x^2 = 151.774$). There were 5 combinations of cases where the quality of life was perceived as high, and the combination of the highest factors was the case of high subjective health status and no chronic disease (92.4%). The combination of second highest factors was the case of high subjective health status, presence of chronic disease, and high income (70.7%; Figure 1).

Evaluations of predictive model

In order to secure the suitability of the decision tree model, split-sample validation was performed by dividing the ratio of training data

TABLE 2 General and health-related characteristics of the study participants ($N = 1,029$).

Categories	Total	Low QoL ($n = 456$)	High QoL ($n = 573$)	χ^2 or t (p)	Cramer's V
	n (%) or Mean ± SD	n (%) or Mean ± SD	n (%) or Mean ± SD		
Age (year)	76.48 ± 6.79	78.40 ± 6.75	74.95 ± 6.43	8.384 (< 0.001)	
Gender					
Male	223 (21.7)	69 (15.1)	154 (26.9)	20.633 (< 0.001)	0.133
Female	806 (78.3)	387 (84.9)	419 (73.1)		
Income (10,000KRW/year)	1372.99 ± 1812.75	1077.11 ± 688.84	1608.46 ± 2324.42	−5.193 (< 0.001)	
Educational level					
High school below	789 (76.7)	393 (86.2)	396 (69.1)	42.278 (< 0.001)	0.200
High school	176 (17.1)	43 (9.4)	133 (23.2)		
College above	64 (6.2)	20 (4.4)	44 (7.7)		
Chronic disease					
Yes	909 (88.3)	442 (96.9)	467 (81.5)	58.676 (< 0.001)	0.240
No	120 (11.7)	14 (3.1)	106 (18.5)		
Disability					
Yes	137 (13.3)	92 (20.2)	45 (7.9)	33.405 (< 0.001)	0.186
No	892 (86.7)	364 (79.8)	528 (92.1)		
Stress					
Barely felt	427 (41.6)	163 (35.7)	264 (46.1)	25.996 (< 0.001)	0.217
Feel a little	410 (39.8)	178 (39.1)	232 (40.5)		
Feel a lot	166 (16.1)	101 (22.1)	65 (11.3)		
Feel very much	26 (2.5)	14 (3.1)	12 (2.1)		
Suicide thoughts					
Yes	123 (12.0)	76 (16.7)	47 (8.2)	17.285 (< 0.001)	0.144
No	906 (88.0)	380 (83.3)	526 (91.8)		
Need care					
Yes	72 (7.0)	65 (14.3)	7 (1.2)	66.277 (< 0.001)	0.252
No	957 (93.0)	391 (85.7)	566 (98.8)		
Commercial treatment center					
Yes	566 (55.0)	263 (57.7)	303 (52.9)	7.312 (0.026)	0.091
No	463 (45.0)	193 (42.3)	270 (47.1)		
SRH	2.91 ± 0.89	2.44 ± 0.80	3.29 ± 0.76	−17.320 (< 0.001)	0.529
Very bad	44 (4.3)	42 (9.2)	2 (0.3)		
Bad	300 (29.2)	218 (47.9)	82 (14.3)		
Moderate	407 (39.5)	151 (33.1)	256 (44.7)		
Good	258 (25.1)	43 (9.4)	215 (37.6)		
Very good	20 (1.9)	2 (0.4)	18 (3.1)		

QoL, Quality of Life; SRH, Self-Rated Health; SD, Standard Deviation.
Bold values denote statistical significance at the $p < 0.05$ level.

and test data to 5:5. The same structure as shown in Figure 1 was confirmed to ensure the validity of the model, and in the case of the training data, the risk estimate was 0.24, confirming that the probability of correct classification was 75.5%. In this study, the AUC value of subjective health status was 0.79 (95% CI = 0.76–0.81), the AUC value of income was 0.64 (95% CI = 0.61–0.68), and the AUC value of age was 0.37 (95% CI = 0.33–0.40), which was similar to the prediction ranking of the decision tree model (Table 4; Figure 2).

Discussion

In an aging society that is intensifying along with economic development, the health status and quality of life of the older adults are attracting considerable attention. Quality of life reflects physical and mental health, which has been widely verified using standardized tools as having a significant correlation with health status (35, 36). Older adults' health is closely related to access to economic and medical resources (37),

and single-person households lacking family care are vulnerable in terms of health and emotional cognition (38–40). Therefore, in this study, in order to identify factors affecting the quality of life of older adult single-person households in South Korea, decision tree analysis using data mining technique was performed to model 5 predictive pathways.

TABLE 3 Means of and correlations among variables ($N = 1,029$).

Variables	Application of weighted value			Relationships with SRH
	Min	Max	Mean ± SD	*r* (*p*)
Quality of life	−0.056	1	0.862 ± 0.14	0.55 (< 0.001)
Exercise ability	0.096	1	0.614 ± 0.45	0.47 (< 0.001)
Self-management	0.046	1	0.867 ± 0.33	0.34 (< 0.001)
ADL	0.051	1	0.702 ± 0.44	0.47 (< 0.001)
Pain and discomfort	0.037	1	0.416 ± 0.47	0.43 (< 0.001)
Anxiety and depression	0.043	1	0.852 ± 0.35	0.33 (< 0.001)

SRH, Self-Rated Health; ADL, Activities of Daily Living; SD, Standard Deviation.
Bold values denote statistical significance at the $p < 0.05$ level.

In this study, the subjective health status, chronic disease, income, and age of older adult single-person households were found to affect the quality of life, supporting the results of previous studies (4, 16–18, 20, 21, 35, 41). First, subjective health status was identified as the most influential factor on the quality of life of older adult single-person households. Subjective health status can better represent a subject's comprehensive health status and quality of life even if objective health status is considered (42–44). Based on the results, the subjective health status of the group with low quality of life was lower than the average, and that of the group with high quality of life was higher than the average. In other words, subjective health status evaluation can be an excellent method of selecting subjects for quality of life improvement since the vulnerable group and the high-risk group are identified. Therefore, accurate evaluation of subjective health status is important, and two methods are proposed. First, subjective health status is not based only on objective health indicators, but also on the complex action of physiological, psychological, social, and cultural factors (45). It is necessary to understand various concepts of health and to recognize the cultural custom of expressing the evaluation of subjective health status as a positive or negative opinion (45). Second, in addition to the scale of subjective health status presented as an existing ranking scale, it is also to evaluate one's own health status compared to those of

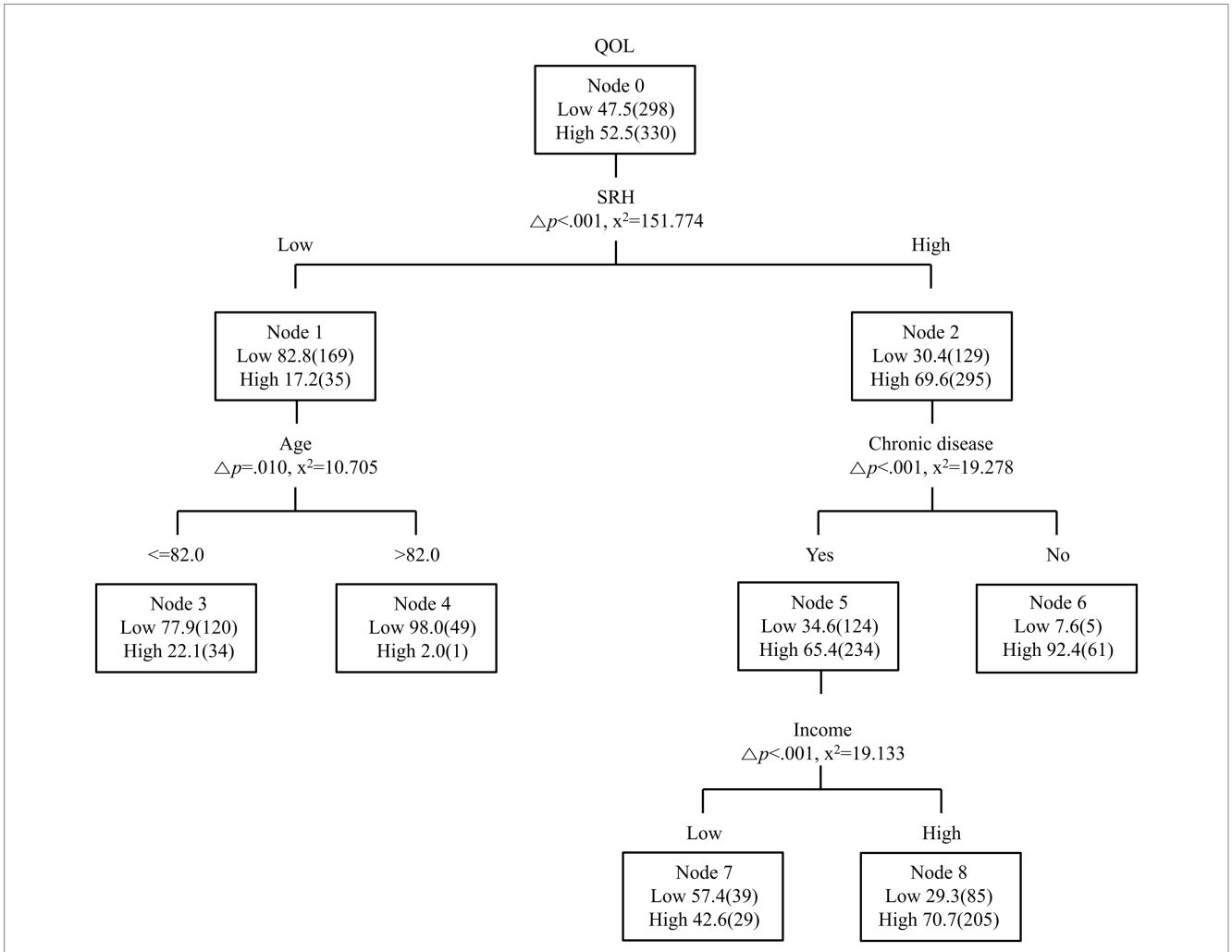


FIGURE 1
Decision tree for quality of life. QOL, Quality of Life; SRH, Self-rated health; Δ, adjusted; (), test data.

the same age. In a study investigating the tendency of the subjective health status of the older adults in the United States, it was found that the subjective health status of middle-aged adults aged 45 to 54 years deteriorated over time (46). Similarly, a study examining changes in the subjective health status of Korean adult single-person households reported that their subjective health status deteriorated over time and faster than that of multi-person households (47). In summary, it can be seen that in order to improve the subjective health status of older adult single-person households, it is necessary to provide health information and education on functional status from middle-aged adulthood. Moreover, when comparing the subjective health status of older adult single-person households in South Korea with other countries, the low subjective health status rate of South Korea is similar to that of Taiwan (33.1%) and higher than that of Japan (26.9%) and Shanghai (15.2%) (48–50). This means that the subjective health status of older adult single-person households in South Korea is particularly poor among major Asian countries. Follow-up research and theoretical development are needed to improve the subjective health status for this particular population.

TABLE 4 Risk chart of decision trees.

Variables	RE	SE	%
Training data	0.24	0.02	75.5
Test data	0.29	0.02	70.8

RE, Risk Estimate; SE, Standard Error.

The second factor affecting quality of life was identified as chronic disease. The improvement of medical technology and the expansion of the supply of medical resources indicate that many people suffer from chronic diseases, which is an important topic in the health care field. Chronic disease causes deterioration of body functions, and is an important predictor of health deterioration, especially in the older adults (44, 51). When the number of chronic diseases is small or absent, health status assessment will be improved. For example, Alzheimer's disease, the most common neurodegenerative disease in the older adults, begins with symptoms of cognitive decline (52). Evaluation of various biomarkers for early identification of mild cognitive impairment can reduce the morbidity of chronic diseases. The next factors that affect quality of life were income and age. Income is an essential resource for maintaining and promoting health, which can help the subject effectively cope with health problems and is related to the cost of diet and exercise to maintain health. It is in the same context as the results reported in a previous study that income is highly related to subjective health status and well-being (53). Aging affects quality of life due to deterioration of physical, mental, and social functions as well as an increase in chronic diseases. Based on the results of this study, it is worth noting that subjective health status and chronic disease are major influencing factors on quality of life, but

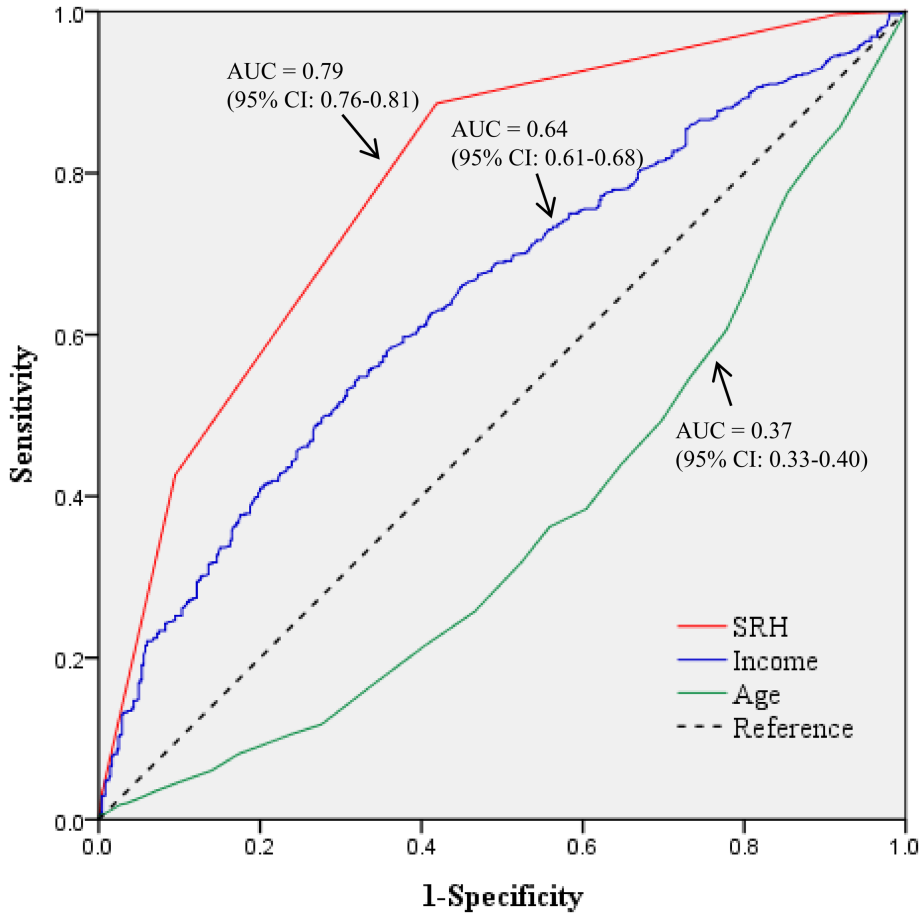


FIGURE 2
The receiver operating characteristic curves of predicting model. AUC, Area Under the Curve; CI, Confidence Interval.

the strongest influencing factor is subjective health status. Subjective health status is a complex judgment about the severity of chronic diseases, and is a higher-level concept that includes symptoms of chronic diseases and undiagnosed diseases (43). The severity of chronic diseases differs from individual to individual, and quality of life is an issue that cannot be explained only by existing diseases and symptoms. Subjective health status is a dynamic viewpoint that evaluates not only the current health level but also the future health level. Chronic diseases and age are irreversible, but subjective health status can be modified, and individual health behaviors can be promoted to improve the positive growth and quality of life of the subject. This suggests that subjective health status should be evaluated independently in future studies.

The first combination that perceived quality of life as high was the case of high subjective health status and no chronic disease, followed by the case of high subjective health status, presence of chronic disease, and high income. The first combination that perceived quality of life as low was the case of low subjective health status and age 82 years or older. These results show there is a need for a community-based customized care program that can classify older adult single-person households that include both characteristics of low quality of life as a priority for improving the quality of life and subjective health status. In addition, chronic disease prevention and management programs should be expanded further since chronic diseases are important for older adult single-person households with high subjective health status. This result identified various approaches to improving the quality of life of older adult single-person households, prioritized management targets considering the combination, and suggested that a specific approach strategy was needed.

Implications for practice, policy, and research

Since the subjective health status of middle-aged adults confirmed in previous studies also affects old age, it is necessary to provide health information and education on functional status in middle-aged adulthood. A community-based customized care program is required for old age. In addition, chronic disease prevention and management programs should be expanded further as chronic diseases are critical for older adult single-person households with high subjective health status. Chronic disease-specific care can be provided in the primary health care system, such as self-management support, decision support, and delivery system Design (54). This can ultimately improve the quality of life of older adult single-person households.

Based on the results of this study, the following suggestions are made. First, in providing programs to improve the quality of life of the older adults, the older adult single-person household should be given primary importance because it is a vulnerable group. Second, although the EQ-5D-3L has good measurement properties, it has been shown to have a ceiling effect in some studies, so replication studies using various quality of life tools are needed. Third, decision tree analysis is an effective method to classify a large amount of data and predict both categorical and continuous values (24), but it is difficult to determine the effect of each predictor variable like logistic regression analysis. Therefore, it is required to compare the predictive power of models constructed by performing complex sample logistic regression analysis to confirm the change in explanatory power and influence of explanatory variables by sequentially introducing them.

Limitations

This study has several limitations. It was not possible to use various tools to evaluate the quality of life as a secondary data analysis study. Also, it was not possible to evaluate the difference in the change in quality of life since only one-year data were used.

Conclusion

This study examined the characteristics of older adult single-person households using data from the Korea Health Panel and presented an approach strategy in practice by constructing a predictive model for improving the quality of life using decision tree analysis. In conclusion, the path for predicting the quality of life of older adult single-person households differed according to the subjective health status. Our study makes a significant contribution to the literature because of the novelty and innovation of this work and the direct practical relevance of our findings to informing research directions and medical guidelines. This paper will be of interest to the readership of your journal because of our focus on a highly understudied topic of importance within the interdisciplinary field of public health.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: the Korea Health Panel 2019 Annual Data Version 2.0.1 (25) hosted by the Korea Institute for Health and Social Affairs and the National Health Insurance Service.

Ethics statement

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board of statistical data of the Korea Health Panel (Approval No. 2022-017).

Author contributions

DR and SS: conceptualization, methodology, validation, formal analysis, data curation, writing-original draft preparation, and writing-review and editing. SS: supervision. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors gratefully acknowledge the Korea Health Panel for providing statistical data.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Korean Statistical Information Service a. Life expectancy (OECD) (2022). Available at:https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_2KAA209_OECD&conn_path=I2 (accessed August 22, 2022).

2. Kowal P, Goodkind D, He W. (2015). An aging world. International population reports (2015) Available at: https://www.census.gov/content/dam/Census/library/publications/2016/demo/p95-16-1.pdf (accessed August 21 2022).

3. Kim E, Sok S, Won C. Factors affecting frailty among community-dwelling older adults: a multi-group path analysis according to nutritional status. *Int J Nurs Stud*. (2021) 115:103850–11. doi: 10.1016/j.ijnurstu.2020.103850

4. Sok S, Kim S, Shin E, Kim M, Cho Y. Effects of multicomponent oriental integrative intervention on cognitive function, health status, life satisfaction, and Yangsaeng of community-dwelling elderly. *Int J Environ Res Public Health*. (2022) 19:12113. doi: 10.3390/ijerph191912113

5. Jung K. Current status of living alone in old age and policy response strategies. *Health Welf Issue Focus*. (2015) 300:1–8.

6. Kang E, Lee M. Single-person households in South Korea and their policy implications. *Health Soc Welfare Rev*. (2016) 234:47–56.

7. Kim SH, Kim YL, Kim KW, Kim KH. The health behavior of single adult households in Korean over 30: the 6th Korean National Health and nutrition examination survey. *Korean J Family Pract*. (2017) 7:330–6. doi: 10.21215/kjfp.2017.7.3.330

8. Song IH, Youn H, Sung S. Comparison of health related quality of life of one-and multi-person households using EQ-5D based on the 7th Korea National Health and nutrition examination survey. *Korean J Family Pract*. (2022) 12:22–7. doi: 10.21215/kjfp.2022.12.1.22

9. PS OS, Gallagher S, Steptoe A. Loneliness, living alone, and all-cause mortality: the role of emotional and social loneliness in the elderly during 19 years of follow-up. *Psychosom Med*. (2019) 81:521–6. doi: 10.1097/PSY.0000000000000710

10. World Health Organisation. Active ageing: a policy framework. (2022) Available at: http://apps.who.int/iris/bitstream/10665/67215/1/WHO_NMH_NPH_02.8.pdf (accessed April 28 2022).

11. Organisation for Economic Cooperation and Development. Health at a glance 2019. (2019). (accessed August 20 2022).

12. Sugisawa H, Sugisawa A. Development of research on self-rated health in the United States. [Nihon koshu eisei zasshi]. *Japan J Public Health*. (1995) 42:366–8.

13. Falk H, Skoog I, Johansson L, Guerchet M, Mayston R, Hörder H, et al. Self-rated health and its association with mortality in older adults in China, India and Latin America-a 10/66 dementia research group study. *Age Ageing*. (2017) 46:932–9. doi: 10.1093/ageing/afx126

14. Palladino R, Tayu Lee J, Ashworth M, Triassi M, Millett C. Associations between multimorbidity, healthcare utilisation and health status: evidence from 16 European countries. *Age Ageing*. (2016) 45:431–5. doi: 10.1093/ageing/afw044

15. The Whoqol Group. The World Health Organization quality of life assessment (WHOQOL): development and general psychometric properties. *Soc Sci Med*. (1998) 46:1569–85. doi: 10.1016/s0277-9536(98)00009-4

16. Haraldstad K, Wahl A, Andenæs R, Andersen JR, Andersen MH, Beisland E, et al. A systematic review of quality of life research in medicine and health sciences. *Qual Life Res*. (2019) 28:2641–50. doi: 10.1007/s11136-019-02214-9

17. Oluchi SE, Manaf RA, Ismail S, Kadir Shahar H, Mahmud A, Udeani TK. Health related quality of life measurements for diabetes: a systematic review. *Int J Environ Res Public Health*. (2021) 18:9245. doi: 10.3390/ijerph18179245

18. Zazzeroni L, Pasquinelli G, Nanni E, Cremonini V, Rubbi I. Comparison of quality of life in patients undergoing hemodialysis and peritoneal Dialysis: a systematic review and Meta-analysis. *Kidney Blood Press Res*. (2017) 42:717–7. doi: 10.1159/000484115

19. Abellán BJDLH, Sotos R, López L, CL VJ. Healthy eating and self-perception of health. *Aten Primaria*. (2016) 48:535–2. doi: 10.1016/j.aprim.2015.12.001

20. Gomez LF, Soto-Salazar C, Guerrero J, Garcia M, Parra DC. Neighborhood environment, self-rated health and quality of life in Latin America. *Health Promot Int*. (2020) 35:196–4. doi: 10.1093/heapro/day117

21. Kim M. An analysis of the factors affecting the quality of life: a comparison by age and gender. *J Korea Gerontol Soc*. (2012) 32:145–1.

22. Marques A, Peralta M, Santos T, Martins J, Gaspar de Matos M. Self-rated health and health-related quality of life are related with adolescents' healthy lifestyle. *Public Health*. (2019) 170:89–94. doi: 10.1016/j.puhe.2019.02.022

23. Kang Y, McHugh MD, Chittams J, Bowles KH. Utilizing home healthcare electronic health records for telehomecare patients with heart failure: a decision tree approach to detect associations with rehospitalizations. *Comput Inform Nurs*. (2016) 34:175–2. doi: 10.1097/cin.0000000000000223

24. Seo J, Kim M. A prediction model for quality of life by resilience in disaster female victims. *Korean J Adult Nurs*. (2021) 33:639–8. doi: 10.7475/kjan.2021.33.6.639

25. Xiang S, Li L, Wang L, Liu J, Tan Y, Hu J. A decision tree model of cerebral palsy based on risk factors. *J Matern Fetal Neonatal Med*. (2021) 34:3922–7. doi: 10.1080/14767058.2019.1702944

26. Makovski TT, Schmitz S, Zeegers MP, Stranges S, van den Akker M. Multimorbidity and quality of life: systematic literature review and meta-analysis. *Ageing Res Rev*. (2019) 53:100903. doi: 10.1016/j.arr.2019.04.005

27. Vagetti GC, Barbosa Filho VC, Moreira NB, Oliveira V, Mazzardo O, Campos W. Association between physical activity and quality of life in the elderly: a systematic review, 2000-2012. *Braz J Psychiatry*. (2014) 36:76–88. doi: 10.1590/1516-4446-2012-0895

28. Al-Ghafri BR, Al-Mahrezi A, Chan MF. Effectiveness of life review on depression among elderly: a systematic review and meta-analysis. *Pan Afr Med J*. (2021) 40:168. doi: 10.11604/pamj.2021.40.168.30040

29. de Medeiros MMD, Carletti TM, Magno MB, Maia LC, Cavalcanti YW, Rodrigues-Garcia RCM. Does the institutionalization influence elderly's quality of life? A systematic review and meta-analysis. *BMC Geriatr*. (2020) 20:44. doi: 10.1186/s12877-020-1452-0

30. Kim J, Lee JE. Social support and health-related quality of life among elderly individuals living alone in South Korea: a cross-sectional study. *J Nurs Res*. (2018) 26:316–3. doi: 10.1097/jnr.0000000000000241

31. Korea Institute for Health and Social Affairs & National Health Insurance Service. Korea health panel annual data 2019. (2019). Available at: https://www.khp.re.kr:444/web/data/board/view.do?bbsid=63&seq=2612 (accessed April 20 2022).

32. Oh H. Important significant factors of health-related quality of life(EQ-5D) by age group in Korea based on KNHANES(2014). *J Korean Data Inform Sci Soc*. (2017) 28:573–4. doi: 10.7465/jkdi.2017.28.3.573

33. Kim KS, Kim KH. A prediction model for internet game addiction in adolescents: using a decision tree analysis. *J Korean Acad Nurs*. (2010) 40:378–8. doi: 10.7465/jkdi.2017.28.3.573

34. Murphy EL, Comiskey CM. Using chi-squared automatic interaction detection (CHAID) modelling to identify groups of methadone treatment clients experiencing significantly poorer treatment outcomes. *J Subst Abus Treat*. (2013) 45:343–9. doi: 10.1016/j.jsat.2013.05.003

35. Ning H, Kershaw KN, Allen NB, Wilkins J, Lloyd-Jones DM. Association of health-related quality of life with atherosclerotic cardiovascular disease: lifetime risk pooling project. *Am J Prev Cardiol*. (2021) 7:100222. doi: 10.1016/j.ajpc.2021.100222

36. Staquet M, Berzon R, Osoba D, Machin D. Guidelines for reporting results of quality of life assessments in clinical trials. *Qual Life Res*. (1996) 5:496–2. doi: 10.1007/bf00540022

37. Fan C, Ouyang W, Tian L, Song Y, Miao W. Elderly health inequality in China and its determinants: a geographical perspective. *Int J Environ Res Public Health*. (2019) 16:2953. doi: 10.3390/ijerph16162953

38. Bi T, Kou H, Kong Y, Shao B. Widowhood impairs emotional cognition among elderly. *Front Aging Neurosci*. (2022) 13:808885. doi: 10.3389/fnagi.2021.808885

39. Narayanasamy NS, Das A, Narayanasamy A, Prusty RK. Self reported health status and its determinants among elderly widows in Puducherry India. *Indian J Community Med*. (2021) 46:606–9. doi: 10.4103/ijcm.IJCM_253_20

40. Ugargol AP, Hutter I, James KS, Bailey A. Care needs and caregivers: associations and effects of living arrangements on caregiving to older adults in India. *Ageing Int*. (2016) 41:193–3. doi: 10.1007/s12126-016-9243-9

41. Naimi AJ, Naderiravesh N, Bayat ZS, Shakeri N, Matbouei M. Correlation between health literacy and health-related quality of life in patients with hypertension, in Tehran, Iran, 2015-2016. *Electron Physician*. (2017) 9:5712–20. doi: 10.19082/5712

42. Heinonen H, Aro AR, Aalto AM, Uutela A. Is the evaluation of the global quality of life determined by emotional status? *Qual Life Res*. (2004) 13:1347–56. doi: 10.1023/B:QURE.0000040788.12947.b9

43. Idler EL, Benyamini Y. Self-rated health and mortality: a review of twenty-seven community studies. *J Health Soc Behav*. (1997) 38:21–37. doi: 10.2307/2955359

44. Tian H, Chen J. Health of widowed elderly and related factors in China. *J Men's Health*. (2022) 18:163. doi: 10.31083/j.jomh1808163

45. Jylhä M. What is self-rated health and why does it predict mortality? Towards a unified conceptual model. *Soc Sci Med*. (2009) 69:307–6. doi: 10.1016/j.socscimed.2009.05.013

46. Lamidi EO. Still feeling better? Trends in self-rated health of older adults in the U.S. *Res Aging*. (2021) 43:358–7. doi: 10.1177/0164027520963659

47. Kim E, Kim H, Yoon J. Trajectories of self-rated health among one-person households: a latent class growth analysis. *J Korean Acad Community Health Nurs*. (2019) 30:449–9. doi: 10.12799/jkachn.2019.30.4.449

48. Chen Y, While AE, Hicks A. Self-rated health and associated factors among older people living alone in Shanghai. *Geriatr Gerontol Int*. (2015) 15:457–4. doi: 10.1111/ggi.12298

49. Huang LH, Lin YC. The health status and needs of community elderly living alone. *J Nurs Res*. (2002) 10:227–6. doi: 10.1097/01.jnr.0000347602.81885.69

50. Sun W, Watanabe M, Tanimoto Y, Shibutani T, Kono R, Saito M, et al. Factors associated with good self-rated health of non-disabled elderly living alone in Japan: a cross-sectional study. *BMC*. (2007) 7:297. doi: 10.1186/1471-2458-7-297

51. Govindaraju T, Owen AJ, McCaffrey TA. Past, present and future influences of diet among older adults - a scoping review. *Ageing Res Rev*. (2022) 77:101600. doi: 10.1016/j.arr.2022.101600

52. Yang D, Hong KS, Yoo SH, Kim CS. Evaluation of neural degeneration biomarkers in the prefrontal cortex for early identification of patients with mild cognitive impairment: an fNIRS study. *Front Hum Neurosci*. (2019) 13:317. doi: 10.3389/fnhum.2019.00317

53. Kondo N, Sembajwe G, Kawachi I, van Dam RM, Subramanian SV, Yamagata Z. Income inequality, mortality, and self rated health: meta-analysis of multilevel studies. *BMJ*. (2009) 339:b4471. doi: 10.1136/bmj.b4471

54. Reynolds R, Dennis S, Hasan I, Slewa J, Chen W, Tian D, et al. A systematic review of chronic disease management interventions in primary care. *BMC Fam Pract*. (2018) 19:11. doi: 10.1186/s12875-017-0692-3

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 06 September 2023
DOI 10.3389/fpubh.2023.1231779

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Tanvi Kiran,
Post Graduate Institute of Medical Education and Research (PGIMER), India
Limei Jing,
Shanghai University of Traditional Chinese Medicine, China

*CORRESPONDENCE
Madara Miķelsone
✉ madara.mikelsone@rsu.lv

RECEIVED 30 May 2023
ACCEPTED 15 August 2023
PUBLISHED 06 September 2023

CITATION
Miķelsone M, Reine I, Tomsone S, Guðmundsson H, Ivanovs A and Guðmundsson HS (2023) Construction of healthy aging index from two different datasets.
Front. Public Health 11:1231779.
doi: 10.3389/fpubh.2023.1231779

COPYRIGHT
© 2023 Miķelsone, Reine, Tomsone, Guðmundsson, Ivanovs and Guðmundsson. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Construction of healthy aging index from two different datasets

Madara Miķelsone[1]*, Ieva Reine[1,2], Signe Tomsone[3], Helgi Guðmundsson[4], Andrejs Ivanovs[1] and Halldór S. Guðmundsson[5]

[1]Statistics Unit, Riga Stradiņš University, Riga, Latvia, [2]Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden, [3]Faculty of Rehabilitation, Riga Stradiņš University, Riga, Latvia, [4]Social Science Research Institute, University of Iceland, Reykjavik, Iceland, [5]Faculty of Social Work, University of Iceland, Reykjavik, Iceland

Introduction: The aging population presents both unique challenges and opportunities for societies around the world. To develop an effective healthy aging strategy, a tool for assessing aging process is needed. Numerous attempts to quantify the aging process have been made. However, there is still a challenge in developing and choosing a good enough score that is easy to apply, has a construct of variables that are available in most nationwide surveys for comparable results, and at the same time reflects the aging process of older individuals. The purpose of this study is to present our approach to construct a comparable Healthy Aging Index (HAI).

Materials and methods: In Latvia, data from Wave 8 of the Survey of Health, Aging and Retirement in Europe (SHARE), involving 420 respondents, were used. For comparative analysis, data from a HL20 study on the health and wellbeing of the older adults in Iceland, which included 1,033 respondents, were used.

Results: For Latvia, 13 items were selected, and for Iceland, nine items were selected. We constructed the HAI with four similar subscales for both countries—"Autonomy," "Health," "Wellbeing," and "Activities," and an additional subscale "Cognitive" for Latvia. We found matching items in all four subscales. For the Autonomy subscale, they were related to difficulties with everyday and daily tasks. In the Health subscale, the only matching item was self-rated physical health. One item related to loneliness was found for the Wellbeing subscale and one item related to social participation for the Activities subscale.

Discussion: In our study, we found evidence for the successful construction of a HAI in two different datasets. The strength of our construct lies in the use of data from one of the largest social science panel studies in Europe (SHARE). As we were able to apply the construct to the Icelandic study, we believe that items presented in our approach are available in other population-based studies as well, and, therefore, can be easily replicated by others. By examining the existing SHARE data, HAI could be used to analyze long-term changes and could provide a foundation for comparing and monitoring the evolution of aging over time as well as comparing the aging process across societies. This is required for the authorities to conduct further analyses, proposals, and action plans in support of healthy aging.

KEYWORDS

Survey of Health, Ageing and Retirement in Europe, wellbeing, autonomy, health, activities, cognitive, Latvia

Introduction

Throughout the development of a definition of healthy aging, different concepts were available, starting from a negative aspect until the 1960s, when aging was considered a progressive, linear decline toward death (1). Moving forward, attitudes changed to a more positive approach. In 1987, when Rowe & Kahn developed the concept of successful aging, they emphasized the role of intrinsic and extrinsic factors on an individual's health. However, their concept received much criticism as it focused more on the absence of disease. In 1997, they expanded their definition by addressing the importance of protective factors (2, 3). In 2002, the World Health Organization (WHO) presented the "global policy guidelines for active aging" with a definition of active aging as the process of optimizing opportunities for health, participation, and security to enhance the quality of life as people age (4). Since 2015, the WHO has developed the Healthy Aging Strategy, which is a combination of previous concepts and defines healthy aging as "the process of developing and maintaining the functional ability that enables wellbeing in older age" (5).

Healthy aging concept addresses the change in how we think, feel, and act toward age and aging. The three interrelated components of healthy aging are functional ability, intrinsic capacity, and environments (5). Functional ability combines the intrinsic capacity of the individual, the environment a person lives in, and how people interact with their environment. The key concepts are the ability to meet basic needs, to learn, grow, and make decisions, to be mobile, to build and maintain relationships, and to contribute to society. Intrinsic capacity includes locomotor (physical movement), sensory (vision, hearing), vitality (energy and balance), cognition, and psychological capacity. Information on all domains of each component can help prioritize and tailor interventions to an older person's specific needs, preferences, and goals.

To develop an effective healthy aging strategy, a tool for assessing aging process is vital. However, there is a lack of a unanimous definition and standardized metric for the evaluation of healthy aging (6–9). The HAI serves as a valuable tool for policymakers to design evidence-based policies and programs that promote healthy aging and address the unique needs of older adults. It provides a data-driven framework for decision-making and resource allocation in such areas as healthcare, social services, and community support systems.

World Health Organization baseline report on the Decade of healthy aging has summarized 25 items in measuring intrinsic capacity and 27 items in measuring functional abilities (5). Therefore, healthy aging can be measured, even nationwide, if sufficient comparable items are included. In most studies, only some of them are reported, which does not encourage comparative research.

Recent systematic review by Behr et al. (1) shows, that 13 attempts to measure the aging process already have been published. Only one of them includes all intrinsic capacity domains (10), but lacks several functional ability domains. Some of those scores are hard to apply due to complex calculations and the construction of specific items. None of them have been replicated by others. The most common factors in those attempts included general health status, functioning and disability, quality of life (QoL), emotional and psychological health, cognitive functioning, and lifestyle factors. Less often, such factors as medical information and activities of daily living (ADL)/instrumental activities of daily living (iADL) were used.

The challenge around the world lies in developing and choosing a good enough score that is easy to apply, has a construct of variables that are available in most nationwide surveys for comparable results, and at the same time reflects the aging process of older individuals.

The purpose of this study is to examine specifically whether there is a theoretical and practical basis for developing/calculating HAI in the data of two countries. The HAI that would be constructed under the basis of available data would create a discussion and position in each country, and call for an examination of factors and conditions that creates a different score on the HAI. In addition, the use of existing data and HAIs opens up development and monitoring over time.

Methodology

Participants

Latvia

Study was based on the sample of older individuals from wave 8 of the Survey of Health, Aging and Retirement in Europe (SHARE) during the period from June till August 2020.

Survey of Health, Aging and Retirement in Europe is the largest social science panel study and has set new standards in research and scientific data collection. It has a global impact since it not only covers all EU member countries in a strictly harmonized way but additionally is embedded in a network of sister studies all over the world, from the Americas to Eastern Asia (11, 12).

Iceland

The wellbeing of older adults in Iceland was studied through a HL20 research conducted in 2020. The study focused on Icelandic citizens who had attained retirement age, and a simple random sample of 1,800 individuals was selected from the national registry. Out of this sample, 1,033 respondents completed the survey either via computer-assisted telephone interview (42%) or computer-assisted web interview (58%). The survey was carried out from November 2020 to January 2021.

To perform comparison between both countries, the sample of Latvia was limited to respondents aged 67 and older, with participation in both—the main questionnaire and COVID-19 add-on. Sample size for Latvia consisted of 420 respondents.

Statistical analysis

Statistical analysis was conducted using Jamovi v.2.3.21, IBM SPSS Statistics v.27 and R v.4.3.0. For comparison of the constructed HAI such descriptive statistics measures as median and quartiles were used. To test the fitting of the created construct of HAI, a confirmatory factor analysis (CFA) was used.

$p < 0.05$ was set as the significance level.

Construct and calculations of the healthy aging index

In the first step of constructing the HAI, we explored both datasets to find similar items for our construct (see Figure 1). For Latvia, a total of 13 items were selected. For Iceland, nine items were selected.

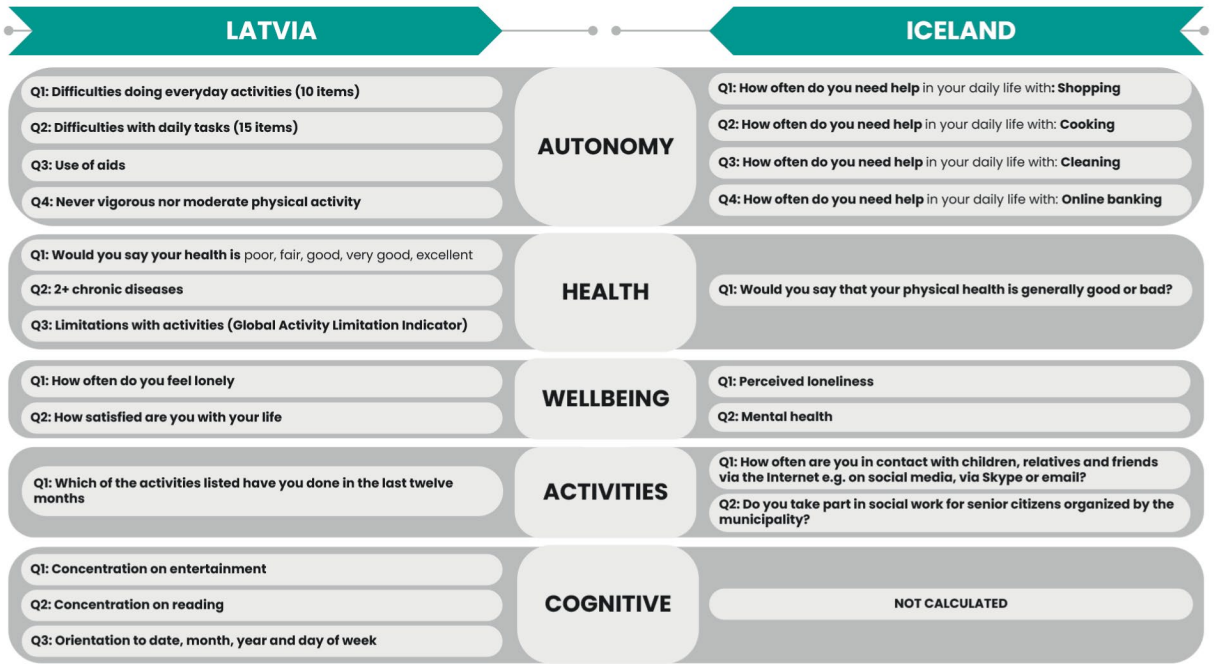


FIGURE 1
Comparison of items included in the HAI.

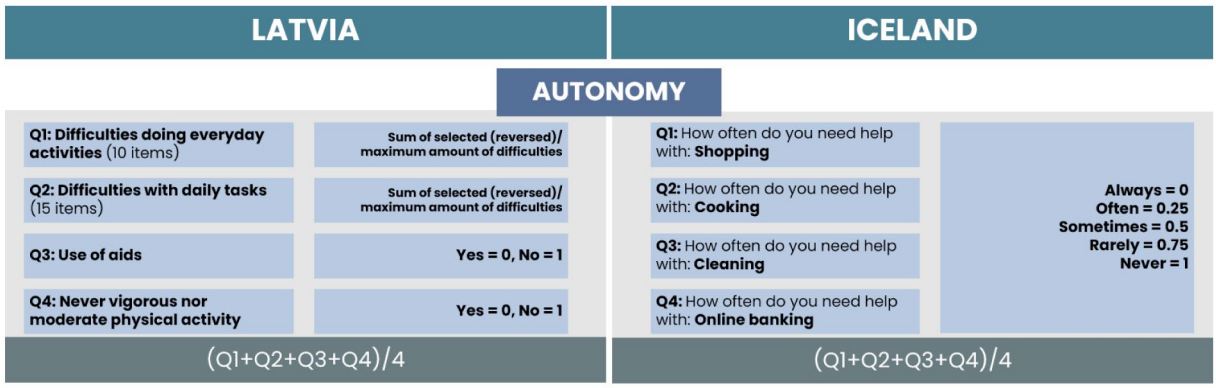


FIGURE 2
Comparison of items and calculation process for the Autonomy subscale.

We divided all items into five subscales. As Icelandic data did not cover the cognitive aspect of healthy aging, this subscale was used only for Latvia.

For the Autonomy subscale, four items were selected for both countries (see Figure 2). We found matching items for both countries related to difficulties with everyday and daily tasks. The only difference in the statement of the question and the received responses. In Latvia, respondents were asked to select from 10 everyday tasks or 15 daily tasks with answers of "selected" or "not selected" (see Figure 3).

In the Icelandic data, four daily tasks were included, with a statement to rate the frequency of help needed. For calculation of the HAI in the Latvian dataset, we counted the total amount of selected difficulties for each respondent, reversed the score (0 difficulties as 10 points, 10 difficulties as 0 points, 0 difficulties as 15 points, and 15 difficulties as 0 points), and divided by the maximum number of difficulties reached. For Icelandic data, we coded the frequency of help needed from 0 to 1, where 0 indicates that help is always needed and 1 indicates that help is never needed. Two additional items were selected for Latvia related to the use of aids and the level of physical activity. As they were on a dichotomous scale, the coding of 0 or 1 was applied. The total score of the autonomy subscale is the average value of the scores of all items.

For the Health subscale, we found one matching item for both countries related to self-rated physical health (see Figure 4). The answers were on a five-point Likert type scale. From the Latvian dataset, two additional items were selected related to the presence of chronic diseases and limitations with activities (global activity limitation index). As they were on a dichotomous scale, the coding of

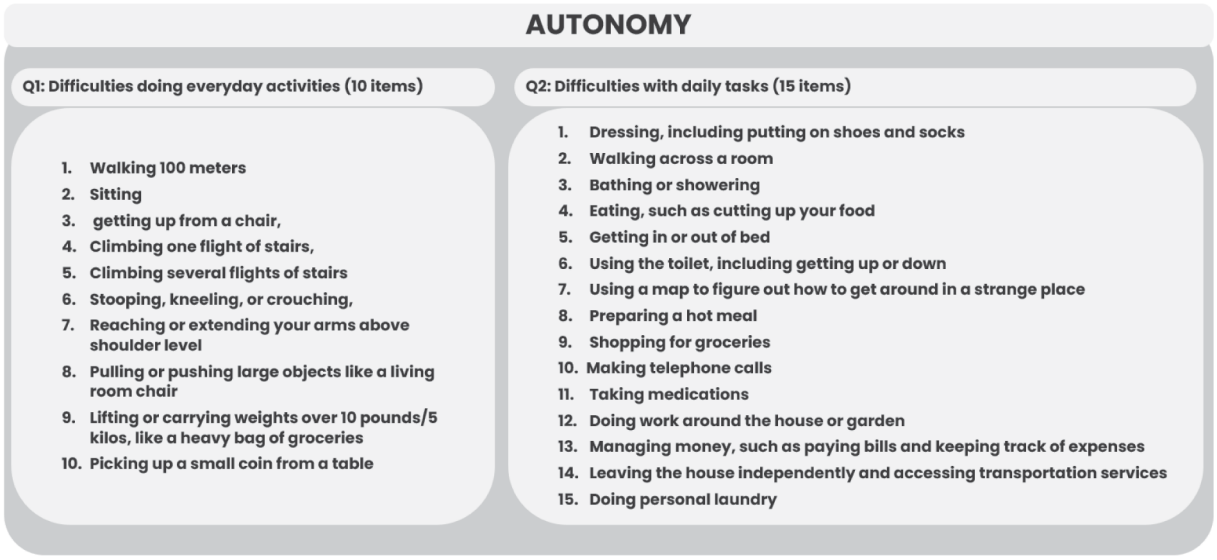


FIGURE 3
List of difficulties doing everyday activities and daily tasks for the HAI of Latvia.

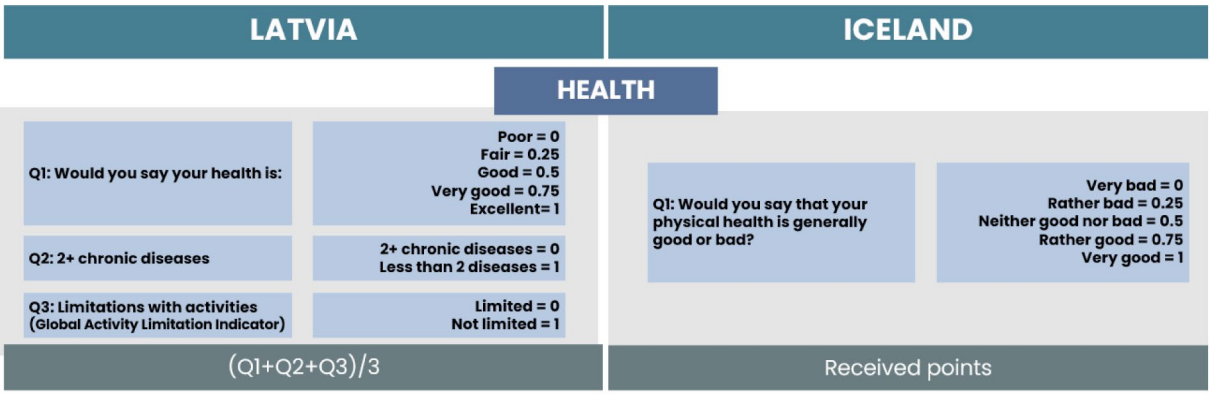


FIGURE 4
Comparison of items and calculation process for the Health subscale.

0 or 1 was applied. The total score of the health subscale is the average value of the scores of all items. In the Icelandic dataset, this was the only item for health, and the received points are the total score of the subscale.

For the Wellbeing subscale, two items were selected for both countries. We found one matching item related to loneliness (see Figure 5). The only difference is in the received responses; in Latvia, respondents were asked to rate the frequency of loneliness on a three-point scale. For Iceland, the answers were on a five-point Likert type scale. The responses can be compared as "Often" can be related to "Very often or always," "Some of the time" with "Sometimes," and "Hardly ever or never" with "Very seldom or never" (see Figure 5). For both countries, responses were coded from 0 to 1, where 0 indicates feelings of loneliness very seldom or never/hardly ever or never and 1 indicates feelings of loneliness very often or always/often.

For Latvia, we included one additional item related to satisfaction with life. The answers were on a 10-point scale, where the received points were divided by 10. For Iceland, we included one additional item related to mental health. The answers were on a five-point Likert-type scale, and we applied a similar approach for coding the data, where 0 points indicate very bad mental health and 1 point indicates very good mental health. The total score of the wellbeing subscale is the average value of the scores of all items.

For the Activities subscale, one item for Latvia and two items for Iceland were selected (see Figure 6). The chosen item for Latvia included nine items from different social activities. For calculation of the HAI in the Latvian dataset, we counted the total amount of selected activities for each respondent and divided it by the maximum number of activities reached. For Icelandic data, one item was related to electronic contact frequency with children, relatives, and friends. We coded the frequency of contacts from 0 to 1, where 0 indicates more seldom or never contact and 1 indicates daily or more often electronic contact frequency. The second included item for Iceland

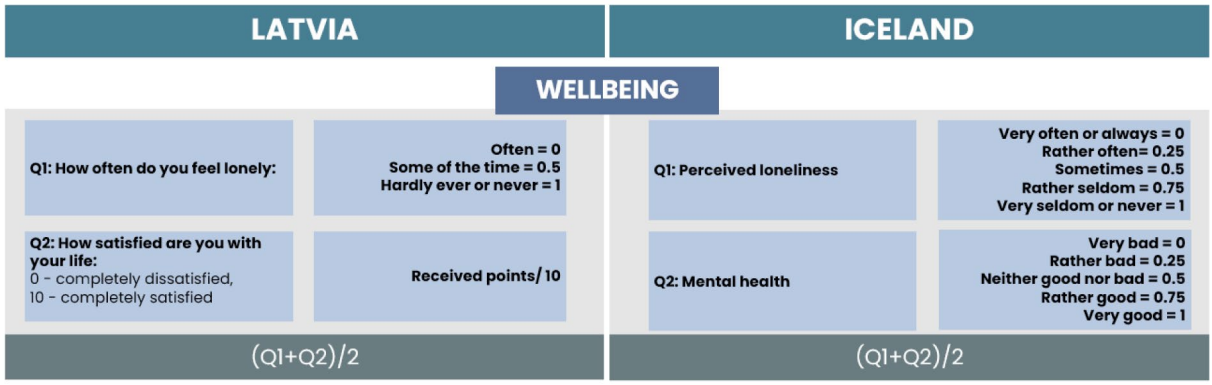


FIGURE 5
Comparison of items and calculation process for the Wellbeing subscale.

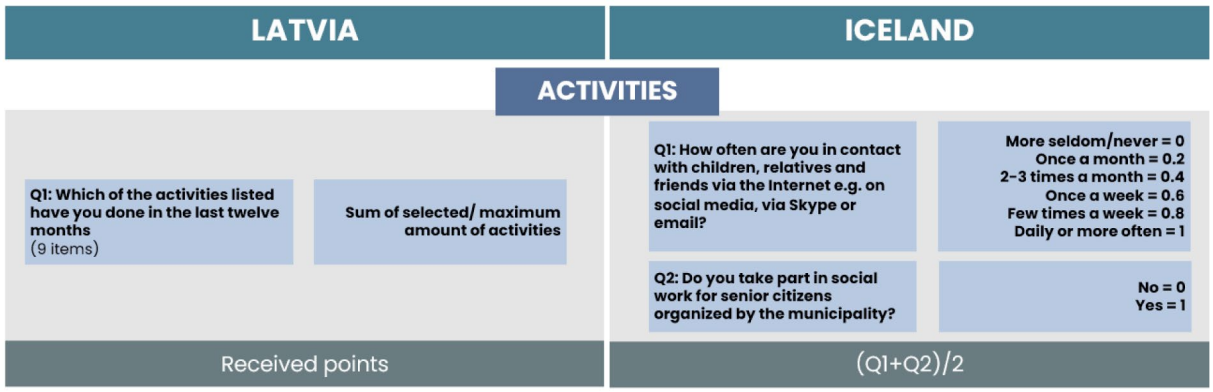


FIGURE 6
Comparison of items and calculation process for the Activities subscale.

was related to taking part in social work for senior citizens organized by the municipality. As responses were dichotomous, we coded them with 0 for no such activities and 1 for participation in such activities. The total score of the activities subscale is the average value of the scores of all items.

We found three items related to the Cognitive subscale for Latvia (see Figure 7). For Iceland this subscale is not calculated as no items were present in a dataset. Two items were related to concentration on entertainment and reading, and one item was related to orientation to date, time, year, and day of the week. The dichotomous responses for concentration on entertainment and reading were coded with 0 and 1, where 0 indicates difficulties in concentration and 1 indicates no such difficulties. Responses regarding orientation were on a four-point scale, where 0 indicates bad orientation in each item (date, month, year, and day of the week) and 4 indicates good orientation in all four items. The total score of the cognitive subscale is the average value of the scores of all items.

For further analysis to compare the overall process of healthy aging, we calculated the outcome as the average score of all subscales (see Figure 8). For easier interpretation, the total score was multiplied by 10.

Results

Factor loadings and fit indices of the constructed healthy aging index

Results for confirmatory factor analysis for both Latvia and Iceland showed high factor loadings between items and factors. For Latvia, the lowest loading was 0.23 and the highest 0.89 with most loadings being in the range of 0.47–0.89; for Iceland apart from one loading being −0.05, the lowest loading was −0.50; and the highest loading was 0.92.

Factor solution for both countries showed a good fit (see Table 1). For both the Latvian and Icelandic solution, most of the fit indexes we looked at indicated a good fit, only SRMR was slightly above the threshold for Iceland (13).

Comparison of overall healthy aging index and its subscales

The construct of the HAI can measure physical, mental capacities (intrinsic capacity) and functional abilities of older individuals,

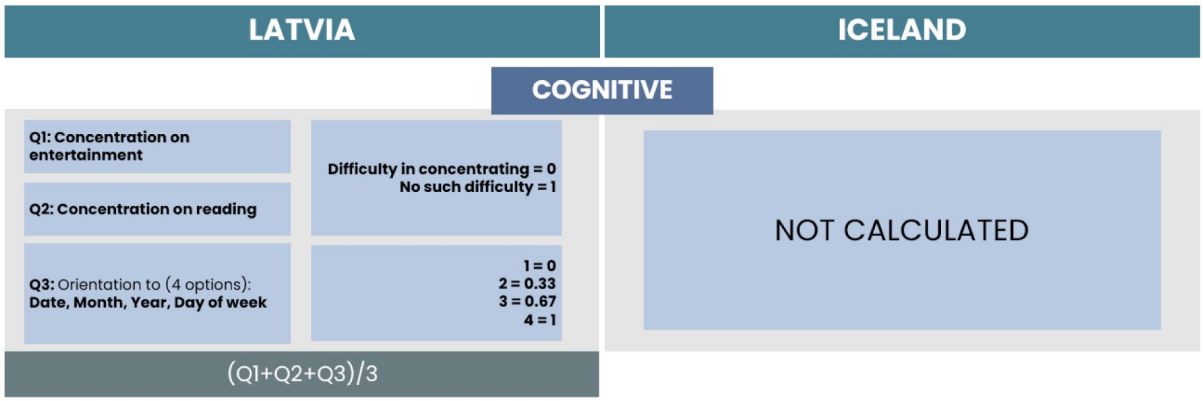


FIGURE 7
Comparison of items and calculation process for the Cognitive subscale.

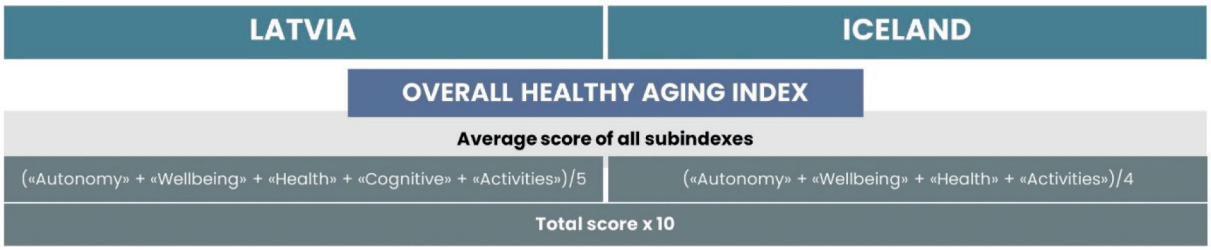


FIGURE 8
Calculation of overall HAI.

according to the WHO conceptual model of healthy aging. The overall score of our construct is measured on a 10-point scale, where 10—indicates healthy aging (less or no decline in items related to mental, physical, and functional abilities) and 0—indicates "unhealthy" aging (more difficulties, lower levels of self-rated health and satisfaction with life, higher levels of loneliness, and less participation in social activities).

Overall, the distribution of the HAI for older individuals in Latvia was lower, compared to Iceland, with median points for Latvia of 4.44 (without Cognitive subscale) and for Iceland of 7.03 points (see Figure 9). The lower score for Latvia is due to fewer points scored in the subscales of Health (self-rated health, presence of chronic diseases, and limitations with activities) and Activities (less participation in social activities).

The comparison of subscales for both countries shows that lower scores are obtained in such subscales as Health, Activities, and Cognitive for Latvia (see Figure 10).

The highest obtained scores for both countries were in the subscales of Autonomy and Wellbeing (see Figure 11).

Discussion

On the datasets

The main goal of the study was to examine if and how the different datasets of two countries could be used to develop an index that could be useful for comparison and further discussion on the factors contributing to healthy aging in diverse cultural and societal contexts. It can also facilitate knowledge sharing and the exchange of best practices among countries.

In our study, we reached the aim as regard constructing a comparable Healthy Aging Index (HAI) from two different datasets. For Latvia, 13 items and for Iceland, nine items were used. We constructed HAI with four similar subscales for both countries—"Autonomy," "Health," "Wellbeing," and "Activities," and an additional subscale "Cognitive" for Latvia.

Furthermore, in our study, we demonstrated that items measuring underlying concepts of healthy aging can be found not only in large datasets, like the Survey of Health, Aging, and Retirement in Europe (SHARE) survey, but also in a variety of national datasets, e.g., the Icelandic HL20 study.

Although the available datasets from different population studies may not be completely identical, they might share similar items aligned with the theoretical framework. Conducting further analysis could ascertain whether these datasets form the HAI index and its subcomponents in each respective case.

The use of data from one of Europe's largest social science panel studies (SHARE) contributes to the strength of our model. As we were able to apply the construct to the Icelandic HL20 study, the items presented in our approach can be easily found in other population-based studies, including all countries that participate in the SHARE survey, and can thus be easily replicated by others. We examined the available data for other countries participating in SHARE. The results

TABLE 1 Model fit for confirmatory factor analysis for the HAI.*

	Chi-square	Df	*p* value	Root mean square error of approximation (RMSEA)	Standardized root mean square residual (SRMR)	Non normal fit index (NNFI)	Comparative fit index (CFI)	Adjusted goodness of fit (AGFI)
Latvia	51.8	32	0.015	0.039	0.048	0.986	0.990	0.999
Iceland	104.6	32	<0.001	0.049	0.058	0.975	0.982	0.989

*As Cognitive subscale was not calculated for Iceland, it was excluded from the CFA for Latvia.

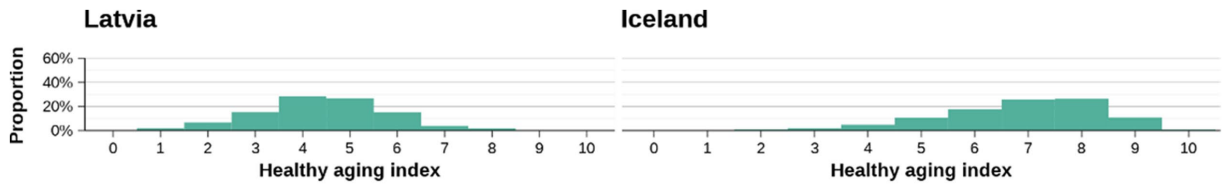


FIGURE 9
Distribution of the HAI.

indicate that there is a suitable foundation for comparing our HAI model across different countries. However, any additional in-depth discussion or detailed explanation of these findings falls outside the scope of this article.

Utilizing the existing secondary data offers a cost-effective, time-efficient, and flexible approach for research. It enables researchers to access large sample sizes, conduct longitudinal analyses, and perform comparative studies without the financial burden of primary data collection.

On the method

After analyzing the available data from both countries, we conducted a theoretical review of the factors relevant to the existing and recent literature on the HAI. Subsequently, we performed confirmatory factor analysis (CFA) on both datasets and successfully confirmed the presence of HAIs in them. There are several different methods that might be used for the construction of an index, for example the UNDP approach (14, 15), Principal component analysis (16) etc. CFA was the most suitable method as it allowed us to test specific hypotheses regarding the underlying factor structure and the model's fit to the data.

There is ongoing discussion related to the development of new healthy aging measurement tools, with the implication of focusing more on the validation of existing ones (1). Before constructing our approach, we also reviewed some of the existing scores to assess differences and similarities.

On the theoretical approach and practical use

One of the remaining challenges is related to the lack of a unified definition of healthy aging. Rodriguez-Laso et al. (17) tested four different definitions of healthy aging. The measured prevalence of more positive results toward healthy aging increased depending on definitions, rising from 4.5% for Rowe and Kahn's definition (freedom from disease, disability, and risk factors for disease; high physical function; and cognitive function at or above the median for one's gender and age group) to 49.2% for a definition with fewer criteria (freedom from disability; high physical function; and freedom from severe cognitive impairment). Freedom from disease and risk factors for disease were the main reasons for not meeting the more rigorous definitions.

To reduce such bias, our construct of HAI is based on a combination of various definitions. The main factors selected for our construct are related to being free of chronic diseases, autonomy in activities of daily living, wellbeing, good quality of life, high social participation, only mild cognitive or functional impairment, and little or no disability (18). Instead of using the factor "being free of chronic diseases" due to its criticism, we chose the item "prevalence of at least two chronic diseases."

From all existing attempts to measure the aging process, three of them used the SHARE survey (10, 19, 20). We have utilized similar approach as in a study by Sanchez-Niubo et al. (10), where they also based their theoretical framework on the WHO concept of healthy aging. The strength of their methodology lies in the use of two large studies: the Aging Trajectories of Health-Longitudinal Opportunities and Synergies (ATHLOS) project, with the data of 16 international cohorts, and the SHARE survey. It leads to the conclusion that items, related to concepts of healthy aging, can easily be found in various studies. They used item response theory (IRT) modeling, which allows testing and adjusting the effect of potential confounders on individual responses, such as the specific effects of cohorts, gender, and cultural factors. From all the attempts to measure aging process, this can be considered one of the best. However, we also found some weaknesses related to replicability issues in this approach. First, they were able to cover all domains of intrinsic capacity by including 41 items, but for replicability, all items need to be present in a dataset. By

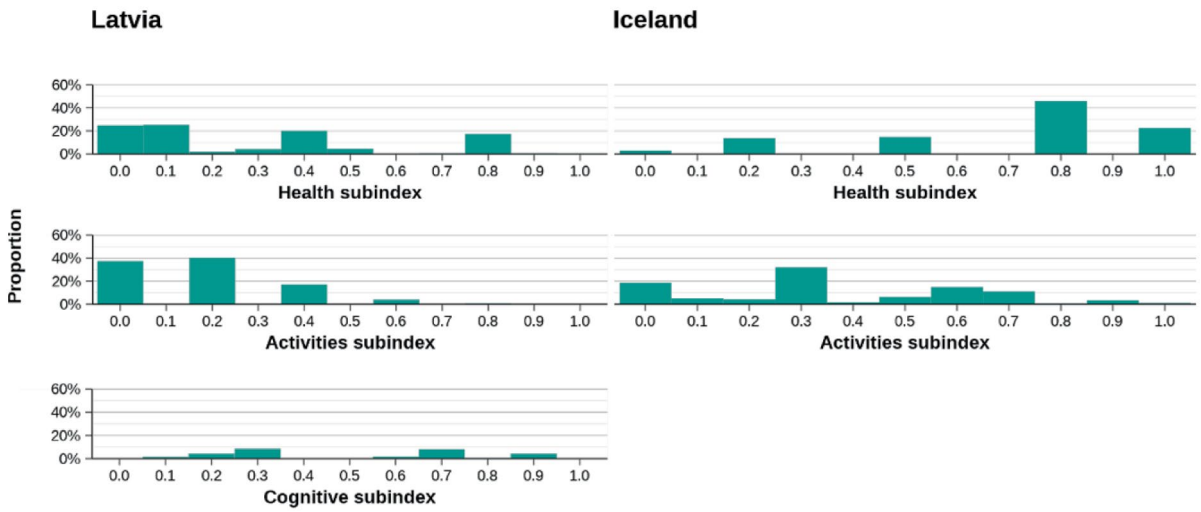


FIGURE 10
Distribution for subscales with lower scores.

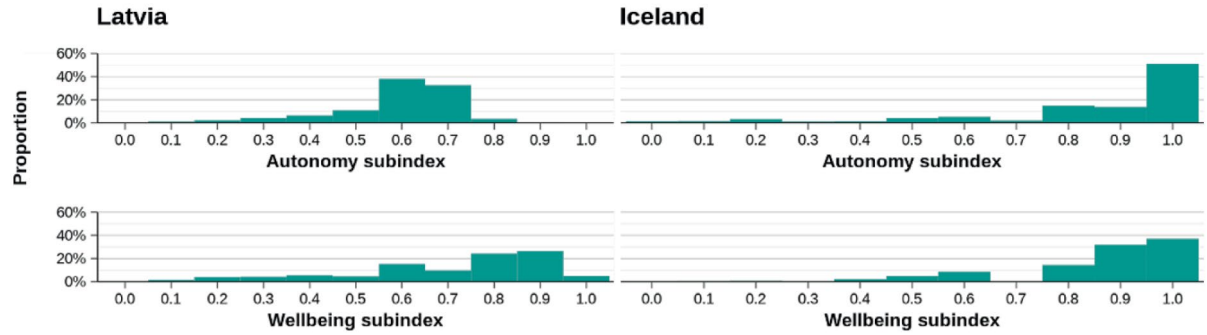


FIGURE 11
Distribution for the subscales with higher scores.

exploring the available data for Latvia from the SHARE survey, some factors were not available, and this issue might be relevant for other SHARE participant countries as well. Second, no items related to functional abilities were present. We found only one study that used the same scoring for that outcome (7).

The ideal construct of a healthy aging measurement tool also depends on standardized items within each domain. Some of the domains of intrinsic capacity were represented in almost all existing studies; however, all domains of intrinsic capacity were included in only three of them (7, 10, 21, 22). Such domains as vitality, cognition, and psychology are the most commonly used, i.e., 76% of the reviewed studies reported them. Such domains as locomotion and sensory were reported in only 4–5 studies (7, 10, 23–25).

We deliberately did not include factors related to the sensory domain, as no such items were available in the Icelandic dataset, and items regarding sensory functions have little or no impact on healthy aging, compared to other factors.

The most different approach exists in the vitality domain. Biomarkers and functional tests (Cystatin C, CRP, glomerular filtration rate, level of blood glucose, creatinine, systolic blood pressure, peak expiratory flow, and BMI) were used in some studies for measuring the vitality domain (26–31). However, the presence of chronic diseases, limitations in physical functions, and factors related to self-rated physical health are more frequently used to measure vitality.

According to the WHO, vitality domains can be measured with different types of biomarkers. At the same time, they also state that such biomarkers as body mass index, weight, waist circumference, waist-to-hip ratio, and calf circumference can lead to bias due to inaccuracy for older people due to posture, scoliosis, variability by age, sex, and ethnicity, as well as problems with selecting appropriate cut-off points (5). Inclusion of biomarkers in the construct of the HAI can strengthen the limitation of the replicability of developed scores, as specific biomarkers in large cohort studies might not be available.

However, we noticed similarities in measuring psychological domains and functional abilities. In most of the studies, items related to functional abilities—ADL or iADL and difficulties performing the activities of daily living and everyday tasks were used (17).

Psychosocial factors, such as wellbeing, depression, and loneliness, are important measures, especially since the COVID-19 pandemic. As these measures are often included in health and retirement studies and are proposed by the WHO for assessment of functional abilities, they can be used in a standardized score of healthy aging (5, 10, 21, 24, 32–35). Previous research related to the exploration of the intrinsic capacity factors for the Latvian population also confirms this evidence (36, 37).

Another vital component of healthy aging is social wellbeing, which can be investigated through questions about participation in different social activities, social networks, and social support (1). They were present in some of the reviewed studies (7, 21, 22, 24, 29, 33, 35, 38). The only factor included in our construct related to social wellbeing was participation in various social activities.

On statistics

An ideal approach for evaluating healthy aging lies in a simple score, scale, or index that weights domains of intrinsic capacity, functional ability, and environment (1). However, the universal weighing procedure is almost impossible. The importance of each domain may vary across different populations and can have significant variations in individual preferences and priorities when it comes to healthy aging. The final score of our construct is based on the average value of all subscales. The HAI composite indicator was calculated with equal weighting (EW) for each dimension. Further, each item in the dimensions had an EW. Since assigning different weights to the underlying dimensions is subjective; assigning different weights would express different importance of the items. There is no existing evidence about the importance of different items of the HAI. This approach provides a more balanced representation of each subscale by considering multiple indicators rather than relying on a single item.

There are different data preprocessing techniques for item scaling. Normalization is used to eliminate the influence of the original scale or units of measurement, and is commonly used in PCA. Min-Max normalization is useful to scale the data to a specific range and preserve the original data's distribution and relationships, but this approach is sensitive to outliers, and extreme values may disproportionately influence the scaling. We performed a scaling procedure that is similar to the Min-Max approach: responses for each item were transformed from 0 to 1 for easier interpretation and comparison.

After scaling, the total score for each country for HAI is on a scale of 1–10. The resulting values provide a relative reflection of the variables present in the data of each country. These scores, both theoretically and statistically, form the basis for constructing the HAI.

Scores or scales also involve the danger of oversimplification. Oversimplification can happen if multiple measures are dichotomized and summed to build a quantitative score instead of using the multidimensional underlying data. Some of the reviewed studies used the percentile approach for grouping the outcome, which links the score to the characteristics of the cohort utilized and is not feasible for different cohorts (26–28, 31, 34, 39, 40). The categorization of outcomes involved statements such as "healthiest and unhealthiest," "healthiest, less healthy, and least healthy," "healthy aging, intermediate aging, and poor aging."

Our approach to the construct has less bias regarding the dichotomization of items included and the outcome itself. We used original responses for items included in the construct for both countries. We chose the outcome of our construct as a score because a continuous outcome can capture a broader range of responses and provide more nuanced insights into the measured construct. Also, scores can promote greater statistical power, measurement validity, and flexibility in data analysis.

Besides the limitations related to the lack of consensus and standardization regarding the definition and assessment of healthy aging a balance between complexity and simplicity is needed. As our construct is based on different datasets, linguistic bias can also be present regarding the way a question is phrased or the specific words used, as it can prime respondents to think in a particular way or direct their attention to certain aspects. It can be reduced by employing the same methodology consistently across different populations and using standardized language and questionnaires, as well as ensuring clarity and neutrality in the wording of questions.

Validation and long-term evaluation of the developed index are critical. Assessment of its long-term predictive value can ensure that the index remains relevant and reliable in assessing healthy aging outcomes.

The diversity of the data presents both a challenge and an opportunity for exploration. The demographic variations among communities manifest in the diverse range of scores, thereby highlighting the strengths and weaknesses of each respective society. The findings of this study, along with the HAI index for each country, serve as a foundation for stimulating discussions and explanations regarding the reasons behind the observed deviations among countries. Through such discussions, insights into the disparities and underlying factors can be gained, fostering a deeper understanding of the societal dynamics at play.

In conclusion, the used approach to develop and test the Healthy Aging Index (HAI) could serve for validation of other scales to measure aging processes.

Our HAI construct has proven usefulness in examining and comparing the aging process in various societies. For example, by examining existing the SHARE data, HAI could be used to analyze long-term changes. In this way, the HAI could provide a foundation for comparing and monitoring the evolution of aging over time, as well as comparing the aging process across societies. In this way, a clearer picture of the aging process can be obtained, particularly with regard to those personal abilities that tend to deteriorate with age. This image is required for the authorities to conduct further analyses, proposals, and action plans in support of healthy aging.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

MM, IR, ST, and HaG: conceptualization. MM, ST, IR, HeG, and HaG: methodology. MM and HeG: software and formal analysis. AI:

validation. MM: investigation, writing—original draft preparation, and visualization. IR, HaG, ST, and AI: writing—review and editing and supervision. All authors contributed to the article and approved the submitted version.

Funding

Collaboration between Riga Stradiņš University and the University of Iceland was supported by the EEA initiative FM2021/23 (EEZ/NOFI/DIV) in the project "Modeling of the Impact of COVID-19 on Public Health of Elderly People" in Latvia and Iceland. The use of the Icelandic data from HL20 is based on the consent from all funding. The use of Icelandic HL20 data is based on the approval of public bodies and other parties that originally organized and paid for the costs of the research.

Acknowledgments

This paper uses data from SHARE Waves 1–9 (DOIs: 10.6103/SHARE.w1.800, 10.6103/SHARE.w2.800, 10.6103/SHARE.w3.800, 10.6103/SHARE.w4.800, 10.6103/SHARE.w5.800, 10.6103/SHARE.w6.800, 10.6103/SHARE.w7.800, 10.6103/SHARE.w8.800, 10.6103/SHARE.w8ca.800, and 10.6103/SHARE.w9ca800) see Börsch-Supan et al. (41) for methodological details. The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, and SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, and the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, and RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Behr LC, Simm A, Kluttig A, Großkopf AG. 60 years of healthy aging: on definitions, biomarkers, scores and challenges. *Ageing Res Rev*. (2023) 88:101934. doi: 10.1016/j.arr.2023.101934

2. Rowe JW, Kahn RL. Human aging: usual and successful. *Science*. (1987) 237:143–9. doi: 10.1126/science.3299702

3. Rowe JW, Kahn RL. Successful aging. *Gerontologist*. (1997) 37:433–40. doi: 10.1093/geront/37.4.433

4. World Health Organization (2002). Active ageing: A policy framework (No. WHO/NMH/NPH/02.8). World Health Organization.

5. World Health Organization (2020). Decade of healthy ageing. Baseline report. World Health Organization.

6. Cosco TD, Stephan BCM, Brayne C. Validation of an a priori, index model of successful aging in a population-based cohort study: the successful aging index. *Int Psychogeriatr*. (2015) 27:1971–7. doi: 10.1017/s1041610215000708

7. Daskalopoulou C, Chua K, Koukounari A, Caballero FS, Prince M, Prina M. Development of a healthy ageing index in Latin American countries—a 10/66 dementia research group population-based study. *BMC Med Res Methodol*. (2019) 19:226. doi: 10.1186/s12874-019-0849-y

8. Sowa A, Tobiasz-Adamczyk B, Topór-Mądry R, Poscia A, La Milia DI. Predictors of healthy ageing: public health policy targets. *BMC Health Serv Res*. (2016) 16:289. doi: 10.1186/s12913-016-1520-5

9. Tyrovolas S, Haro JM, Mariolis A, Piscopo S, Valacchi G, Tsakountakis N, et al. Successful aging, dietary habits and health status of elderly individuals: a k-dimensional approach within the multi-national MEDIS study. *Exp Gerontol*. (2014) 60:57–63. doi: 10.1016/j.exger.2014.09.010

10. Sanchez-Niubo A, Forero CG, Wu Y, Gine-Vazquez I, Prina M, De La Fuente J, et al. Development of a common scale for measuring healthy ageing across the world: results from the ATHLOS consortium. *Int J Epidemiol*. (2021) 50:880–92. doi: 10.1093/ije/dyaa236

11. Börsch-Supan A. (2022). Survey of health, ageing and retirement in Europe (SHARE) wave 8. Release version: 8.0.0. SHARE-ERIC. Data set.

12. Börsch-Supan A. (2022). Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 8. COVID-19 Survey 1. Release version: 8.0.0. SHARE-ERIC. Data set. doi: 10.6103/SHARE.w8ca.800

13. Hooper D, Coughlan J, Mullen MT. Structural equation modelling: guidelines for determining model fit. The electronic journal of business research. *Methods*. (2008) 6:53–60. doi: 10.21427/d7cf7r

14. Kiran T, Junaid KP, Rajagopal V, Gupta M, Sharma D. Measurement and mapping of maternal health service coverage through a novel composite index: a sub-national level analysis in India. *BioMed BMC Pregnancy Childbirth*. (2022) 22:1–17. doi: 10.1186/s12884-022-05080-5

15. Sharma D, Kiran T, Goel K, Junaid KP, Rajagopal V, Gupta M, et al. Comprehensive assessment of age-specific mortality rate and its incremental changes using a composite measure: a sub-national analysis of rural Indian women. *Front Med*. (2022) 9:1046072. doi: 10.3389/fmed.2022.1046072

16. Lalloué B, Monnez JM, Padilla C, Kihal W, Meur NL, Zmirou-Navier D, et al. A statistical procedure to create a neighborhood socioeconomic index for health inequalities analysis—international journal for equity in health. *BioMed Central*. (2013) 12:21. doi: 10.1186/1475-9276-12-21

17. Rodríguez-Laso Á, McLaughlin SJ, Urdaneta E, Yanguas J. Defining and estimating healthy aging in Spain: a cross-sectional study. *Gerontologist*. (2018) 58:388–98. doi: 10.1093/geront/gnw266

18. Fuchs J, Scheidt-Nave C, Hinrichs T, Mergenthaler A, Stein J, Riedel-Heller SG, et al. Indicators for healthy ageing — a debate. *Int J Environ Res Public Health*. (2013) 10:6630–44. doi: 10.3390/ijerph10126630

19. Gonçalves J, Gomes MJ, Fonseca M, Teodoro T, Barros PP, Botelho MF. Selfie aging index: an index for the self-assessment of healthy and active aging. *Front Med*. (2017) 4:236. doi: 10.3389/fmed.2017.00236

20. Rojo-Perez F, Rodriguez-Rodriguez V, Molina-Martinez MA, Fernandez-Mayoralas G, Sanchez-Gonzalez D, Rojo-Abuin JM, et al. Active ageing profiles among older adults in Spain: a multivariate analysis based on SHARE study. *PLoS One*. (2022) 17:e0272549. doi: 10.1371/journal.pone.0272549

21. Afrin S, Haque MA. Construction of the active aging index in Bangladesh: challenges and opportunities. *Heliyon*. (2022) 8:e10922. doi: 10.1016/j.heliyon.2022.e10922

22. Pham VVH, Chen Y, Van Duong T, Nguyen TD, Chie W. Adaptation and validation of active aging index among older Vietnamese adults. *J Aging Health*. (2019) 32:604–15. doi: 10.1177/0898264319841524

23. Gao J, Xu J, Chen Y, Wang Y, Ye B, Fu H. Development and validation of a multidimensional population-based healthy aging scale: results from the China health and retirement longitudinal study. *Front Med*. (2022) 9:853759. doi: 10.3389/fmed.2022.853759

24. Lu C, Zong J, Wang L, Du Y, Wang Q. Healthy aging index and its link with relative education between individual and neighborhood: a population-based, cohort study. *BMC Geriatr*. (2022) 22:778. doi: 10.1186/s12877-022-03469-7

25. McCabe EL, Larson MG, Lunetta KL, Newman AB, Cheng S, Murabito JM. Association of an Index of healthy aging with incident cardiovascular disease and mortality in a community-based sample of older adults. *J Gerontol*. (2016) 71:1695–701. doi: 10.1093/gerona/glw077

26. Li K, Xu W, Hu B, Shan Q, Liu L, Cao J. The modified healthy aging index is associated with mobility limitations and falls in a community-based sample of oldest old. *Aging Clin Exp Res*. (2021) 33:555–62. doi: 10.1007/s40520-020-01560-w

27. Newman AB, Boudreau RM, Naydeck BL, Fried LP, Harris TB. A physiologic index of comorbidity: relationship to mortality and disability. *J Gerontol*. (2008) 63:603–9. doi: 10.1093/gerona/63.6.603

28. Sanders JL, Boudreau RM, Penninx BW, Simonsick EM, Kritchevsky SB, Satterfield S, et al. Association of a Modified Physiologic Index with Mortality and Incident Disability: the health, aging, and body composition study. *J Gerontol*. (2012) 67:1439–46. doi: 10.1093/gerona/gls123

29. Zaidi A., Gasior K., Hofmarcher M.M., Lelkes O., Marin B., Rodrigues R., et al. (2012). Active ageing index 2012. Concept, methodology and final results. Vienna: European Centre.

30. Wang Y, Li Y, Zhang N, Sun X, Xin B. The change and correlates of healthy ageing among Chinese older adults: findings from the China health and retirement longitudinal study. *BMC Geriatr*. (2021) 21:78. doi: 10.1186/s12877-021-02026-y

31. Wu C, Smit E, Sanders JL, Newman AB, Odden MC. A modified healthy aging index and its association with mortality: the National Health and nutrition examination survey, 1999–2002. *J Gerontol*. (2017) 72:1437–44. doi: 10.1093/gerona/glw334

32. Assmann KE, Andreeva VA, Jeandel C, Hercberg S, Galan P, Kesse-Guyot E. Healthy aging 5 years after a period of daily supplementation with antioxidant nutrients: a post hoc analysis of the French randomized trial SU.VI.MAX. *Am J Epidemiol*. (2015) 182:694–704. doi: 10.1093/aje/kwv105

33. Gwee X, Nyunt MSZ, Kua EH, Jeste DV, Kumar R, Ng TP. Reliability and validity of a self-rated analogue scale for global measure of successful aging. *Am J Geriatr Psychiatr*. (2014) 22:829–37. doi: 10.1016/j.jagp.2013.09.002

34. Jaspers L, Schoufour JD, Erler NS, Darweesh SK, Portegies ML, Sedaghat S, et al. Development of a healthy aging score in the population-based Rotterdam study: evaluating age and sex differences. *J Am Med Dir Assoc*. (2017) 18:276.e1–7. doi: 10.1016/j.jamda.2016.11.021

35. Rehkopf DH, Furstenberg FF, Elser H, Jackson CS, Lévy N, Rowe JC. A US state index of successful aging: differences between states and over time. *Milbank Q*. (2021) 100:102–33. doi: 10.1111/1468-0009.12542

36. Mikelsone M, Reine I, Baltmane D, Ivanovs A, Tomsone S. Comparison of intrinsic capacity factors in older individuals before and during COVID-19 in the context of healthy ageing in Baltic countries. *SHS Web Conf*. (2022) 131:01004. doi: 10.1051/shsconf/202213101004

37. Reine I., Miķelsone M., Guðmundsson H. S., Ivanovs A., Tomsone S., Guðmundsson H. S. (2023). Loneliness, social isolation and ageing: a methodological approach to compare Latvian and Icelandic older populations in the course of COVID-19 pandemic. Research Square [Preprint]. doi: 10.21203/rs.3.rs-2870118/v1

38. Thanakwang K, Isaramalai S, Hatthakit U. Development and psychometric testing of the active aging scale for Thai adults. *Clin Interv Aging*. (2014) 9:1211–21. doi: 10.2147/cia.s66069

39. Hogervorst E, Schröder-Butterfill E, Handajani YS, Kreager P, Rahardjo TBW. Dementia and dependency vs. proxy indicators of the active ageing index in Indonesia. *Int J Environ Res Public Health*. (2021) 18:8235. doi: 10.3390/ijerph18168235

40. Tu R, He H, Wang S, Ding J, Zeng Q, Guo L, et al. The association between healthy aging index and trajectories of disability: a population-based cohort study. *Aging Clin Exp Res*. (2022) 34:1893–900. doi: 10.1007/s40520-022-02117-9

41. Börsch-Supan A, Brandt M, Hunkler C, Kneip T, Korbmacher J, Malter F, et al. Data Resource Profile: The Survey of Health, Ageing and Retirement in Europe (SHARE). *International Journal of Epidemiology*. (2013). doi: 10.1093/ije/dyt088

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 07 September 2023
DOI 10.3389/fpubh.2023.1228920

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Yibo Wu,
Peking University, China
Bo Hou,
Bradford Teaching Hospitals NHS Foundation Trust, United Kingdom
Pankaja Desai,
Rush University Medical Center, United States

*CORRESPONDENCE
Maciej Polak
✉ maciej.1.polak@uj.edu.pl

†These authors have contributed equally to this work and share first authorship

RECEIVED 25 May 2023
ACCEPTED 21 August 2023
PUBLISHED 07 September 2023

CITATION
Pająk A, Polak M, Kozela M, Doryńska A and Bobak M (2023) Trajectories in physical functioning at older age in relation to childhood and adulthood SES and social mobility: a population-based cohort study. *Front. Public Health* 11:1228920. doi: 10.3389/fpubh.2023.1228920

COPYRIGHT
© 2023 Pająk, Polak, Kozela, Doryńska and Bobak. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Trajectories in physical functioning at older age in relation to childhood and adulthood SES and social mobility: a population-based cohort study

Andrzej Pająk[1†], Maciej Polak[1*†], Magdalena Kozela[1], Agnieszka Doryńska[2] and Martin Bobak[3,4]

[1]Department of Epidemiology and Population Studies, Faculty of Health Sciences, Institute of Public Health, Jagiellonian University Medical College, Krakow, Poland, [2]Department of Epidemiology, Cardiovascular Disease Prevention and Health Promotion, National Institute of Cardiology, Warsaw, Poland, [3]Research Centre for Toxic Compounds in the Environment (RECETOX), Masaryk University, Brno, Czechia, [4]Research Department of Epidemiology and Public Health, University College London, London, United Kingdom

Introduction: Older age is associated with the deterioration of physical functioning (PF), and low PF is strongly related to poor quality of life among older people. We conducted a study to examine the trajectories of PF between middle and old age, considering sex differences as well as the association between socioeconomic status (SES) at different life stages and changes in PF.

Methods: We analyzed data from the Polish arm of the HAPIEE (Health, Alcohol and Psychosocial factors In Eastern Europe) study, including 1,116 men and 1,178 women aged 45–64 years at baseline. Adult and childhood SES and social mobility were assessed using a retrospectively focused questionnaire. PF was assessed using the 10-question SF-36 scale at baseline examination, face-to-face re-examination, and three postal surveys, covering up to 20 years (on average, 18 years). We employed Generalized Estimating Equations models to assess changes in PF scores over time and compare PF trajectories across different SES categories.

Results: After adjusting for age and other covariates, we found that, in both sexes, participants with always middle or high SES, as well as those who reported upward mobility, had higher PF scores at baseline compared to those with always low SES. A decline in PF between middle and old age was observed in all SES groups; however, the decline was slower in participants with always middle or high SES compared to those with always low SES.

Conclusion: This cohort study revealed that lower SES and downward social mobility were cross-sectionally associated with poorer PF, while upward social mobility seemed to largely reverse the effect of low childhood SES. In addition to the cross-sectional associations observed at baseline, advantaged SES was also significantly associated with a slower decline in PF over an 18-year follow-up period.

KEYWORDS

physical functioning, socioeconomic status, social mobility, aging, cohort study

1. Introduction

Old age is associated with deterioration of physical functioning (PF), which can be attributed to physiological changes associated with aging, chronic diseases, and long-lasting complications from acute diseases. The development of PF limitations is a lifelong process, and it is widely recognized that low PF is strongly related to poor quality of life among older people. Maintaining PF is a key component of healthy aging (1, 2). However, the extent to which age-related decline in PF can be modified by psychosocial, economic, environmental, behavioral, and medical care factors remains uncertain (3).

Socioeconomic status (SES) has been extensively studied as a determinant of health, both within and between countries (4–6). The effect of socioeconomic factors on the health of older people reflects the accumulation of disadvantages throughout their life course (the cumulative advantage/disadvantage hypothesis) (7–11). However, some studies have proposed that social differences in health may decrease in old age (12–14), possibly due to the fact that individuals with poorer health and lower SES are more likely to die before reaching old age (the age-as-leveler hypothesis) (15, 16). Recent analyses of data from the Survey of Health, Aging, and Retirement in Europe (SHARE) have indicated that both social causation and health selection may contribute to social inequalities in health (17).

Individual SES is a complex concept, and the significance of its components varies depending on the culture and overall socioeconomic position of the population (18). In addition to factors such as educational attainment, occupation, and material conditions, childhood circumstances are key determinants of future health. One proposed explanation for social inequalities in health is that early-life disadvantages accelerate biological aging processes (19, 20). Childhood SES has been found to influence health through material, structural, psychosocial, and behavioral factors (21). It has been associated with both physical health and psychological well-being (17, 22).

On the other hand, low SES in adulthood was related to higher exposure to cardiovascular disease risk factors, such as smoking, physical inactivity, overweight, poor dietary quality (23), and unfavorable blood lipid profiles (24). It has also been associated with other general health parameters, including low hemoglobin levels (25) and poor self-rated health (21).

A wealth of evidence exists on the relationship between SES and PF. For example, a recent study of over 5,000 participants in the English Longitudinal Study of Aging revealed that lower SES was associated with greater declines in grip strength, gait speed, chair stand failure, sensory function, cognitive function, depressive symptoms, reduced enjoyment of life, poorer social functioning, and some markers of physiological function (e.g., C-reactive protein, fibrinogen, and lung function), underscoring the critical role of SES in the aging process (26).

Although the relationship between socioeconomic status and physical functioning is well documented, most studies use one point estimate on physical functioning and few address the problem of social mobility. Recently, there has been an increased focus on the life course approach in studying the effects of SES on health. This approach allows for investigations beyond simple measures of childhood and adulthood SES and provides a better understanding of the role of SES exposure in disease development (27, 28). Vertical social mobility, which refers to upward or downward changes in a person's SES over their life course (29), appears to be particularly important. However, limited evidence is available regarding its effect on aging, specifically on PF in old age. Most of the existing evidence comes from ecological analyses, cross-sectional studies, or cohort studies with short follow-up periods, and the results are inconsistent (30–32).

Health disparities by SES are pronounced in Central and Eastern Europe, yet relatively few studies have focused on older populations in this region (33–36). Studying Eastern European populations is intriguing because they generally have shorter life expectancies and have experienced revolutionary political and economic reforms that have led to rapid changes in social structures (37, 38). A recent study utilizing harmonized data from 37 populations, including six from Central and Eastern Europe, indicated that the magnitude of social inequalities in PF was related to the economic strength of the country (39). In this report, based on a Polish cohort from the HAPIEE (Health, Alcohol and Psychosocial Factors in Eastern Europe) study, we hypothesized that upward social mobility is associated with a slower decline in PF compared to stable low SES and that downward social mobility is associated with a faster decline compared to consistently high SES. Specifically, we aimed to assess (1) the trajectories of PF between middle and old age stratified by sex, (2) the socioeconomic gradient in the change of PF, and (3) the relationship between social mobility and changes in PF.

2. Methods

2.1. Data and study design

The present analysis was conducted within the Polish arm of the HAPIEE study. This multicenter prospective cohort study aims to investigate the psychosocial and dietary factors that contribute to cardiovascular diseases (CVD) and other chronic conditions in Central and Eastern Europe. Detailed information regarding the study design and methods has been previously published (40). The present analysis involved a random sample of permanent residents of Krakow between the ages of 45 and 69, selected from the registry of residents. The exclusion criterion was a lack of informed consent. At the baseline, from 2002 to 2005, a total of 10,728 women and men underwent examination, with a participation rate of 62%. Adult SES and PF were assessed for all participants, and potential confounding factors and covariates were measured. Childhood SES and social mobility were also assessed at the baseline survey using a retrospectively focused questionnaire. To assess the trajectories of PF, participants from the baseline survey were followed up through face-to-face re-examinations and three postal surveys, spanning a period of up to 20 years (with an average follow-up of 18 years).

2.2. Physical functioning score

In the HAPIEE Study, the assessment of PF was conducted using a subset of the SF-36 scale, which consists of 10 questions related to activities involving vigorous and moderate physical exertion, lifting groceries, mobility, and self-care tasks (41). Participants were asked to rate themselves as "limited a lot," "limited a little," or "not limited at all" for each item. A composite score ranging from 0 to 100 was

calculated, with a higher score indicating better PF. The PF score was assessed five times during the follow-up period. The first assessment took place at baseline between 2002 and 2005, the second assessment between 2006 and 2008, the third assessment between 2009 and 2010, the fourth assessment between 2012 and 2014, and the final assessment between 2020 and 2022. For inclusion in the present analysis, valid PF data had to be available for the first and last examinations, as well as for at least two out of the three intermediate assessments.

2.3. Socioeconomic status

The information regarding SES was collected at baseline (2002–2005) for both childhood SES (using a retrospective manner) and adulthood SES. Childhood SES was determined by considering the educational level of both parents (incomplete primary or no formal education, primary, vocational, secondary, or university) and information about housing standards at around the age of 10 (availability of cold tap water, hot tap water, radio, fridge, own kitchen, and own toilet). These factors were combined into an index to measure the amenities experienced during childhood.

Adulthood SES was assessed using five items: educational attainment, professional activity, household amenities, and current financial situation. The details of how the SES index was constructed have been previously described (42), and a summary is provided below.

A two-step clustering algorithm was employed to classify participants into homogeneous groups of low, middle, or high SES for both childhood and adulthood. The classification was based on reasonable evidence of the cluster structure, indicated by the silhouette coefficient s(i) of 0.51 (43). Based on the SES category in childhood and adulthood, four social mobility categories were generated for each participant: (1) always low SES, (2) downward mobility if the childhood SES was middle or high but adulthood SES was low, (3) upward mobility if the childhood SES was low but adulthood SES was middle or high, and (4) always middle or high SES. Supplementary Table 1 presents descriptive statistics for the SES clusters and the distribution of characteristics used to construct the SES index.

2.4. Covariates

During the baseline examination (2002–2005), a standardized questionnaire was administered to collect information on age, gender, education, marital status, and smoking habits. Body weight and height were measured to calculate the body mass index (BMI, kg/m^2). Participants were asked about any self-reported diagnosis or hospitalization for spine or joint problems in the past year. Consumption of alcohol was assessed using the graduated frequency questionnaire (GFQ). By assessing drinking frequency and amounts consumed, the total annual alcohol consumption was calculated. It was assumed that 100 mL of beer, wine, and spirits contained 4, 10, or 36 g of ethanol, respectively (44).

2.5. Statistical analysis

Continuous variables were reported as means with standard deviations (SD). The normal distribution of variables was tested using the Shapiro–Wilk test. Categorical variables were presented as percentages. The Chi-square test was used to compare the distribution of categorical variables. The unpaired Student's *t*-test was performed to assess differences between groups for numerical variables.

Given that the PF score was assessed at least four times during the follow-up, the Generalized Estimating Equations (GEE) technique was employed to model the longitudinal data (45). This approach allowed for the assessment of changes in the PF score over time and comparisons of the PF score trajectories across different SES categories. In the GEE models, the PF scores at each time point were the dependent variables. Considering the numerical nature of the PF score, the "Identity link" and unstructured-free estimation were used to account for within-subject correlation. Two sets of models were performed, separately for childhood SES, adulthood SES, and social mobility: Model A included age only, and Model B included additional adjustments for marital status, BMI, smoking status, spine/joint problems, and annual alcohol consumption.

The results of the GEE models were reported as coefficients with standard errors (SE) for differences at baseline and for differences in the trajectories of the PF score during the follow-up (interaction with time), presented as the decline per 1 year. Statistical analyses were performed using IBM Corp. software released in 2021 (IBM SPSS Statistics for Windows; version 28.0.; IBM Corp, Armonk, NY, United States) or R Core Team (2021). (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria). $p < 0.05$ was accepted as statistically significant (46).

3. Results

A total of 1,116 men and 1,178 women were included in the analysis, all of whom completed at least four examinations, including the first and last ones. Supplementary Figure 1 provides detailed information on the sample recruitment process.

The participants included in the analysis were younger [mean (SD) age of 56 (6.4) years vs. 58 (7.1) years], had higher levels of education (42% vs. 25% with university-level education), were more frequently married or cohabiting (80.6% vs. 75.0%), and had a lower prevalence of smoking (24.3% vs. 34.2%) compared to the remaining participants from the baseline examination (2002–2005) of the entire sample participating in the Polish part of the HAPIEE study. There was no difference in gender distribution (51.4% men vs. 51.2% women; Supplementary Table 2).

Within the analytical sample, men were slightly older than women and had higher rates of professional activity and were married or cohabiting. There was almost no difference in current smoking rates, but men had a higher frequency of past smoking. Notably, there was a significant difference in alcohol consumption between men and women (the median consumption was over eight times larger). Men also had slightly higher mean BMI and a higher prevalence of spine/joint problems (Table 1).

Regarding childhood SES, there were no differences in the distribution by SES category between men and women. Each of the three categories was equally represented by both sexes. However, in adulthood, a higher proportion of women had low SES (24.1% vs. 16.7%), while a higher proportion of men had high SES (60.9% vs. 53.7%). This difference reflects the fact that among women, the categories of always low and downward social mobility were more

10.3389/fpubh.2023.1228920

TABLE 1 Characteristics of the studied group.

	Men	Women		All
	N = 1,116	*N* = 1,178	*p*	
PF score (first examination), mean (SD)	89 (15.1)	83 (18)	<0.001	86 (16.94)
PF score (second examination), mean (SD)	90 (15)	85 (17)	<0.001	87 (16.28)
PF score (third examination), mean (SD)	82 (21.2)	73 (23.2)	<0.001	77 (22.68)
PF score (fourth examination), mean (SD)	79 (21.7)	70 (24.1)	<0.001	74 (23.4)
PF score (fifth examination), mean (SD)	71 (26.6)	64 (27.7)	<0.001	67 (27.33)
Age [years], mean (SD)	57 (6.5)	56 (6.2)	<0.001	56 (6.4)
Married or cohabiting, *n* (%)	1,024 (92.0%)	821 (70.0%)	<0.001	1,845 (80.6%)
Childhood SES, *n* (%)				
Low	388 (35.4%)	394 (33.9%)		782 (34.6%)
Middle	388 (35.4%)	409 (35.2%)	0.65	797 (35.3%)
High	321 (29.3%)	359 (30.9%)		680 (30.1%)
Adulthood SES, *n* (%)				
Low	186 (16.7%)	284 (24.1%)		470 (20.5%)
Middle	250 (22.4%)	261 (22.2%)	<0.001	511 (22.3%)
High	680 (60.9%)	633 (53.7%)		1,313 (57.2%)
Social mobility, *n* (%)				
Always low SES	67 (6.2%)	104 (9.1%)		171 (7.7%)
Downward mobility	109 (10.1%)	166 (14.5%)		275 (12.4%)
Upward mobility	314 (29.1%)	286 (25.0%)	0.002	600 (27.0%)
Always middle or high SES	591 (54.7%)	589 (51.4%)		1,180 (53.1%)
Smoking status, *n* (%)				
Current	266 (23.9%)	290 (24.7%)		556 (24.3%)
Former	452 (40.7%)	293 (24.9%)	<0.001	745 (32.6%)
Never	394 (35.4%)	593 (50.4%)		987 (43.1%)
BMI [kg/m^2] mean (SD)	27.7 (3.73)	27.4 (4.56)	0.049	27.6 (4.18)
Spine/joint problems, *n* (%)	257 (23.1%)	228 (19.5%)	0.04	485 (21.2%)
Annual alcohol consumption [g], median (Q1–Q3)	840 (120–2,750)	100 (0–430)	<0.001	300 (0–1,530)

frequent compared to men. On the other hand, the proportions of participants in the categories of always middle or high and upward mobility were higher in men than in women.

At the baseline examination (2002–2005), the mean PF score was higher in men compared to women (89 vs. 83 points). Over time, there was a decline in PF scores in both sexes (Supplementary Figure 2). However, there was no significant difference in the trajectories of PF scores between men and women (p for interaction = 0.70). The decline in PF scores over time was consistent across all subsequent statistical models.

Table 2 presents the differences in baseline PF scores and the trajectories of PF scores according to childhood SES, adulthood SES, and social mobility categories. At the baseline (2002–2005), after adjusting for age, men with middle SES in childhood had a lower mean PF score compared to those with low SES in childhood by 3.2 points. On the other hand, women with high SES in childhood had a higher mean PF score compared to those with low SES by 4.2 points. SES in adulthood and social mobility were significantly and positively associated with PF scores in both sexes.

In women, compared to those with low SES in adulthood, those with middle and high SES in adulthood had higher mean PF scores by more than 10.5 and 11.2 points, respectively. Similarly, compared to those with always low SES, women with upward social mobility and women who always had middle or high SES had higher PF scores by approximately 10.5 and 12.8 points, respectively.

In men, the differences in PF scores according to adulthood SES and social mobility categories were similar to those observed in women although the magnitude of the differences was slightly smaller (7.3 and 9.2 points in the case of adulthood SES and 7.2 and 6.2 points in the case of social mobility categories).

The trajectories of PF between the baseline and final examinations varied significantly according to childhood SES, adulthood SES, and social mobility categories in both men and women.

In men, those with middle and high SES in childhood experienced a slower decline in PF compared to those with low childhood SES. Similarly, men with middle and high SES in adulthood experienced a slower decline in PF compared to those with low adulthood SES. Regarding social mobility, only men who had always high or middle SES demonstrated a slower decline in PF compared to those who had always low SES (by 0.47 points per year).

Among women, those with high SES in childhood (but not those with middle childhood SES) had a slower decline in PF compared to those with low childhood SES. Women with middle adulthood SES

TABLE 2 Age-adjusted differences in physical functioning (PF) score at baseline and in trajectories of PF score by childhood SES, adulthood SES, and social mobility.

	Men		Women	
	Difference[a] (SE)	*p*	Difference[a] (SE)	*p*
Baseline PF				
Low childhood SES	Reference		Reference	
Middle childhood SES	**−3.2 (0.95)**	**0.002**	1.0 (1.04)	0.35
High childhood SES	1.1 (0.89)	0.33	**4.2 (0.97)**	**0.001**
Difference in the decline of PF (per year)				
Low childhood SES	Reference		Reference	
Middle childhood SES	**0.24 (0.112)**	**0.02**	−0.02 (0.126)	0.86
High childhood SES	**0.26 (0.122)**	**0.023**	**0.28 (0.119)**	**0.016**
Baseline PF				
Low adulthood SES	Reference		Reference	
Middle adulthood SES	**7.3 (1.19)**	**<0.001**	**10.5 (1.39)**	**<0.001**
High adulthood SES	**9.2 (1.26)**	**<0.001**	**11.2 (1.1)**	**<0.001**
Difference in the decline of PF (per year)				
Low adulthood SES	Reference		Reference	
Middle adulthood SES	**0.30 (0.178)**	**0.03**	**−0.29 (0.134)**	**0.03**
High adulthood SES	**0.32 (0.148)**	**0.008**	**0.51 (0.128)**	**<0.01**
Baseline SES				
Always low SES	Reference		Reference	
Downward mobility	−3.3 (2.53)	0.13	1.9 (2.11)	0.32
Upward mobility	**7.2 (2.07)**	**0.002**	**10.5 (1.86)**	**<0.001**
Always middle or high SES	**6.2 (2.02)**	**0.007**	**12.8 (1.77)**	**<0.001**
Difference in the decline of PF (per year)				
Always low SES	Reference		Reference	
Downward mobility	0.43 (1.879)	0.06	−0.04 (0.200)	0.82
Upward mobility	0.29 (0.198)	0.185	0.14 (0.178)	0.42
Always middle or high SES	**0.47 (0.199)**	**0.014**	**0.31 (0.160)**	**0.048**

[a]Age-adjusted coefficient of the GEE model; SE, standard error; significant results are bolded.

and women with high adulthood SES also experienced a slower decline in PF compared to those with low adulthood SES. Similar to men, in the social mobility analyses, only women with always high or middle SES demonstrated a slower decline in PF compared to those who had always low SES (by 0.31 points per year).

Additional adjustments for covariates such as marital status, history of spine/joint problems, BMI, smoking, and alcohol consumption did not significantly change most of the results. The only exception was the difference in the trajectories of PF between men with middle adulthood SES and men with low adulthood SES, which lost significance after adjustment for covariates although the change in the estimate was minimal (Table 3; Figures 1, 2).

4. Discussion

In this population-based cohort study conducted in Central and Eastern Europe, we observed significant differences in PF based on SES indicators measured at baseline. Moreover, we identified variations in the decline of PF over time among different SES categories. The analysis of trajectories suggests that while health disparities related to childhood SES may diminish during middle age if people improve their socioeconomic position, these disparities may reappear as a delayed effect during the transition from middle to old age.

Previous studies have proposed that upward social mobility, along with the stress associated with climbing the social ladder, could have harmful effects on health (47–49). However, there is also evidence that upward social mobility was associated with slower biological aging and people with more socioeconomic resources appeared biologically younger than people of the same chronological age with fewer socioeconomic resources (50). A study conducted in the United States examined healthy aging using blood chemistry and DNA methylation measures of biological aging in a national sample of older adults. The study found that individuals who grew up in socioeconomically disadvantaged families and those who accumulated less wealth over their lives experienced faster biological aging compared to those who grew up in

TABLE 3 Differences in physical functioning (PF) score at baseline and in trajectories of PF score by childhood SES, adulthood SES, and social mobility (adjusted for all covariates).

	Men		Women	
	Difference[b] (SE)	*p*	Difference[b] (SE)	*p*
Baseline PF				
Low childhood SES	Reference		Reference	
Middle childhood SES	**−3.5 (1.03)**	**0.006**	0.7 (1.09)	0.51
High childhood SES	0.1 (1.10)	0.94	**2.3 (1.14)**	**0.04**
Difference in the decline of PF (per year)				
Low childhood SES	Reference		Reference	
Middle childhood SES	**0.28 (0.106)**	**0.009**	−0.01 (0.113)	0.91
High childhood SES	**0.32 (0.123)**	**0.004**	**0.33 (0.116)**	**0.005**
Baseline PF				
Low adulthood SES	Reference		Reference	
Middle adulthood SES	**6.9 (1.37)**	**<0.001**	**9.3 (1.32)**	**<0.001**
High adulthood SES	**7.7 (1.17)**	**<0.001**	**8.5 (1.11)**	**<0.001**
Difference in the decline of PF (per year)				
Low adulthood SES	Reference		Reference	
Middle adulthood SES	0.25 (0.138)	0.072	**−0.30 (0.134)**	**0.026**
High adulthood SES	**0.39 (0.120)**	**0.001**	**0.50 (0.112)**	**<0.001**
Baseline SES				
Always low SES	Reference		Reference	
Downward mobility	−3.1 (2.20)	0.16	1.8 (1.89)	0.344
Upward mobility	**6.6 (1.90)**	**<0.001**	**9.1 (1.73)**	**<0.001**
Always middle or high SES	**4.8(1.83)**	**0.009**	**10.1 (1.62)**	**<0.001**
Difference in the decline of PF (per year)				
Always low SES	Reference		Reference	
Downward mobility	0.44 (0.226)	0.06	0.02 (0.196)	0.94
Upward mobility	0.32 (0.196)	0.100	0.16 (0.179)	0.38
Always middle or high SES	**0.55 (0.188)**	**0.003**	**0.34 (0.166)**	**0.04**

[b]Coefficient of the GEE model, adjusted for age, marital status, BMI, smoking status, spine/joint problems, and annual alcohol consumption; SE, standard error; significant results are bolded.

socioeconomically advantaged families. Additionally, participants who experienced upward social mobility demonstrated slower biological aging in later life compared to non-mobile or downwardly mobile participants (51). Similarly, a British study revealed that DNA methylation age acceleration was associated with both early-life SES and adult SES. Furthermore, upward mobility was linked to lower accelerated aging compared to individuals who experienced disadvantages throughout their life course (52).

The findings from our previous study on disparities in PF in three populations from Central and Eastern Europe provided support for the cumulative advantage/disadvantage hypothesis. High SES was associated with better PF at baseline and a slower decline during the follow-up period (36). Our results contradict some previous studies that suggested health costs associated with upward social mobility (53–55). They are also inconsistent with the findings of a recent analysis of SHARE data of people aged 50 years and older, which demonstrated a reciprocal relationship between SES and health. In that study, the influence of health selection (reverse causation) was stronger than the causal mechanisms through which SES could affect PF and other objectively measured health indices (social causation). Additionally, higher baseline SES, which was associated with less SES increase and better initial health, was related to less improvement in health (17, 56). However, our findings align with a joint analysis of longitudinal SHARE and ESLA data, which showed that participants' health significantly depended on their prior status, and social causation played a prominent role in the transition from adulthood to old age (57).

Overall, our study confirmed earlier findings that psychological and social factors play an important role in slowing down the age-related decline in PF and that lower social status is associated with accelerated aging (26, 58). In our study, this difference was reflected in the trajectory of PF between individuals with always middle or high SES and those with always low SES. Our results also align with an American cross-sectional study, which demonstrated that stable low SES was associated with worse PF assessed using objective measures such as aerobic endurance, gait speed, and lower body strength. Moreover, the study found no significant

10.3389/fpubh.2023.1228920

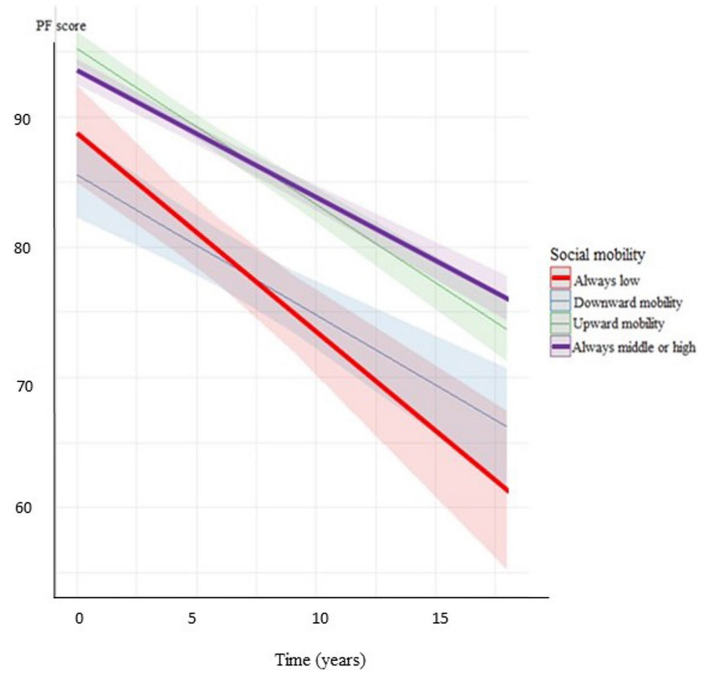


FIGURE 1
Decline of PF score by the categories of social mobility in men (adjusted for age, marital status, BMI, smoking status, spine/joint problems, and annual alcohol consumption).

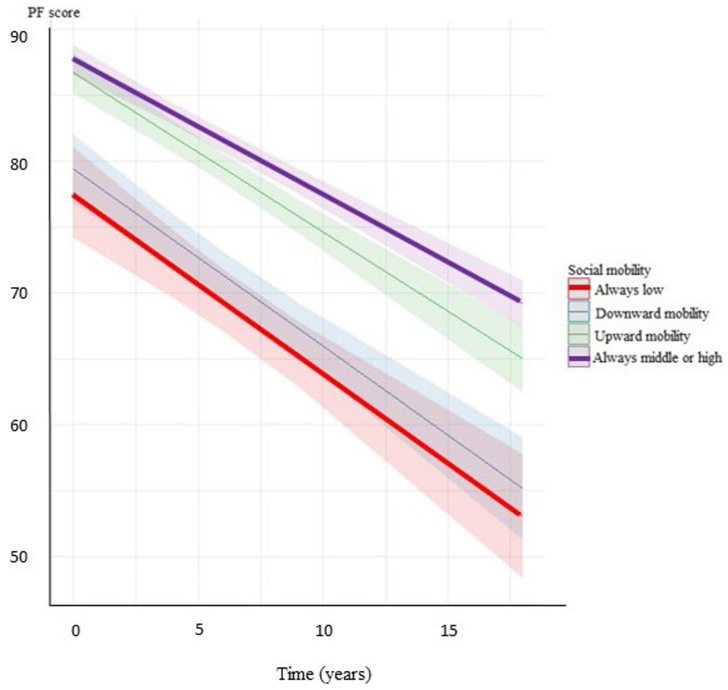


FIGURE 2
Decline of PF score by the categories of social mobility in women (adjusted for age, marital status, BMI, smoking status, spine/joint problems, and annual alcohol consumption).

difference in PF between upward mobility and stable high or middle SES groups, while stable low SES and downward social mobility were strongly and equally associated with poorer PF compared to upward mobility (31).

In a previous Polish study involving over 2,500 adults across a wide age range, participants from low social classes reported worse self-rated health. However, upward social mobility was only related to

better psychological well-being, not self-rated health. The differences between that study and our findings, where upward social mobility was significantly associated with better PF, could be explained by variations in study design (cross-sectional vs. longitudinal), outcomes assessed (self-rated health vs. PF), and the method used to classify SES (based on occupational status only in the previous study) (35). Additionally, the strength of the relationship between SES and self-rated health is known to depend on the SES indicator used (59), and the results of a Swedish study suggest a strong mediation effect of working conditions on the association between social class and physical impairment in older age (60).

4.1. Limitations

There are several limitations to our study that should be taken into consideration. Firstly, the measures of childhood and adulthood SES were self-reported, which introduces the possibility of reporting bias and misclassification. Additionally, the selected measures may not capture the full range of all relevant SES indicators that could potentially influence health and PF.

Secondly, we lacked prospective data on SES and PF over the entire life course. While childhood circumstances and educational attainment tend to remain stable since early adulthood, material conditions may have changed during the follow-up period. Moreover, the assessment of covariates at a single time point is a concern, as these factors may have fluctuated over the course of nearly two decades. In addition, the use of interviews to collect these data may introduce biases. For example, the assessment of alcohol intake relied on a questionnaire method, which is known to underestimate actual consumption. However, it should be noted that this method is reliable in ranking participants based on their alcohol consumption (61).

Thirdly, there may be concerns regarding the assessment of PF. Although we used a standardized method validated for the Polish population throughout the follow-up, the interview-based assessment could still be influenced by local culture, social roles, cognitive abilities, and other factors.

Finally, the analyses included a healthier subset of the population from which the sample was selected. This is due to both natural attrition, as over 30% of participants did not survive or were lost to follow-up until the final examination, and the low participation rate in at least four assessments of PF. In a previous report, we found that non-participants were at a higher risk of death (62). Therefore, generalizing the findings to the entire general population may be uncertain.

4.2. Strengths

This study examined a general population sample from Central Europe, a region with relatively lower life expectancy compared to Western Europe and the United States (37). This region has received less attention in terms of studying the relationships between health and psycho-socioeconomic factors. The measurement of PF was conducted using a well-established method that has been validated for the Polish population (41). The repeated measurements of PF using the same method allowed us to assess longitudinal trajectories of PF over an average period of 18 years, spanning from middle to old age. Furthermore, we were able to account for important potential confounding factors in our analyses, including alcohol consumption, which we have previously observed to be a significant determinant of PF trajectories (63, 64).

5. Conclusion

As the proportion of older people in the population continues to rise, the issue of declining PF with age has become a critical public health concern. This cohort study revealed that lower SES and downward social mobility were associated with worse PF, while upward social mobility appeared to counteract the negative effects of low childhood SES. Furthermore, in addition to the cross-sectional associations observed at baseline, higher SES was significantly linked to a slower decline in PF over an 18-year follow-up period. Addressing childhood social inequalities and maintaining high SES levels appear to be crucial in mitigating the decline in PF during old age and could help to maintain the self-sufficiency and social engagement of older people. Future long-term observational studies should focus on investigating the extent to which reducing childhood inequalities could impact the decline of PF in adulthood and old age.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

AP, MP, MK, AD, and MB contributed to the intellectual conceptualization of this study. AP an MP designed the paper and wrote the first draft and finalized the paper. MP performed the statistical analyses. AP and MB jointly designed the HAPIEE study. AD and MK participated in the coordination of data collection. All authors contributed to the article and approved the submitted version.

Funding

This work was supported by a grant from the Polish National Science Centre (grant 2018/29/B/NZ7/02118). The HAPIEE study was funded by the Welcome Trust (grant WT064947 and WT081081), the US National Institute of Aging (grant R01 AG23522), and the MacArthur Foundation. MB's contribution was supported by the European Union's Horizon 2020 Research and Innovation Program projects CETOCOEN Excellence (grant agreement 857560) and R-Exposome Chair (grant agreement 857487).

Acknowledgments

The authors express their gratitude to all investigators and participants of the HAPIEE Study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1228920/full#supplementary-material

References

1. Cosco TD, Prina AM, Perales J, Blosson CMS, Brayne C. Operational definitions of successful aging: a systematic review. *Int Psychogeriatr*. (2014) 26:373–81. doi: 10.1017/S1041610213002287

2. Kozela M, Pająk A, Szafraniec K, Ayuso-Mateos JL, Bobak M, Lu W, et al. ATHLOS healthy aging scale score as the predictor of all-cause mortality in Poland and Czechia. *Front Public Health*. (2023) 11:1114497. doi: 10.3389/fpubh.2023.1114497

3. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *J Gerontol Series A*. (2004) 59:255–63. doi: 10.1093/gerona/59.3.M255 2

4. Feinstein JS. The relationship between socioeconomic status and health: a review of the literature. *Milbank Q*. (1993) 71:279–322. doi: 10.2307/3350401

5. Marmot M, Ryff CD, Bumpass LL, Marks NF. Social inequalities in health: next questions and converging evidence. *Soc Sci Med*. (1997) 44:901–10. doi: 10.1016/s0277-9536(96)00194-3

6. Bobak M, Pikhart H, Rose R, Marmot M. Socioeconomic factors, material inequalities, and perceived control in self-rated health: cross-sectional data from seven post-communist countries. *Soc Sci Med*. (2000) 51:1343–50. doi: 10.1016/s0277-9536(00)00096-4

7. Ross CE, Wu CL. Education, age, and the cumulative advantage in health. *J Health Soc Behav*. (1996) 37:104–20. doi: 10.2307/2137234

8. Kim J, Durden E. Socioeconomic status and age trajectories of health. *Soc Sci Med*. (2007) 65:2489–502. doi: 10.1016/j.socscimed.2007.07.022

9. Chandola T, Ferrie J, Sacker A, Marmot M. Social inequalities in self reported health in early old age: follow-up of prospective cohort study. *BMJ*. (2007) 334:990–3B. doi: 10.1136/bmj.39167.439792.55

10. Kim J, Richardson V. The impact of socioeconomic inequalities and lack of health insurance on physical functioning among middle-aged and older adults in the United States. *Health Soc Care Community*. (2012) 20:42–51. doi: 10.1111/j.1365-2524.2011.01012

11. Zaninotto P, Sacker A, Head J. Relationship between wealth and age trajectories of walking speed among older adults: evidence from the English longitudinal study of ageing. *J Gerontol A Biol Sci Med Sci*. (2013) 68:1525–31. doi: 10.1093/gerona/glt058

12. Taylor MG. Capturing transitions and trajectories: the role of socioeconomic status in later life disability. *J Gerontol B Psychol Sci Soc Sci*. (2010) 65:733–43. doi: 10.1093/geronb/gbq018

13. Gerstorf D, Ram N, Lindenberger U, Smith J. Age and time-to-death trajectories of change in indicators of cognitive, sensory, physical, health, social, and self-related functions. *Dev Psychol*. (2013) 49:1805–21. doi: 10.1037/a0031340

14. Koster A, Bosma H, Broese van Groenou MI, Kempen GIJM, Penninx BWJH, van Eijk JTM, et al. Explanations of socioeconomic differences in changes in physical function in older adults: results from the longitudinal aging study Amsterdam. *BMC Public Health*. (2006) 6:244. doi: 10.1186/1471-2458-6-244

15. House JS, Lepkowski JM, Kinney AM, Mero RP, Kessler RC, Herzog AR. The social stratification of aging and health. *J Health Soc Behav*. (1994) 35:213–34. doi: 10.2307/2137277

16. Lynch SM. Cohort and life-course patterns in the relationship between education and health: a hierarchical approach. *Demography*. (2003) 40:309–31. doi: 10.1353/dem.2003.0016

17. Ahrenfeldt LJ, Möller S. The reciprocal relationship between socioeconomic status and health and the influence of sex: a European SHARE-analysis based on structural equation modeling. *Int J Environ Res Public Health*. (2021) 18:5045. doi: 10.3390/ijerph18095045

18. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey SG. Indicators of socioeconomic position (part 1). *J Epidemiol Community Health*. (2006) 60:7–12. doi: 10.1136/jech.2004.023531

19. Belsky DW, Caspi A, Cohen HJ, Kraus WE, Ramrakha S, Poulton R, et al. Impactofearlypersonal-history characteristics on the pace of aging: implications for clinical trials of therapies to slow aging and extend health span. *Aging Cell*. (2017) 16:644–51. doi: 10.1111/acel.12591

20. Marini S, Davis KA, Soare TW, Zhu Y, Suderman MJ, Simpkin AJ, et al. Adversity exposure during sensitive periods predicts accelerated epigenetic aging in children. *Psychoneuroendocrinology*. (2020) 113:104484. doi: 10.1016/j.psyneuen.2019.104484

21. Moor I, Spallek J, Richter M. Explaining socioeconomic inequalities in selfrated health: a systematic review of the relative contribution of material, psychosocial and behavioural factors. *J Epidemiol Community Health*. (2017) 71:565–75. doi: 10.1136/jech-2016-207589

22. Herrmann J, Vogel M, Pietzner D, Kroll E, Wagner O, Schwarz S, et al. Factors associated with the emotional health of children: high family income as a protective factor. *Eur Child Adolesc Psychiatry*. (2018) 27:319–28. doi: 10.1007/s00787-017-1049-0

23. Poulaina T, Vogela M, Kiess W. Review on the role of socioeconomic status in child health and development. *Curr Opin Pediatr*. (2020) 32:308–14. doi: 10.1097/MOP.0000000000000876

24. Dathan-Stumpf A, Vogel M, Rieger K, Thiery J, Kiess HA. Serum lipid levels were related to socio-demographic characteristics in a German population-based child cohort. *Acta Paediatr*. (2016) 105:e360–7. doi: 10.1111/apa.13438

25. Rieger K, Vogel M, Engel C, Ceglarek U, Harms K, Wurst U, et al. Does physiological distribution of blood parameters in children depend on socioeconomic status? Results of a German cross-sectional study. *BMJ Open*. (2018) 8:019143:e019143. doi: 10.1136/bmjopen-2017-019143

26. Steptoe A, Zaninotto P. Lower socioeconomic status and the acceleration of aging: an outcome-wide analysis. *Proc Natl Acad Sci U S A*. (2020) 117:14911–7. doi: 10.1073/pnas.1915741117

27. Laurie M, Corna A. Life course perspective on socioeconomic inequalities in health: a critical review of conceptual frameworks. *Adv Life Course Res*. (2013) 18:150–9. doi: 10.1016/j.alcr.2013.01.002

28. Cutler DM, Lleras-Muney A, Vogl T. Socioeconomic status and health: Dimensions and mechanisms. (2008). In: *NBER Working Paper No. 14333, 2008*.

29. Sorokin PA. *Social and cultural mobility*. New York: Free Press (1959).

30. Schmengler H, Margot PM, Stevens GWJM, Kunst AE, Delaruelle K, Dierckenes M, et al. Socioeconomic inequalities in adolescent health behaviours across 32 different countries—the role of country-level social mobility. *Soc Sci Med*. (2022) 310:115289. doi: 10.1016/j.socscimed.2022.115289

31. Noppert GA, Brown CS, Chanti-Ketter M, Hall KS, Newby LK, Cohen HJ, et al. The impact of multiple dimensions of socioeconomic status on physical functioning across the life course. *Gerontol Geriatr Med*. (2018) 4:233372141879402–8. doi: 10.1177/2333721418794021

32. Torres JM, Rizzo S, Wong R. Lifetime socioeconomic status and late-life health trajectories: longitudinal results from the Mexican health and aging study. *J Gerontol B Psychol Sci Soc Sci*. (2018) 73:gbw048–360. doi: 10.1093/geronb/gbw048

33. Kozela M, Polak M, Stepaniak U, Bobak M, Pająk A. Changes in socioeconomic status as predictors of cardiovascular disease incidence and mortality: a 10-year follow-up of a polish-population-based HAPIEE cohort. *Int J Environ Res Public Health*. (2022) 19:15411. doi: 10.3390/ijerph192215411

34. Słomczynski KM, Wysmułek I. *Social inequality and the life course: Poland's transformative years, 1988–2013*. Warsaw, Poland: IFiS Publishers (2016).

35. Zelinska O, Gugushvili A, Bulczak G. Social mobility, health and wellbeing in Poland. *Front Sociol*. (2021) 6:736249. doi: 10.3389/fsoc.2021.736249

36. Hu Y, Pikhart H, Pająk A, Kubínová R, Malyutina S, Besala A, et al. Education, material condition and physical functioning trajectories in middle-aged and older adults in central and Eastern Europe: a cross-country comparison. *J Epidemiol Commun Health*. (2016) 70:1128–35. doi: 10.1136/jech-2015-206548

37. World Health Statistics 2022: Monitoring health for the SDGs, sustainable development goals Geneva (2022). Available at: https://www.who.int/data/gho/publications/world-health-statistics (Accessed May 2023).

38. Healey NM. The transition economic of central and eastern Europe: a political, economic, social and technological analysis. *Columbia J World Bus*. (1994) 29:62–70. doi: 10.1016/0022-5428(94)90020-5

39. Stefler D, Prina M, Wu YT, Sánchez-Niubò A, Lu W, Haro JM, et al. Socioeconomic inequalities in physical and cognitive functioning: cross-sectional evidence from 37 cohorts across 28 countries in the ATHLOS project. *J Epidemiol Community Health*. (2021) 75:980–6. doi: 10.1136/jech-2020-214714

40. Peasey A, Bobak M, Kubinova R, Malyutina S, Pajak A, Tamosiunas A, et al. Determinants of cardiovascular disease and other non-communicable diseases in central and Eastern Europe: rationale and design of the HAPIEE study. *BMC Public Health*. (2006) 6:255. doi: 10.1186/1471-2458-6-255

41. Ware JE. SF-36 health survey update. *Spine*. (2000) 25:3130–9. doi: 10.1097/00007632-200012150-00008

42. Polak M, Szafraniec K, Kozela M, Wolfshaut-Wolak R, Bobak M, Pająk A. Socioeconomic status and pulmonary function, transition from childhood to adulthood: cross-sectional results from the polish part of the HAPIEE study. *BMJ Open*. (2019) 9:e022638. doi: 10.1136/bmjopen-2018-022638

43. Bacher J, Wenzig K, Vogler M. (2004) *SPSS TwoStep cluster—a first evaluation. 2nd* ed. Arbeitsund Diskussionspapiere/Universität Erlangen-Nürnberg, Sozialwissenschaftliches Institut, Lehrstuhl für Soziologie, 2004-2. Nürnberg: Universität Erlangen-Nürnberg, Wirtschafts- und Sozialwissenschaftliche Fakultät, Sozialwissenschaftliches Institut Lehrstuhl für Soziologie. Available at: https://nbn-resolving.org/urn:nbn:de:0168-ssoar-327153.

44. Rehm J. Measururing quantity, frequency, and volume of drinking. *Alcohol Clin Exp Res*. (1998) 22:4S–14S. doi: 10.1097/00000374-199802001-00002

45. Ballinger GA. Using generalized estimating equations for longitudinal data analysis. *Organ Res Methods*. (2004) 7:127–50. doi: 10.1177/1094428104263672

46. R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing (2021). Availabe at: https://www.R-project.org/.

47. Colen CG, Geronimus AT, Bound J, James SA. Maternal upward socioeconomic mobility and black–white disparities in infant birthweight. *Am J Public Health*. (2006) 96:2032–9. doi: 10.2105/AJPH.2005.076547

48. Kuh D, Ben-Shlomo Y, Lynch J, Hallqvist J, Power C. Life course epidemiology. *J Epidemiol Community Health*. (2003) 57:778–83. doi: 10.1136/jech.57.10.778

49. McEwen BS, Gianaros PJ. Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease. *Ann N Y Acad Sci*. (2010) 1186:190–222. doi: 10.1111/j.1749-6632.2009.05331.x

50. Raffington L, Belsky DW, Kothari M, Malanchini M, Tucker-Drob EM, Harden KP. Socioeconomic disadvantage and the pace of biological aging in children. *Pediatrics*. (2021) 147:e2020024406. doi: 10.1542/peds.2020-024406

51. Graf GH, Zhang Y, Domingue BW, Harris KM, Kothari M, Kwon D, et al. Social mobility and biological aging among older adults in the United States. *PNAS Nexus*. (2022) 1:1–10. doi: 10.1093/pnasnexus/pgac029

52. Bao Y, Gorrie-Stone T, Hannon E, Hughes A, Andrayas A, Neilson G, et al. Social mobility across the lifecourse and DNA methylation age acceleration in adults in the UK. *Sci Rep*. (2022) 12:22284. doi: 10.1038/s41598-022-26433-2

53. Chen E, Miller GE, Brody GH, Lei M. Neighborhood poverty, college attendance, and diverging profiles of substance use and allostatic load in rural African American youth. *Clin Psychol Sci*. (2015) 3:675–85. doi: 10.1177/2167702614546639

54. Brody GH, Yu T, Chen E, Miller GE. Persistence of skin-deep resilience in African American adults. *Health Psychol*. (2020) 39:921–6. doi: 10.1037/hea0000945

55. Gaydosh L, Schorpp KM, Chen E, Miller GE, Harris KM. College completion predicts lower depression but higher metabolic syndrome among disadvantaged minorities in young adulthood. *Proc Natl Acad Sci U S A*. (2018) 115:109–14. doi: 10.1073/pnas.1714616114

56. Schwartz E, Litwin H. The reciprocal relationship between social connectedness and mental health among older European adults: a SHARE-based analysis. *J Gerontol B Psychol Sci Soc Sci*. (2019) 74:694–702. doi: 10.1093/geronb/gbx131

57. Hoffmann R, Kröger H, Pakpahan E. The reciprocal relationship between material factors and health in the life course: evidence from SHARE and ELSA. *Eur J Ageing*. (2018) 15:379–91. doi: 10.1007/s10433-018-0458-3

58. Saadeh M, Welmer AK, Dekhtyar S, Fratiglioni L, Calderón-Larrañaga A. The role of psychological and social well-being on physical function trajectories in older adults. *J Gerontol A Biol Sci Med Sci*. (2020) 75:1579–85. doi: 10.1093/gerona/glaa114

59. Moor I, Kuipers MAG, Lorant V, Pförtner TK, Kinnunen JM, Rathmann K, et al. Inequalities in adolescent self-rated health and smoking in Europe: comparing different indicators of socioeconomic status. *J Epidemiol Community Health*. (2019) 73:963–70. doi: 10.1136/jech-2018-211794

60. Pandey N, Darin-Mattsson A, Nilsen C. Working conditions mediate the association between social class and physical function in older age in Sweden: a prospective cohort study. *BMC Public Health*. (2020) 20:1360–0. doi: 10.1186/s12889-020-09431-9

61. Gmel G, Rehm J. Measuring alcohol consumption. *Contemp Drug Probs*. (2004) 31:467–540. doi: 10.1177/009145090403100304

62. Topór-Madry R, Bobak M, Pajak A. 5-year mortality in respondents and nonrespondent for the cohort study of 20 000 randomly selected middle aged men and women the HAPIEE project. *Eur J Prev Cardiol*. (2012) 19:S71.

63. Hu Y, Pikhart H, Kubinova R, Malyutina S, Pajak A, Besala A, et al. Alcohol consumption and longitudinal trajectories of physical functioning in central and Eastern Europe: a 10-year follow-up of HAPIEE study. *J Gerontol A Biol Sci Med Sci*. (2016) 71:1063–8. doi: 10.1093/gerona/glv233

64. Hu Y, Pikhart H, Malyutina S, Pajak A, Kubinova R, Nikitin Y, et al. Alcohol consumption and physical functioning among middle-aged and older adults in central and Eastern Europe: results from the HAPIEE study. *Age Ageing*. (2015) 44:84–9. doi: 10.1093/ageing/afu083

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 28 September 2023
DOI 10.3389/fpubh.2023.1215556

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Nannette Nicholson,
Norton Sound Health Corporation,
United States
Nikolai Bisgaard,
Independent Researcher, Kongens Lyngby,
Denmark

*CORRESPONDENCE
Young Joon Seo
okas2000@yonsei.ac.kr

†These authors have contributed equally to this work and share first authorship

RECEIVED 03 May 2023
ACCEPTED 24 August 2023
PUBLISHED 28 September 2023

CITATION
Lee J, Yoon CY, Lee J, Kong TH, Oh SH and Seo YJ (2023) A situational analysis of ear and hearing care in South Korea using WHO ear and Hearing Care Situation Analysis tool.
Front. Public Health 11:1215556.
doi: 10.3389/fpubh.2023.1215556

COPYRIGHT
© 2023 Lee, Yoon, Lee, Kong, Oh and Seo. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

A situational analysis of ear and hearing care in South Korea using WHO ear and Hearing Care Situation Analysis tool

Juhyeong Lee[1,2†], Chul Young Yoon [1,2†], Junhun Lee [1,2], Tae Hoon Kong [1,3], Seung Ha Oh [4] and Young Joon Seo [1,3*]

[1]Research Institute of Hearing Enhancement, Yonsei University Wonju College of Medicine, Wonju, Republic of Korea, [2]Department of Biostatistics, Yonsei University Wonju College of Medicine, Wonju, Republic of Korea, [3]Department of Otorhinolaryngology-Head and Neck Surgery, Yonsei University Wonju College of Medicine, Wonju, Republic of Korea, [4]Department of Otorhinolaryngology-Head and Neck Surgery, Seoul National University College of Medicine, Seoul, Republic of Korea

Objectives: The WHO emphasizes lifelong management of hearing diseases such as hearing loss and advocates for prevention. The Ear and Hearing Care Situation Analysis (EHCSA) tool was designed by the WHO for assessment and quality improvement of state-led management of hearing loss prevention and management programs. The purpose of this study was to use the EHCSA to assess the ear and hearing management program in Korea and to establish goals consistent with best practices for improving policies and services related to ear and hearing care.

Methods: The EHCSA was used as a need assessment of the ear and hearing management services in the country. The EHCSA consists of two sections. Section 1 consists of 41 questions to evaluate health policies and support services. Section 2 consists of 203 questions to evaluate human resources and services of the ear and hearing management sector.

Results: There are an estimated 800,000 people with hearing loss in Korea. Policies such as hearing aid support are in place, and outreach services such as free hearing tests are also being actively conducted. In all medical institutions, ear and hearing management treatment and medication prescriptions could be received without barriers. Workers in the fields of ear and hearing management, such as audiologists, language therapists, special education teachers, and sign language interpreters, are specialized and have well-established guidelines for training.

Conclusion: Overall, the domestic ear and hearing management sector has confirmed that policies and services are well-prepared in comparison with advanced countries such as the United States, Iran, and China. The use of the EHCSA was functional in collecting data on the current state of domestic ear and hearing management policies and services in Korea, can be used for continuous quality improvement and expansion of medical services, and can be used as a reporting mechanism to the WHO.

KEYWORDS

WHO, ear and hearing care, Korean, situation, annual report

1. Introduction

Hearing is one of the five senses and refers to a mechanical sense that detects the frequency and intensity of sound waves transmitted through a medium, such as air or water. The ear is a sensory organ that causes brain activity, which leads to thoughts and emotions, and it has a proportion equivalent to vision in perceiving the surrounding environment (1). By 2050, ∼2.5 billion people are expected to experience hearing loss, a known representative of hearing disorders, and at least 700 million people will need hearing rehabilitation. According to the WHO, as of 2021, more than 1.5 billion people worldwide have experienced hearing loss. Of these, 430 million suffer from severe hearing loss (2). Failure to treat this condition can affect language development, education, employment, mental health, and depression through human relationships. Globally, the failure to properly address hearing loss costs more than $1 trillion each year. This includes the costs associated with healthcare, education, productivity losses, and social interactions. The causes of hearing loss include aging, noise damage, drug side effects, infections, head trauma, and allergies. It is important to mention that most of these causes can be addressed by healthcare-related services (3). The WHO presented a state-led management program called the Prevention of Deficiency and Hearing Loss to emphasize the importance of lifelong management due to the following reasons: it can occur due to various causes at any time, hearing loss is very common, its prevalence rate is increasing rapidly, and lack of social interest on this matter (4).

Accordingly, since 2005, China has been implementing a national project called the Hearing the Future-China National Hearing Care Program, which includes the early diagnosis, prevention, treatment, and rehabilitation of hearing loss. India has also continued to implement a state-led policy called NPPCD since 2008, and Australia is operating a government-led program to manage and supervise hearing screening, diagnosis, hearing loss prevention, and rehabilitation services from newborns to the older adult. The United States is striving to reduce the occurrence of social problems caused by hearing loss through the national "Healthy People 2020" (5).

In Korea, the number of people diagnosed with hearing loss increased from 280,000 in 2012 to 340,000 in 2016, and the treatment of hearing loss affects the increase in medical costs and hospitalization in future (6). For 2 years from 2007, a pilot project for the early diagnosis of neonatal hearing loss by region has been implemented, and newborn hearing screening and confirmation tests for hearing loss are being conducted mainly for low-income families. In addition, as of 2013, an early diagnosis of hearing loss for low-income newborns nationwide is being implemented, with all newborns being tested for congenital metabolic abnormalities and hearing loss. However, these projects are often implemented by municipal governments. As emphasized by the WHO, the government should strategically establish policies considering the adverse consequences associated with the disease. Other countries use the "Ear and Hearing Care Situation Analysis Tool" (EHCSA) distributed by the WHO to identify their Ear and Hearing Care Situations, report them annually, and prepare strategic health policies accordingly. However, Korea is not reporting to the WHO. EHCSA is significant in evaluating the available direct and indirect policies, services, and human resources associated with ear and hearing therapy, and the healthcare systems of the country are helping to promote and maintain ear and hearing management at all levels of the healthcare system (7). The WHO Collaboration Center is an organization designated by the WHO Secretary-General to form part of an international cooperation network established by the WHO to support programs at national, international, regional, and global levels. According to the WHO Policy and Technology Cooperation Strategy, the WHO Collaboration Center also participates in strengthening national resources in terms of information, services, research, and training to support national health development. The WHO Collaboration Center serves as a support for WHO's mission and program goals, development, and strengthening of institutional capabilities in countries and regions, and there are six institutions in the ear and hearing care field. These include the University of Pretoria in the Republic of South Africa, the University of Indonesia, the Ear Science Institute Australia, the Iran University of Medical Sciences, the China Rehabilitation Research Center for Hearing and Speech Impairment (CRRCHSI), and the National Research Center for Audiology and Hearing Rehabilitation in Russia. To prevent deafness and hearing loss, these institutions provide WHO support through the establishment of information on ear and hearing management, support the implementation of EHCSA manuals, and participate in cooperative projects among WHOCC networks related to ear and hearing care (EHC) issues. As such, it is necessary to submit objective data on EHC in Korea, but it is not currently submitted. Therefore, the Research Institute of Hearing Enhancement offers material for submission. Through this study, the goal is to fill EHCSA and identify the current situation of EHC in Korea to establish and improve policies related to medical services and hearing diseases.

2. Methods and materials

2.1. Data analysis

The Ear and Hearing Care Situation Analysis Tool (EHCSA) is a method for situation analysis developed by the WHO and includes the conditions of situation analysis (7). Situation analysis refers to several methods that managers use to analyze an organization's internal and external environments to understand its capabilities and environments. Representative examples include 5C analysis, SWOT analysis, and Porter's Five Forces analysis, which use the "WHO EHCSA" developed by the WHO to understand the capabilities and environment of the country. Through this, the WHO emphasizes the current status of Ear & Hearing care in each country and the development of sustainable support measures. Data directly reported to the WHO are not accessible, but some countries have prepared outputs or conducted projects based on the EHCSA. The Islamic Republic of Iran produced its output by implementing a situational analysis of the ear and hearing care program using EHCSA; in Bangladesh, an article using situational analysis through EHCSA was published to aid in the understanding of the status of rehabilitation services for the disabled (8). In Germany, the Rehabilitation Service Assessment

Tool was developed based on EHCSA to understand the status of rehabilitation services. The EU recognized the importance of hearing management at the national level through the EHCSA and planned to prepare for future hearing health management policies (9). In addition, to generate awareness, the project collected data related to the use of various hearing aids, their effects, and the correlation between factors affecting hearing damage and accompanying diseases through a big data platform called EVOTION. However, no research has been conducted on the EHCSA in Korea.

The "WHO EHCSA" was distributed to collect, evaluate, and report on ear and hearing management policies, services, and human resources and for the assessment of national health systems in the context of ear and hearing management. This can help to understand the dynamics of hearing loss and the systems and policies that support ear and hearing management, including available personnel, infrastructure, and services, and to establish an improved healthcare system that can help with hearing management. The tool has a total of two sections: Section 1 and Section 2 with a total of 41 and 203 questions, respectively. Section 1 provides information on overall health policies and services, such as total population, age distribution, gender distribution, illiteracy rate, Internet penetration rate, life expectancy, fertility rate, vaccination status, deaf patient distribution, infant health policy, youth health policy, and disease management protocol. Section 2 provides detailed information on human resources, such as departments and representatives dealing with ear and hearing care issues in the Ministry of Health and Welfare, ear and hearing care-related institutions, policies, and programs. Questionnaires for assessment are also available (Supplementary material 1).

2.2. Data collection process

The emphasis was on collecting indicators in line with the context of the questions in the WHO ear and hearing care situation analysis tool. Information, such as country profiles and holidays, was collected using documents from national institutions, such as WHO statistics, the Ministry of Health and Welfare, and the National Statistical Office. First, the indicators of the National Statistical Portal (KOSIS) serviced by the National Statistical Office were confirmed. In addition, to confirm the specific information, documents, such as project reports and academic publications of national institutions that calculated the indicators, were checked. Finally, if the index was not secured through the search, consultations were conducted with experts.

2.3. National distribution data

To answer the questions, open materials distributed by the state and materials from the conference were used. Data from the National Statistical Office, 2021 population and housing census, 2021 future population estimation, 2020 death cause statistics, and 2017 and 2021 birth statistics press releases were used. In the data from the Korea Centers for Disease Control and Prevention, the 2021 tuberculosis patient report status, 2020 HIV/AIDS report status year, and tuberculosis treatment guidelines were used. In the data from the Ministry of Health and Welfare, clinical guidelines for screening genetic testing for newborns, criteria for determining the grade of disablement, disaster crisis management measures for infectious diseases, and the classification of medical institutions were used. In addition, the World Population Review's literacy rate by the country in 2022, the Ministry of Science and ICTs 2021 wireless communication service subscriber statistics, the 2021 Internet usage survey, the Ministry of Education's school health inspection guidelines and integrated education guidebook, the National Health Insurance Service and Health Insurance Review and Assessment Service's health insurance statistics year, and hospital inquiry services were included. To use data from National Health Insurance, approval of the institutional review board is required. This study was approved by the Institutional Review Board of Yonsei University Wonju Severance Christian Hospital (Wonju, South Korea) (CR323326). The National Statistical Portal (KOSIS) provided by the National Statistical Office, Population and Housing Survey, and Disability Statistical Yearbook published by the Korea Disabled Development Institute were mainly used.

The Korean Statistical Information Service (KOSIS) is a statistical service provided by the National Statistical Office for users to find the statistics they want at once by collecting major domestic and international statistics. Currently, it contains more than 1,000 types of state-approved statistics on the economy, society, and environment prepared by more than 300 institutions and provides the latest statistics on international finance, the IMF, the World Bank, and the OECD. Most national distribution data, such as the population and housing census and disability statistical yearbook, are uploaded on the portal (10).

The population and housing general survey is a basic national statistical survey conducted by the National Statistical Office to understand the size and characteristics of all people and houses in Korea and is released annually. It is a national basic statistical survey conducted on people and residences in the national territory at a certain time and period and is used as basic data in various fields, including policymaking, planning, research, and evaluation by national institutions, private companies, academic organizations, and the public. It is used to prepare secondary processing statistics, such as the Ministry of Employment and Labor's labor supply plan, the Ministry of Health and Welfare's premium rate and national pension fiscal estimate, the low birth rate and aging index, and the Ministry of Land, Infrastructure, and Transport's housing supply rate (11). The disability statistical yearbook is a statistical record that shows the situation of the disabled and has been distributed by the Korea Disabled Development Institute since 2015 (12). It is based on the Convention on the Rights of the Disabled and the satisfaction of the needs of the disabled in different stages of their life cycle. Administrative data of major ministries related to the disabled are recorded and reprocessed to get linked with the performance of the policies for the disabled currently in effect in Korea, indirectly assessed by the government to actively implement policies and services for the disabled and used as basic data to institutionalize welfare policies for the disabled. The disability statistics yearbook consists of 11 social indicators, nine health and welfare yearbooks, seven disability statistics, and 13 social security categories. It collects indicators that represent the lives of the disabled, including

a survey on household finance and welfare, annual reports on special education, housing, convenience for transportation, and access to information.

The main priority was whether the criteria for determining the data were calculated by national ministries. As most of the data produced by national ministries are targeted at the entire nation and collected at the national level, it can be inferred that these data have been verified in terms of representation and reliability. If there were no data, the data of the academic society or association in the field were used; if there were no data in the institution, the engineer or expert was consulted. The year of the data to be used was set as 2021, as the data from the major national ministries for the year 2022 would be distributed the following year, and the most recent data were used if there were no data for the year 2021.

3. Results

3.1. Section 1

3.1.1. Population profile

The results of the population profile are shown in Table 1. The data sources for the total population, age distribution, and sex distribution were the 2021 population and housing census data from the National Statistical Office (11). The data sources for the rural-urban distribution were the 2021 Population and Housing Survey by the Ministry of Land, Infrastructure, and Transport and the 2021 housing survey (11, 13). The data source for the literacy rate was the 2022 literacy rate by country of World Population Review (14).

3.1.2. Sociopolitical profile

The results of the sociopolitical profile are shown in Table 1. The data source was the 2021 wireless communication service subscriber statistics of the Ministry of Science and ICT (15) and the 2021 Internet usage survey from the Ministry of Science and ICT (16).

3.1.3. Health status indicators

The results of the health status indicators are shown in Table 1. For data sources, the life expectancy at birth is Statistics Korea's 2021 future population estimate (17), the Annual birth rate is 2021 birth statistics from the National Statistical Office (18), and the under-five mortality rate is statistics from the National Statistical Office's 2020 cause of death (19). The data source of birthplace was the National Statistical Office's 2017 birth statistics press release (20). Regarding birthplace, the National Statistical Office has not collected data since 2017; therefore, the presented data are the latest recorded data. The answer to question 6, "Are the following vaccines included in the immunization program of the country?", is yes. Regarding vaccines, measles, mumps, and rubella are covered by one MMR vaccine in Korea, and the vaccination rate is 97.7% at the age of 2 years, 97.3% at the age of 3 years, and 95.0% at the age of 6 years. In the case of meningitis, inoculation with both types of Hib and PCV vaccines must be applied to prevent it. The vaccination rate of the Hib vaccine is 98.1% for the age of 1 year, 96.2% for the age of 2 years, 96.1% for the age of 3 years, and 95.9% for the age of 6 years. The vaccination rate for the PCV vaccine is 98.1% at the age of 1 year, 97.0% at the age of 2 years, 96.8% at the age of 3 years, and 97.1% at the age of 6 years. In Korea, the data on the rubella vaccination rate for adolescents were not separately collected, so the answer could not be confirmed. The data source was the National Child Vaccination Status of the Korea Centers for Disease Control and Prevention in 2021 (21). The sources for multidrug-resistant tuberculosis and HIV/AIDS data are the Korea Centers for Disease Control and Prevention's 2021 tuberculosis patient report status (22) and the Korea Centers for Disease Control and Prevention's 2020 Annual Report on HIV/AIDS (23).

3.1.4. Hearing loss

The results of the hearing loss are shown in Table 1. The data source of prevalence and age distribution was the 2021 disease statistics from the Health Insurance Review and Assessment Service (24). The data source for the early onset of child hearing loss was the guidelines of the Ministry of Health and Welfare for neonatal hearing screening. Disease statistics were checked for each major cause of hearing loss. Trauma and periodic factors could not be confirmed owing to personal information protection of national data. The low proportion of people suffering from mumps, meningitis, and rubella was possibly due to vaccination, and the data sources for the answers to this question were the 2021 disease statistics by the Health Insurance Review and Assessment Service, 2020 underweight childbirth rate by the Korea Women's Policy Institute, and 2020 total surveillance infectious disease statistics by the Korea Centers for Disease Control and Prevention (24–26).

3.1.5. Healthcare strategy

The results of the healthcare strategies are shown in Table 1. The first question asks whether there is a national strategy related to the field in parentheses, and all of the answers are "Yes." Maternal health has guidelines for obstetrics and gynecology in the internship training and treatment guidelines of the Korean Medical Association (27). Child health has clinical guidelines for the genetic screening of newborns distributed by the Ministry of Health and Welfare in 2011 (28). Since 2017, the Ministry of Health and Welfare has implemented an eye care project to prevent blindness in the older adult population. The aim of this project, along with the Korea Blindness Prevention Foundation, was to prevent blindness in the older adult and included eye examination, eye opening surgery, and rehabilitation projects for the older adult with low vision. Disability has a standard for determining the grade of disability, which has been announced by the Ministry of Health and Welfare by law since 2015. Occupational health includes medical management guidelines for workers diagnosed with noise-induced hearing loss in 2021, distributed by the Korea Occupational Safety and Health Agency in 2021, and treatment guidelines for epilepsy and lung disease, distributed in 2018 by the Korean Tuberculosis and Respiratory Society (29). School health has been a sample survey project for school health tests since 1971. Currently, the Ministry of Education oversees it and distributes sample survey operation manuals (30). Representatively, care of the older adult includes dementia-screening projects and dementia

10.3389/fpubh.2023.1215556

TABLE 1 Questionnaires of Section 1.

Subject	No.	Questionnaires
Population profile	**1**	**Total population (in millions)**
	Answer	Approximately 51 million
	2	**Age distribution of population (%)**
	Answer	0–5 years: 3.3%/6–15 years: 8.7% 16–60 years: 64.4%/>60 years: 23.5%
	3	**Sex distribution (%)**
	Answer	Both men and women were 50%
	4	**Rural-urban distribution (%)**
	Answer	Rural: 8.6%/Urban: 91.4%/Slum dwellers: 12%
	5	**Literacy rate (as a % of the total population)**
	Answer	97.9%
Sociopolitical profile	**1**	**Languages**
	Answer	Korean
	2	**% of the population using mobile phone services**
	Answer	Smartphones: 95%/mobile phones: 5%
	3	**% of the population reached by Internet services**
	Answer	99.9%
Health status indicators	**1**	**Life expectancy at birth**
	Answer	83.9 years old
	2	**Annual birth rate**
	Answer	5.2 per 1,000 people
	3	**Under-five mortality rate**
	Answer	3.2 per 1,000 live births
	4	**% of births taking place in health facilities**
	Answer	99.6%
	5	**% of births taking place at home that are attended by skilled birth attendants**
	Answer	–
	6	**Are the following vaccines included in the immunization program of the country? (Measles, Meningitis, Mumps, Rubella, Rubella in adolescents)**
	Answer	Yes
	7	**Number of cases of multidrug-resistant tuberculosis per year**
	Answer	371
	8	**Number of cases of HIV/AIDS per year**
	Answer	818
Hearing Loss	**1**	**Prevalence of disabling hearing loss**
	Answer	5 million people, 10% of the total population
	2	**Age distribution of hearing loss**
	Answer	Teenage: 3.9%/20s: 8.1%/30s: 8.6% 40s: 10.6%/50s: 15%/60s or older: 52%
	3	**Incidence of congenital or early-onset childhood hearing loss (ECHL)**
	Answer	6 people per 1,000 live births
	4	**What are the main causes of disabling hearing loss?**
	Answer	Chronic otitis media: 0.72%, impacted ear wax: 2.4%, low birth weight: 6.7%, meningitis: 0.02%, mumps: 0.02%, noise-induced hearing loss: 0.17%, ear-toxic hearing loss: 0.0003%, rubella: 0.000004% hearing loss in the older adult: 0.56%

(Continued)

TABLE 1 (Continued)

Subject	No.	Questionnaires
Healthcare strategy	**1**	**Does the country have a national strategy for (Maternal health, child health, eye care, disability and rehabilitation, occupational health, school health, care of older adult, communicable diseases, multidrug-resistant tuberculosis, HIV/AIDS, non-communicable diseases, inclusive education)**
	Answer	Yes
	2	**Has the country ratified the United Nations Convention on the Rights of Persons with Disabilities**
	Answer	Yes
	3	**Are there existing policies on employment of persons with disabilities?**
	Answer	Yes
	4	**Are there any other policies that are relevant to ear and hearing care?**
	Answer	Yes
	5	**How would you summarize the overall situation regarding the preparedness of your country for development and implementation of ear and hearing care strategies?**
	Answer	There is awareness among policy-makers about the need for ear and hearing care services. The country is ready to develop and implement a national strategic plan, and resources are available for this purpose

treatment management support projects implemented by the Ministry of Health and Welfare. Communicable diseases have a standard manual for disaster crisis management for infectious diseases announced as the Framework Act on Disaster and Safety Management and clinical care guidelines for the treatment of patients with COVID-19 newly distributed by the Korea Institute of Health and Medical Research and the Korean Medical Association (31). Multidrug-resistant tuberculosis has a tuberculosis treatment guideline that has been continuously revised by the Korea Centers for Disease Control and Prevention since 2005, and a new section related to multidrug-resistant tuberculosis was added in 2020 (32). HIV/AIDS has 2020 HIV/AIDS management guidelines distributed by the Korea Centers for Disease Control and Prevention, and the Korea AIDS Prevention Association conducts projects, such as nursing support projects, home welfare projects, AIDS counseling centers, and AIDS prevention education and training (33). Non-communicable diseases have cancer treatment guidelines, such as the 2022 hepatocellular carcinoma treatment guidelines, distributed by the Korean Liver Cancer Society and the National Cancer Center, and the Ministry of Health and Welfare supports projects, such as medical expenses for patients with pediatric, adult, and lung cancers. The Ministry of Education distributed a guidebook for the implementation of integrated elementary and secondary school education in 2017 (34). Korea is a member of the United Nations Convention on the Rights of People with Disabilities. The answer to the question "Has the country implemented policies on employment of persons with disabilities?" is "Yes" (35). The Ministry of Employment and Labor implements employment policies for the disabled, including employment incentives, establishment of standard workplaces, assistance with engineering equipment, employment management cost support, employment of severely disabled people, and transition support for the disabled. The answer to the question "Are there any other policies that are relevant to ear and hearing care?" is "Yes." The Korea Occupational Safety and Health Service has established a hearing preservation program and implemented policies for workers vulnerable to noise-induced hearing loss, and the Korean Academy of Sciences has distributed guidelines for the treatment of middle ear infections in children in 2014 and guidelines for the development of hearing aids and inspection confirmation in 2016. In the last question of Section 1 as a whole, the following "There is awareness among policy-makers about the need for ear and hearing care services. The country is ready to develop and implement a national strategic plan, and resources are available for this purpose." can be selected as an answer.

3.2. Section 2

3.2.1. Existing strategic plans or policies for ear and hearing care

The results of the EHC policies implemented by the Ministry of Health and Welfare and other institutions are shown in Table 2. The answer to the first question corresponds to "Yes," and the department dealing with it is the Disabled Policy Bureau of the Ministry of Health and Welfare. The representative is the Director of the Disabled Policy Bureau. The answer to the second question is also "Yes." Representative programs include the school health examination sample survey project conducted by the Ministry of Education and the hearing preservation program conducted by the Occupational Safety and Health Corporation. Since the Ministry of Health and Welfare is not in charge of the above program, the answer to the third question is "No." The last question was asked as summarized in 2.1, and we chose "There is a government-led committee or appointed coordinator for EHC. There is also a national strategic plan for EHC. Activities and programs are being implemented throughout the country" as an answer. The Ministry of Health and Welfare is not entirely in charge of the EHC program but other institutions are implementing the program.

10.3389/fpubh.2023.1215556

TABLE 2 Questionnaires of EHC and service delivery.

Subject	No.	Questionnaires
Existing strategic plan or policies for EHC	**1**	**Is there a designated focal point or coordinator for ear and hearing care in the Ministry of Health?**
	Answer	Yes
	2	**Is there an EHC national or sub-national strategy, plan, or program?**
	Answer	Yes
	3	**Is the plan led by the Ministry of Health?**
	Answer	No
	4	**How would you summarize the overall situation regarding the existence and implementation of strategic plans, programs, and policies in the country?**
	Answer	There is a government-led committee or appointed coordinator for EHC. There is also a national strategic plan for EHC. Activities and programs are being implemented throughout the country
Service delivery	**1**	**Does the country or area have a defined package of services for provision of primary healthcare?**
	Answer	Yes
	2	**If yes, is EHC integrated with the package?**
	Answer	Yes
Primary level	**1**	**Is there a health facility at primary level providing healthcare services and child care services and raising health awareness?**
	Answer	Multiple facilities
	2	**Who are the healthcare providers at the primary level facilities?**
	Answer	General physicians, ENT specialists, audiologists, speech therapists, hearing aid technicians, teachers of the deaf, sign language interpreters, pediatricians, and obstetricians
	3	**What is the population (in 1000s) for which the facility caters?**
	Answer	0.05 per 1,000 people
	4	**Which of the following EHC services are provided at this level?**
	Answer	Health awareness, tympanoplasty, information, education and communication, mastoid surgery, ear examination through otoscopy, hearing aid fitting, hearing assessment, cochlear implantation, treatment of acute otitis media, hearing and speech therapy, removal of foreign bodies from the ear, educational support for children with hearing loss, removal of earwax, and grommet insertion services
	5	**Are outreach services for EHC available at the primary level?**
	Answer	Yes
	6	**If a person reports an ear or hearing problem that requires attention, to whom is he or she referred from the primary level of care?**
	Answer	Private facilities, secondary, and tertiary hospitals
Secondary level	**1**	**Is there a health facility at primary level providing healthcare services and child care services and raising health awareness?**
	Answer	Yes
	2	**Who are the healthcare providers at the primary level facilities?**
	Answer	Multiple facilities
	3	**What is the population (in 1000s) for which the facility caters?**
	Answer	0.008 per 1,000 people
	4	**Which of the following EHC services are provided at this level?**
	Answer	Other than grommet insertion and educational support for children with hearing loss
	5	**Are outreach services for EHC available at the primary level?**
	Answer	Free hearing tests for welfare centers
	6	**If a person reports an ear or hearing problem that requires attention, to whom is he or she referred from the secondary level of care?**
	Answer	Tertiary hospitals

(Continued)

TABLE 2 (Continued)

Subject	No.	Questionnaires
Tertiary level	**1**	**Are EHC services available at tertiary level?**
	Answer	Yes
	2	**What is the health facility at tertiary level providing EHC services?**
	Answer	General hospitals and advanced general hospitals according to the classification of medical institutions by the Ministry of Health and Welfare and Articles 1, 2, and 3 of the Medical Act
	3	**What is the population (in 1000s) for which the facility caters?**
	Answer	0.007 per 1,000 people
	4	**Who are the healthcare providers at the tertiary level facilities?**
	Answer	ENT specialists
	5	**Which of the following EHC services are provided at this level?**
	Answer	Health awareness, tympanoplasty, information, education and communication, mastoid surgery, ear examination through otoscopy, hearing aid fitting, hearing assessment, cochlear implantation, treatment of acute otitis media, hearing and speech therapy, removal of foreign bodies from the ear, and removal of earwax
	6	**Are outreach services for EHC available at the tertiary level?**
	Answer	Medical support projects
	7	**If a person reports an ear or hearing problem that requires attention, to whom is he or she referred from the tertiary level of care?**
	Answer	Tertiary hospital
	8	**What percentage of EHC services and healthcare services are provided by the public health system/ the private sector**
	Answer	71%
	9	**How would you summarize the overall situation regarding services for provision of EHC in the country?**
	Answer	EHC services are available at all tertiary, secondary, and primary-level health facilities

3.2.2. Service delivery

The results of the existence of primary medical care and the presence or absence of EHC are shown in Table 2. As primary care also includes otolaryngology, the answer to both questions is "Yes," and the data source was the article defined for primary care (36).

3.2.2.1. Primary level

The results of the overall state of the primary medical institutions are shown in Table 2. The answer to the first question is "multiple facilities." There are a total of five primary medical institutions according to the classification of medical institutions by the Ministry of Health and Welfare, and the items are clinics, health centers, health branches, health clinics, and healthcare centers (37). Healthcare providers at primary-level facilities include general physicians, ENT specialists, audiologists, speech therapists, hearing aid technicians, teachers of the deaf, sign language interpreters, pediatricians, and obstetricians. As of 2020, the number of facilities was 2,665, with 2,569 clinics, 91 health centers, and four healthcare centers nationwide, accounting for a ratio of 0.05 per 1,000 people. The data sources were the National Health Insurance Corporation's 2020 regional statistical year of medical use and the current status of lawmakers by city, county, district, and marked subjects (37, 38). At this level, health awareness, tympanoplasty, information, education and communication, mastoid surgery, ear examination through otoscopy, hearing aid fitting, hearing assessment, cochlear implantation, treatment of acute otitis media, hearing and speech therapy, removal of foreign bodies from the ear, educational support for children with hearing loss, removal of earwax, and grommet insertion services are all provided. The data source was the hospital inquiry service of the Health Insurance Review and Assessment Service. The answer to whether primary medical institutions provide outreach services is "Yes." Many hearing aid companies provide free hearing tests, hearing aid checks, and hearing counseling for the older adult at welfare centers. At the primary level, to learn about hearing problems, patients can visit private facilities, secondary, and tertiary hospitals.

3.2.2.2. Secondary level

The results of the overall state of the secondary medical institutions are shown in Table 2. The answers to the first and second questions are "Yes" and "Multiple facilities," respectively. Secondary medical institutions include hospitals and nursing hospitals according to the classification of medical institutions by the Ministry of Health and Welfare and Articles 1, 2, and 3 of the Medical Act. In secondary medical institutions, only ENT specialists provide EHC services. As of 2020, there were 241 hospitals and 157 nursing hospitals, with a total of 398 facilities per 1,000 people with a ratio of 0.008. The data sources were the National Health Insurance Corporation's 2020 regional statistical year of medical use and the current status of lawmakers by city,

county, district, and marked subjects (37, 38). The EHC services included items other than grommet insertion and educational support for children with hearing loss. Outreach services provide free hearing tests for welfare centers at hearing aid companies, and others. At the secondary level, on learning about hearing problems, patients can visit a tertiary hospital.

3.2.2.3. Tertiary level

The results of the overall state of the tertiary medical institutions are shown in Table 2. The answer to the first question is "Yes." Tertiary medical institutions include general hospitals and advanced general hospitals according to the classification of medical institutions by the Ministry of Health and Welfare and Articles 1, 2, and 3 of the Medical Act. Only ENT specialists provide EHC services in tertiary medical institutions. As of 2020, there were 187 general hospitals and 42 advanced general hospitals, for a total of 361, and the number of facilities was in the ratio of 0.007 per 1,000 people. The data source was the National Health Insurance Corporation's 2020 Annual Report on Medical Use by Region (38). Medical institutions provide health awareness, tympanoplasty, information, education and communication, mastoid surgery, ear examination through otoscopy, hearing aid fitting, hearing assessment, cochlear implantation, treatment of acute otitis media, hearing and speech therapy, removal of foreign bodies from the ear, and removal of earwax. Municipal governments support outreach services when conducting medical support projects, and the data source was a medical support project for the homeless in Seoul. At the tertiary level, on learning about hearing problems, patients can visit a tertiary hospital. Advanced general hospitals were divided into national and private hospitals, with 12 out of 42 national and public hospitals accounting for 29% and 30 private hospitals accounting for 71%. The last question, "EHC services are available at all tertiary, secondary, and primary level health facilities" can be selected as a summary answer for 2.2.

3.2.3. Health workforce

3.2.3.1. ENT specialists

Section 2.3 concerns people employed in the EHC field. The results of the overall state of ENT specialists are shown in Table 3. As of the fourth quarter of 2020, the number of ENT specialists in Korea was 3,977, with a ratio of 0.8 per 100,000 people. The data source was the current status of the specialist workforce by type of nursing institution 2020 in the National Statistical Portal (39). The minimum education period is 2 years for preparatory courses, 4 years for the main course, 1 year for training, and 4 years for specialists; the source was the Korea Medical University Association. Some institutions educate ENT specialists in Korea, with a total of 40 universities and medical graduate schools. The number of graduates produced annually is 116, based on those who passed the 2020 professional qualification exam. The skills of the ENT specialist include medical management of common ear conditions, surgical management of common ear conditions, myringotomy, grommet insertion, tympanoplasty, mastoid surgery, stapedectomy, cochlear implantation, audiometry, tympanometry, otoacoustic emissions/auditory brainstem response/auditory steady-state response, hearing aid fitting, earmold preparation, audio-verbal therapy, and speech therapy.

3.2.3.2. Audiologists

The results of the overall state of audiologists are shown in Table 3. As of 2022, the number of audiologists in Korea is 475, with a ratio of 0.5 per 100,000 people. The data source was the audiologist's qualification examination center. The minimum training period is 4 years. There are educational instruments and six universities in Korea based on the Department of Language and Hearing. The number of audiologists produced annually is 210, and the data source was the audiologist qualification examination center. Audiologists' skills include audiometry, tympanometry, otoacoustic emissions/auditory brainstem response/auditory state response, hearing aid fitting, audio-verbal therapy, speech therapy, family counseling, counseling on the use of hearing aids, earmold preparation, use of environmental aids, otoscopy, and diagnosis of common ear conditions.

3.2.3.3. Speech and audio-verbal therapists

The results of the overall state of speech and audio-verbal therapists are shown in Table 3. As of 2022, there are 2,800 language rehabilitation workers in Korea, and the data source was the Korean Language Rehabilitation Association. The minimum education period for speech and audio-verbal therapists is 4 years. There are educational instruments and 29 universities in Korea with language therapy-related departments. The number of speech and audio-verbal therapists produced annually is ∼900, and the source was the current status of applicants for the language rehabilitation certificate of the National Institute of Health (40). Skills of speech and audio-verbal therapists include audio-verbal therapy, speech therapy, audiometry, and counseling on the use of environmental aids.

3.2.3.4. Hearing aid and earmold technicians

The results of the overall state of hearing aid and earmold technicians are shown in Table 3. As of 2022, there are 288 hearing aid distributors in Korea, the data source of which was the Korean Hearing Society. Hearing aid technicians and earmold technicians have a minimum educational period of 2 years, and there are educational instruments and six universities related to audiology in Korea. The number of hearing aid and earmold technicians produced annually is ∼260, and the data source was the status of those who had passed the hearing management certificate of the Korean Acoustics Association (41). The skills of hearing aid and earmold technicians include audiometry, tympanometry, family counseling, speech therapy, audio-verbal therapy, and counseling on the use of environmental aids.

3.2.3.5. Teachers of the deaf

The results of the overall state of teachers of the deaf are shown in Table 3. As of 2020, the number of teachers in this department in Korea was 650, with a ratio of 1.2 per 100,000 people. The data source was the 2020 Special Education Statistics of the Ministry of Education. The minimum training period is 4 years. There are educational institutions and 36 universities based in the Department of General Education and Special Education. The annual number of teachers in the department was about 180 in 2020, and the data source was the Ministry of Education's 2020 special education statistics. The skills of teachers of the deaf include educational support for preschool children with hearing

10.3389/fpubh.2023.1215556

TABLE 3 Questionnaires of Health Workforce.

Subject	No.	Questionnaires
ENT specialists	**1**	**Total number in the country**
	Answer	3,977 (0.8 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	2 years for preparatory courses, 4 years for the main course, 1 year for training, and 4 years for specialists
	3	**Are there educational institutions offering degree or diploma courses for training of ENT specialists?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma in ENT specialists**
	Answer	40 universities and medical graduate schools
	5	**Number of persons graduating each year**
	Answer	116
	6	**Skills of the ENT specialists**
	Answer	Medical management of common ear conditions, surgical management of common ear conditions, myringotomy, grommet insertion, tympanoplasty, mastoid surgery, stapedectomy, cochlear implantation, audiometry, tympanometry, otoacoustic emissions/auditory brainstem response/auditory steady-state response, hearing aid fitting, earmold preparation, audio-verbal therapy, and speech therapy
Audiologists	**1**	**Total number in the country**
	Answer	475 (0.5 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	4 years
	3	**Are there educational institutions offering degree or diploma courses for training of audiologists?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma in audiology**
	Answer	6 universities in Korea based on the Department of Language and Hearing.
	5	**Number of persons graduating each year**
	Answer	210
	6	**Skills of the audiologists**
	Answer	Audiometry, tympanometry, otoacoustic emissions/auditory brainstem response/auditory state response, hearing aid fitting, audio-verbal therapy, speech therapy, family counseling, counseling on the use of hearing aids, earmold preparation, use of environmental aids, otoscopy, and diagnosis of common ear conditions
Speech therapists and Audio-verbal therapists	**1**	**Total number in the country**
	Answer	2,800
	2	**Minimum educational qualification required**
	Answer	4 years
	3	**Are there educational institutions offering degree or diploma courses for training speech therapists or audio-verbal/auditory-oral therapists?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma course**
	Answer	29 universities in Korea with language therapy-related departments
	5	**Number of persons graduating each year**
	Answer	900
	6	**Skills of teachers of the speech therapists and Audio-verbal therapists**
	Answer	Audio-verbal therapy, speech therapy, audiometry, and counseling on the use of environmental aids

(Continued)

TABLE 3 (Continued)

Subject	No.	Questionnaires
Hearing aid and earmold technicians	**1**	**Total number in the country**
	Answer	288
	2	**Minimum educational qualification required**
	Answer	2 years
	3	**Are there educational institutions offering degree or diploma courses for training of Hearing aid or earmold technicians?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma**
	Answer	6 universities related to audiology
	5	**Number of persons graduating each year**
	Answer	260
	6	**Skills of the hearing aid or earmold technicians**
	Answer	Audiometry, tympanometry, family counseling, speech therapy, audio-verbal therapy, and counseling on the use of environmental aids
Teachers of the deaf	**1**	**Total number in the country**
	Answer	650 (1.2 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	4 years
	3	**Are there educational institutions offering degree or diploma courses for training of teachers of the deaf?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma**
	Answer	36 universities based in the Department of General Education and Special Education
	5	**Number of persons graduating each year**
	Answer	180
	6	**Skills of teachers of the deaf**
	Answer	Educational support for preschool children with hearing loss, educational support for school children with hearing loss, sign language practice, family counseling, and counseling on the use of hearing aids and environmental aids
Sign language interpreters	**1**	**Total number in the country**
	Answer	2,968 (5.7 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	1 year, and an additional 50 h of maintenance training must be completed after obtaining a sign language interpreter certificate
	3	**Are there educational institutions offering degree or diploma courses for training of sign language interpreters?**
	Answer	Yes
	4	**Total number of educational facilities offering degree or diploma**
	Answer	4 departments including the Korean Deaf Association and Sign Language Interpretation-related departments
	5	**Number of persons graduating each year**
	Answer	100
	6	**Skills of sign language interpreters**
	Answer	Sign language interpretation, family and individual counseling, and counseling on the use of hearing aids and environmental aids
General physicians	**1**	**Total number in the country**
	Answer	6,030 (11.6 per 100,000 people)

(Continued)

TABLE 3 (Continued)

Subject	No.	Questionnaires
	2	**Minimum educational qualification required**
	Answer	6 years
	3	**Which of the following ear and hearing care services do general physicians provide?**
	Answer	Diagnosis and medical management of acute ear infections, diagnosis and medical management of chronic ear infections, hearing tests, and removal of ear wax and foreign bodies
Emergency medical technician	**1**	**Total number in the country**
	Answer	11,000 (22 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	6 months
	3	**Which agency provides training for emergency medical technicians?**
	Answer	Firefighting schools and Emergency rescue education centers
	4	**Which of the following ear and hearing care services do emergency medical technicians provide?**
	Answer	Raising health awareness in the community, medical management of ear infections, reference services, and removal of foreign bodies
Health education specialist	**1**	**Total number in the country**
	Answer	14,000 (28 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	4 years
	3	**Which agency provides training for health education specialists?**
	Answer	The Korea Health Association, the Korea Nursing Association, the International Association for Moderation, and the Korea Health Promotion and Development Institute
	4	**Which of the following ear and hearing care services do emergency health education specialists provide?**
	Answer	Raising health awareness in the community, medical management of early influences, and reference services according to the notification of national qualification management for health educators
Caregivers	**1**	**Total number in the country**
	Answer	13,000 (26 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	6 months
	3	**Which agency provides training for caregivers?**
	Answer	Caregiver center
	4	**Which of the following ear and hearing care services do caregivers provide?**
	Answer	Raising health awareness in the community, medical management of early influences, referenced services, wax, and foreign body removal
Practical nurse	**1**	**Total number in the country**
	Answer	400,000 (800 per 100,000 people)
	2	**Minimum educational qualification required**
	Answer	1 year
	3	**Which agency provides training for practical nurses?**
	Answer	Practical nurse training centers and Practical nurse academies
	4	**Which of the following ear and hearing care services do practical nurses provide?**
	Answer	Raising health awareness in the community, medical management of early influences, referenced services, wax, and foreign body removal

(Continued)

TABLE 3 (Continued)

Subject	No.	Questionnaires
Summarize	**1**	**How would you summarize the overall situation regarding availability of human resources for ear and hearing care within the country?**
	Answer	There are an adequate number of human resources for EHC available in all urban and rural areas of the country
	2	**How would you summarize the overall situation regarding availability of educational facilities for training of human resources for EHC within the country?**
	Answer	Training facilities for health workers are available as well as educational facilities for professional training, and these are adequate to provide EHC for the entire country

loss, educational support for school children with hearing loss, sign language practice, family counseling, counseling on the use of hearing aids and environmental aids, and the data source was the Korean Occupational Dictionary of the Ministry of Employment and Labor (42).

3.2.3.6. Sign language interpreters

The results of the overall state of sign language interpreters are shown in Table 3. As of 2018, the number of sign language interpreters in Korea was 2,968, with a ratio of 5.7 per 100,000 people. The source was research data on how to revitalize sign language interpreters provided by the Korea Disabled Development Institute (43). The minimum training period is 1 year, and an additional 50 h of maintenance training must be completed after obtaining a sign language interpreter certificate. There are educational instruments and a total of four departments, including the Korean Deaf Association and Sign Language Interpretation-related departments. According to the Ministry of Education's 2020 Special Education Statistics, the number of sign language interpreters produced annually is ∼100. Skills of sign language interpreters include sign language interpretation, family and individual counseling, and counseling on the use of hearing aids and environmental aids.

3.2.3.7. General physicians

The results of the overall state of general physicians are shown in Table 3. As of the fourth quarter of 2020, the number of general physicians in Korea was 6,030, with a ratio of 11.6 per 100,000 people. The data source was the current state of the national statistical portal. The minimum training period is 6 years (39). General physicians can provide diagnosis and medical management of acute ear infections, diagnosis and medical management of chronic ear infections, hearing tests, and removal of ear wax and foreign bodies.

3.2.3.8. Health workers

Health workers, excluding medical personnel (doctors, dentists, oriental doctors, nurses, midwives, pharmacists, and herbalists) specified in the Medical Act, include emergency medical technicians, caregivers, health education specialists, and practical nurses.

3.2.3.8.1. Emergency medical technician

The results of the overall state of emergency medical technicians are shown in Table 3. As of 2020, ∼11,000 emergency medical technicians were employed in Korea, with a ratio of 22 per 100,000 people. The source was statistics on the emergency medical status of the National Medical Center (44). The minimum training period is 6 months, according to the emergency rescue test information of the National Testing Service, a Korean healthcare institution. Educational institutions have firefighting schools and emergency rescue education centers according to the Emergency Medical Act (45). Emergency responders can provide services, such as raising health awareness in the community, medical management of ear infections, reference services, and removal of foreign bodies. The data source was the Korean vocational dictionary of the Ministry of Employment and Labor.

3.2.3.8.2. Health education specialist

The results of the overall state of health education specialists are shown in Table 3. Health education specialists are those who provide education related to health and health promotion and specialize in conducting health promotion projects. As of 2021, about 14,000 people were employed in Korea, with a ratio of 28 per 100,000 people. The data source was a survey on the current status of health education personnel activities at the Korea Institute of Health Promotion and Development (46). The minimum education period is 4 years, depending on the matter in the survey on the status of health education history activities of the Korea Health Promotion and Development Institute. According to the Ministry of Health and Welfare's notice on the national qualification management of health educators, there is the Korea Health Association, the Korea Nursing Association, the International Association for Moderation, and the Korea Health Promotion and Development Institute. Health educators can provide services, such as raising health awareness in the community, medical management of early influences, and reference services, according to the notification of national qualification management for health educators.

3.2.3.8.3. Caregiver

The results of the overall state of caregivers are shown in Table 3. As of 2020, ∼13,000 caregivers were employed in Korea, with a ratio of 26 per 100,000 people. The data source was the National Health Insurance Corporation's Statistical Yearbook of Long-Term Care Insurance for the older adult (47). The minimum education period is 6 months in accordance with the Ministry of Health and Welfare's 2021 guidelines for training caregivers, and the educational institution is the caregiver center. Caregivers can provide services for raising health awareness in the community, medical management of early influences, referenced services, and

wax and foreign body removal, according to the guidelines of the Ministry of Health and Welfare (48).

3.2.3.8.4. Practical nurse

The results of the overall state of practical nurses are shown in Table 3. As of 2020, ~400,000 practical nurses were employed in Korea, with a ratio of 800 per 100,000 people. The data source was the 2020 Health and Medical Personnel Survey of the Ministry of Health and Welfare (49). The minimum training period is 1 year, depending on the qualification for applying for the practical nurse examination at the National Examination Institute, a Korean healthcare institution. Educational institutions include practical nurse training centers and practical nurse academies, according to the rules of nursing assistants and medical-related businesses of the Ministry of Health and Welfare (50). Practical nurses can provide services by raising health awareness in the community, medical management of early influences, referenced services, and wax and foreign body removal, according to the 2021 guidelines of the Ministry of Health and Welfare for nursing care education.

3.2.3.9. Summarize

Table 3 comprehensively summarizes about domestic medical workers, and the summarized answer to the first question can be selected as "There are an adequate number of human resources for EHC available in all urban and rural areas of the country." The summarized answer to the second question can be selected as "Training facilities for health workers are available as well as educational facilities for professional training, and these are adequate to provide EHC for the entire country."

3.2.4. Medical products and health technology

3.2.4.1. Hearing devices

3.2.4.1.1. Hearing aids

The results of the overall state of hearing aids are shown in Table 4. The answer to the first question is "Yes," and digital technology, analog technology, body-worn, behind-the-ear, in-the-ear, open-fit, and custom-made earmolds are all possible. For the third and fourth questions, there is a hearing aid fitting guidance for each hearing aid company, but it is not provided separately by grade and child age. Hearing aid is covered under insurance, so the answer to the fifth question is "at full cost." Regarding the maintenance of hearing aids, there are guidelines for each company, so the answer is "Yes," and the fitting program manual of Resound, one of the hearing aid companies, was checked (51). Battery provision is not included in the public hearing aid fitting program, and hearing aid services can be received in the private sector. Representative institutions among non-governmental organizations include Snail of Love and Dasan.

3.2.4.1.2. Cochlear implants

Cochlear implants are available in both public health systems and the private sector, similar to hearing aids. This was confirmed in the hospital inquiry service of the Health Insurance Review and Assessment Service, and the guidelines are publicly distributed by Snail of Love, a non-profit organization (52).

3.2.4.2. Other assistive devices

The results of the overall state of other assistive devices are shown in Table 4. All the answers to questions about loop systems are "Yes," and Wave Hearing carried out installments at Incheon International Airport, a church in Gangnam, Seoul, Hyundae Motor Studio in Goyang, Daejeon's Cathedral, and Cheonan's Independence Hall. In addition, installments were carried out in several elementary and middle schools by applying the hearing-loop system to the Goyang Special Education Support Office. Captioning services are also available on major TV channels. The guidelines for the provision of broadcasting programs for the disabled announced by the Korea Communications Commission stipulate that "closed caption broadcasting, screen commentary broadcasting, and Korean sign language broadcasting should be produced and organized in terrestrial broadcasting," and there were 41 terrestrial broadcasters in 2021 (53).

3.2.4.3. Medicines

The results of the overall state of medicines are shown in Table 4. According to the Prescription Act, Article 17 of the Medical Act, broad-spectrum antibiotics, antibiotic ear drops, antifungal ear drops, and nasal decongestants can be prescribed at all medical institutions because no classification of drugs can be selectively prescribed according to the medical institution. The answer to the last question is a summary of 2.4, and since measures and guidelines are in place for all questions, "Hearing aid services are available and accessible to most people in urban and rural areas of the country. CI are available and accessible to those in need of them" (54).

3.2.5. Health financing

3.2.5.1. Financing of ear and hearing care services

The results of the overall state of enactment of the hearing care service are shown in Table 5. The answer to the first question is "Yes." The Ministry of Health and Welfare had set up a budget for 2021 in the name of training public medical personnel, strengthening the publicity of local hospitals, and training professionals in vulnerable areas (55). The government is conducting projects, such as the newborn hearing loss test support project and hearing aid support project, but the support rate differs depending on income, so the appropriate answer selection would be "Some services are available free of charge, but others have to be paid for, fully or partially" (56). In Korea, some of the medical expenses are covered by health insurance, so we choose "Costs are partially covered by health insurance" as the answer. For the last question, "EHC services are completely free" would be a reasonable choice.

3.2.5.2. Health insurance

The results of the overall state of health insurance are shown in Table 5. The answer to the first question is "Yes." On 1 November 2020, out of the total population of about 51.829 million living in Korea, 51.345 million people subscribed to the National Health Insurance, accounting for 99% of the population. The data source was the 2020 health insurance statistical yearbook published by the National Health Insurance

10.3389/fpubh.2023.1215556

TABLE 4 Questionnaires of Medical products and health technology.

Subject	No.	Questionnaires
Hearing aids	**1**	**Are hearing aid services available through the public health system?**
	Answer	Yes
	2	**What types of hearing aids are available through the public health system?**
	Answer	Digital technology, analog technology, body-worn, behind-the-ear, in-the-ear, open-fit, and custom-made earmolds are all possible
	3	**Is there standardized guidance or recommendations for hearing aid fitting in adults?**
	Answer	Hearing aid fitting guidance for each hearing aid company
	4	**Is there standardized guidance or recommendations for hearing aid fitting in children?**
	Answer	Hearing aid fitting guidance for each hearing aid company
	5	**Are hearing aids fitted:** **☐ Free of cost ☐ at subsidized cost ☐ at full cost**
	Answer	At full cost
	6	**Are repair and maintenance issues included in the hearing aid fitting program?**
	Answer	Yes
	7	**Is battery provision part of the hearing aid fitting program?**
	Answer	No
	8	**Are hearing aid services available in the private sector?**
	Answer	Yes
	9	**Are any non-governmental organizations providing hearing aid services?**
	Answer	Snail of Love and Dasan
Cochlear implants	**1**	**Are CI services available through the public health system?**
	Answer	Yes
	2	**Are CI services available in the private sector?**
	Answer	Yes
	3	**Is there standardized guidance or recommendations on cochlear implantation?**
	Answer	The guidelines are publicly distributed by Snail of Love, a non-profit organization
Other assistive devices	**1**	**Are loop systems available in public places?**
	Answer	Yes
	2	**Are loop systems available in schools or special schools?**
	Answer	Yes
	3	**Are captioning services available on majority of TV channels?**
	Answer	Yes
Medicines	**1**	**Which of the following broad-spectrum antibiotics are available through the public health system and at which care level?**
	Answer	All
	2	**Which of the following antibiotic ear drops are available through the public health system and at which care level?**
	Answer	All
	3	**Which of the following antifungal ear drops are available through the public health system and at which care level?**
	Answer	All
	4	**Which of the following nasal decongestants are available through the public health system and at which care level?**
	Answer	All
	5	**How would you summarize the overall situation regarding the availability and accessibility of hearing devices in the country?**
	Answer	Hearing aid services are available and accessible to most people in urban and rural areas of the country. CI are available and accessible to those in need of them

TABLE 5 Questionnaires of Health financing and Health information and research.

Subject	No.	Questionnaires
Financing of ear and hearing care services	**1**	**Is there a budget allocation for EHC in the Ministry of Health?**
	Answer	Yes
	2	**Does the government provide EHC services?**
	Answer	Yes
	3	**Are EHC services provided by privately practicing specialists?**
	Answer	Yes
	4	**Are EHC services provided by any non-governmental agency?**
	Answer	Yes
Health insurance	**1**	**Is health insurance available in the country?**
	Answer	Yes
	2	**If yes, what percentage of the population is covered by it?**
	Answer	99%
	3	**Are EHC services provided by privately practicing specialists?**
	Answer	Yes
	4	**Who are the key providers of health insurance in the country?**
	Answer	Government
Health information system	**1**	**Does the country have a national health information system?**
	Answer	Yes
	2	**Are health-related data and information collected and centrally administered in the country?**
	Answer	Yes
	3	**What are the sources of health information reported by the country?**
	Answer	Program reports
	4	**Is there a system of personal child health records (through health or other departments)?**
	Answer	Yes
	5	**Is information on ear or hearing included as part of this record?**
	Answer	Yes
	6	**Is any information or indicator related to EHC reported at government level?**
	Answer	Yes
Research	**1**	**Are there any government-led agencies or institutes conducting research in the field of EHC?**
	Answer	Yes
	2	**What are the key areas of focus of the research in the field of EHC?**
	Answer	Clinical
	3	**Which are the key funding agencies supporting research in the field of EHC?**
	Answer	The Korea Research Foundation and the Korea Academic Promotion Foundation
	4	**How would you summarize the overall situation regarding the health information system in the country?**
	Answer	There is a government-led health information system in the country. It includes some information or indicators on EHC

Service and the Health Insurance Review and Assessment Service (57). Compared to the 78% private health insurance subscription rate in Korea as of 2020, the key provider of health insurance in the country was the government. The data source was the 2020 private medical insurance subscription rate distributed by the National Statistics Portal (58). The answer to the last question is about the summary of 2.5, and "Most of the cost of EHC is covered through government-led health financing schemes, and it is affordable for all." is the appropriate answer.

3.2.6. Health information and research

3.2.6.1. Health information system

The results of the overall state of health-related data are shown in Table 5. The answers to the first and second questions are "Yes" because the National Health Insurance Service (NHIS), the Health Insurance Review and Assessment Service (HIRA), the National Cancer Center, and the Korea Centers for Disease Control and Prevention exist. In the case of the National Health Insurance Service and the Health Insurance Review and Assessment Service, the answer to the third question is "Program reports" because it is reported based on the information of the subjects subscribed to the national health insurance. The answers to the fourth and fifth questions are "Yes" because there is an infant screening cohort database among the databases of the National Health Insurance Service and early or hearing information is included in the DB. Although there are no data that the government reports only EHC distribution, the answer to the last question is "Yes" because there are data, such as the annual disability statistics, released by the Korea Disabled Development Institute (12).

3.2.6.2. Research

The results of the overall state of EHC research are shown in Table 5. The first question is whether there is a government-led institution that conducts EHC research in Korea. The answer is "Yes" because the Korea Vocational Ability Research Institute is conducting research in the field of hearing management as a learning module development and utilization project. The second question asked about the focus of domestic EHC research, and referring to an article listed in the Korean academic journal Index in otolaryngology in 2022, we answered with "Clinical" because there were a maximum number of clinical papers. The third question is whether any institutions support EHC research; this is the case with the Korea Research Foundation and the Korea Academic Promotion Foundation. The last answer for the summary question of 2.6. is "There is a government-led health information system in the country. It includes some information or indicators on EHC." since EHC research is being actively conducted in Korea and the government is also supporting it.

4. Discussion

This study aimed to identify the current status of EHC in Korea using EHCSA distributed by the WHO in 2015, compare it with other countries, and establish and improve policies related to medical services and hearing diseases. To this end, we would like to examine various areas, such as domestic health policies, the status of patients with hearing-impairment, and the status of medical personnel, and report to WHO on the state of EHC in Korea.

In Iran, a situation analysis was conducted on the domestic ear and hearing care program based on the EHCSA. Through this, inadequate health literacy, weak intra-sectoral and intersectoral cooperation, inadequacy of policy responses, non-integration of the EHC in the primary healthcare system, poor standard processes and resources of EHC, and lack of an EHC surveillance system were identified as major problems (8). In Bangladesh, ~1,200 experts were interviewed using the EHCSA, with insufficient rehabilitation staff training, lack of qualified medical personnel, insufficient primary and secondary medical facilities, and high rates of care service charges (59). Twenty-two countries in sub-Saharan Africa had less than one ENT specialist, audiologist, and speech therapist per 100,000 people in all countries except South Africa (60). In some countries, such as Burundi and Malawi, there are no cultivated speech therapists (61). In Guatemala, ENT specialists were present in a ratio of 2.8 per 1 million people and 61 per 1 million people in Argentina, while in Southeast Asia, ENT specialists were in a ratio of 2.68 per 100,000 people in all countries except Thailand, and audiologists, speech experts, and sign language interpreters were all in low numbers (62). The WHO used the WHO Workforce Indicator for Staffing Needs tool to assess the human resource gap in EHC. The gap in education for the development of related service experts was most prominent in low- and middle-income countries. In the case of arrogance, all those affected by earwax need 137 ENT specialists to be treated, with only 40 being able to treat, showing a 70% availability rate. In India, 1,075 ENT specialists are required to identify and diagnose common ear diseases in all patients up to the age of 15 years (63). At a tertiary medical institution in Santiago, Chile, 78 experts fit hearing aids, with ~0.01% of them in charge of the work (64).

In contrast, Russia supplemented its nationwide implant and hearing aid programs by introducing a cochlear implant in 1991. Therefore, infants born with hearing impairments could receive hearing aids or cochlear implants and rehabilitation services as needed, and up to 1,100 infants receive cochlear implants each year. In addition, people of all ages can receive hearing tests and hearing aid fitting services at audiological centers, which are paid through the national budget (65). In the UK, the National Health Service (NHS) supports people in need of hearing aids and cochlear implants. Approximately 750,000 hearing aids and cochlear implants are provided through the NHS each year, and a national supply chain of hearing aids has been established to provide them at low prices (66). In China, various measures are being implemented to bridge the gap in human resources, such as auditory and verbal therapy. Since 1995, the Specialized Educational Program has been launched in collaboration with hearing and language rehabilitation experts, and more than 1,000 experts have been trained to date, providing hearing and language rehabilitation and aiming to establish a Chinese rehabilitation university. In addition, vocational training courses have been conducted since 2008 for high-quality hearing aid fitting (67).

Comparing policies and workforce status in other countries, data, such as Korea's EHC program and workforce status, are at the level of advanced countries. The Ministry of Health and Welfare publishes a health and welfare white paper every year to understand major policies and achievements in the health and welfare sector and to help the government achieve new national goals and tasks. The policies implemented by the Ministry of Health and Welfare, the current status of projects, and plans for implementing new policies are specified. There are child welfare policies, older adult welfare policies, low birth rate measures, disability welfare policies, oral health policies, mental health policies, and herbal medicine policies; however, EHC policies are not implemented or planned, except for innate hearing tests and hearing aid support policies (68).

The Korea Health Industry Promotion Agency's "Hearing Aid Market Analysis" published in 2015 reported that the average growth rate of hearing aids worldwide is 6.9%. Looking at the

ranking, Korea showed the fourth-highest growth rate of 8.5% after 18.3% in China, 10.3% in Germany, and 9.1% in France (69). There are ∼12,250 audiologists, 5,570 hearing aid sellers working as hearing experts, and ∼13,000 hearing aid centers in the United States. Japan has 3,750 hearing aid centers, and Korea has 1,582 hearing aid centers that have been reported and are operating (70).

A survey was conducted to investigate the current status of the domestic hearing aid market, and 61.6 and 71.7% of the respondents said they needed an obscure certificate to sell hearing aids in the category of factors that hinder the development of the domestic hearing aid market and need education as a hearing expert, respectively (71). In addition, it is difficult to determine the exact status of the supply of hearing aids because anyone can sell them by reporting to the medical device sales business (72).

The above data are not updated continuously, so it is difficult to state that it represents the current situation because it is not the latest data and the survey was conducted with a limited number of people. Therefore, this study is meaningful, and the information on the latest status of the EHC programs was collected. Overall, both the Health workforce and EHC programs are well-prepared, but incidences of hearing diseases, such as hearing loss, are continuously increasing, so various support measures need to be prepared to convert hearing aid-related certificates into national certificates or rehabilitation and support. In addition, domestic health policy improvements and medical service expansion should be achieved through the continuous collection of data on EHC.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Institutional Review Board of Yonsei University Wonju Severance Christian Hospital (CR323326). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

Conceptualization: YS. Data curation: JuhL and JunL. Formal analysis, methodology, and visualization: CY and JuhL. Project administration, writing—reviewing, and editing: CY, YS, SO, and TK. Writing—original draft: JuhL. All authors contributed to the article and approved the submitted version.

Funding

The study was grant-funded by three institutions supported by the Korean government. The National Research Foundation of Korea (No. NRF-2020R1A2C1009789). The Korean Fund for Regenerative Medicine (21C0721L1). The Commercialization Promotion Agency for R&D Outcomes (2023, 1711199152).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1215556/full#supplementary-material

References

1. Moore BCJ, editor. *Hearing*. New York, NY: Academic Press (1995).

2. Stephenson J. WHO Report Predicts Hearing Loss for 1 in 4 People Worldwide by 2050. *JAMA Health Forum*. (2021) 2:e210357. doi: 10.1001/jamahealthforum.2021.0357

3. World Health Organization. *Deafness and Hearing Loss*. (2019). Available online at: https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss (accessed February 2023).

4. Curhan SG. World hearing forum: prioritizing global ear and hearing care. *Hear J*. (2018) 71:26. doi: 10.1097/01.HJ.0000550394.51777.59

5. World Health Organization et al. *Multi-country Assessment of National Capacity to Provide Hearing Care*. (2013). Available online at: https://www.who.int/publications/i/item/9789240020481 (accessed February 2023).

6. Reed NS, Altan A, Deal JA, Yeh C, Kravetz AD, Wallhagen M, et al. Trends in health care costs and utilization associated with untreated hearing loss over 10 years. *JAMA Otolaryngol–Head Neck Surg*. (2019) 145:27–34. doi: 10.1001/jamaoto.2018.2875

7. World Health Organization, et al. *Ear and Hearing Care: Situation Analysis Tool*. Geneva: World Health Organization (2015).

8. Mahmoudian S, Farhadi M, Akrami F, Kamrava SK, Asghari A, Damari B. Situation analysis of ear and hearing care program in Islamic Republic of Iran: system's challenges and proper interventions. *Med J Islam Repub Iran.* (2021) 35:183. doi: 10.47176/mjiri.35.183

9. Santana-Garcia W, Castro-Mondragon JA, Padilla-Gálvez M, Nguyen NTT, Elizondo-Salas A, Ksouri N, et al. RSAT 2022: regulatory sequence analysis tools. *Nucleic Acids Res.* (2022) 50:W670–6. doi: 10.1093/nar/gkac312

10. KOSIS. *Korean Statistical Information Service*. Daejeon: KOSIS (2019).

11. Statistics Korea. *Population and Housing Census*. Daejeon: Statistics Korea (2021).

12. Kim HJ, Kim YJ, et al. Statistical Yearbook of Disability 2021. Seoul: Korea Disabled people's Development Institute (2021).

13. Ministry of Land. *Korea Housing Survey*. Sejong-si: Ministry of Land (2021).

14. World Population Review. *2022 World Population by Country*. Available online at: http://worldpopulationreview.com/ (accessed February 2023).

15. Ministry of Science and ICT. *Statistics of Wireless Communication Service Subscribers*. Sejong: Ministry of Science and ICT (2021).

16. Ministry of Science and ICT. *Survey on Internet Usage*. Sejong: Ministry of Science and ICT (2021).

17. Statistics Korea. *Population Projections for Korea*. Daejeon: Statistics Korea (2021).

18. Statistics Korea. *Vital Statistics for Korea*. Daejeon: Statistics Korea (2021).

19. Statistics Korea. *Causes of Death Statistics*. Daejeon: Statistics Korea (2021).

20. Statistics Korea. *Vital Statistics for Korea*. Daejeon: Statistics Korea (2017).

21. Korea Diseases Control and Prevention Agency (KDCA). *Standard Vaccination Schedule*. Cheongju-si: KDCA (2021).

22. Korea Diseases Control and Prevention Agency (KDCA). *Annual Report on the Notified Tuberculosis in Korea*. Cheongju-si: KDCA (2021).

23. Korea Diseases Control and Prevention Agency (KDCA). *Annual Report on the Notified HIV/AIDS in Korea*. Cheongju-si: KDCA (2020).

24. Health Insurance Review & Assessment Service (HIRA). *Diseases Statistics in Korea*. Wonju: HIRA (2021).

25. Korean Women's Development Institute. *Gender Statistics in Korea*. Seoul: Korean Women's Development Institute (2020).

26. Korea Diseases Control and Prevention Agency (KDCA). *Annual Report on the Mandatory Surveillance Infectious Diseases in Korea*. Cheongju-si: KDCA (2020).

27. Korean Academy of Medical Sciences. *Medical Intern Handbook*. Seoul: Korean Academy of Medical Sciences (2022), 215–20.

28. Ministry of Health and Welfare. *Clinical Guidelines for Screening Genetic Testing for Newborns*. Taipei City: Ministry of Health and Welfare (2022).

29. Korea Occupational Safety and Health Agency (KOSHA). *Medical Management Guidelines for Workers Diagnosed with Noise-Induced Hearing Loss*. Ulsan: KOSHA (2021).

30. Ministry of Education. *Student Health Survey Manual*. Sejong-si: Ministry of Education (2021).

31. Ministry of Health and Welfare. *Infectious Disease Crisis Management Manual*. Taipei City: Ministry of Health and Welfare (2021).

32. Korea Diseases Control and Prevention Agency. *Korean Guidelines for Tuberculosis*. Cheongju-si: KDCA (2021).

33. Korea Diseases Control and Prevention Agency. *Korean Guidelines for HIV/AIDS*. Cheongju-si: KDCA (2020).

34. Ministry of Education. *Elementary and Middle School Inclusive Education Implementation Guidebook*. Sejong-si: Ministry of Education (2017).

35. Márton SM, Polk G, Fiala DRC. *Convention on the Rights of Persons with Disabilities*. New York, NY: United Nations (2013).

36. Yun JM, Choi S, Cho Y, Park SM, Kim Y. Definition and status of funtional primary clinic in Korea. *Korean J Fam Pract.* (2021) 11:3–9. doi: 10.21215/kjfp.2021.11.1.3

37. Ministry of Health and Welfare. *Handbook of Opening and Operating Medical Institutions and Medical Corporations*. Taipei City: Ministry of Health and Welfare (2019).

38. National Health Insurance Service. *Statistical Yearbook on the Usage of Medical Services by Region*. Wonju-si: National Health Insurance Service (2020).

39. Korean Statistical Information Service (KOSIS). *Current Status of Specialists by Type of Health Care Institution*. Daejeon: KOSIS (2020).

40. Korea Health Personnel Licensing Examination Institute. *Korea Health Personnel Licensing Examination Institute White Paper*. Seoul: Korea Health Personnel Licensing Examination Institute (2020).

41. Acoustical Society of Korea. *List of Successful Candidates of Hearing Aid Technicians License*. (2022). Available online at: https://www.haes.or.kr/ (accessed February 2023).

42. Ministry of Education. *Special Education Statistics 2020*. Sejong-si: Ministry of Education (2020).

43. Korea Disabled people's Development Institute. *A Study on Activating Sign Language Interpreters*. Seoul: Korea Disabled people's Development Institute (2018).

44. National Medical Center. *Statistics of Emergency Medical*. Seoul: National Medical Center (2020).

45. Korean Law Information Center. *Emergency Medical Service Act 25*. (2019). Available online at: https://www.law.go.kr/ (accessed February 2023).

46. Korea Health Promotion Institute. *Survey of Health Education Specialist*. Seoul: Korea Health Promotion Institute (2021).

47. National Health Insurance Service. *Long Term Care Insurance Statistical Yearbook*. Wonju-si: National Health Insurance Service (2020).

48. Ministry of Health and Welfare. *Caregiver Training Guidelines*. Taipei City: Ministry of Health and Welfare (2021).

49. Ministry of Health and Welfare. *Survey on Health and Medical Personnel*. Taipei City: Ministry of Health and Welfare (2020).

50. Korean Law Information Center. *Rules of Practical Nurses and Medical Service Providers*. (2022). Available online at: https://www.law.go.kr/ (accessed February 2023).

51. Resoundkorea. *Beltone Solus Max1.12&Solus Pro3.0 guidelines*, 2022.PDF file. Available online at: https://www.resoundkorea.com/resources/download/Verso%20UG(Custom).pdf

52. The Snail of Love. *Guidebook to Cochlear Implants at a Glance*. welfare organization Snail of Love (2019).

53. Korea Communications Commission. *Guidelines for Provision of Broadcasting Programs for the Disabled*. Seoul: Korea Communications Commission (2019).

54. Korean Law Information Center. *Medical Service Act 17*. (2020). Available online at: https://www.law.go.kr/ (accessed February 2023).

55. Ministry of Health and Welfare. *Budget and Fund Management Plan of the Ministry of Health and Welfare*. Taipei City: Ministry of Health and Welfare (2021).

56. Korean Law Information Center. *National Health Insurance Act*. (2021). Available online at: https://www.law.go.kr/ (accessed February 2023).

57. National Health Insurance Service & Health Insurance Review and Assessment Service. *National Health Insurance Statistical Yearbook*. Wonju-si: National Health Insurance Service (2020).

58. Korean Statistical Information Service (KOSIS). *Private Health Insurance Enrollment Rate*. Daejeon: KOSIS (2020).

59. Al Imam MH, Jahan I, Das MC, Muhit M, Akbar D, Badawi N, et al. Situation analysis of rehabilitation services for persons with disabilities in Bangladesh: identifying service gaps and scopes for improvement. *Disabil Rehabil.* (2022) 44:5571–84. doi: 10.1080/09638288.2021.1939799

60. Mulwafu W, Ensink R, Kuper H, Fagan J. Survey of ENT services in sub-Saharan Africa: little progress between 2009 and 2015. *Glob Health Action.* (2017) 10:1289736. doi: 10.1080/16549716.2017.1289736

61. Bright T, Mújica OJ, Ramke J, Moreno CM, Der C, Melendez A, et al. Inequality in the distribution of ear, nose and throat specialists in 15 Latin American countries: an ecological study. *BMJ Open.* (2019) 9:e030220. doi: 10.1136/bmjopen-2019-030220

62. World Health Organization. *Report on status of ear and hearing care in South-East Asia (SEA) Region*. World Health Organization (2014). Available online at: https://apps.searo.who.int/PDSDOCS/B1466.pdf (accessed February 2023).

63. Suen JJ, Bhatnagar K, Emmett SD, Marrone N, Kleindienst Robler S, Swanepoel DW, et al. Hearing care across the life course provided in the community. *Bull World Health Organ.* (2019) 97:681–90. doi: 10.2471/BLT.18.227371

64. World Health Organization. *Access to Adults' Hearing Aids: Policies and Technologies Used in Eight Countries*. Geneva: World Health Organization (2019). Available online at: http://www.who.int/bulletin/volumes/97/10/18--228676/en/ (accessed February 2023).

65. World Health Organization. *Ear and Hearing Care: Indicators for Monitoring Provision of Services*. Geneva: World Health Organization (2019). Available online at: https://www.who.int/publications-detail/ear-and-hearing-care-indicators-for-monitoring-provision-of-services (accessed February 2023).

66. *Health Promotion and the Policy Process*. Oxford: Oxford University Press. Available online at: https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199658039.001.0001/acprof-9780199658039 (accessed February 2023).

67. Baltussen R, Li J, Wu LD, Ge XH, Teng BY, Sun XB, et al. Costs of screening children for hearing disorders and delivery of hearing aids in China. *BMC Health Serv Res.* (2009) 9:64. doi: 10.1186/1472-6963-9-64

68. Ministry of Health and Welfare of South Korea. *The Health and Welfare White Paper*. Taipei City: Ministry of Health and Welfare (2021).

69. KHIDI. *Hearing Aids Domestic and Overseas Market Analysis. Medical Device Market Research Report*, Vol. 34. Korea Health Industry Development Institute (2015). Available online at: http://www.bizhospital.co.kr/lib/download.php?tbn=special&no=304&PHPSESSID=dc820d85b5ec8c6d175c2d11a9dc12f1 (accessed July 31, 2015).

70. Staab WJ. The independent hearing aid dispenser. *Hear Rev.* (2015) 22:10. Available online at: https://hearingreview.com/practice-building/practice-management/continuing-education/blog-independent-hearing-aid-dispenser

71. Sim S, Kim J. A current status of centers and market for hearing aids in Korea. *Audiol Speech Res*. (2019) 15:184–95. doi: 10.21848/asr.2019.15.3.184

72. NHISS. *The Status of Registered Assistant Device Companies for the Disabled*. National Health and Insurance Sharing Service. (2018). Available online at: https://nhiss.nhis.or.kr/bd/ay/bdaya001iv.do (accessed February 2023).

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 02 October 2023
DOI 10.3389/fpubh.2023.1252157

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Sup Amornpinyo,
Khon Kaen University, Thailand
Francesco Tommasi,
University of Verona, Italy

*CORRESPONDENCE
Lili Yang
✉ 3200006@zju.edu.cn

RECEIVED 03 July 2023
ACCEPTED 29 August 2023
PUBLISHED 02 October 2023

CITATION
Menhas R, Yang L and Danish Nisar R (2023) Community-based social healthcare practices in China for healthy aging: a social prescription perspective analysis.
Front. Public Health 11:1252157.
doi: 10.3389/fpubh.2023.1252157

COPYRIGHT
© 2023 Menhas, Yang and Danish Nisar. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Community-based social healthcare practices in China for healthy aging: a social prescription perspective analysis

Rashid Menhas[1], Lili Yang[1]* and Rana Danish Nisar[2]

[1]Department of Nursing, The Fourth Affiliated Hospital, Zhejiang University School of Medicine, Yiwu, Zhejiang, China, [2]Department of Politics and International Relations (DPIR), University of Sargodha, Sargodha, Pakistan

Background: The global population is aging, and the number of people suffering from chronic diseases is increasing. In response to these trends, community-enhanced social healthcare practices are a novel paradigm of social prescribing that aims to improve both the community's and the individual's level of health by combining community involvement, organizational change, and individual-level practice.

Objective: The study examined the state of community-based social healthcare practices using the lens of social prescription in China with an eye on promoting healthy aging there.

Method: Thematic analysis approach was used in this investigation. A social prescription lens was used to conduct an open-ended theme study of China's community-based social healthcare practices for healthy aging. The research was conducted in Yiwu in Zhejiang Province, P. R. China. A sample of 24 "comprehensive evaluation team members (CETM)" was chosen using a purposive selection strategy.

Results: In the context of the social prescription, we analyzed social healthcare practices for healthy aging at the community level. All the comprehensive evaluation team members described community social healthcare practices under the paradigm of social prescription. After analyzing the community social healthcare practices under the paradigm of social prescription, six main themes (E-Social Prescription, Nature-based Social Prescription, Healthy Living Social Prescription, Culture-based Social Prescription, Health Screening Social Prescription, and Health Education Social Prescription) emerged for healthy aging at the community level.

Conclusion: Social prescribing links individuals to non-clinical services and activities, typically provided by the nonprofit and community sectors. Community-based social healthcare practices under social prescription can be an efficient and cost-effective way to assist patients with chronic diseases in managing their illnesses and enhancing their overall health and wellbeing.

KEYWORDS

community, social healthcare, practices, social prescription, nature, culture, healthy living

Introduction

There will be significant challenges for China's healthcare system as the country's population ages. By 2050, China will have a population of 1.4 billion, with 400 million people aged 65 and over and another 150 million aged 80 and up. There is already a lot of pressure on the modern public healthcare system, and it's only worsening as the number of older adults cared for by their traditional families decreases (1). The Chinese government has taken several preventative measures toward a long and healthy life expectancy, including the "Healthy China 2030" planning blueprint (2). The Chinese government established a national medical insurance policy to address the rising medical costs of middle-aged and older adult citizens (3). The "Healthy China Action" program, which runs from 2019 to 2030, promotes healthy aging and aims to improve the health of the Chinese people as a whole (4). Promoting healthy lifestyles, bolstering social welfare, and bettering the environment are all examples of non-clinical acts included in the plan (5). The Chinese government promotes healthy aging by integrating nursing and healthcare for older adults (6). The significance of community-based approaches to social healthcare in promoting healthy aging in China is growing in importance. Community pharmacies often serve as patients' first entry points into the healthcare system. They have provided many public health services, but those dealing with the prevention and treatment of drug abuse, the promotion of a healthy diet and lifestyle, the reduction of risk factors for infectious illness, the improvement of prevention for cardiovascular disease, and the aiding in the cessation of smoking have received the most attention (7). Community healthcare for seniors has been researched, as have the elements that affect seniors' preferences regarding their older adult care (8).

China promotes healthy aging via community-based social healthcare. It includes community occupational therapy, appropriate eating programs, social interaction strategies, and exercise (9). Public health therapists provide a broad range of services, including help with quitting smoking, improving one's diet and way of life, and warding against or treating conditions including cardiovascular disease, infections, drug abuse, and addiction (1, 2). Engaging in social activities is beneficial for the healthy aging of Chinese seniors. To age well, one needs social support, stable housing, and active societal membership. Objective social support includes having a safe place to live and accessing necessary resources; subjective social support includes experiencing encouragement and acceptance. For older adults, objective social assistance is more effective than subjective help (10). The cognitive abilities of Chinese seniors are boosted by their participation in communal activities (11). Participation in social activities, financial stability, the presence or absence of chronic health conditions, and the ability to provide for grandchildren are among the most important factors in the health of older adult Chinese (12). Chinese seniors who don't actively participate in their communities are less likely to age healthily. Active social lives are associated with better cognitive performance, episodic memory, and visual-spatial ability among Chinese seniors (13). Volunteering, joining a social club, and going to church are all examples of what we mean by "social participation." Social support has influenced the relationships between social engagement, wellbeing, and mental health issues among Chinese seniors. Their social interactions have also greatly impacted seniors' mental health (14). Physical health and suicidal thoughts in rural Chinese seniors correlate, although social engagement mediates this relationship (15). Social determinants of health screening are important for good aging among Chinese seniors, and traditional attitudes such as pessimism, self-overhaul, and the sizzling and excellent balance have an effect. The perspectives of older adult Chinese women on fitness, ailment, and anticipatory medicine are influenced by these notions. Ethnic sights, dialectal blockades, doctor-patient communiqué, and entrée to health care are all potential cancer risk factors in this population (16). Since isolation is a major and independent risk factor for depression in older adults, (17, 18) it is beneficial for the subjective wellbeing of older Chinese people to get support from their offspring. Community healthcare practices are important to the social prescription for good aging. These practices involve co-creating individualized strategies to promote patients' health and wellbeing in the voluntary, community, and social enterprise sectors (19). Social medicine aims to enhance patients' quality of life by reducing their feelings of isolation and anxiety and assisting patients experiencing difficulties with their homes or finances (20). Community development is important to social medicine because it can strengthen a community's cohesiveness and improve individuals' health (21).

Social healthcare practices for health and wellbeing at community level

Participation in community-based programming that encourages healthy aging has been linked to higher levels of social engagement among older adults (22). According to studies (23, 24), elders who are socially engaged and invested in their communities can better keep their health in check and live independently as they age. Participation in communal activities, such as joining a club or society, is associated with a lower risk of dementia (25). Participating in social activities and maintaining relationships with one's family and friends are important for healthy aging. Studies have indicated that maintaining social connections and engaging in socially beneficial activities, such as continuing to work, gaining new skills, attending cultural events, and volunteering, can help people maintain their health as they age (26). Screening for various health conditions within the community is essential to assist people in aging healthily. It is critical to provide systematic screening as a high priority for high-risk groups and to follow up screening with more accurate evaluations and the appropriate therapies (27).

Additionally, it is essential to prioritize systematic screening for low-risk groups. Community health care providers can also use alterations in health status as a screening criterion to encourage health screening (28). Education about health is one of the most important aspects of helping older people mature healthily. It has been demonstrated that community-based health education interventions are beneficial in preventing frailty in older persons, encouraging physical exercise, nutrition, and social involvement, optimizing nutritional status, and lowering depression, anxiety, and

stress (29–33). People should be taught through health education programs how to take better care of themselves, how to live and behave healthily, and how to obtain knowledge and resources related to health to maintain the excellent health of the older adult members of the community (32). It has been demonstrated that approaches to public health, such as community interventions to prevent frailty, can assist older individuals in growing older in a healthy manner (33). The general public needs to be aware of how vital health screenings are for senior citizens, as well as for senior citizens themselves, to be aware of how important it is to maintain their health. Furthermore, it is essential for families and employees working in community health centers to be aware of how to monitor the health of senior citizens. Getting a nutritional assessment, becoming a member of a club in the community that caters to seniors, and receiving instruction on how to exercise precisely are three of the most typical components of health promotion programs for older citizens (34).

Social prescription for health and wellbeing in a community setting

Social prescription, also known as community referral or social prescribing, is an all-encompassing approach to improving community members' health and wellbeing. Exercise groups, art therapy, and gardening clubs are examples of non-medical support services and community-driven activities linked via this method (35). Supplementary, folks are turning to societal prescriptions to improve their health and the health of their communities. Understanding that health and wellbeing are affected by a wide range of circumstances outside those within the purview of conventional medicine is the basis of social prescribing. Social prescription promotes community health and wellbeing by focusing on underlying social factors. A social prescription may promote mental and physical health, increase social support, and decrease dependency on healthcare services by linking people with non-medical support services and activities customized to their requirements (36). Nursing practitioners' potential interactions with social prescribing platforms to strengthen communities' resilience are outlined in social prescription, a subset of the broader NHS England concept for universal customized care. During home visits or trips to community clinics, community nurses evaluate their patient's psychological and social wellbeing. They help determine who needs help beyond medical care and might benefit from a social prescription approach. Community nurses assess their patient's needs and interests before directing them to the most suitable community-based activities and services (such as support groups, fitness courses, arts and crafts workshops, and volunteer opportunities). Community nurses collaborate with other healthcare team members to create individualized patient treatment plans. Patients are followed up with by community nurses so that the efficacy of the social prescription method may be assessed. To ensure the treatment plan is still useful and up-to-date, they provide input to patients, their families, and other medical staff. Patients and their loved ones may learn much from community nurses about living healthier and more active lives just by listening to what these professionals say. To offer social prescription services and guarantee that patients have access to various resources and assistance, community nurses build and maintain partnerships with local organizations, service providers, and community groups (37). Practices of social prescribing move medical care outside of traditional professional settings and focus on how social circumstances influence an individual's health (38). Healthy aging rounds consist of one-on-one conversations with mentors who are healthy older individuals. During these conversations, participants practice assessment, interviewing, and counseling for social support and physical activity (39).

The current study

Older people's participation in community health screenings, which has become a hot subject in China, has been discovered to be influenced by factors such as self-rated health, physical condition, and mental health (40). However, there is a lack of research comparing and contrasting different strategies. So, it's important to evaluate the impact of various social healthcare programs and variables on healthcare services and expenditures incurred by the Chinese middle-aged and older adult (41). It has been suggested that big data and machine learning may be used to identify the factors impacting older adults' health conditions and life satisfaction (42). Integrating a strong legal framework with such services is also being studied (43) to encourage the healthy and sustainable growth of older adult care services. It has recently come to light in China that community-based social healthcare projects may effectively foster good aging. Non-medical social prescription has gained popularity as a means of addressing social determinants of health by linking individuals to community resources that may improve their health and wellbeing. China has launched a community-led social prescribing effort with the help of 40 local organizations. The majority of research and attention has gone into improving the mental health and supplying the psychosocial needs of seniors via local organizations. Primary care community health facilities were used in the original project's integration into the larger health system infrastructure to screen for health-related social needs for seniors during their yearly check-up. The function of the link worker was taken on by community health professionals, social workers, and the larger mental health support team, who worked with each individual to match them with the best community resources for their specific situation. For this reason, the "comprehensive evaluation team" was used in place of the term "link workers" (44) to reflect the fact that it was not just one profession that was responsible for bridging the gap between medical and social care. Since then, recommendations for expanding social prescribing have been published (45), and the Chinese Society of Geriatric Psychiatry has supported a proposal to expand the program. Although non-clinical community-based social healthcare practices in China effectively promote healthy aging, there is a shortage of information on their applicability and effectiveness, especially from a social prescription perspective. Using the lens of social prescription (see Figure 1), this study will examine the state of community-based social healthcare in China with an eye on promoting healthy aging there. This study will also help enhance the quality of life for older adults by shedding light on

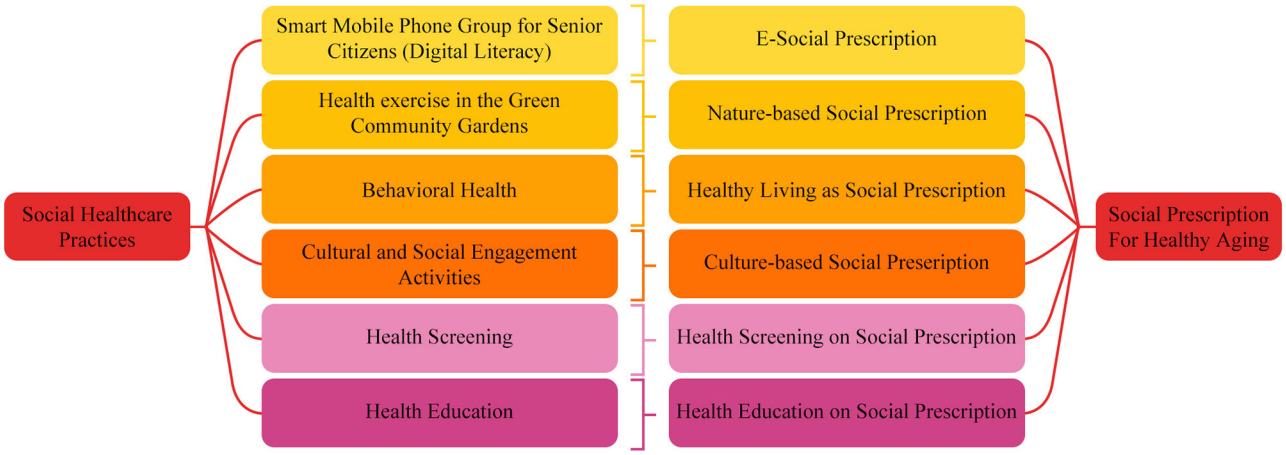


FIGURE 1
Conceptual framework.

the efficacy of community-based social healthcare practices from the standpoint of social prescription.

Methodology

Study design

Thematic analysis, developed by Braun and Clarke (46), was used in this investigation. A social prescription lens was used to conduct an open-ended theme study of China's community-based social healthcare practices for healthy aging. The research was conducted in Yiwu in Zhejiang Province, China.

Study participants

It is common practice in qualitative studies to choose samples for certain reasons. Researchers contacted the "comprehensive evaluation team" through text messages and wechat. In China, 40 community partners have participated in a grassroots campaign to practice social prescription. Older folks' mental health and psychosocial needs have been the main focus of community programs. The concept was initially included in the more significant infrastructure of the health system by using primary care health centers in the community to detect health-related social needs during older individuals' yearly health examinations. A group of health professionals in the community, social workers, and other mental health care specialists took on the job of a link worker. By referring to this group as the "comprehensive evaluation team" rather than just "link workers," it recognizes the multifaceted skills of the healthcare workers who fill the divide between social and medical services (47). The Chinese Society of Geriatric Psychiatry has given their support for the desire to increase the scope of this project, and they have also released recommendations for implementing social prescribing on a bigger scale. A training program for the team doing the comprehensive review has also been created through collaboration. With the help of this curriculum, community services are adequately referred to, and effective screening for psychosocial needs is ensured. As part of the Healthy China 2030 Action Plan, China is moving its national strategy toward illness prevention and health maintenance. Although social prescription benefits society and the health system beyond merely older people, it is nevertheless vital to promote it (48). A sample of 24 "comprehensive evaluation team members (CETM)" was chosen (see Table 1) using a purposive selection strategy.

The procedure

Data collection instrument

Data for this investigation were gathered with the use of an interview guide. The interview guide employed open-ended questions that allowed participants to elaborate on the study's major research question. Social healthcare practices within the social prescription paradigm were the focus of the inquiries, as were the methods for classifying such social healthcare activities. With Patton's approach, this interview guide was written (49). In this type of interview, the interviewers who follow a strict script strictly follow the question language and order. The interviews are still considered qualitative rather than quantitative because the responses are open-ended. It is the most systematic and efficient qualitative interviewing technique and helps reduce biases.

Data collection

Interviews with community people who were part of the "comprehensive evaluation team" were conducted by researchers using a purposive sampling strategy. To make the most of limited resources, qualitative researchers often use the purposeful sampling approach (49). It involves selecting examples that are statistically more likely to contain useful information about the topic at hand. Each research participant was interviewed

TABLE 1 Demographics of the participants.

Participants	Age (years)	Education	Gender	Working experience (Years)	Work station name
CETM 1	29	Master	M	4	Jiangbin Community
CETM 2	30	Graduate	F	5	Shengli Community
CETM 3	27	Bachelor	F	3	Linjiang Community
CETM 4	28	Bachelor	F	3	Jimingshan Community
CETM 5	31	Master	F	5	Dongzhou Community
CETM 6	32	Bachelor	M	3	Taxiazhou Community
CETM 7	26	Graduate	F	3	Wanghu Community
CETM 8	29	Master	M	4	Tonghui Community
CETM 9	28	Master	F	3	Xiuhu Community
CETM 10	33	Master	M	3	Wuai Community
CETM 11	30	Graduate	F	4	Xuefeng Community
CETM 12	28	Master	M	4	Jiangnan Community
CETM 13	35	Master	M	6	Yinyuan Community
CETM 14	27	Master	M	3	Xiaozi Temple Community
CETM 15	34	Graduate	F	5	Fenghuang Community
CETM 16	25	Bachelor	F	3	Jindu Community
CETM 17	29	Master	F	4	Liming Community
CETM 18	31	Graduate	F	5	Xiangxi Community
CETM 19	26	Master	M	4	Songmenli Community
CETM 20	37	Graduate	M	6	Shangbo Community
CETM 21	36	Graduate	F	5	Panxi Community
CETM 22	39	Graduate	F	7	Binwang Community
CETM 23	38	Graduate	F	7	Liuci Community
CETM 24	37	Graduate	M	8	Jianshe Community

CETM, Comprehensive evaluation team member.

both in-person and remotely, using a hybrid approach that considered their schedule and preferences. Participant permission was gained prior to their interview once the study's goal was explained.

Data analysis

Quality check of the interview data

Members checked each other's work to ensure the accuracy of the data obtained during interviews. One method for ensuring the reliability of survey findings is via member checks, also known as participant or respondent validation. Data or outcomes are sent back to participants to double-check the accuracy and consistency of their accounts (50).

Final data analysis

The interview data were subjected to a quality check and then analyzed using the theme analysis method developed by Braun and Clarke (46). It followed coding steps and necessitated the transcription of interview tapes. In the first step, writers reviewed and reread transcripts to pick up prospective topics, which they then sent to the head writer. The second analysis phase involved the original and final writers looking at these preliminary codes. They seriously considered how to create overarching motifs and higher-level subthemes while preserving the original codes' variety. Third, the quotations consistent with the overall themes were discovered via analysis undertaken by the first and final writers. After that, the writers looked through topics before defining and naming them. Once the report's concepts were finalized–by both the first and last authors–the actual writing could begin.

Results

Derived themes and sub-themes

E-social prescription

The theme of E-Social Prescription revolves around utilizing technology to enhance social connectedness, wellbeing, and overall health through various activities. All the study participants know

TABLE 2 Derived themes and sub-themes.

Main theme	Sub-theme	Context/Activities
E-social prescription	Smart mobile phone groups for senior citizen	Telecare services, Digital literacy, Wechat, and Q.Q. Groups for social connectedness, E-learning, Wearable fitness, and health trackers (Health monitoring and management), Online healthcare community
Nature-based social prescription	Activities in the green community gardens, walk-in green and wetland parks	Tai Chi and Qigong in the green community and public parks, Outdoor walks in the green and wetland parks, gardening, vegetation, and others
Healthy living social prescription	Behavioral health	Nutritious meals and dietary counseling, Smoking cessation, reducing alcohol consumption, physical activity
Culture social prescription	Culture and Social Engagement	Group outings, card games, board games, singing, dancing, arts and crafts activities, love confession activity
Health screening social prescription	Preventive health	Blood sugar check-up, Blood pressure check-up, Ophthalmic, dental, and physical examination
Health education social prescription	Health awareness	Lectures on health management, peer education regarding health, distribution of brochures, flyers, and posters containing health awareness information

the importance of "E-Social Prescription" and recommend it to the Chinese older adult for healthy aging (see Table 2 and Figure 2).

> *E-Social prescription aims to enhance individuals' overall health and wellbeing by fostering social support, promoting health monitoring and management, and providing continuous learning and engagement opportunities. (CETM 1, 3)*
>
> *An e-Social prescription is a multifaceted approach that leverages digital tools such as telecare services, social media platforms, wearable fitness and health trackers, e-learning, and online healthcare communities to promote social connectedness, digital literacy, and health monitoring and management, thereby enhancing the overall wellbeing of individuals and communities. (CETM, 5, 7)*
>
> *Smart mobile phones can provide a range of services to senior citizens, including telecare services, digital literacy training, social connection, knowledge enhancement, health monitoring and management, and support and information sharing. (CETM, 22, 24)*
>
> *Smart mobile phone groups can provide several benefits to senior citizens. These groups can improve health and wellbeing, increase social connection, enhance cognitive function, reduce isolation, and increase independence. (CETM, 2, 17)*



FIGURE 2
Main themes.

Nature-based social prescription

The theme of Nature-based Social Prescription emphasizes the holistic wellbeing of individuals through engaging in nature-based activities. It recognizes the intrinsic connection between nature and human health, promoting physical activity, relaxation, social interaction, and a sense of purpose within natural environments, thus enhancing overall health and quality of life. All study participants know the importance of "Nature-based Social Prescription" and acknowledge its role in promoting healthy aging (see Table 2 and Figure 2).

> *Nature-based social prescription activities, such as Tai Chi & Qigong in green community gardens, outdoor walking in green parks, and gardening, provide opportunities for individuals to connect with nature, enhance their physical and mental wellbeing, and promote social interactions and community engagement. These activities also offer a sustainable and cost-effective approach to improving health outcomes and promoting environmental awareness and conservation. (CETM, 21, 4)*

> *Nature-based social prescription (NBSP) is an intervention that uses exposure to nature to improve health and wellbeing. NBSP interventions can be delivered in various settings, including green community gardens, green parks, and other natural areas. (CETM, 11, 3)*
>
> *NBSP is a promising intervention that can be used to improve health and wellbeing. NBSP interventions can be delivered in various settings and tailored to the individual's needs and interests. (CETM, 19, 6)*

Healthy living social prescription

This thematic statement captures the essence of healthy living initiatives as social prescriptions. It highlights the healthy living initiatives' comprehensive nature and potential impact on individual wellbeing, emphasizing the holistic approach to improving health through social interventions. Healthy living initiatives as social prescription offer a holistic approach to healthcare, addressing physical health and promoting mental and emotional wellbeing (see Table 2 and Figure 2).

> *Through activities such as nutritious meals and dietary counseling, smoking cessation, reducing alcohol consumption, and physical activity, individuals can improve their overall health, increase their self-esteem, and foster a sense of community and social support. Such initiatives prevent chronic diseases, reduce healthcare costs, and create a healthier society. (CETM, 11, 3)*
>
> *Healthy living initiatives as the social prescription is a way to improve the health and wellbeing of individuals and communities by providing them with access to resources and support that can help them make healthy lifestyle choices. (CETM, 17, 2)*

Culture-based social prescription

The theme of Culture Social Prescription explores the therapeutic benefits of diverse cultural activities, promoting social connection, self-expression, and emotional wellbeing. Cultural activities allow individuals to connect with others, express themselves creatively, and explore different cultural experiences, ultimately leading to a sense of belonging and improved overall quality of life (see Table 2 and Figure 2).

> *Through group outings, card games, singing, dancing, arts and crafts activities, love confession activities, and opera, individuals engage in culturally rich experiences that foster personal growth, community bonds, and holistic healing. (CETM, 5, 7)*
>
> *Cultural, social prescriptions, such as group outings, card games, singing, dancing, arts and crafts activities, love confession activities, and opera, provide individuals with opportunities to engage in meaningful and enjoyable social interactions that promote mental and emotional wellbeing. (CETM, 11, 13)*
>
> *Culture-social prescription is an intervention that uses cultural activities to improve health and wellbeing. It can be delivered in various settings, including community centers, libraries, and museums. (CETM, 21, 4)*
>
> *By providing people access to cultural activities, we can help them improve their health and wellbeing and reduce the burden of chronic disease on our communities. (CETM, 19, 6)*

Health screening social prescription

The Health screening Social Prescription theme encompasses a comprehensive approach to preventive healthcare. It emphasizes the importance of early detection, monitoring, and intervention to promote overall wellbeing and prevent the progression of health conditions conditions (see Table 2 and Figure 2).

> *By integrating these screening activities into social prescriptions, individuals are empowered to take proactive measures for their health, leading to improved healthcare outcomes and enhanced quality of life. (CETM, 1, 3: CETM 11, 13)*
>
> *By implementing health screening social prescription, individuals are empowered to proactively monitor their health through regular blood sugar and blood pressure check-up and ophthalmic, dental, and physical examinations, promoting early detection and prevention of potential health issues. (CETM, 17, 2: CETM, 22, 24)*
>
> *Health screening social prescription is an intervention that uses health screenings to improve health and wellbeing. Health screening social prescriptions can be delivered in various settings, including community health centers, hospitals, and doctor's offices. (CETM, 19, 6)*

Health education social prescription

Health education as social prescription is an intervention that uses health education to improve health and wellbeing. It can be delivered in various settings, including community health centers (see Table 2 and Figure 2).

> *Implementing diverse and accessible health education strategies, such as lectures on health management, peer education, and distributing brochures, flyers, and posters to Chinese older adult, promotes holistic wellbeing and empowers individuals to actively engage in self-care and disease prevention. (CETM, 11, 13: CETM, 21, 4)*
>
> *The theme of "Health Education Social Prescription" aims to promote healthy living and wellbeing through various educational activities such as lectures on health management, peer education, and distributing brochures, flyers, and posters to the Chinese older adult. These activities serve as valuable resources for disseminating important*

> *health information and encouraging behavioral changes that can lead to improved health outcomes and a better quality of life for older adults in the Chinese community. (CETM, 19, 6: CETM, 5, 7)*

Discussion

In the Zhejiang Province of China, social care techniques for senior citizens often comprise linking people to neighborhood volunteer and community services, as well as giving access to psychotherapy and lifestyle guidance. In addition, older adult care procedures can aid in addressing psychological and social problems that may be a factor in a person's illness (51). In the context of the social prescription, we analyzed social healthcare practices for healthy aging at the community level. All the comprehensive evaluation team members described community social healthcare practices under the paradigm of social prescription. The three primary facets of community care are daycare services, in-home caregiving assistance, and participation in leisure activities like sports and cultural events. The central government releases a variety of policy initiatives to entice and encourage service providers to engage in the senior care field to build capability (52). To evaluate the efficacy of various initiatives and support services for senior citizens in Zhejiang Province, the government has started trial assessment mechanisms in a few areas. Older adults can also benefit from community health support programs that include health promotion, coaching, and health education (51). Plans for older adult care policy ask local governments to develop senior education and recreation facilities to support healthy aging (53). China has been advancing older people's access to integrated care through a community-based social and health care system. Integrated community-based social and health care system includes prevention and control of chronic disease, increased health services, and a trained health workforce (54).

In a community, various non-medical services are offered, such as social security benefits, volunteer opportunities, fellowship gatherings, training possibilities, and chances to exercise and study (55). Wellbeing results from numerous variables, aside from medical, behavioral, and social facets of life, which also present the potential for healthcare. Those with protracted or chronic mental and physical disorders must make a special effort to adopt healthy behaviors. According to definitions, social prescribing is a "clear, coherent, and collaborative procedure in which healthcare professionals collaborate with patients and service users to choose and refer to the available services in the community (51)." A "social prescribing" initiative was implemented by the National Health Service (NHS) of the U.K. in 2016 to combat depression and loneliness among U.K. citizens while easing the workload for general practitioners (GPs). Connecting individuals with non-medical community services is referred to as "social prescribing," which provides a service that extends beyond medical therapy for a sickness (56). The concept of "social prescribing" came into existence due to the significant contribution that the community may make to overall wellness and health. Social prescribing directs People to several non-clinical and non-health resources (57). Social prescribing uses a patient- and values-centered psychological method to assist people in recognizing the adverse social drivers of the present situation, address them, and devise a joint strategy to remedy them. SP is defined as "a pathway to refer clients to non-clinical services; linking clients to community support to improve overall health, to foster life quality, to promote consciousness wherever suitable, and to reduce vulnerability inside the society alongside the person (58)."

Using computers and mobile applications may also assist individuals in leading healthier lives and experiencing fewer health issues as they age (59). The government supports smart digital technology because it understands how technical advancement may make home care easier (53). Older people use robotics, monitoring, call-service platforms, and virtual nursing systems (53). Older adult Chinese citizens like to get their care at home, but when assistance is required, they can also use community services. Healthcare has risen in importance in policy over the last 10 years, and the Chinese government is putting a lot of effort into creating smart home care technologies (54). Social media apps use the Internet and Web 2.0 technology to let users engage in different virtual communities and produce and exchange information through features like communicating, exchanging, working together, posting, and connecting (60). According to the findings of our study, smart mobile phone groups (Wechat and Q.Q. groups) for senior Chinese citizens were created at the community level. The purpose of these groups is telecare services, digital literacy, social connectedness, e-learning, guidance about wearable fitness and health trackers (Health monitoring and management), and online healthcare services. All these activities come under "E-social Prescription" and are vital in promoting healthy aging at the community level. Call-service platforms and virtual nursing systems are encouraged to be established by the 12th and 13th FYPs. Automation, artificial intelligence, cloud technology, and the new generation of digital technologies are advancing quickly. The Guideline Views of Actively Encouraging Internet + Activities were released by the central government in 2015, and in 2017 they were followed by "The Action Plan for the Growth of Smart Health and the Aged Care Industry (2017–2020)". To enter the Internet - of - things sector emphasizing community and home care activities (61). Older adult care services have developed into the fourth scientific and technological revolution, defined by the Internet of Things (IoTs), information technology, big data, and cloud services. The development of aging-in-place has been facilitated by several emerging technologies, one of which is smart home technology for older people to address their senior's needs, including comfort, freedom, healthcare, and help. Smart Home for senior care is committed to offering various reasonably priced services (62, 63). In China, utilizing the Wechat app for communication is prevalent. The "hypertension management group" comprised patients who used the Wechat mobile app. Therefore, the "kangkang shengshi" public account was created. In this Wechat community, general practitioners frequently provide information about developing and preventing hypertension through daily posts. Members of the Social messaging group were urged to interact with each other, express their emotions, and support each other (64).

Older people are invited to participate in social functions, volunteer, and participate in economic pursuits, such as starting their enterprises (13th FYP). It is frequently stressed how important physical activity is for older adults. Older adults should exercise

more than 50% of the time (12th FYP) (55). Our findings indicated that CETMs recommend nature and culture-based activities for healthy aging at the community level to foster social connectedness. Using nature as therapy is a subset of the larger social prescribing trend, which promotes utilizing additional actions as efficient and frequently low-cost therapies, such as exercise, socialization, house enhancements, and other things (65). The benefits of living in a neighborhood that encourages encounters with water or "blue spaces" may also extend to mental wellness. Better mental health is linked to living near nature, participating in outdoor activities, and experiencing a connection (66). Our findings show that CETM's recommended nature-based activities such as Tai Chi and Qigong in the green community and public parks, Outdoor walks in the green and wetland parks, gardening, and vegetation. Group outings, card games, board games, singing, dancing, arts and crafts activities, and love confession activity for social engagement under culture prescription. Blue space is "all visible, outdoor, natural surface waters to promote human health and wellness." Stream, river, and coastal regions are examples of blue space (67). A social prescription is a recommendation that enables you to interact with your community; it's not a medication that comes in a pharmacy bottle or blister pack. Under social prescription, participation in communal activities such as the arts, education, athletics, reading, or volunteering is advised, as well as seeking guidance and assistance regarding one's health and wellbeing (68). Medical practitioners and policymakers are increasingly promoting using nature-based health interventions (NBIs) and conventional medication and psychological therapies to meet the rising demands associated with poor mental health. A growing amount of research indicates that nature can help those with mental disorders by reducing their suffering. Along a wide range of mental health indicators, blue spaces, defined as environments mainly consisting of water, have been demonstrated to be more effective at boosting wellbeing than green spaces (69, 70).

Social prescribing has become an effective tool for assisting patients in overcoming some of the social and behavioral causes of poor wellbeing (71). All the study participants reported that health behavior and health awareness under social prescription are vital for healthy aging among Chinese seniors. Doctors, sociologists, associated medical practitioners, members of the charity sector, and those involved in commissions have all shown an increased devotion to social prescribing. It has aided physicians in convincing appropriate patients to engage in novel and beneficial behavior changes. It uses a patient- and values-centered psychological method to assist people in recognizing the adverse social drivers of the present situation, address them, and devise a joint strategy to remedy them. SP is "a pathway to refer clients to non-clinical services; linking clients to community support to improve overall health, to foster life quality, to promote consciousness wherever suitable, and to reduce vulnerability inside the society alongside the person (72)." Individuals in China also benefit from music therapy and dance therapy to promote good aging. There is a common misunderstanding that these treatments improve mental health and brain function (5). Giving older adult individuals emotional support and entertainment in the neighborhood helps lessen psychological issues like sadness and anxiety and further safeguards their brain health (73). Daily living assistance, medical assistance, and health services frequently impact older people's ability to think clearly. Adverse affective feelings, including despair and anxiousness, have been linked to cognitive decline (74). Care in the community has become a way for older adults to receive daycare while still living at home, either through visiting services or by residing in a daycare facility. Older persons who follow this plan could occasionally receive assistance from family members rather than having to leave the house (75).

Art-based therapies in China have improved patients' mental and emotional wellbeing. A patient with schizophrenia benefit from group art therapy incorporating traditional Chinese objects because it increases their sense of competence and social functioning, decrease their difficulties with these areas of functioning, and enhances their overall quality of life (76). Promoting older individuals' health can be aided through social engagement, a crucial active living component. Older people should have a better quality of life to maintain their wellbeing, social contact, and optimal health. Social engagement is one of the elements of active aging. It is a positive activity where individuals and groups actively and willingly participate in community events to connect and communicate with one another (77). Healthcare consciousness is one of the crucial ways to enhance the health status of older persons, who typically suffer from several long-term illnesses. Older adults who live in the community, as opposed to those who are institutionalized, are more independent, require more health information, and want to maximize their opportunities for participation, health, and security in to enhance their standard of living, a direct indication of successful aging (78). All the study participants reported about health screening activities for older adults at the community level. Health screening is a new component of the traditional care system for healthy aging. Integrating social and medical care for older people in China is a relatively new concept. The State Council has been releasing "Many Views on Accelerated the Growth of the Older adult Care Sector" since 2013, suggesting expanding traditional older adult care to include medical treatment and create a thriving old-age care service sector known as "Yiyang Jiehe" in Chinese (79).

Conclusion

Prescription of non-medical interventions can be considered an example of social prescription, which can potentially promote health and wellbeing on a community level in China. In China, significant components of social medicine include encouraging people to engage in physical activity, assisting individuals in developing their social capital, and enhancing the quality of life in their communities. Health professionals often refer people to community social events to improve their health and wellbeing. At the community level in China, "social prescription" refers to the practice in which healthcare practitioners advise their patients to engage in activities that are not medical to improve their health and overall quality of life. Among these interventions are programs for physical activity, events for social interaction, and activities in natural settings. At this point, the moral imperative of social prescribing makes it abundantly evident that action must be taken concerning this topic. As part of a social prescription for good aging, non-medical interventions are utilized to improve the health and wellbeing of older adults. It aims to enhance the quality of life

for the older adult population. The social prescription for healthy aging includes active participation in one's local community. It also demonstrates that health and social care employees have a new responsibility to act as a bridge between public services and local communities to assist individuals struggling with various health issues in becoming active members of their communities. The policy of social prescribing advocates for a gradual implementation that will be concentrated on primary care network organizations.

Implications

The outcomes of the investigation carry several implications.

Theoretical implications

The notion of "social prescription" is congruent with the fundamental tenets of social medicine. The proposition posits that healthcare practitioners in China ought to broaden their scope beyond medical therapies and incorporate non-medical approaches to augment the holistic wellbeing of individuals and communities. The research emphasizes the significance of implementing interventions at the community level to enhance health and wellbeing. It highlights that strengthening social capital, participating in physical activities, and nurturing community quality of life can be as crucial to medical therapies. Implementing social prescribing requires a collaborative effort between healthcare professionals and community organizations, emphasizing the importance of multidisciplinary collaboration. The study suggests a greater emphasis on interdisciplinary collaboration is necessary to effectively connect healthcare services with community resources.

The social and applied implications

These implications encompass the impact on individuals, communities, and society as a whole. Developing and implementing social prescribing programmes should involve collaboration between health organizations and community groups. It is recommended that these programmes provide a diverse range of non-medical interventions, including physical exercise programmes and social events, to those who are actively striving to enhance their overall wellbeing. Healthcare professionals must undergo comprehensive training to acquire the necessary skills to proficiently prescribe non-medical therapies and facilitate the proper linkage of patients with suitable community resources. Integrating this training into medical education and continuous professional growth is crucial. Integrating social prescribing within primary care network organizations can be a viable paradigm for gradually deploying these practices within the healthcare system.

The policy implications

The study's outcomes underscore the necessity of legislative modifications that facilitate the integration of social prescription into the healthcare system. This necessitates a transition toward a progressive amalgamation, specifically emphasizing organizations dedicated to primary care networks. Policymakers should deliberate the formulation of guidelines, implementation of training programmes, and establishment of support structures to facilitate the proficient prescription and supervision of non-medical interventions by healthcare professionals. Furthermore, the allocation of funds and distribution of resources must align with the recognition of social prescription as a legitimate healthcare strategy.

Future scope of the study

The study's conclusion suggests an opportunity for a more comprehensive healthcare approach in China, emphasizing the potential of social prescription to enhance community health and wellbeing. This statement suggests that additional research and policy development are necessary to effectively utilize the advantages of this strategy and establish a healthcare system that is comprehensive and interconnected. This work offers significant contributions to understanding social prescription in the context of China. However, it also highlights various potential areas for future research.

Evaluation of effectiveness

Undertake comprehensive research to evaluate the efficacy of many non-medical interventions recommended via social prescribing. It will facilitate a more extensive comprehension of the activities that produce the most substantial advantages for health and wellbeing.

Long-term health outcomes

Investigating the enduring health consequences associated with the implementation of non-medical interventions. It may entail conducting longitudinal research to ascertain whether continuous engagement in activity diminishes healthcare burdens and enhances overall health outcomes in individuals.

Technology integration in social prescription

Technology integration has become increasingly prevalent in the healthcare field, particularly in the realm of digital health solutions. As such, future research endeavors can focus on exploring the potential benefits of technology in improving the delivery and accessibility of social prescribing interventions.

Study limitations

The research possesses certain constraints that necessitate careful consideration when evaluating its results. The study utilized a purposive sampling technique to recruit participants from the "comprehensive evaluation team," which may have introduced bias in the sample selection process. The presence of this bias can potentially restrict the results' applicability to a broader range of healthcare professionals or those with a vested interest in the field. Moreover, the research's emphasis on Yiwu, located in Zhejiang Province, China, may lead to a restricted geographical perspective,

thus reducing the generalizability of the results to other areas or nations characterized by unique healthcare environments.

Data availability statement

The datasets for this manuscript are not publicly available due to ethical requirements. Requests to access the datasets should be directed to the corresponding author(s).

Ethics statement

The studies involving humans were approved by the Fourth Affiliated Hospital of Zhejiang University, School of Medicine, Human Research Ethics Committee approval no: K2023034. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RM and LY: methodology and conceptualization. RM and RDN: validation, software, formal analysis, and original draft writing. LY: supervision, reviewing, and editing. RM: wrote the final article. All authors contributed to the article and approved the submitted version.

Acknowledgments

We thank all the researchers for data collection and processing and acknowledge our study's participants.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Fang EF, Scheibye-Knudsen M, Jahn HJ Li J, Ling L, Guo H, Zhu X, et al. research agenda for aging in China in the 21st century. *Ageing Res Rev.* (2015) 24:197–205. doi: 10.1016/j.arr.2015.08.003

2. Li H, Zeng Y, Gan L, Tuersun Y, Yang J, Liu J, et al. Urban-rural disparities in the healthy ageing trajectory in China: a population-based study. *BMC Public Health.* (2022) 22:1–3. doi: 10.1186/s12889-022-13757-x

3. Zhou Y, Wushouer H, Vuillermin D, Ni B, Guan X, Shi L. Medical insurance and healthcare utilization among the middle-aged and elderly in China: evidence from the China health and retirement longitudinal study 2011, 2013 and 2015. *BMC Health Serv Res.* (2020) 20:1–9. doi: 10.1186/s12913-020-05522-w

4. Ren R, Qi J, Lin S, Liu X, Yin P, Wang Z, et al. The China Alzheimer report 2022. *General Psychiatry.* (2022) 35:1. doi: 10.1136/gpsych-2022-100751

5. Yang Y, Meng Y. Is China moving toward healthy aging? A tracking study based on 5 phases of CLHLS data. *Int J Environ Res Pub Health.* (2020) 17:4343. doi: 10.3390/ijerph17124343

6. Hu M, Hao Z, Yin Y. Promoting the integration of elderly healthcare and elderly nursing: evidence from the Chinese government. *Int J Environ Res Public Health.* (2022) 19:16379. doi: 10.3390/ijerph192416379

7. Zheng SQ, Yang L, Zhou PX Li HB, Liu F, Zhao RS. Recommendations and guidance for providing pharmaceutical care services during COVID-19 pandemic: a China perspective. *Res Soc Admin Pharm.* (2021) 17:1819–24. doi: 10.1016/j.sapharm.2020.03.012

8. Liu T, Hao X, Zhang Z. Identifying community healthcare supports for the elderly and the factors affecting their aging care model preference: evidence from three districts of Beijing. *BMC Health Serv Res.* (2016) 16:83–92. doi: 10.1186/s12913-016-1863-y

9. Aung MN, Koyanagi Y, Ueno S, Tiraphat S, Yuasa M. Age-friendly environment and community-based social innovation in Japan: a mixed-method study. *Gerontologist.* (2022) 62:89–99. doi: 10.1093/geront/gnab121

10. Feng Z, Jones K, Wang WW. An exploratory discrete-time multilevel analysis of the effect of social support on the survival of elderly people in China. *Soc Sci Med.* (2015) 130:181–9. doi: 10.1016/j.socscimed.2015.02.020

11. Li J, Wang Z, Lian Z, Zhu Z, Liu Y. Social networks, community engagement, and cognitive impairment among community-dwelling Chinese older adults. *Dement Geriatr Cogn Dis Extra.* (2020) 9:330–7. doi: 10.1159/000502090

12. Zhang W, Feng Q, Liu L, Zhen Z. Social engagement and health: Findings from the 2013 survey of the Shanghai elderly life and opinion. *Int J Aging Hum Dev.* (2015) 80:332–56. doi: 10.1177/0091415015603173

13. Fu C, Li Z, Mao Z. Association between social activities and cognitive function among the elderly in China: a cross-sectional study. *Int J Environ Res Public Health.* (2018) 15:231. doi: 10.3390/ijerph15020231

14. Li C, Jiang S, Li N, Zhang Q. Influence of social participation on life satisfaction and depression among Chinese elderly: Social support as a mediator. *J Commun Psychol.* (2018) 46:345–55. doi: 10.1002/jcop.21944

15. Zhang D, Yang Y, Wu M, Zhao X, Sun Y, Xie H, et al. The moderating effect of social support on the relationship between physical health and suicidal thoughts among Chinese rural elderly: a nursing home sample. *Int J Ment Health Nurs.* (2018) 27:1371–82. doi: 10.1111/inm.12436

16. Liang W, Yuan E, Mandelblatt JS, Pasick RJ. How do older Chinese women view health and cancer screening? Results from focus groups and implications for interventions. *Ethn Health.* (2004) 9:283–304. doi: 10.1080/1355785042000250111

17. Liu T, Lu S, Leung DK, Sze LC, Kwok WW, Tang JY. Adapting the UCLA 3-item loneliness scale for community-based depressive symptoms screening interview among older Chinese: a cross-sectional study. *BMJ Open.* (2020) 10:e041921. doi: 10.1136/bmjopen-2020-041921

18. Mao X. The relationship between social support and subjective well-being among older adults in China. New York, NY: New York University (2018).

19. Araki K, Takahashi Y, Okada H, Nakayama T. Social prescribing from the patient's perspective: a literature review. *J Gen Family Med.* (2022) 23:299–309. doi: 10.1002/jgf2.551

20. Dowden A. How social prescribing can benefit patients and prescribers. *Prescriber.* (2019) 30:21–4. doi: 10.1002/psb.1754

21. Wei Z, Wang B, Chen T, Lin Y. Community development in urban Guangzhou since 1980: a social sustainability perspective. *Int Rev Spatial Plan Sust Dev.* (2016) 4:58–68. doi: 10.14246/irspsd.4.4_58

22. Hou SI. Physical activity and social relationships on social engagement among community-dwelling older adults. *Innov Aging.* (2021) 5:28. doi: 10.1093/geroni/igab046.099

23. Hunt J, Travis A. Lessons on using health research and technology to broaden resources for older adults across the state. *Innov Aging.* (2021) 5:97. doi: 10.1093/geroni/igab046.366

24. Li W, Quach L. Mobility, physical activity, and social engagement of community-living older adults. *Innov Aging.* (2021) 5:27. doi: 10.1093/geroni/igab046.096

25. Fancourt D, Steptoe A, Cadar D. Community engagement and dementia risk: time-to-event analyses from a national cohort study. *J Epidemiol Commun Health.* (2020) 74:71–7. doi: 10.1136/jech-2019-213029

26. Golinowska S, Groot W, Baji P, Pavlova M. Health promotion targeting older people. *BMC Health Serv Res.* (2016) 16:367–9. doi: 10.1186/s12913-016-1514-3

27. Dwyer JT, Gahche JJ, Weiler M, Arensberg MB. Screening community-living older adults for protein energy malnutrition and frailty: update and next steps. *J Commun Health.* (2020) 45:640–60. doi: 10.1007/s10900-019-00739-1

28. Du B, Mu Y. The relationship between health changes and community health screening participation among older people. *Front Pub Health.* (2022) 10:870157. doi: 10.3389/fpubh.2022.870157

29. Zhang Q, Guo H, Gu H, Zhao X. Gender-associated factors for frailty and their impact on hospitalization and mortality among community-dwelling older adults: a cross-sectional population-based study. *PeerJ.* (2018) 6:e4326. doi: 10.7717/peerj.4326

30. MacNab L. *Assessment of Dietary Intakes, Nutritional Risk and Whole Grain Behaviors of Community-Residing Adult's Age 60+ years* [Doctoral dissertation]. Ames, IA: Iowa State University. (2015).

31. Lincoln K. Best of both worlds: bridging research and practice to achieve health equity. *Innov Aging.* (2020) 4:867. doi: 10.1093/geroni/igaa057.3204

32. Huang L, Chen H, Ye B, Qi S, Ruan Y, Chen X. Frailty index-predicted mortality is moderated by health-related behaviors: a 4-year community-based longitudinal-cohort study. *Research Square [Preprint]* (2022). doi: 10.21203/rs.2.21751/v1

33. Walker W, Pierce D, Davidson S, Walker J. P02-107-Evaluation of a health promotion program for reducing depression, anxiety and stress in community-dwelling older adults. *Eur Psychiatry.* (2011) 26:703. doi: 10.1016/S0924-9338(11)72408-7

34. Shinkai S, Yoshida H, Taniguchi Y, Murayama H, Nishi M, Amano H, et al. Public health approach to preventing frailty in the community and its effect on healthy aging in Japan. *Geriatr Gerontol Int.* (2016) 16:87–97. doi: 10.1111/ggi.12726

35. Kuhirunyaratn P, Jindawong B. Source of information and experience of participation in elderly health promotion program funded by national health security local fund in northeastern part of Thailand. *Ind J Pub Health.* (2020) 11:1426. doi: 10.37506/ijphrd.v11i6.10010

36. Alderwick H, Dixon J. The NHS long term plan. *BMJ.* (2019) 364:184. doi: 10.1136/bmj.l84

37. Polley MJ, Fleming J, Anfilogoff T, Carpenter A. *Making Sense of Social Prescribing*. Westminster: University of Westminster (2017).

38. Aggar C, Thomas T, Gordon C, Bloomfield J, Baker J. Social prescribing for individuals living with mental illness in an Australian community setting: a pilot study. *Commun Ment Health J.* (2021) 57:189–95. doi: 10.1007/s10597-020-00631-6

39. Golden TL, Maier Lokuta A, Mohanty A, Tiedemann A, Ng TW, Mendu M, et al. Social prescription in the US: a pilot evaluation of mass cultural council's "CultureRx". *Front Pub Health.* (2023) 10:1016136. doi: 10.3389/fpubh.2022.1016136

40. Cadman D, Chambers L, Feldman W, Sackett D. Assessing the effectiveness of community screening programs. *JAMA.* (1984) 251:1580–5. doi: 10.1001/jama.251.12.1580

41. Wang Z, Li X, Chen M, Si L. Social health insurance, healthcare utilization, and costs in middle-aged and elderly community-dwelling adults in China. *Int J Equity Health.* (2018) 17:1–3. doi: 10.1186/s12939-018-0733-0

42. Ding B, Gu D, Jiang Z. *Big Data, Machine Learning, and Health Knowledge Discovery in the Elderly in China. Waste Management Techniques for Improved Environmental and Public Health: Emerging Research and Opportunities*. London: IGI Global (2020), pp. 29-52

43. Chen W. An investigation on the integration of healthy rule of law and elderly care services. *Educ Reform Dev.* (2022) 4:61–4. doi: 10.26689/erd.v4i1.4138

44. Reinhardt GY, Vidovic D, Hammerton C. Understanding loneliness: a systematic review of the impact of social prescribing initiatives on loneliness. *Perspect Public Health.* (2021) 141:204–13. doi: 10.1177/1757913920967040

45. *Announcement of the Chinese Society of Geriatrics on Publishing the Group Standards of "Assessment Standards for Visual Function Decline in the Elderly" and "Standards for Mental Health Services in the Elderly."* (2023). Available online at: http://www.ttbz.org.cn/Home/Show/46727 (accessed June 15, 2023).

46. Braun V, Clarke V. Using thematic analysis in psychology. *Q. Res Psychol.* (2006) 3:77–101. doi: 10.1191/1478088706qp063oa

47. *Social Prescribing Around the World: A World Map of Global Developments in Social Prescribing across Different Health System Contexts*. (2019); Available online at: https://socialprescribingacademy.org.uk/media/4lbdy5ip/social-prescribing-around-the-world.pdf (accessed January 20, 2023).

48. Chen P, Li F, Harmer P. Healthy China 2030: moving from blueprint to action with a new focus on public health. *The Lancet Public Health.* (2019) 4:e447. doi: 10.1016/S2468-2667(19)30160-4

49. Patton M. *Qualitative Research and Evaluation Methods*. London: Sage Publications. (2002)

50. Birt L, Scott S, Cavers D, Campbell C. Walter F. Member checking: a tool to enhance trustworthiness or merely a nod to validation? *Q. Health Res.* (2016) 26:1802–11. doi: 10.1177/1049732316654870

51. Gao L, Wang B, Yang X, Pan Y, Feng W, Pei X, et al. Can the organization of health resource integration be analyzed in terms of the current state of unmet demand for health services? Take the health needs of the elderly in a place in Zhejiang province, china, as an example. *BMC Primary Care.* (2022) 23:1–6. doi: 10.1186/s12875-022-01893-7

52. Hu B, Li B, Wang J, Shi C. Home and community care for older people in urban China: Receipt of services and sources of payment. *Health Soc Care Commun.* (2020) 28:225–35. doi: 10.1111/hsc.12856

53. Sun J. Chinese older adults taking care of grandchildren: Practices and policies for productive aging. *Ageing Int.* (2013) 38:58–70. doi: 10.1007/s12126-012-9161-4

54. Wong YC, Leung J. Long-term care in China: Issues and prospects. *J Gerontol Soc Work.* (2012) 55:570–86. doi: 10.1080/01634372.2011.650319

55. Munford LA, Panagioti M, Bower P, Skevington SM. Community asset participation and social medicine increases qualities of life. *Soc Sci Med.* (2020) 259:113149. doi: 10.1016/j.socscimed.2020.113149

56. *National Academy for Social Prescribing. A Social Revolution in Well-Being.* (2020). Available at: https://socialprescribingacademy.org.uk/media/mzrh4imh/nasp_strategic-plan_web.pdf (accessed June 15, 2023).

57. Robinson A. Social prescribing: coffee mornings, singing groups, and dance lessons on the NHS. *BMJ.* (2018) 19:363. doi: 10.1136/bmj.k4857

58. Kimberlee, R. *Developing a Social Prescribing Approach for Bristol; Project Report; Bristol Health and Wellbeing Board: Bristol, UK.* (2013). Available online at: http://eprints.uwe.ac.uk/23221 (accessed August 23, 2023).

59. Guo Y, Wen T, Yue S, Zhao X, Huang K. The influence of health information attention and app usage frequency of older adults on persuasive strategies in mHealth education apps. *Digital Health.* (2023) 9:20552076231167003. doi: 10.1177/20552076231167003

60. Zhao S. Kinshuk, Yao Y, Ya N. Adoption of mobile social media for learning among Chinese older adults in senior citizen colleges. *Educ Technol Res Dev.* (2021) 69:3413–35. doi: 10.1007/s11423-021-10048-x

61. Krings MF, van Wijngaarden JD, Yuan S, Huijsman R. China's elder care policies 1994–2020: a narrative document analysis. *Int J Environ Res Public Health.* (2022) 19:6141. doi: 10.3390/ijerph19106141

62. Beard J. Innovative approaches to dealing with population ageing. *Gerontechnology.* (2010) 9:64. doi: 10.4017/gt.2010.09.02.002.00

63. Farber N, Shinkle D, Lynott J, Fox-Grage W, Harrell R. *Aging in Place: A State Survey of Livability Policies and Practices* (2011). Available online at: http://assets.aarp.org/rgcenter/ppi/liv-com/aging-in-place-2011-full.pdf (accessed January 11, 2023).

64. Yin BD, Tu DH, Yang N, Wang J. The application effect of internet technology on managing patients with hypertension in a medical center: a prospective case–control study. *Medicine.* (2021) 100:50. doi: 10.1097/MD.0000000000028027

65. Bratman GN, Hamilton JP, Hahn KS, Daily GC, Gross JJ. Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proc Natl Acad Sci USA.* (2015) 112:8567–72. doi: 10.1073/pnas.1510459112

66. McDougall CW, Hanley N, Quilliam RS, Bartie PJ, Robertson T, Griffiths M. Neighbourhood blue space and mental health: A nationwide ecological study of antidepressant medication prescribed to older adults. *Landscape Urb Planning.* (2021) 214:104132. doi: 10.1016/j.landurbplan.2021.104132

67. Grellier J, White MP, Albin M, Bell S, Elliott LR, Gascón M. BlueHealth: a study programme protocol for mapping and quantifying the potential benefits to public health and well-being from Europe's blue spaces. *BMJ Open.* (2017) 7:e016188. doi: 10.1136/bmjopen-2017-016188

68. Kellezi B, Wakefield JR, Stevenson C, McNamara N, Mair E, Bowe M. The social cure of social prescribing: a mixed-methods study on the benefits of social connectedness on quality and effectiveness of care provision. *BMJ Open.* (2019) 9:e033137. doi: 10.1136/bmjopen-2019-033137

69. Maund PR, Irvine KN, Reeves J, Strong E, Cromie R, Dallimer M, et al. Wetlands for well-being: piloting a nature-based health intervention for the management of anxiety and depression. *Int J Environ Res Public Health.* (2019) 16:4413. doi: 10.3390/ijerph16224413

70. Nutsford D, Pearson AL, Kingham S, Reitsma F. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. *Health Place.* (2016) 39:70–8 doi: 10.1016/j.healthplace.2016.03.002

71. Kilgarriff-Foster A, O'Cathain A. Exploring the components and impact of social prescribing. *J Pub Mental Health.* (2015) 12:1–27. doi: 10.1108/JPMH-06-2014-0027

72. Loftus AM, McCauley F, McCarron MO. Impact of social prescribing on general practice workload and polypharmacy. *Public Health*. (2017) 148:96–101. doi: 10.1016/j.puhe.2017.03.010

73. Donovan NJ, Wu Q, Rentz DM, Sperling RA, Marshall GA, Glymour MM. Loneliness, depression and cognitive function in older US adults. *Int J Geriatr Psychiatry*. (2017) 32:564–73. doi: 10.1002/gps.4495

74. Kassem AM, Ganguli M, Yaffe K, Hanlon JT, Lopez OL, Wilson JW, et al. Osteoporotic fractures in men (MrOS) study research group. Anxiety symptoms and risk of cognitive decline in older community-dwelling men. *International Psychogeriatrics*. (2017) 29:1137–45. doi: 10.1017/S1041610217000045X

75. Yeung WJ, Thang LL. Long-Term care for older adults in ASEAN plus three: the roles of family, community, and the state in addressing unmet eldercare needs. *J Aging Health*. (2018) 30:1499–515. doi: 10.1177/0898264318796345

76. Tong J, Yu W, Fan X, Sun X, Zhang J, Zhang J, et al. Impact of group art therapy using traditional Chinese materials on self-efficacy and social function for individuals diagnosed with schizophrenia. *Front Psychol*. (2021) 11:571124. doi: 10.3389/fpsyg.2020.571124

77. Tomaka J, Thompson S, Palacios R. The relation of social isolation, loneliness, and social support to disease outcomes among the elderly. *J Aging Health*. (2006) 18:359–84. doi: 10.1177/0898264305280993

78. World Health Organization. Report of the World Health Organization: active ageing: a policy framework. *Aging Male*. (2002) 5:1–37. doi: 10.1080/tam.5.1.1.37

79. Wang Z, Liu Z. Older adults' demand for integrated care and its influencing factors: a scoping review. *Int J Integr Care*. (2021) 21:4. doi: 10.5334/ijic.5946

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 04 October 2023
DOI 10.3389/fpubh.2023.1215417

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Mohammad Hossein Kaveh,
Shiraz University of Medical Sciences, Iran
Stefan Thomas Kamin,
Fraunhofer Institute for Integrated Circuits (IIS), Germany

*CORRESPONDENCE
Skender Redzovic
✉ skender.e.redzovic@ntnu.no

RECEIVED 01 May 2023
ACCEPTED 21 September 2023
PUBLISHED 04 October 2023

CITATION
Redzovic S, Vereijken B and Bonsaksen T (2023) Aging at home: factors associated with independence in activities of daily living among older adults in Norway—a HUNT study. *Front. Public Health* 11:1215417. doi: 10.3389/fpubh.2023.1215417

COPYRIGHT
© 2023 Redzovic, Vereijken and Bonsaksen. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Aging at home: factors associated with independence in activities of daily living among older adults in Norway—a HUNT study

Skender Redzovic[1]*, Beatrix Vereijken[1] and Tore Bonsaksen[2,3]

[1]Department of Neuromedicine and Movement Science, Norwegian University of Science and Technology, Trondheim, Norway, [2]Department of Health and Nursing Science, Inland Norway University of Applied Sciences, Elverum, Norway, [3]Department of Health, VID Specialized University, Stavanger, Norway

Background: Maintaining independence in activities of daily living (ADL) is essential for the well-being of older adults. This study examined the relationship between demographic and living situation factors and ADL independence among community-dwelling older adults in Norway.

Methods: Data was collected in Norway between 2017 and 2019 as part of the fourth wave of the ongoing Trøndelag Health Study (HUNT) survey, sent to all citizens in Trøndelag county over 20 years of age, which is considered representative of the Norwegian population. Included in the current cross-sectional study were 22,504 community-living individuals aged 70 years or older who completed the survey and responded to all items constituting the ADL outcome measure. Group differences in ADL independence were examined with Chi Square tests, while crude and adjusted associations with ADL independence were examined with logistic regression analyses. Statistical significance was set at $p < 0.05$.

Results: The participants reported a high degree of independence in primary ADL and slightly lower in instrumental ADL. In the fully adjusted analyses, ADL independence was associated with lower age, female gender, higher levels of education and income, higher subjective well-being, having no chronic or disabling disease, and having someone to talk to in confidence. Surprisingly, women who were married had higher likelihood of ADL independence than unmarried women, whereas married men had lower likelihood of ADL independence than unmarried men.

Conclusion: In addition to known demographic and disease-related factors, the social context affects independence in ADL even in a society that offers advanced health and homecare services to all older adults equally. Furthermore, the same social setting can have differential effects on men and women. Despite the healthcare system in Norway being well-developed, it does not completely address this issue. Further improvements are necessary to address potential challenges that older adults encounter regarding their social connections and feelings of inclusion. Individuals with limited education and income are especially susceptible to ADL dependency as they age, necessitating healthcare services to specifically cater to this disadvantaged demographic.

KEYWORDS

independence, activities of daily living, community-dwelling older adults, demographic factors, living situation factors, successful aging, Trøndelag Health Study

Introduction

In Norway, as well as globally, the older adult population is increasing due to a rise in life expectancy (1). The current dependency ratio of the retired over the working part of the population is expected to have doubled by 2060 (2, 3), which will strain healthcare systems and increase public expenditures. To address this issue, Norwegian authorities have identified aging in place as a crucial strategy (4).

Aging in place refers to older adults living independently in their own homes, alone or with family (5). This idea has been broadened by the WHO to include remaining in the current community and living in the residence of one's choice (6). Older adults typically prefer to age in place as it contributes to their well-being and promotes a sense of belonging and identity, as well as feelings of security (7, 8).

A relevant model for aging in place is the Competence-Press Model of aging that was introduced by Lawton and Nahemow (9), which envisions individuals possessing competences while the environment exerts demands or "press." The model portrays the connection between personal competence and environmental press as an adaptation process yielding positive or negative outcomes. Competence is defined as the degree to which people are able to effectively interact with their situation, and encompasses five domains: biological health, functional health, cognition, time use, and social behavior (10). Lawton saw the first two as intrinsic to the individual's physical state, while the latter three are more influenced by life experiences. Environmental press signifies contextual demands, emerging from five environmental domains: personal, group, supra-personal (cohort-related), social, and physical (natural or constructed environment). In more recent times, the Competence-Press Model of aging has been expanded to include the significant influence of social relationships and a sense of belonging among older adults (11, 12). Furthermore, empirical evidence has indicated a shift from seeking information to developing intimacy-centered social motivations as individuals grow older (13).

Gaugler et al. (14) reported that one of the main reasons for institutionalization of older adults is the loss of the ability to engage in activities of daily living (ADL). Activities of daily living are the essential basic routine activities that individuals perform daily to maintain their independence and ability to function, such as eating, bathing, going to the toilet (15), as well as instrumental activities of daily living (IADL), such as shopping, preparing food, housekeeping, and using transportation (16). ADL give structure to the day, provide a sense of meaning, and enhance independence and quality of life (17). Both physical and social environments have been shown to influence the independence of older adults in ADL (18–20).

Several studies have reported that aging is generally associated with a decrease in ADL independency (21–23). Higher levels of household income and education have been found to affect ADL independency positively (24). Gender has also been shown to play a role, with women having a higher probability of developing functional disabilities as they age than men, largely because they are prone to live longer. Older women have been reported to have lower functioning than older men in grooming, dressing, eating, ambulating, transferring, and going to the toilet (25). Another study found that older men between 60 and 80 years had better performance in ADL that require lower limb strength than age-matched women because they preserve leg strength longer (26). Furthermore, living situation in terms of whether older adults are married, separated, or divorced, have access to support when needed and someone to talk to in confidence, can influence ADL independency (22, 27).

Although older adults living in the community generally have sufficient levels of ADL abilities, demographic and living situation factors may play a crucial role in sustaining these abilities and preventing institutionalization (28, 29). This study seeks to investigate the relationship between demographic and living situation factors and independence in ADL among community-dwelling older adults in Norway.

Prior research has investigated several factors within individuals that may impact their performance in ADL, including factors such as physical, spiritual, cognitive, and emotional aspects (30). In addition, environmental factors such as the physical surroundings and social context have been explored (18–20). However, there are several areas where our knowledge is incomplete. Firstly, cultural and societal contexts surrounding older adults vary across geographical locations, and there is a shortage of large-scale investigations on this topic conducted in Europe, with none having taken place in Norway (19, 31, 32). Secondly, Norway takes pride in possessing one of the world's most advanced government-funded healthcare systems. This system provides comprehensive care to all older adults where needed, which could decrease the need for practical assistance provided by social connections. Consequently, Norway is an interesting case to investigate how the social context influences ADL among older adults. Thirdly, aging in place may not necessarily be beneficial to older adults if appropriate support to facilitate community engagement is not provided (7, 33). Filling in these gaps in our knowledge may lead to new insights that may contribute to both practical applications and theoretical understandings in this field. This holds particular relevance for healthcare planning and the pursuit of promoting successful aging among older adults.

Methods

Study design

The data for this cross-sectional study was collected among older community-dwelling adults in Trøndelag county, Norway, between 2017 and 2019, as part of the fourth wave of the Trøndelag Health Study (HUNT4), which is one of the world's largest and most comprehensive ongoing population-based health surveys (34). The population in Trøndelag county is considered representative of the Norwegian population (34), and all individuals living in the county who were over 20 years of age were invited to participate in the survey. The HUNT4 participation rate was high (n = 56.042, 54.0% in North Trøndelag and n = 107.711, 42.6% in South Trøndelag), indicating small risk of selection bias. However, participation was slightly higher among people aged 40–79 years, and lower among those who were unmarried and living in urban areas. The sample was ethnically homogeneous, limiting generalizability to people with non-European backgrounds (34).

Participants

Of the 26,668 adults aged 70 years or older that completed the HUNT4 survey, 22,504 (84.4%) lived in their own home and responded to all items constituting the ADL outcome measure used in this study. These individuals were included in the data analyses. The sample consisted of 10,905 (48.5%) men and 11,599 (51.5%) women, with the larger proportion aged 70–74 years ($n = 10,003$, 44.4%). Approximately a third of the sample had higher education ($n = 7,340$, 32.9 valid %), and 12,619 (64.0 valid %) were married.

Participants filled out the questionnaires at the field station or their (nursery) home, after they had been informed about the study and provided consent. Study assessors were available in case of questions (34).

Measures

Independence in activities of daily living

ADL independence was assessed on 16 discrete activities of daily living. Seven of the items were primary ADL (walk indoors, go to the toilet, wash the body, take bath or shower, get dressed/undressed, go to bed/get out of bed, eat) and the remaining nine items were instrumental ADL (cook a warm meal, do light housework, house cleaning, do the laundry, go shopping, pay the bills, take medications, go outside, take the bus). On each item, the participants indicated whether they were able or unable to perform the activity independently. A dichotomous variable was constructed based on the ADL items, where participants were classified according to their ability to perform all ADL independently (1) or not (0), and used as outcome variable in the analyses.

Sociodemographic variables

Age was collected as a continuous variable and categorized into 70–74 years, 75–79 years, 80–84 years, and 85+ years of age. Information was also collected about gender (male, female). For this study, educational level was categorized as elementary school, high school or vocational training, and higher education. Household annual income (in NOK) was categorized as less than 250,000, between 251,000 and 450,000, between 451,000 and 750,000, and above 750,000.

Health-related variables

Perceived health was assessed with one item: "How is your health at the moment?" Response options were "poor," "not so good," "good," and "very good." Higher scores indicated better perceived health. The participants were also asked whether they had a chronic and disabling disease or injury, with response options "yes" and "no."

Living situation variables

The participants indicated whether they were married, unmarried, widow(er), separated, divorced, or did not want to respond. Subsequently, a dichotomous marital status variable was created by distinguishing between those reporting to be married and those who reported otherwise.

Social support was measured with the question: "Do you have someone who can provide help when you need it?" Response options were "yes" and "no." Closeness was measured with the question: "Do you have someone you can talk to in confidence?" Response options were "yes" and "no."

No secondary data was used in the current study.

Statistical analysis

Individuals with missing scores on variables other than the ADL measures were removed casewise. Missing values constituted between 0 and 12.6% of the total amount of data, with only two variables containing more than 3% missing values (i.e., household income [3.8%] and marital status [12.6%]). ADL independence was defined as having an ADL score of 16, indicating the ability to perform all specified activities independently.

ADL independence was cross tabulated with all independent variables, and group differences in proportions with full ADL independence were examined with Pearson's Chi Square coefficient. We checked for multicollinearity among the explanatory variables by examining bivariate correlations between conceptually related variables (marital status, social support, closeness). Social support and closeness were associated with a small to medium effect size ($r = 0.25$, $p < 0.001$), otherwise correlations were between 0.09 and 0.10.

Univariate and multivariate logistic regression analyses were performed to obtain effect sizes (odds ratio, OR) for the unadjusted and adjusted associations between each of the independent variables and ADL independence. Thus, each OR indicates the change (increase or decrease) in likelihood for being classified as ADL independent by each increase in the relevant independent variable. Possible interactions were examined post-hoc in logistic regression analyses. Statistical significance was set at $p < 0.05$.

Results

Independence in activities of daily living

The number and proportions of the sample being independent in each of the ADL are displayed in Table 1. Independence in primary ADL ranged between 97.2% (wash the body, take a bath/shower) and 99.2% (eat). For instrumental ADL, independence ranged between 88.7% (house cleaning) and 98.5% (take medications). Full ADL independence was reported by 18,101 (80.4%) of the participants, and the mean ADL score (range 0–16) was 15.5 (SD 1.6). ADL independence in different sample subgroups is shown in Table 1. Among those reporting being not fully independent in all ADL ($n = 4,403$, 19.6%), the mean ADL score was 13.2 (SD 2.7).

ADL independence in sample subgroups

Independence in all ADL was reported among larger proportions of individuals in the younger age groups, among women, and among those with higher levels of education and household income. Similarly, independence in all ADL was more

TABLE 1 Independence in each of the activities of daily living (ADL; $n = 22,504$).

ADL	Not independent	Independent
	n (%)	*n* (%)
Primary ADL		
Walk indoors	259 (1.2)	22,245 (98.8)
Go to the toilet	235 (1.0)	22,269 (99.0)
Wash the body	354 (1.6)	22,150 (98.4)
Take a bath/shower	621 (2.8)	21,883 (97.2)
Get dressed/ undressed	321 (1.4)	22,183 (98.6)
Go to bed/get out of bed	272 (1.2)	22,232 (98.8)
Eat	178 (0.8)	22,326 (99.2)
Instrumental ADL		
Cook a warm meal	605 (2.7)	21,899 (97.3)
Do light housework	389 (1.7)	22,115 (98.3)
House cleaning	2,553 (11.3)	19,951 (88.7)
Do the laundry	1,446 (6.4)	21,058 (93.6)
Go shopping	901 (4.0)	21,603 (96.0)
Pay the bills	1,413 (6.3)	21,091 (93.7)
Take medications	339 (1.5)	22,165 (98.5)
Go outside	476 (2.1)	22,028 (97.9)
Take the bus	1865 (8.3)	20,639 (91.7)

frequently reported among individuals with better perceived health, and among those who reported no chronic or disabling disease or injury during the past year. Independence in all ADL was also more frequently reported among individuals who were married and individuals who had someone they could talk to in confidence (see Table 2).

Multivariate associations with activities of daily living independence

Results from the univariate and multivariate logistic regression analyses are displayed in Table 3. The multivariate model was statistically significant ($p < 0.001$) with pseudo R^2 ranging between 0.18 (Cox & Snell) and 0.29 (Nagelkerke). Individuals of higher age were significantly less likely to report ADL independence compared to their younger counterparts, whereas females were more likely ADL independent than men. Individuals with higher levels of education had higher likelihood of being ADL independent, compared to individuals with elementary education. Higher levels of household income were associated with ADL independence. Similarly, better perceived health and reporting not having a chronic or disabling disease or injury were associated with higher likelihood of ADL independence.

Of the living situation variables, being married was associated with higher likelihood of ADL independence in the unadjusted analysis, while this association was reversed in the multivariate

TABLE 2 ADL independence by sample subgroups.

Characteristics	Not independent in all ADL	Independent in all ADL	*p*
Sociodemographic variables	*n* (%)	*n* (%)	
Age			
70–74 years	979 (9.8)	9,024 (90.2)	<0.001
75–79 years	1,272 (18.2)	5,732 (81.8)	
80–84 years	1,059 (30.2)	2,451 (69.8)	
85 + years	1,093 (55.0)	894 (45.0)	
Gender			
Male	2,222 (20.4)	8,683 (79.6)	<0.01
Female	2,181 (18.8)	9,418 (81.2)	
Education level			
Elementary school	2,421 (24.1)	7,623 (75.9)	<0.001
High school/ vocational training	966 (19.5)	3,991 (80.5)	
Higher education	982 (13.4)	6,358 (86.6)	
Household income (NOK)			
< 250,000	977 (31.3)	2,145 (68.7)	<0.001
250,000-450,000	1808 (21.2)	6,719 (78.8)	
451,000-750,000	1,138 (15.3)	6,318 (84.7)	
>750,000	264 (10.0)	2,383 (90.0)	
Health-related variables			
Perceived health			
Poor	366 (78.9)	98 (21.1)	<0.001
Not so good	2,249 (34.7)	4,234 (65.3)	
Good	1,527 (11.9)	11,308 (88.1)	
Very good	119 (5.5)	2030 (94.5)	
Chronic and disabling disease			
Yes	3,544 (28.7)	8,794 (71.3)	<0.001
No	782 (8.0)	9,003 (92.0)	
Living situation			
Marital status			
Not married	1,553 (21.9)	5,550 (78.1)	<0.001
Married	2,364 (18.7)	10,255 (81.3)	
Social support			
Someone can provide support	4,203 (19.4)	17,498 (80.6)	0.05
No-one can provide support	129 (22.7)	440 (77.3)	
Closeness			
Someone to talk to in confidence	4,048 (19.2)	17,046 (80.8)	<0.001
No-one to talk to in confidence	278 (25.2)	823 (74.8)	

Missing values range between 0 and 12.4%. Not married implies either unmarried, separated, divorced, or widow(−er). Independent in all ADL implies a score of 16 on the ADL scale (range 0–16). Not independent in all ADL implies a score in the 0–15 range. *p* values are derived from Chi Square tests of independence.

TABLE 3 Logistic regression analyses showing univariate and multivariate associations with ADL independence (multivariate model: $n = 18,146$).

Independent variables	Unadjusted associations			Adjusted associations		
	OR	95% CI	*p*	AOR	95% CI	*p*
Sociodemographic						
Age						
70–74 years	11.27	10.09–12.58	<0.001	8.75	7.61–10.06	<0.001
75–79 years	5.51	4.95–6.13	<0.001	5.14	4.49–5.87	<0.001
80 + years	2.83	2.53–3.17	<0.001	2.75	2.39–3.16	<0.001
85 + years (ref.)	–	–	–	–	–	–
Gender						
Female	1.11	1.04–1.18	<0.01	1.33	1.22–1.45	<0.001
Male (ref.)	–	–	–	–	–	–
Education level						
Higher education	2.06	1.90–2.23	<0.001	1.39	1.24–1.56	<0.001
High school/vocational	1.31	1.21–1.43	<0.001	1.14	1.02–1.27	<0.05
Elementary (ref.)	–	–	–	–	–	–
Household income (NOK)						
> 750,000	4.11	3.55–4.77	<0.001	1.63	1.32–2.01	<0.001
451,000–750,000	2.53	2.29–2.79	<0.001	1.39	1.20–1.60	<0.001
250,000–450,000	1.69	1.54–1.86	<0.001	1.30	1.15–1.47	<0.001
< 250,000 (ref.)	–	–	–	–	–	–
Health-related						
Subjective well-being (cont.)	3.95	3.72–4.19	<0.001	2.96	2.74–3.19	<0.001
Chronic and disabling disease						
No	4.64	4.27–5.04	<0.001	1.79	1.61–1.99	<0.001
Yes (ref.)	–	–	–	–	–	–
Living situation						
Marital status						
Married	1.21	1.13–1.30	<0.001	0.75	0.68–0.83	<0.001
Not married (ref.)	–	–	–	–	–	–
Social support						
Someone can provide support	1.22	1.00–1.49	0.05	0.91	0.70–1.18	0.46
No-one can provide support (ref.)	–	–	–	–	–	–
Closeness						
Someone to talk to in confidence	1.42	1.24–1.64	<0.001	1.34	1.12–1.61	0.001
No-one to talk to in confidence (ref.)	–	–	–	–	–	–
Model parameters						
Hosmer Lemeshow test, *p*					8.83	0.36
Model Chi Square, *p*					3,587	<0.001
Cox & Snell R^2					0.18	
Nagelkerke R^2					0.29	

The adjusted model shows associations adjusted for all variables in the model. In the adjusted model, 4,358 cases had one or more missing values on the included variables, and these cases were removed from the analysis.

analysis. Reporting having social support was unrelated to ADL independence in both unadjusted and adjusted analyses. Having someone to talk to in confidence was related to higher likelihood of ADL independence.

Post-hoc interaction analyses

The effect of gender on ADL independence was larger in the adjusted model compared to the unadjusted model, whereas the

association between marital status and ADL independence was reversed when adjusting for all variables. To explore a possible explanation for these results, we examined the interaction between gender and marital status in explaining ADL independence.

A logistic regression model including gender and marital status as the only independent variables revealed a statistically significant association between female gender and ADL independence, and also between being married and ADL independence. When included in the second step, the interaction term gender × marital status was significant, suggesting that the association between marital status and ADL independence was dependent on gender. Hence, we examined the associations between marital status and ADL independence separately for men and women. Among men, being married was associated with lower odds of ADL independence (OR: 0.88, 95%CI: 0.78–0.99, $p < 0.05$). In contrast, among women, being married was associated with higher odds of ADL independence (OR: 1.66, 95%CI: 1.51–1.94, $p < 0.001$).

Discussion

This study investigated the relationship between demographic and living situation factors and independence in ADL in community-dwelling older adults in Norway. Consistent with earlier research in this field, the results indicated that independence in ADL is associated with younger age, female gender, higher education, higher household income, better perceived health, and having someone to talk to in confidence. Surprisingly, the association between marital status and ADL independence was dependent on gender, with being married associated with lower likelihood of ADL independence among men, but higher likelihood of ADL independence among women.

In recent decades, reports have indicated that the prevalence of ADL and IADL disability among people in the older population ranges between 11 and 49% (23, 35), but that disability may be partly reversible with adequate support (23). Not surprisingly, the current study confirmed that community-dwelling older adults in Norway generally have a high degree of independence in ADL, but that independence decreases with age. ADL dependency was more commonly reported by participants in their 80s, which further accelerated at age 85+. This is also consistent with previous research (22, 23, 35), although it seems that the prevalence of ADL dependency is higher in Norway than in other comparable countries. For instance, only 48% of individuals in Sweden who were 85 years old in 2015 reported ADL dependency, compared to 55% in the current study. However, differences in study design, definitions, and methods used to measure ADL independence may partly explain some of the variation.

A larger proportion of study participants reported needing help with IADL, such as with cleaning, using public transportation, managing finances, doing laundry, and grocery shopping. This suggests higher environmental "press" in these activities that demand higher levels of physical and cognitive functioning, and are thus more challenging to maintain as people age (9). Many older adults reside in homes, communities and environments that may not be suitable for declining functional abilities. Recent studies reported that having more age-friendly features in a community was associated with a greater perception of age-friendliness by older adults and a stronger desire to age in place. Moreover, higher perceived accessibility to services and sites was associated with greater quality of life (20, 36).

The findings in the present study highlight that both health state, health perception, education and income are major factors associated with an independent life and aging in place, which is consistent with previous studies (24, 30, 37). However, for some groups in particular, individual proficiency may not align with external pressures and result in unfavorable consequences for their ADL independency (9). For example, older adults with lower education and income may have had more strenuous working tasks, limited purchasing power, fewer leisure activities, and poorer health literacy and access to health services, which can all contribute to a larger burden on their health and functioning over time.

In the current study, women had higher likelihood of ADL independency compared to men. Although existing evidence is mixed with regard to gender differences in ADL disability (38), most studies have reported no differences or women having higher likelihood of ADL dependency (25, 26, 39, 40). Given that women have been found to have higher rates of functional impairment as measured by both clinical tests and self-reports (37, 41), our findings are interesting and may point to positive effects of Norway's longstanding efforts to promote gender equality by enhancing women's rights as related to education, income and work opportunities (42). This development may have strengthened women's personal resources and enhanced their ability to cope with environmental demands at older age (9).

One of the most interesting findings in the present study is that having someone to confide in was linked to greater ADL independence. This is in line with previous findings that social and emotional support are important for older adults to maintain their independence in ADL and supports the notion that meaningful contacts and relationships are important for ageing well (11, 19, 31, 32, 43–45). Nevertheless, a number of these impacts remain unclear. The variable "closeness" can be interpreted as a measure of whether they feel socially and emotionally connected to someone else, but can also encompass a practical dimension as closeness to others gives access to support. Thus, older adults' social situation can positively or negatively influence their ADL independence (46, 47). On the other hand, assistance from health services (i.e., being dependent in ADL), which is provided to all citizens in Norway regardless of their income, may also help in alleviating burdensome feelings, as previous studies have reported a statistically significant relationship between receiving support in carrying out ADL and lower levels of social and emotional loneliness, in addition to having frequent social interactions with family, friends, or neighbors (46, 48). Environmental barriers, migration patterns, unsafe neighborhoods, inaccessible housing, inadequate resources for socializing, the role of recent losses of family and friends, as well as mental health issues are reported to contribute to loneliness in older adults (49). In contrast, social connection in older adults is a predictor of good physical and mental health and their quality of life (50).

Studies conducted in Western societies have shown that living arrangement (i.e., living with a partner or not) can affect morbidity to a larger extent than marital status. An earlier study found that individuals living with a partner had lower morbidity rates compared to those living alone, and that excess risk of illness among the never married, widowed, and divorced was reduced by 40–70% for most health measures after controlling for living arrangement (51). These findings indicate that health effects of marital status are largely tied to

the inherent living arrangement, with people in paired living arrangements without being married experiencing similar health benefits as those who are married. Our study showed that being married was associated with higher likelihood of ADL independence among women, while the opposite was the case for men. In contrast, another study showed that women living alone had less chance of experiencing a decline in functional status than those living with spouses or others (52). Our findings underscore the significance of understanding the role of relationships in the aging journey. Many aspects of relationships are interconnected, and gender differences concerned with caring attitudes among older people may play a part (53). Possibly, older women may be inclined to identify with a caring role, indicating that their motivation to care for others may help them maintain ADL independence - not just for their own sake, but also for the benefit of their spouse. Conversely, older men who are married may be less inclined to maintain ADL independence if their needs can be taken care of by their wife. On the other hand, older men who are not cared for by a spouse in the event of functional decline may have a stronger drive toward maintaining ADL independence. Nonetheless, the challenge of social relationships is to optimize the advantages that offer protection while minimizing any unfavorable negative factors (11). Further research is needed to investigate the implications of marital status and living in a paired relationship for men and women in greater detail.

While the results of the current study confirm and further validate previously established scientific understanding, the present study provides several insights to existing knowledge. Firstly, despite the evidence that social surroundings impact ADL and IADL, there is a scarcity of large-scale studies conducted in Europe, and none has been conducted in Norway (19, 31, 32). The social environment surrounding older adults is deeply rooted in the cultural fabric of a society, potentially assuming diverse roles in different geographical locations. Secondly, Norway stands out as a country with one of the world's most advanced government-funded healthcare systems. This comprehensive system caters to the needs of all older adults equally, which could reduce the need for social connections to provide practical assistance in daily life. Nevertheless, our findings indicate that even in a society like the one in Norway, social context is important for ADL independency in older adults. Moreover, our results indicate that similar social circumstances can yield different effects on men and women. Thirdly, our results indicate that further efforts are needed to identify and provide support to those susceptible to losing independence, which constitutes a vital aspect for healthcare planning and the advancement of successful aging for older adults.

Implications for practice and policy

Older adults place high importance on maintaining ADL independence. Therefore, it is crucial to identify modifiable factors that contribute to the onset of ADL disability and can inform the development and employment of support mechanisms.

As longevity increases, home care services need to be designed to meet increasing needs for support from community-dwelling older individuals, especially those who are 85 years or older.

Special attention should be paid to supporting independence in ADL for community-dwelling individuals with lower education and income, as this can contribute to an active and longer independent life, lower demands for home care services, and lower expenditures. A recommendation from this study involves directing special attention toward aiding independence in ADL for those who lack confidants. Furthermore, these findings indicate that even in a fully established homecare system within an egalitarian welfare state such as Norway, there is a requirement for additional development to tackle the potential challenges faced by older adults concerning their relationships and sense of belonging. In turn, this enhancement may serve to maintain older people's independence in ADL.

Study strengths and limitations

The main strengths of this study are a large and representative sample of Norwegian older adults and access to a wide range of variables that may be relevant for ADL functioning.

The outcome measure (ADL independence) might be challenging to define as it encompasses large variation; some individuals may have difficulty with one activity while others struggle with multiple activities. At the same time, what one is capable of doing is rarely a fixed capacity across different situations, and factors such as daily form and context may affect independence but were not taken into account. Furthermore, while "marital status" most often implies living with a partner, "not married" can obscure whether people are in fact living in a paired relationship with another person. Thus, results related to marital status should be treated with some caution. Social support, closeness, and perceived health status were all measured using single-item scales. Thus, the constructs underpinning these measures may be somewhat loosely defined and subject to the respondents' interpretation.

Generally, missing data is a threat to the validity of results, and sophisticated methods for overcoming problems with missing data have been developed in recent years (54). However, while the case-wise deletion method used in the present study may increase the risk of biased results by excluding participants with missing data, we considered that the very large sample size and the relatively small sample proportions with missing data (less than 3% on all except for two variables) constituted only a modest risk of skewed results.

As our study is cross-sectional, we are unable to identify factors that may impact ADL independency over time. In addition, we cannot establish the direction of statistical relationships. Nevertheless, this study identified focus areas that can be examined longitudinally across multiple HUNT surveys in future research.

Conclusion

This study has highlighted several demographic and living situation factors that are significantly associated with independence in ADL among community-dwelling older people in Norway, namely age, gender, education, household income, perceived health, marital status and having someone to talk to in confidence. People with lower levels of education and income are at particular risk of experiencing ADL dependency in older age, and policymakers and healthcare services should target this disadvantaged group. Additionally, the study's most intriguing results indicate that the social context holds influential and enduring impacts on independence in ADL even in a society where advanced health- and homecare services are provided to all older adults in need. Furthermore, similar social environments can exert varying influences on men and women. Even though health

services in Norway are highly developed, they might not fully tackle this concern. Taking proactive measures, such as selecting, compensating, and optimizing interactions with relationship partners, can have a favorable influence on the aging process and on effectively managing the challenges associated with growing older.

Data availability statement

The data analyzed in this study was obtained from the Trøndelag Health Study (HUNT; http://www.ntnu.edu/hunt/data). The following licenses/restrictions apply: the data are stored in the HUNT Databank and biological material are stored in the HUNT Biobank. The HUNT Research Centre has permission from the Norwegian Data Inspectorate to store and handle these data. The key identification in the data base is the personal identification number given to all Norwegians at birth or immigration, while de-identified data are sent to researchers upon approval of a research protocol by the Regional Ethical Committee and the HUNT Research Centre. To protect participants' privacy, the HUNT Research Centre aims to limit storage of data outside of the HUNT Databank, and cannot deposit data in open repositories. The HUNT Databank has precise information on all data exported to different projects and are able to reproduce these on request. There are no restrictions regarding data export given approval of applications to the HUNT Research Centre. Requests to access these datasets should be directed to the HUNT Research Centre, kontakt@hunt.ntnu.no.

Ethics statement

The Regional Committee for Medical Research Ethics in Norway approved the study (Project ID 186668).

Author contributions

SR, BV, and TB contributed substantially to the conceptualization and design of the study. TB performed the statistical analysis and reported the findings. All authors contributed to the interpretation of the data. SR wrote the first draft. BV and TB revised it critically for important intellectual content. All authors contributed to the article and approved the submitted version.

Acknowledgments

The Trøndelag Health Study (HUNT) is a collaboration between HUNT Research Centre (Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology NTNU), Trøndelag County Council, Central Norway Regional Health Authority, and the Norwegian Institute of Public Health.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Bloom DEP, Chatterji SMD, Kowal PP, Lloyd-Sherlock PP, McKee MP, Rechel BP, et al. Macroeconomic implications of population ageing and selected policy responses. *Lancet*. (2015) 385:649–57. doi: 10.1016/S0140-6736(14)61464-1

2. Statistics Norway. Facts about the population – how many lives in Norway? (2023). Available from: https://www.ssb.no/befolkning/faktaside/befolkningen.

3. Astri Syse DQP, Keilman N. Befolkningsframskrivninger 2016–2100: Dødelighet og levealder. *Økonomiske Analyser*. (2016) 3:25–36.

4. Ministry of Health and Care Services. White paper number 15: Live your whole life - a quality reform for the elderly. Oslo; (2018). Available at: https://www.regjeringen.no/contentassets/196f99e63aa14f849c4e4b9b9906a3f8/no/pdfs/stm201720180015000dddpdfs.pdf

5. Cutchin MP. The process of mediated aging-in-place: a theoretically and empirically based model. *Soc Sci Med*. (2003) 57:1077–90. doi: 10.1016/S0277-9536(02)00486-0

6. WHO Centre for Health and Development. A glossary of terms for community health care and services for older persons. Geneva; (2004). Available at: https://apps.who.int/iris/handle/10665/68896

7. Wiles JL, Leibing A, Guberman N, Reeve J, Allen RES. The meaning of "aging in place" to older people. *Gerontologist*. (2012) 52:357–66. doi: 10.1093/geront/gnr098

8. American Association of Retired Persons. Home and community preferences survey Chartbook. (2018). Available at: https://www.aarp.org/content/dam/aarp/research/surveys_statistics/liv-com/2018/home-community-preferences-chartbook.doi.10.26419-2Fres.00231.002.pdf.

9. Lawton MP, Nahemow L. *Ecology and the aging process. The psychology of adult development and aging*. Washington, DC, US: American Psychological Association; (1973). p. 619–674.

10. Lawton M. Behavior-relevant ecological factors In: KW Schaie and C Schooler, editors. *Social structure and aging: Psychological processes*. Hillsdale, NJ: Lawrence Erlbaum.[Google Scholar] (1989). 57–78.

11. Rohr MK, Lang FR. Aging well together – a Mini-review. *Gerontology*. (2009) 55:333–43. doi: 10.1159/000212161

12. Wahl H-W, Iwarsson S, Oswald F. Aging well and the environment: toward an integrative model and research agenda for the future. *Gerontologist*. (2012) 52:306–16. doi: 10.1093/geront/gnr154

13. Carstensen LL. Influence of a sense of time on human development. *Science*. (2006) 312:1913–5. doi: 10.1126/science.1127488

14. Gaugler JE, Duval S, Anderson KA, Kane RL. Predicting nursing home admission in the U.S: a meta-analysis. *BMC Geriatr*. (2007) 7, 1–14. doi: 10.1186/1471-2318-7-13

15. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: the index of ADL: a standardized measure of biological and psychosocial function. *JAMA*. (1963) 185:914–9. doi: 10.1001/jama.1963.03060120024016

16. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily Living1. *Gerontologist*. (1969) 9:179–86. doi: 10.1093/geront/9.3_Part_1.179

17. Hasselkus BR. The world of everyday occupation: real people, real lives. *Am J Occup Ther*. (2006) 60:627–40. doi: 10.5014/ajot.60.6.627

18. Oswald F, Wahl H-W, Schilling O, Nygren C, Fange A, Sixsmith A, et al. Relationships between housing and healthy aging in very old age. *Gerontologist*. (2007) 47:96–107. doi: 10.1093/geront/47.1.96

19. Zidrou C, Kleisiaris C, Adamakidou T. Associations between disability in activities of daily living and social capital aspects among older adults: a scoping review. *J Frailty Sarcopenia Falls*. (2021) 6:119–30. doi: 10.22540/jfsf-06-119

20. Choi YJ. Understanding aging in place: home and community features, perceived age-friendliness of community, and intention toward aging in place. *Gerontologist*. (2022) 62:46–55. doi: 10.1093/geront/gnab070

21. Sato S, Demura S, Tanaka K, Kasuga K, Kobayashi H. ADL ability characteristics of partially dependent older people: gender and age differences in ADL ability. *Environ Health Prev Med*. (2001) 6:92–6. doi: 10.1007/BF02897952

22. Connolly D, Garvey J, McKee G. Factors associated with ADL/IADL disability in community dwelling older adults in the Irish longitudinal study on ageing (TILDA). *Disabil Rehabil*. (2017) 39:809–16. doi: 10.3109/09638288.2016.1161848

23. Zhang P-D, Lv Y-B, Li Z-H, Yin Z-X, Li F-R, Wang J-N, et al. Age, period, and cohort effects on activities of daily living, physical performance, and cognitive functioning impairment among the oldest-old in China. *J Gerontol: Series A*. (2019) 75:1214–21. doi: 10.1093/gerona/glz196

24. Hyejin L, Bumjo O, Sunyoung K, Kiheon L. ADL/ IADL dependencies and unmet healthcare needs in older persons: a nationwide survey. *Arch Gerontol Geriatr*. (2021) 96:104458. doi: 10.1016/j.archger.2021.104458

25. Martin JC, Engle VF, Graney MJ. Health status gender differences of newly admitted black nursing home residents. *J Am Geriatr Soc*. (1997) 45:166–73. doi: 10.1111/j.1532-5415.1997.tb04502.x

26. Demura S, Sato S, Minami M, Kasuga K. Gender and age differences in basic ADL ability on the elderly: comparison between the independent and the dependent elderly. *J Physiol Anthropol Appl Human Sci*. (2003) 22:19–27. doi: 10.2114/jpa.22.19

27. Holt-Lunstad J. Why social relationships are important for physical health: a systems approach to understanding and modifying risk and protection. *Annu Rev Psychol*. (2018) 69:437–58. doi: 10.1146/annurev-psych-122216-011902

28. World Health Organization. *International classification of functioning, disability and health: ICF*. Geneva: Switzerland (2001).

29. Bielecki A, Kokoszka A, Holas P. Dynamic systems theory approach to consciousness. *Int J Neurosci*. (2000) 104:29–47. doi: 10.3109/00207450009035007

30. Storeng SH, Sund ER, Krokstad S. Factors associated with basic and instrumental activities of daily living in elderly participants of a population-based survey: the Nord-Trøndelag health study, Norway. *BMJ Open*. (2018) 8:e018942. doi: 10.1136/bmjopen-2017-018942

31. Beltz S, Gloystein S, Litschko T, Laag S, van den Berg N. Multivariate analysis of independent determinants of ADL/IADL and quality of life in the elderly. *BMC Geriatr*. (2022) 22:894. doi: 10.1186/s12877-022-03621-3

32. Ćwirlej-Sozańska A, Wiśniowska-Szurlej A, Wilmowska-Pietruszyńska A, Sozański B. Determinants of ADL and IADL disability in older adults in southeastern Poland. *BMC Geriatr*. (2019) 19:297. doi: 10.1186/s12877-019-1319-4

33. Golant SM. Low-income elderly homeowners in very old dwellings: the need for public policy debate. *J Aging Soc Policy*. (2008) 20:1–28. doi: 10.1300/J031v20n01_01

34. Åsvold BO, Langhammer A, Rehn TA, Kjelvik G, Grøntvedt TV, Sørgjerd EP, et al. Cohort profile update: the HUNT Study, Norway. *Int J Epidemol*. (2022) 52:e80–91. doi: 10.1093/ije/dyac095

35. Freedman VA, Martin LG, Schoeni RF. Recent trends in disability and functioning among older adults in the United States: a systematic review. *JAMA*. (2002) 288:3137–46. doi: 10.1001/jama.288.24.3137

36. Vitman Schorr A, Khalaila R. Aging in place and quality of life among the elderly in Europe: a moderated mediation model. *Arch Gerontol Geriatr*. (2018) 77:196–204. doi: 10.1016/j.archger.2018.04.009

37. Moe JO, Hagen TP. Trends and variation in mild disability and functional limitations among older adults in Norway, 1986–2008. *Eur J Ageing*. (2011) 8:49–61. doi: 10.1007/s10433-011-0179-3

38. Leveille SG, Resnick HE, Balfour J. Gender differences in disability: evidence and underlying reasons. *Aging Clin Exp Res*. (2000) 12:106–12. doi: 10.1007/BF03339897

39. Schön P, Parker MG, Kåreholt I, Thorslund M. Gender differences in associations between ADL and other health indicators in 1992 and 2002. *Aging Clin Exp Res*. (2011) 23:91–8. doi: 10.1007/BF03351074

40. Scheel-Hincke LL, Möller S, Lindahl-Jacobsen R, Jeune B, Ahrenfeldt LJ. Cross-national comparison of sex differences in ADL and IADL in Europe: findings from SHARE. *Eur J Ageing*. (2020) 17:69–79. doi: 10.1007/s10433-019-00524-y

41. Wray LA, Blaum CS. Explaining the role of sex on disability: a population-based study. *Gerontologist*. (2001) 41:499–510. doi: 10.1093/geront/41.4.499

42. Statistics Norway. Facts about gender equality. (2023). Available from: https://www.ssb.no/befolkning/faktaside/likestilling.

43. Kim S, Choe K, Lee K. Depression, loneliness, social support, activities of daily living, and life satisfaction in older adults at high-risk of dementia. *Int J Environ Res Public Health*. (2020) 17, 1–10. doi: 10.3390/ijerph17249448

44. Tomioka K, Kurumatani N, Hosoi H. Association between social participation and instrumental activities of daily living among community-dwelling older adults. *J Epidemiol*. (2016) 26:553–61. doi: 10.2188/jea.JE20150253

45. Mendes de Leon CF, Glass TA, Berkman LF. Social engagement and disability in a community population of older adults: the New Haven EPESE. *Am J Epidemiol*. (2003) 157:633–42. doi: 10.1093/aje/kwg028

46. Bondevik M, Skogstad A. The oldest old, ADL, social network, and loneliness. *West J Nurs Res*. (1998) 20:325–43. doi: 10.1177/019394599802000305

47. Lawton MP. Community supports for the aged. *Aust J Soc Issues*. (1981) 37:102–15. doi: 10.1111/j.1540-4560.1981.tb00831.x

48. Drageset J. The importance of activities of daily living and social contact for loneliness: a survey among residents in nursing homes. *Scand J Caring Sci*. (2004) 18:65–71. doi: 10.1111/j.0283-9318.2003.00251.x

49. Cohen-Mansfield J, Hazan H, Lerman Y, Shalom V. Correlates and predictors of loneliness in older-adults: a review of quantitative results informed by qualitative insights. *Int Psychogeriatr*. (2016) 28:557–76. doi: 10.1017/S1041610215001532

50. Clemens S, Aelick K, Babineau J, Bretzlaff M, Edwards C, Gibson JL, et al. Home- and community-level predictors of social connection in nursing home residents: a scoping review. *Health Sci Reports*. (2022) 5, 1–12. doi: 10.1002/hsr2.743

51. Joung IMA, Mheen HVD, Stronks K, Poppel FWAV, Mackenbach JP. Differences in self-reported morbidity by marital status and by living arrangement. *Int J Epidemiol*. (1994) 23:91–7. doi: 10.1093/ije/23.1.91

52. Sarwari AR, Fredman L, Langenberg P, Magaziner J. Prospective study on the relation between living arrangement and change in functional health status of elderly women. *Am J Epidemiol*. (1998) 147:370–8. doi: 10.1093/oxfordjournals.aje.a009459

53. Floridi G, Quashie NT, Glaser K, Brandt M. Partner care arrangements and well-being in mid- and later life: the role of gender across care contexts. *J Gerontol: Series B*. (2021) 77:435–45. doi: 10.1093/geronb/gbab209

54. Van Ginkel JR, Linting M, Rippe RCA, Van der Voort A. Rebutting existing misconceptions about multiple imputation as a method for handling missing data. *J Pers Assess*. (2020) 102:297–308. doi: 10.1080/00223891.2018.1530680

frontiers | Frontiers in Public Health

TYPE Review
PUBLISHED 09 October 2023
DOI 10.3389/fpubh.2023.1254172

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Martin Nwadiugwu,
Tulane University, United States
Arkers Kwan Ching Wong,
Hong Kong Polytechnic University,
Hong Kong SAR, China

*CORRESPONDENCE
Estela González-González
✉ esgog@unileon.es

†These authors have contributed equally to this work

RECEIVED 06 July 2023
ACCEPTED 26 September 2023
PUBLISHED 09 October 2023

CITATION
González-González E and Requena C (2023) Self-care interventions of community-dwelling older adults: a systematic review and meta-analysis.
Front. Public Health 11:1254172.
doi: 10.3389/fpubh.2023.1254172

COPYRIGHT
© 2023 González-González and Requena. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Self-care interventions of community-dwelling older adults: a systematic review and meta-analysis

Estela González-González*† and Carmen Requena†

Catedra de Envejecimiento en todas las edades, University of León, León, Spain

Introduction: The current notion of "care in old age" should be reconceptualized in the ageing societies of the 21st century. Currently, "being old" means that one is actively involved in their care and has the desire to retain control and independence.

Objective: Understand and analyze the efficacy of interventions in the physical and psychological self-care practices of healthy community-dwelling older people.

Methodology: Systematic review and meta-analysis. The guidelines of the PRISMA guide were followed. The methodological quality of the studies was checked using Cochrane Effective Practice and Organisation of Care criteria, and the search was performed between 2016 and 2021.

Results: Of the 1,866 evaluated, 8 studies met the criteria. The systematic review reveals that self-care interventions focus on physical health-related variables but not on psychological variables. The meta-analysis shows that interventions significantly improve physical health-related variables (care visits, hospital admission, medication, and gait speed).

Conclusion: Self-care training programs should include psychological variables to increase health and well-being in healthy older people.

KEYWORDS

self-care, healthy older adults, community-dwelling, interventions, health

1. Introduction

The chance that older people currently have of living longer is made in better bio-psych-social conditions, with a higher educational level and better-qualified work performance that sexagenarians from as recently as one decade ago (1). Moreover, today's older adults (or pre-older adults) population practice healthier lifestyles, have good social networks and freely choose how to spend their free time (2). Attending to the new profile of older people in ageing 21st century societies necessitate reconceptualizing the current notion that "being old" means that one is a passive subject needing care. This proactive ageing approach is characterized by considering that ageing is not only the result of the curse of time in genetic determinants but conditioned by social and environmental factors. Furthermore, these social and environmental factors could get to determine the course of ageing up to 75% (3). Therefore, more than just genetic factors or hereditary conditions on age and sex are involved in the sociopolitical

decisions that determine the independent functionality of older people until the end of their lives. Hence, the real challenge of ageing research is to eradicate the biased medical vision of ageing as an inevitable period of loss leading to dependency and disability and replace it with a multidimensional model that predicts personal development in ageing through self-care practices (4).

Classically, self-care has been studied from the unidisciplinary approaches of nursing and is defined as the set of all those human physical, mental, and psychological practices aimed at maintaining and/or restoring the health and well-being of people in the community (5). The main life-cycle theories underlying this health approach advocate that adulthood is a largely period of loss mitigation and prioritization of goals related to maintaining functional independence (ability to perform daily tasks) over the long term (6). In this framework, self-care education programs for older adults promote daily self-management of chronic conditions. In general, chronic diseases (e.g., hypertension or diabetes) cannot be cured, but symptoms can be controlled with lifestyle changes (7). Also, these educational programs propose practices to prevent and treat diseases such as Alzheimer's (e.g., cognitive stimulation programs or memory training) (8).

While loss mitigation is an important goal, we argue that it is equally necessary to investigate how older adults can improve their current state, especially among those who do not experience functional or cognitive deficits. Prominent life course theories propose that the core of self-care is not only about preserving health as the absence of disease but also includes practices that stimulate life and optimal personal development (9). This conceptualization of self-care is more in line with the WHO model of healthy ageing (10), which focuses on the practices of activities that enhance a person's physical and mental capacities. It is also biopsychosocial and developmental approaches that emphasize the concept of resilience, neuroplasticity, and people's continuous capacity to adapt and develop throughout life (11).

One should consider that one of the demands of the new older adults has to do with the challenge of self-care in their own home. Consequently, it is essential to provide a socio-community intervention plan for good self-care practices. These types of practices should consider not only a care network of family, friends, and institutions on which one can count but also, especially, a psychoeducational plan of personal development in the long term (12). A psychoeducational plan of personal development focuses on adapting for growth by learning new skills to prepare older people to handle any changes that may emerge over time. Therefore, new social healthcare policies must respond to new social and psychological claims, in addition to the health promotion that contributes to maintaining a full life in one's own home.

So far, some systematic reviews and meta-analyses have examined the effect of specific behavioral interventions for the care of older adults with long-term conditions (LTCs) (13), such as frailty (14) or sarcopenia (15). However, as far as the authors know, there are no studies that synthesize the findings in a comprehensive range of behavioral interventions for self-care that target healthy community-living older adults. Behavioral interventions focus on training in daily living practices related to behaviors that optimize physical and psychological health. Unlike other behavioral interventions, they are not focused on the management of chronic diseases. This divide between interventions for LTCs and interventions for optimizing health is addressed by examining how studies include intervention in daily living care programs and what interventions, if any, provided such benefits to the target population. It is important to highlight that this review will emphasize the comparisons between classic interventions, which treat older people as "the passive subject of care," and interventions based on the proactive model of ageing, which advocates for a caregiving-engaged older person profile. Moreover, following the Cochrane Effective Practice and Organisation of Care Review Group quality criteria for reviews (16), essential comparisons within and between interventions are considered, as there may be some intervention types with similar strengths in the same trial interventions (i.e., active control groups adequate) or with systematic weakness in the trials (i.e., inadequate boosts). Furthermore, this review will identify which indicators are better for promoting and maintaining older adults' self-care habits/practices for those who want to stay home. It will select the details of the intervention that are evaluated in the transfer, such as duration and dose, and it will consider the follow-up period. Ultimately, this systematic review and meta-analysis specifically pursue: (1) summarizing similarities and differences between different care intervention programs and their results, (2) identifying care intervention programs that grant benefits in cognitive, psychological, and physical domains, and (3) highlighting the limitations that should be addressed in future research.

2. Methods

2.1. Rationale

This systematic review and meta-analysis only considered randomized controlled trials (RCTs) that were aimed at supporting self-care in community-dwelling older adults. Participants of the intervention are distributed into two groups: an intervention group, which received psychoeducational self-care interventions, and a control group, which received usual care (not receive psychoeducational self-care structured programs). The definition of self-care used in this review was associated with care practices in which older people decide not only to promote or maintain health and functioning in ageing but also how to optimize it. Studies that focused on disease-specific self-care were outside the scope of this review since these programs involved disease-specific skill-based training, and the support is often delivered after hospital discharge.

2.2. Inclusion and exclusion criteria

Only articles from peer-reviewed journals published in English with a focus on healthy community-dwelling older adults (60+ years) and from any country were included. Included studies reported the outcome of a behavioral intervention on physical and psychological health. Papers based on the same study sample were included. The PICO framework used to define the eligibility criteria is seen below:

P—Population: healthy and community-dwelling older adults 60 years of age and older.

I—Intervention: psychoeducational self-care interventions.

C—Comparison: usual care.

O—Outcome: physical and psychological health.

Only RCTs on psychoeducational (behavioral) self-care interventions were eligible (see Table 1). Studies involving people under 60 years, people with dementia diagnosis, physical impairment, or long-term conditions (LTC), and pharmaceutical interventions were excluded. The search items can be seen in Table 2.

2.3. Search strategy

The review was conducted in PubMed, Medline, Scopus, Web of Science (WoS) and Cochrane Library databases. Keywords for the type of care intervention, context, and population were used to search each database. The terms can be seen in the database search history (Supplementary material B).

The key categories searched were care (self-care), healthy community-dwelling, and older adults. Synonyms for each key category generated were individually searched and then collectively combined with the "OR" logical operator. An intersection between the three key categories searched was done using the "AND" operator as shown in Table 2. The screening process from the five databases yielded 1866 total hits and is presented in the PRISMA flow diagram in Figure 1 [Pubmed ($n = 261$ articles), Medline ($n = 178$ articles), Scopus ($n = 648$ articles), the Wos ($n = 667$ articles) and the Cochrane Library ($n = 112$ articles)]. Duplicated articles were excluded ($n = 557$). Across both search strategies, a total of 1,309 articles were screened, and 1,117 articles were excluded based on title and abstract. The remaining 192 articles were screened in full. Of those, 184 were excluded. Excluded studies were: not peer-reviewed ($n = 7$), protocol papers with no reported results ($n = 11$), not focused on an intervention on care ($n = 73$), not reporting healthcare outcome measures ($n = 20$), not behavioral interventions with posttest measures ($n = 38$), not age-eligible or did not include community-dwelling older adults ($n = 23$), or a systematic review or meta-analysis that was pulled for cross-check purposes only ($n = 12$). Finally, 8 unique articles referring to a total of 7 studies were included in the current systematic review (Figure 1).

TABLE 1 Inclusion/exclusion criteria.

	Inclusion	Exclusion	Rationale
Population	Healthy and community-dwelling older adults 60 years of age and older	People under 60 years or older people with serious diseases	To review self-care activities in healthy community older adults
Intervention	Behavioral self-care intervention	Pharmaceutical or disease management intervention	To focus on self-care interventions
Comparison	Usual care		
Outocome	Health and wellbeing benefits	Improvement of the disease or compensatory strategies	To investigate benefits on physical and psychological health

TABLE 2 Search items.

Care (step 1)		Context (step 2)		Population (step 3)
Terms	AND	Terms	AND	Terms
"care" OR "take care" OR "self-care" OR "care of the self" OR "be cared for"		"healthy" OR "health" OR "healthy ageing" OR "healthy ageing" OR "community-dwelling"		"older age" OR "older people" OR "older adult" OR "ageing" OR "ageing"
Combined with OR		**Combined with OR**		**Combined with OR**

2.4. Data extraction and quality assessment

Two reviewers (CR and E-GG) independently reviewed articles in-depth and extracted data independently based on the inclusion criteria. Each article was crosschecked by both authors, and any discrepancies were resolved through mutual discussion to achieve consensus.

Data from the eight selected studies were extracted under these headings: name of the author (s), year of publication, study design, methods, and intervention. Methodological quality was assessed using the Cochrane Effective Practice and Organisation of Care Review Group quality criteria for reviews (16). These quality criteria evaluate the risk of bias in each intervention. Specifically, this validated methodology is composed of nine criteria (Random sequence generation, Allocation concealment, Baseline outcome measurements similar, Baseline characteristics similar, Incomplete outcome data, Knowledge of the allocated interventions adequately prevented during the study, Protection against contamination, Selective outcome reporting, and Other risks of bias) with the aim of summarizing the evidence to guide health system decision-making to improve socio and health services and population health outcomes. If information was omitted from the article, reviewers are referred to protocol papers and ClinicalTrials.gov or other trial registration platforms. Each item was scored either: low risk of bias, unclear risk of bias, or high risk of bias. An outcome was considered to have a "low risk of bias" if the study showed a low risk of bias in all key domains, "unclear risk of bias" if the risk of bias was unclear for one or more key domains, and "high risk of bias" if there was a high risk of bias in one or more key domains (17).

2.5. Statistical analysis

Meta-analyses were conducted using Review Manager (version 5.4). We decided to use fixed effects meta-analysis, considering the size of the study and its own variance as the only determinants of its weight. The standardized mean differences (SMDs) and their 95% confidence intervals (CIs) were calculated from post-intervention outcomes for continuous data, while the odds ratio (OR) was obtained from dichotomous data. Pooled ORs (95% CI) were calculated, and a two-sided p-value <0.1 was considered to indicate statistical significance (18).

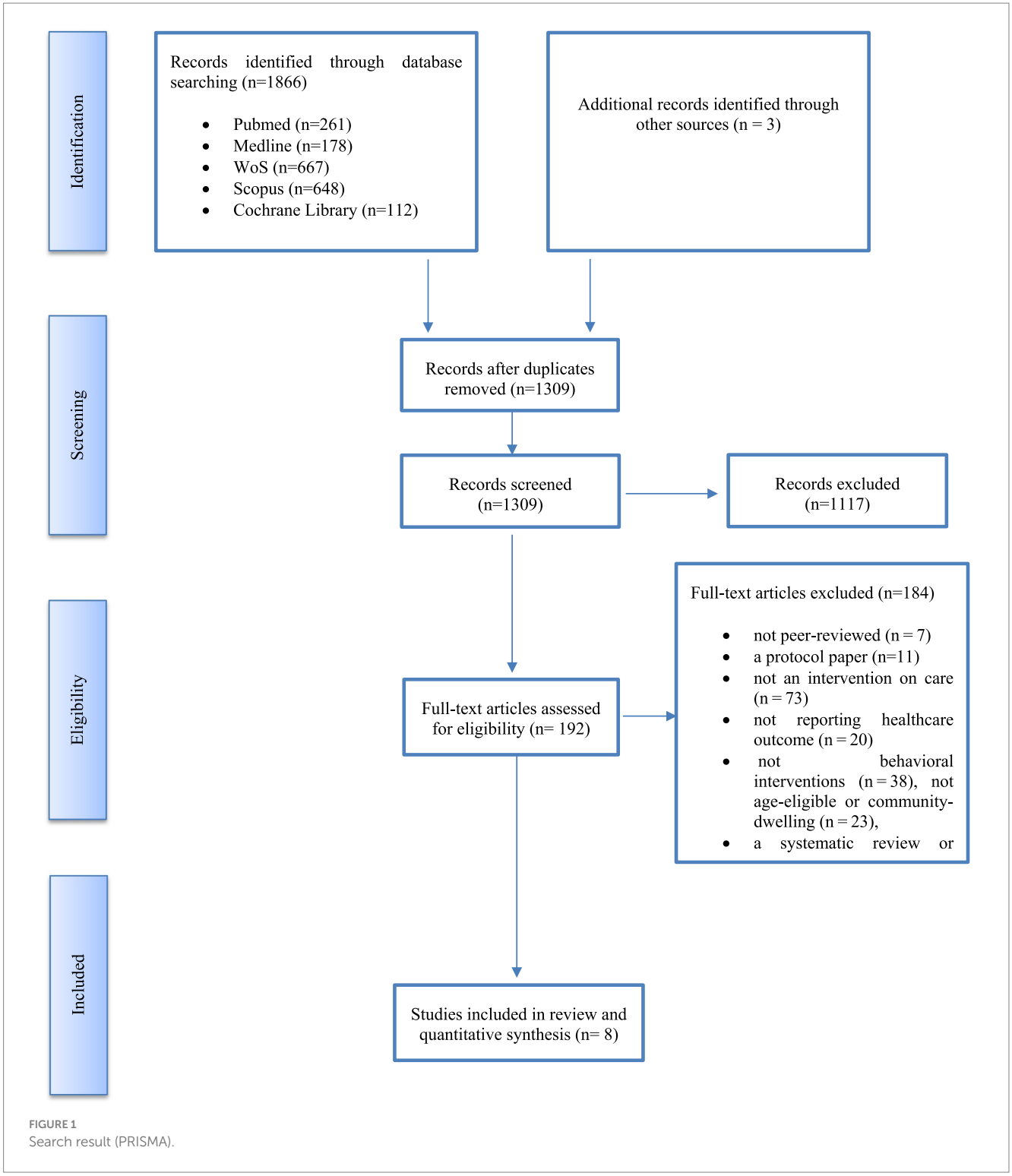


FIGURE 1
Search result (PRISMA).

3. Results

3.1. Study characteristics

Of the 8 studies included in this study, 2 were related to the same research (19, 20). Among the 8 studies, 1,798 participants between 31 (21) and 540 participants (22) were included, with an average sample size of 257 participants per study. The average age was 75.21 years, ranging between 60 and 92 years. On the other hand, the female gender had a representation average in the studies of 64.9% of the sample, ranging from 51.6% (21) to 75.1% (19, 20). The Wong et al. (22) study does not identify gender or age.

Studies used various channels, visit numbers, durations, and providers to carry out the care interventions in community-living

older adults. Regarding delivery channels, 2 (25%) trials used only home visits, 3 (37.5%) used home visits and a telephone follow-up, 1 (12.5%) used home visits and group training, and 1 (12.5%) used visits to a community center. Two care program types were identified: intensive (care duration longer than 6 months) (6 studies) and intermediate (care duration between 6 months to 1 year) (2 studies). None of the included studies was of the extensive type (care duration longer than 1 year). Participants received an average of 20.66 sessions, ranging from 8 to 48, with an average duration of 62 min, ranging between 30 and 90. One study (23) did not specify the number of sessions carried out in the intervention. Regarding care program providers, three 3 of them were from a single discipline [two from nursing (22, 24) and one from occupational therapy (25)], 3 were multidisciplinary by socio-health care providers [two combined nurses with social and community workers (19, 20), and one was performed by a team composed by physical therapists and educators (26)]. Finally, two articles did not specify who the interventions providers were Dolovich et al. (23) only refers to volunteers, and Wong et al. (20) is online. The protocol was not found in 1 study (24). A summary of study characteristics can be seen in Table 3.

3.2. Methodological quality of the studies

Agreement between two independent reviewers was greater than 90% in all aspects of the quality assessment of the methodology. The quality of the studies was heterogeneous, although the majority have a "high" risk of bias. All the studies adequately described the random sequence generation. Moreover, the great majority informed the Allocation concealment in the correct form, except for the Tavakkoli Oskuei et al. study (24), which may have led to a selection bias. Moreover, the totality of the studies showed a "low" risk of bias for the "selective outcome reporting" criterion.

On the other hand, a great risk of bias [either "high" (18, 19, 21) or "unclear" (21, 23–25)] is obtained in the indicator of baseline characteristics similar, because the baseline characteristics of the intervention and control providers were either correctly reported or not similar. At least half of the studies presented an "unclear" or "high" risk of bias for the baseline similar outcome measurements, to the knowledge of the allocated interventions or other risk criteria.

Finally, regarding the general assessment of the studies' risk of bias, no publication achieved a "low" risk of bias, 2 studies obtained an "unclear" risk of bias (21, 25), and the 5 remaining studies obtained

TABLE 3 Characteristics of the included studies.

				Intervention						
Study	Sample	Age	Gender	Chanel	Visit	Duration	Provider	Approach	CG	Results
18	457 (IG = 230; CG = 227)	78 (±7.92)	75.1% females	Home and telephone calls	8 session (3 month)	First: 1 h. Next: 1 h. Telep.: 20 m.	Nurse and social and community workes	Classic	Usual care	Improve psychological health
19	457 (IG = 230; CG = 227)	78 (±7.92)	75.1% females	Home and telephone calls	8 session (3 month)	First: 1 h. Next: 1 h. Telep.: 20 m.	Nurse and social and community workes	Classic	Usual care	Improves psychological and physical health
20	31 (IG = 15; CG = 16)	73.9 (± 6.4)	61.6% females	Home and telephone calls	48session (4 month)	30–40 m.	Online	Classic	Usual care	Improve cognitive, not brain health
21	540 (IG = 271; CG = 269)	–	–	Home and telephone calls	8 session (3 month)	First: 1 h. Next: 1 h. Telep.: 20 m.	Nurse	Classic	Usual care	Reducing service cost. Program cost effective.
22	312 (IG = 158; CG = 154)	IG = 78.06 (± 6.3) CG = 79.06 (± 6.6)	62.2% females	Home	6 month	–	Volunteers	Classic	Usual care	More care visit, fewer hospital admission
23	136 (IG = 69; CG = 67)		58.8% females	Local venue and home	8 session (2 month) + 8 follow session	1 h/session +30 m/day follow	Nurse	Classic	Not education program	Improves healthy lifestyle
24	262 (IG = 136; CG = 126)	IG = 72.9 CG = 71.3	74.8% females	Local venue	20session (4 month)	–	Ocupattional therapy	Classic	Usual care	Intervention not effective for UK
25	60 (IG = 30; CG = 30)	IG = 74 (±4.9)	66.6% females	University	24session (6 month)	90 m.	Physic therapist and educators	Classic	Didactic teaching method	Improves healthy lifestyle

IG, intervention group; CG, control group; h, hour; m, minute.

a high score in the risk of bias. The assessment of the methodological quality of the studies can be seen in Table 4.

3.3. Quantitative synthesis

In the quantitative synthesis are two separate sections: sanitary and psychological aspects. Each section describes the result of the meta-analyses of some sanitary and psychological variables.

3.3.1. Sanitary aspect

Care visit. This variable includes 3 studies (43%) with a total of 1,228 participants. For 3 months, data seem to show a trend of greater health service utilization on the part of the control group ($I^2 = 90\%$; DME = −0.06; IC of 95% = −0.18, 0.05; $p = 0.27$), although the differences were not statistically significant. At 6 months, the trend of fewer care visit by the intervention group continued keeping ($I^2 = 92\%$; DME = −0.10; IC of 95% = −0.22, 0.01; $p = 0.07$).

Hospital admission. This variable includes the same studies as the care visit variable. For 3 months, a common significant effect of minor recourse utilization on the part of the intervention group was observed ($I^2 = 0\%$; DME = −0.35; IC of 95% = −0.35, −0.08; $p = 0.002$). At 6 months, the same trend of fewer hospital admission by intervention group continued keeping ($I^2 = 0\%$; DME = −0.21; IC of 95% = −0.34, −0.07; $p = 003$).

Medication. This variable includes 2 studies (29%) with a total of 769 participants. Data for the intervention group show a significant trend of better medication intake ($I^2 = 65\%$; DME = −0.31; IC of 95% = −0.57, −0.04; $p = 0.03$).

Gait speed. This variable includes 2 studies (29%) with a total of 91 participants. Data for the intervention group seem to show an upward trend in gait speed ($I^2 = 0\%$; DME = −0.09; IC del 95% = −0.18, 0.01; $p = 0.06$), but the difference is not significant among groups.

Figure 2 shows the forest plot of sanitary variables analyzed.

3.3.2. Psychological aspect

Self-efficacy. This variable includes 2 studies (29%) with a total of 769 participants. Data do not seem to show any trend in the improvement of self-efficacy ($I^2 = 0\%$; DME = 0.00; IC of 95% = −0.013, 0.13; $p = 0.98$), and there are no significant differences between groups.

Quality of life, psychological component. This variable includes 4 studies (57%), with a total of 1.571 participants. Data for the control group seem to show a trend of great quality life ($I^2 = 76\%$; DME = 0.11; IC of 95% = 0.01, 0.22; $p = 0.03$).

Depression. This variable included 2 studies (29%) with a total of 769 participants. Data for the control group seem to show a tendency of great depression ($I^2 = 0\%$; DME = 0.05; IC of 95% = −0.06, 0.17; $p = 0.35$), but significant differences do not exist among groups; consequently, it is not possible to establish any general conclusion.

Figure 3 shows the forest plot of psychological variables analyzed.

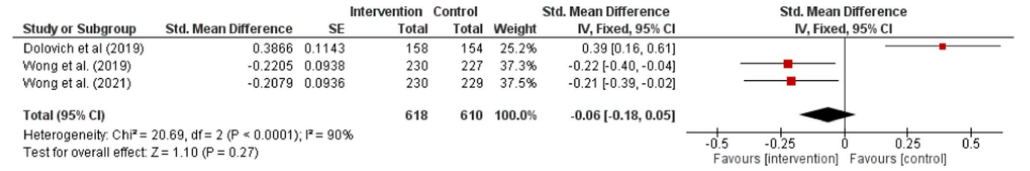
4. Discussion

As far as the authors know, this is the first study on systematic review and meta-analysis of self-care interventions carried out in the community with a healthy population that did not have any diseases or disabilities. Results prove that in addition to there being scarce

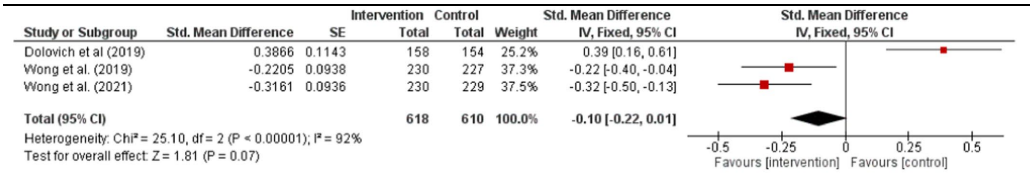
TABLE 4 Evaluation of methodological quality by Cochrane criteria.

Study	Random sequence generation	Allocation concealment	Baseline outcome measurements similar	Baseline characteristics similar	Incomplete outcome data	Knowledge of the allocated interventions	Protection against contamination	Selective outcome reporting	Other risks	Total
18	Low	Low	Low	High	High	Low	Low	Low	Unclear	High
19	Low	Low	High	High	High	Unclear	Low	Low	Unclear	High
20	Low	Low	Unclear	Unclear	Low	Unclear	Low	Low	Low	Unclear
21	Low	Low	Unclear	High	Low	Low	Low	Low	Unclear	High
22	Low	Low	Low	Unclear	Low	High	Low	Low	High	High
23	Low	Unclear	High	Unclear	Low	High	Low	Low	High	High
24	Low	Low	Low	Unclear	Low	Low	Low	Low	Low	Unclear
25	Low	Low	Low	Low	Low	Low	High	Low	Low	High

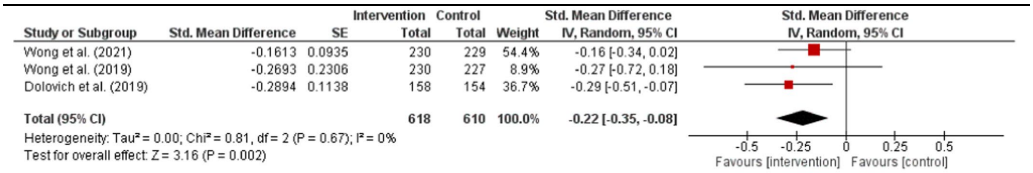
Health Service Utilization: 3 months



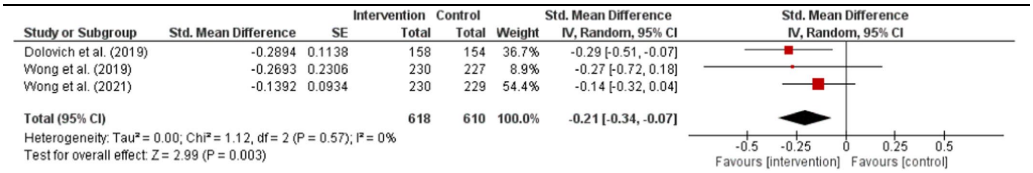
Health Service Utilization: 6 months



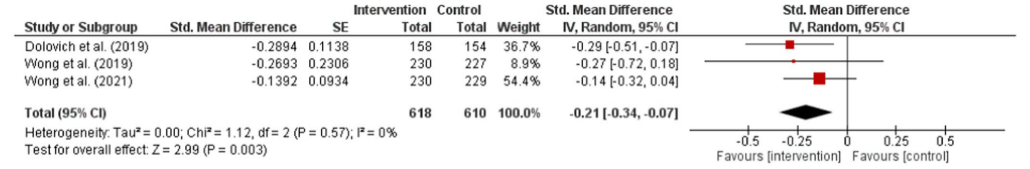
Hospital admissions: 3 months



Hospital admissions: 6 months



Medication



Gait Speed

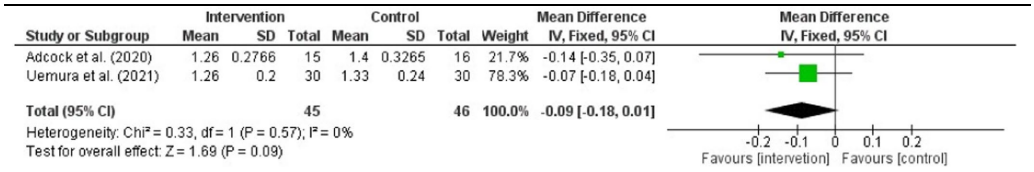
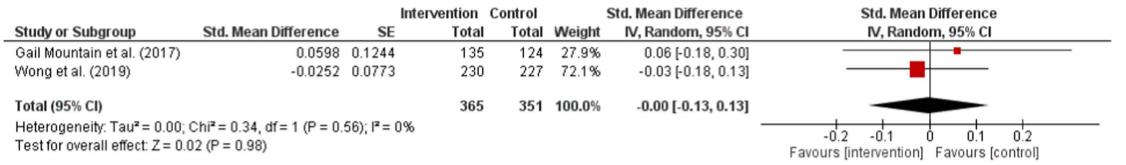
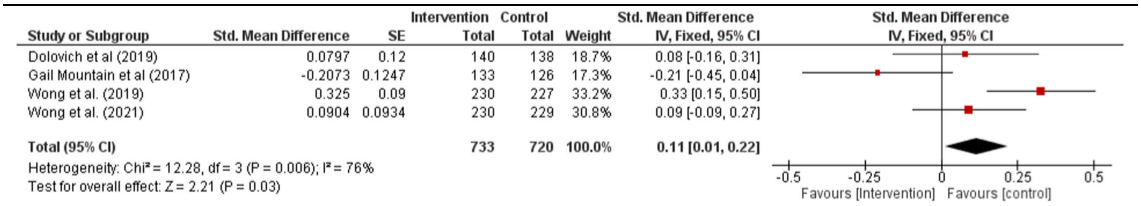


FIGURE 2
Forest plot between self-care intervention and control group in sanitary aspects.

Self-Efficacy



Quality of life



Depression

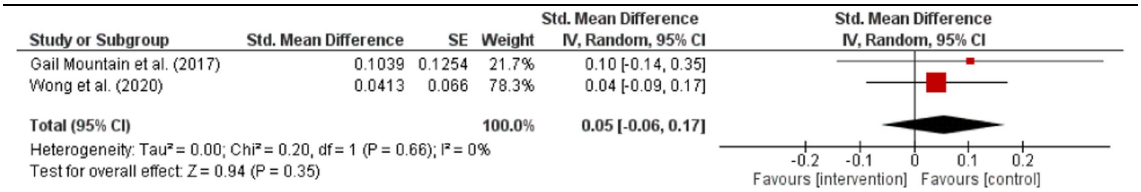


FIGURE 3
Forest plot between self-care intervention and control group in psychological aspects.

scientific literature on self-care interventions in healthy older adults, the studies included in this review present a high risk of bias in some criteria of the Cochrane Effective Practice and Organisation of Care Review Group related to a characteristics and outcomes baseline. Nevertheless, the revised interventions reveal that these types of programs are potentially effective and beneficial in the long term with respect to decreasing hospital admissions and show a lower trend to request medical appointments. Moreover, good practices are observed in compliance with prescribed medication intake, and improved agility in physical movement. No effects of these programs on the psychological component of quality of life and self-efficacy, but it does influence mood, although this effect is the opposite of the expected one. Nor has it been possible to establish doses or amounts of normative training.

Results of the systematic review revealed that the contents of the intervention focus on health variables associated with disease, regardless of whether the context of application is health or social field (see Supplementary material A) (27). Although interventions have a preventative purpose, they are based on classic ageing models and the themes topics focus on how to cope with inevitably age-related limitations or declines (28). Interventions are provided by health staff, principally nurses, and are sometimes supported by social works (20, 22). In particular, the variables addressed in the intervention programs are essentially physical health variables such as nutrition or physical exercise (see Supplementary material A). These data could be explained on the basis that older people who do not have healthy behaviors either overuse health and social care resources or need more frequent medical care due to a lack of good self-care practices (29). Older people who present unfavorable measures in impairment and cognition, *inter alia*, tend to use less preventative health services (30), which increases the likelihood of institutionalization and healthcare cost (31). Furthermore, some studies show that older adults who do not practice self-care tend to suffer from a greater variety of psychological disorders more frequently (32). In contrast, when people are engaged with their physical and psychological health, they have a higher probability of maintaining their emotional independence, improving their perception of their quality of life, and having greater control over their negative responses (33).

The sample of this study was mainly females (around 65%) with an average age of 75 years, hence they belong to the classification of "ageing" group (34). Usually, in research with older populations, the profile of greater participation of females is repeated, as well as the practice of forming samples with both males and females, but in the analysis of the results no studies have been found that disaggregate

data by sex (35). However, the topic of "self-care" needs specific programs for men and women due to the cultural tradition of associating care practice with females as opposed to males (36). That is for older females, care is continuous, while for males, care is an essential role who must learn in the end of their lives.

For its part, the ageing profile by which self-care programs are inspired is biased toward decline and losses (see Table 1). Furthermore, considering the Baltes lifespan Model, intervention proposals underscore how to carry out environmental or personal compensation for future losses (6). In this sense, some studies propose care interventions in the clinical-specific context of ageing, despite having verified that these types of programs have a greater efficacy when they are applied in an informal psychoeducational context, in which psychological topics related to vital well-being and personal growth (37). However, another more optimistic perspective on development in ageing is possible, as proposed by Nguyen et al. (6). Some experts propose swapping the image of older people as passive agents of care who live in static environments for a realistic and more adaptive model based on the new "ageing" who want to stay home and engage with the community (38). Consequently, health must be understood from a more holistic and comprehensive perspective, taking into account forms of self-care interventions that have not only physical health content, but also long-term life plans that involve challenges of personal development. Moreover, an interdisciplinary approach that addresses psychological, sanitary, environmental and designs that contribute to optimal care until the end of one's life is needed (39).

Confidence in self-care behaviors is one of the key factors that determines adherence and compliance to self-care (see Supplementary material). Feeling confident in one's own ability to adequately handle the stressors of daily life refers to the concept of self-efficacy expectation (40). In general, older people know that certain actions such as exercising, taking classes, or reuniting with their peer group benefit their health and well-being (41). In this sense, some studies have demonstrated that learning good care practices and training on the interventions can have a sustained effect on self-efficacy; that is to say, the confidence one has in one's ability to manage one's own health (42). Even more, in practice the action, older people who feel effective choose more challenging tasks, set high goals and are more persistent in achieving them (43). Nevertheless, no research has been found that can provide clarity certainly as to whether self-efficacy in self-care behaviors can last in the long term after interventions cease (44).

This study presents some limitations related to bias that affects methodological quality, the type and sample size and specifically with the emerging state of care which is the central topic of this research. However, despite these limitations, this review shines light on the need for promoting self-care programs for healthy older adults without disabilities who live and want to continue living in their houses. That is, actions are needed not only to promote physical health, but also good self-care practices aimed at fostering an optimal state of personal social and psychological growth.

5. Conclusion

The research conducted shows that self-care practices intervention promotes the physical health of healthy older people. However, although these programs implement psychological variables in the evaluation of the effect, these are not considered in the training phase. Future studies that implement multidimensional components are needed to understand the real scope of these interventions.

Author contributions

EG-G: Writing – original draft, Writing – review & editing. CR: Writing – original draft, Writing – review & editing.

Funding

This research has been founded by Ministry of Universities, Government of Spain (ref. FPU20/02377).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1254172/full#supplementary-material

References

1. Voigt M. *Health inequalities in Spain: analysis of structural inequalities and the effects on health and mortality*. [dissertation's thesis]. Spain: CSIC (2019).

2. Commission E, Eurostat. *Ageing Europe: looking at the lives of older people in the EU: 2020th edition*. [dissertation] Luxembourg: Publications Office (2020).

3. Villavicencio M, Díaz M, González-Pérez G, Bañuelos J, Valle-Barbosa M. Declive cognitivo de atención y memoria en adultos mayores sanos. *Cuadernos de Neuropsicología*. (2020) 14:1–65.

4. Lawless MT, Tieu M, Feo R, Kitson AL. Theories of self-care and self-management of long-term conditions by community-dwelling older adults: a systematic review and meta-ethnography. *Soc Sci Med*. (2021) 287:114393. doi: 10.1016/j.socscimed.2021.114393

5. Orem D. *Nursing: concepts of practice*. St. Louis, Missouri: Mosby (2001).

6. Nguyen C, Leanos S, Natsuaki MN, Rebok GW, Wu R. Adaptation for growth via learning new skills as a means to long-term functional Independence in older adulthood:

insights from emerging adulthood. *Gerontologist*. (2018) 60:4–11. doi: 10.1093/geront/gny128

7. Jaarsma T, Strömberg A, Dunbar SB, Fitzsimons D, Lee C, Middleton S, et al. Self-care research: how to grow the evidence base? *Int J Nurs Stud*. (2020) 105:103555. doi: 10.1016/j.ijnurstu.2020.103555

8. El-Osta A. The self-care matrix: a unifying framework for self-care. *Int J Self Help Self Care*. (2019) 10:38–56. doi: 10.6084/m9.figshare.12578741

9. Collière MF. *Promover la vida*. Madrid: S.A. Mcgraw-hill / Interamericana de España (1993).

10. World Health Organization. *World report on ageing and health*. Geneva, Switzerland: report WHO (2015).

11. Aw S, Koh GCH, Tan CS, Wong ML, Vrijhoef HJM, Harding SC, et al. Promoting bio psycho social health of older adults using a community for successful ageing program (com SA) in Singapore: a mixed-methods evaluation. *Soc Sci Med*. (2020) 258:113104. doi: 10.1016/j.socscimed.2020.113104

12. Dale B, Söderhamn U, Söderhamn O. Life situation and identity among single older home-living people: a phenomenological–hermeneutic study. *Int J Qual Stud Health Well-being*. (2012) 7:18456. doi: 10.3402/qhw.v7i0.18456

13. Zarrin A, Tourchian N, Heckman GA. Chronic disease self-management among Iranian older adults: a scoping review. *J Appl Gerontol*. (2020) 39:922–30. doi: 10.1177/0733464819832198

14. Faller JW, Pereira D, de Souza S, Nampo FK, Orlandi FS, Matumoto S. Instruments for the detection of frailty syndrome in older adults: a systematic review. *PLoS One*. (2019) 14:e0216166. doi: 10.1371/journal.pone.0216166

15. Vlietstra L, Hendrickx W, Waters DL. Exercise interventions in healthy older adults with sarcopenia: a systematic review and meta-analysis. *Australas J Ageing*. (2018) 37:169–83. doi: 10.1111/ajag.12521

16. Effective Practice and Organisation of Care (EPOC). *Cochrane: effective practice and organisation of care. Suggested risk of Bias criteria for EPOC reviews. EPOC-specific resources for review authors*. Effective Practice and Organisation of Care (EPOC). (2015).

17. van het Bolscher-Niehuis MJT, den Ouden MEM, de Vocht HM, Francke AL. Effects of self-management support programmes on activities of daily living of older adults: a systematic review. *Int J Nurs Stud*. (2016) 61:230–47. doi: 10.1016/j.ijnurstu.2016.06.014

18. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. *Cochrane handbook for systematic reviews of interventions*. Chichester, United Kingdom: Wiley (2019).

19. Wong AKC, Wong FKY. The psychological impact of a nurse-led proactive self-care program on independent, non-frail community-dwelling older adults: a randomized controlled trial. *Int J Nurs Stud*. (2020) 110:103724. doi: 10.1016/j.ijnurstu.2020.103724

20. Wong AKC, Wong FKY, Chang K. Effectiveness of a community-based self-care promoting program for community-dwelling older adults: a randomized controlled trial. *Age Ageing*. (2019) 48:852–8. doi: 10.1093/ageing/afz095

21. Adcock M, Fankhauser M, Post J, Lutz K, Zizlsperger L, Luft AR, et al. Effects of an in-home multicomponent exergame training on physical functions, cognition, and brain volume of older adults: a randomized controlled trial. *Front Med*. (2020) 6:321. doi: 10.3389/fmed.2019.00321

22. Wong AKC, Wong FKY, So C. Cost-effectiveness of a preventive self-care health management program for community-dwelling older adults: a randomised controlled trial. *Age Ageing*. (2021) 50:440–6. doi: 10.1093/ageing/afaa127

23. Dolovich L, Oliver D, Lamarche L, Thabane L, Valaitis R, Agarwal G, et al. Combining volunteers and primary care teamwork to support health goals and needs of older adults: a pragmatic randomized controlled trial. *Can Med Assoc J*. (2019) 191:E491–500. doi: 10.1503/cmaj.181173

24. Tavakkoli Oskuei M, Barzanjeh Atri S, Davoodi A, Van Son C, Asghari-Jafarabadi M, Hosseinzadeh M. Evaluation of a self-care education program for older adults in Iran using a lifestyle improvement model. *Int J Older People Nursing*. (2022) 17:e12419. doi: 10.1111/opn.12419

25. Mountain G, Windle G, Hind D, Walters S, Keertharuth A, Chatters R, et al. A preventative lifestyle intervention for older adults (lifestyle matters): a randomised controlled trial. *Age Ageing*. (2017) 46:627–34. doi: 10.1093/ageing/afx021

26. Uemura K, Yamada M, Okamoto H. The effectiveness of an active learning program in promoting a healthy lifestyle among older adults with low health literacy: a randomized controlled trial. *Gerontology*. (2021) 67:25–35. doi: 10.1159/000511357

27. Prince MJ, Wu F, Guo Y, Gutierrez Robledo LM, O'Donnell M, Sullivan R, et al. The burden of disease in older people and implications for health policy and practice. *Lancet*. (2015) 385:549–62. doi: 10.1016/S0140-6736(14)61347-7

28. Merck ManualLenartowicz M. (2022). *Overview of prevention in older adults*. Available at: https://www.merckmanuals.com/professional/geriatrics/prevention-of-disease-and-disability-in-older-adults/overview-of-prevention-in-older-adults.

29. Dennison CR, McEntee ML, Samuel L, Johnson BJ, Rotman S, Kielty A, et al. Adequate health literacy is associated with higher heart failure knowledge and self-care confidence in hospitalized patients. *J Cardiovasc Nurs*. (2011) 26:359–67. doi: 10.1097/JCN.0b013e3181f16f88

30. Thorpe JM, Kalinowski CT, Patterson ME, Sleath BL. Psychological distress as a barrier to preventive care in community-dwelling elderly in the United States. *Med Care*. (2006) 44:187–91. doi: 10.1097/01.mlr.0000196965.54871.d5

31. Kim SH, Cho B, Won CW, Hong YH, Son KY. Self-reported health status as a predictor of functional decline in a community-dwelling elderly population: Nationwide longitudinal survey in Korea. *Geriatr Gerontol Int*. (2017) 17:885–92. doi: 10.1111/ggi.12797

32. Cohen-Mansfield J, Jensen B. Adequacy of spouses as informants regarding older persons' self-care practices and their perceived importance. *Fam Syst Health*. (2007) 25:53–67. doi: 10.1037/1091-7527.25.1.53

33. Department of Health. *Supporting people with long term conditions to self care: a guide to developing local strategies and good practice*. [dissertation]. West Yorkshire, Great Britain (2006).

34. Ouchi Y, Rakugi H, Arai H, Akishita M, Ito H, Toba K, et al. Redefining the elderly as aged 75 years and older: proposal from the joint Committee of Japan Gerontological Society and the Japan Geriatrics Society. *Geriatr Gerontol Int*. (2017) 17:1045–7. doi: 10.1111/ggi.13118

35. Laguna N, Andrés Rodríguez-Trelles FD. Participación de las mujeres en los ensayos clínicos según los informes de la Agencia Española de Medicamentos y Productos Sanitarios: 2007. *Rev Esp Salud Publica*. (2008) 82:343–50. doi: 10.1590/S1135-57272008000300010

36. Bom J, Bakx P, Schut F, van Doorslaer E. The impact of informal caregiving for older adults on the health of various types of caregivers: a systematic review. *Gerontologist*. (2019) 59:e629–42. doi: 10.1093/geront/gny137

37. Kitson A, Feo R, Lawless M, Arciuli J, Clark R, Golley R, et al. Towards a unifying caring life-course theory for better self-care and caring solutions: a discussion paper. *J Adv Nurs*. (2022) 78:e6–e20. doi: 10.1111/jan.14887

38. Lewis C, Buffel T. Aging in place and the places of aging: a longitudinal study. *J Aging Stud*. (2020) 54:100870. doi: 10.1016/j.jaging.2020.100870

39. González E, Requena C, Álvarez-Merino P. Single time-point study of the home environment and functionality of older adults in Spain. *Int J Environ Res Public Health*. (2020) 17:8317. doi: 10.3390/ijerph17228317

40. Bandura A. *Self-efficacy: the exercise of control*. New York: W H Freeman/Times Books/Henry Holt & Co (1997).

41. Lee MK, Oh J. Health-related quality of life in older adults: its association with health literacy, self-efficacy, social support, and health-promoting behavior. *Healthcare*. (2020) 8:4. doi: 10.3390/healthcare8040407

42. Callaghan D. Healthy behaviors, self-efficacy, self-care, and basic conditioning factors in older adults. *J Community Health Nurs*. (2005) 22:169–78. doi: 10.1207/s15327655jchn2203_4

43. Hastings EC, West RL. Goal orientation and self-efficacy in relation to memory in adulthood. *Aging Neuropsychol Cognit*. (2011) 18:471–93. doi: 10.1080/13825585.2011.575926

44. Wong KC, Wong FKY, Yeung WF, Chang K. The effect of complex interventions on supporting self-care among community-dwelling older adults: a systematic review and meta-analysis. *Age Ageing*. (2018) 47:185–93. doi: 10.1093/ageing/afx151

frontiers | Frontiers in Public Health

TYPE Review
PUBLISHED 11 October 2023
DOI 10.3389/fpubh.2023.1253267

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Yun Zhang,
Columbia University, United States
Xun Luo,
Kerry Rehabilitation Medicine Research Institute, China

*CORRESPONDENCE
Patricia J. van der Laag
✉ p.j.vanderlaag-3@umcutrecht.nl

RECEIVED 05 July 2023
ACCEPTED 08 September 2023
PUBLISHED 11 October 2023

CITATION
van der Laag PJ, Dorhout BG, Heeren AA, Veenhof C, Barten D-JJA and Schoonhoven L (2023) Barriers and facilitators for implementation of a combined lifestyle intervention in community-dwelling older adults: a scoping review.
Front. Public Health 11:1253267.
doi: 10.3389/fpubh.2023.1253267

COPYRIGHT
© 2023 van der Laag, Dorhout, Heeren, Veenhof, Barten and Schoonhoven. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Barriers and facilitators for implementation of a combined lifestyle intervention in community-dwelling older adults: a scoping review

Patricia J. van der Laag[1]*, Berber G. Dorhout[2,3], Aaron A. Heeren[2], Cindy Veenhof[2,4,5], Di-Janne J. A. Barten[2,4] and Lisette Schoonhoven[1,6]

[1]Julius Center for Health Sciences and Primary Care, Nursing Science, University Medical Center Utrecht, University Utrecht, Utrecht, Netherlands, [2]Research Group Innovation of Human Movement Care, Research Centre for Healthy and Sustainable Living, Utrecht University of Applied Sciences, Utrecht, Netherlands, [3]Division of Human Nutrition and Health, Wageningen University and Research, Wageningen, Netherlands, [4]Department of Rehabilitation, Physical Therapy Science & Sports, University Medical Center Utrecht, Utrecht University, Utrecht, Netherlands, [5]Center for Physical Therapy Research and Innovation in Primary Care, Julius Health Care Centers, Utrecht, Netherlands, [6]Faculty of Health Sciences, University of Southampton, Southampton, United Kingdom

Background: Lifestyle interventions, combining nutrition and exercise, are effective in improving the physical functioning of community-dwelling older adults and preventing healthcare risks due to loss in muscle mass. However, the potential of these types of interventions is not being fully exploited due to insufficient implementation. Having insight into the determinants that could hinder or facilitate the implementation of a combined lifestyle intervention could improve the development of matching implementation strategies and enhance the implementation of such lifestyle interventions. The aim of this study was to identify barriers and facilitators for the successful implementation of a combined lifestyle intervention for community-dwelling older adults.

Method: A scoping review was conducted. A literature search was conducted in four electronic databases, and references were checked for additional inclusion. Studies were screened if they met the inclusion criteria. Barriers and facilitators were extracted from the included studies. To validate the results of the literature search, healthcare professionals and community-dwelling older adults were interviewed. Barriers and facilitators were categorized by two researchers according to the constructs of the Consolidated Framework for Implementation Research (CFIR).

Results: The search identified 12,364 studies, and 23 were found eligible for inclusion in the review. Barriers and facilitators for 26 of the 39 constructs of the CFIR were extracted. The interviews with healthcare professionals and older adults yielded six extra barriers and facilitators for implementation, resulting in determinants for 32 of the 39 CFIR constructs. According to literature and healthcare professionals, cosmopolitanism (network with external organizations), patient needs and resources, readiness for implementation, costs, knowledge and beliefs about the intervention, network and communication, and engaging were found to be the most important determinants for implementation of a combined lifestyle intervention.

Conclusion: A broad range of barriers and facilitators across all domains of the CFIR framework emerged in this study. The results of this review reflect on determinants that should be taken into account when planning for the implementation of a combined lifestyle intervention. A further step in the implementation process is the development of implementation strategies aiming at the identified determinants to enhance the implementation of a combined lifestyle intervention in community care.

KEYWORDS

determinants, community, implementation, lifestyle intervention, older adults

1. Introduction

The world's population is aging rapidly (1). Aging is associated with a decline in muscle mass and strength, which ultimately can lead to a decrease in physical function and quality of life (2–4). Decreased physical functioning is a predictor of disability and loss of independence. Older adults with mobility disabilities are found to have higher rates of hospital admissions, depression, morbidity, and even mortality (5).

Although physical decline is inevitable, a healthy lifestyle is found to delay this age-related deterioration of health. Exercise and physical activity, healthy weight, healthy nutrition, and participation in joyful activities are themes that are included in various guidelines of healthcare associations to encourage a healthy lifestyle in older adults (6, 7). Physical activity is an effective contributor to counteracting physical decline. However, a multifactorial approach combining physical activity with, for example, healthy nutrition, is more effective to obtain and maintain a healthy lifestyle (1). In most cases, attention to such lifestyle aspects is offered in so-called combined lifestyle interventions.

Combined lifestyle interventions targeting multiple aspects of obtaining and maintaining a healthy lifestyle showed promising results in several populations. In addition to widespread positive effects in people with chronic disabilities or illnesses (7–9), effective interventions are described in the general population of older adults in primary care (10, 11). One of these combined lifestyle interventions is ProMuscle. ProMuscle targets community-dwelling older adults (>65 years) and combines resistance exercise training with dietary protein intake (12–14). ProMuscle was found to be effective in improving muscle strength, lean body mass, and physical functioning in community-dwelling older adults (4, 14, 15).

Despite the promising effects of ProMuscle, it is not self-evident that ProMuscle is already widely used in daily practice. Unfortunately, this "evidence to practice gap" is not unique to ProMuscle. It reflects many of the hundreds of evidence-based programs that are thoroughly investigated and found effective every year. Just a small amount, 20% of the evidence-based programs, is actually implemented in daily practice (16), which, among others, results in a waste of research funding (17). Moreover, there is a chance that older adults do not receive new evidence-based care to prevent them from health-related complications, consequently leading to increasing healthcare costs (18). Therefore, successful implementation of evidence-based, combined lifestyle interventions such as ProMuscle is necessary, given the increasing population of older adults (19).

Implementation success is not only enhanced by an effective intervention, but a large number of contextual factors also play an important role in the perceived implementation success. Proctor et al. suggested an equation to model implementation success where it depends on the effectiveness of the treatment and the implementation factors (such as attitudes, behavior, and contextual factors) (20). Therefore, it is important to identify contextual factors so that implementation can be carefully planned, and strategies strategically employed. Moreover, implementation is a complex process (16) and comprises multiple steps to enhance the chance of successful implementation. To deal with this complexity, it is important to use a systematic approach and careful planning of the implementation process (21). Mapping the context in which the innovation is implemented, including identifying barriers and facilitators for implementation, is one essential step in this process.

It is known that a large number of determinants can hinder or facilitate successful implementation and may arise on several levels (21–23). Some studies already identified determinants that could hinder or facilitate the implementation of a combined lifestyle intervention. For example, Belizan et al. (24) identified financial resources, support and acceptance by local authorities and the community, and training as determinants that could influence the implementation of interventions that promote physical activity and a healthy diet. In addition, other studies investigated determinants for the implementation of interventions for people with specific health-related diagnoses (9, 25). However, the implementation of a combined lifestyle intervention for community-dwelling older adults is probably affected by other determinants. To date, no other research identified the determinants that could hinder or facilitate the implementation of a lifestyle intervention combining exercise for community-dwelling older adults.

Therefore, the aim of this study was to identify barriers and facilitators for the successful implementation of a combined lifestyle intervention for community-dwelling older adults in primary care.

2. Methods

A scoping review was conducted according to the framework for scoping reviews described by Arksey & O'Malley and the Joanna

Briggs Institute guidelines (26, 27). The six steps of this framework describe a structured guidance to conduct a scoping review: (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, (5) collecting, summarizing, and reporting the results, and (6) consulting with key stakeholders. The method and analysis of these six steps are described below (26). The Preferred Reporting Items for Systematic Reviews and Meta-analyses Extension for Scoping Review (PRISMA-ScR) (28) was used to guide the reporting of the methodology and results. This study was approved by the Medical Committee University Utrecht (22/050). All participants gave written informed consent.

2.1. Research question

The research question of this scoping review is as follows: Which determinants hinder or facilitate the successful implementation of a combined lifestyle intervention for community-dwelling older adults in primary care?

2.2. Search strategy

A search strategy was designed in consultation with an experienced research librarian at Utrecht University. Four electronic databases with a scope in health(care) were searched: PubMed, Embase, CINAHL, and PsychInfo. In addition, reference lists of the included studies were screened for additional studies. Studies were screened on the following eligibility criteria: (1) Intervention was aimed at community-dwelling older adults (>65 years); (2) studies described a multicomponent intervention that contains at least an exercise component; (3) studies described perceived barriers and/or facilitators for implementation; (4) studies were published in English or Dutch; and (5) full texts were available. Published studies using quantitative, qualitative, or mixed-methods designs were considered eligible, as well as conference abstracts. Studies were excluded if (1) the intervention was delivered exclusively as an e-health or web-based intervention and (2) the intervention was aimed at a specific patient group (e.g., cancer, addiction, and mental health problems). Moreover, case studies and literature reviews were excluded. The extended search strategy for PubMed is presented in Appendix 1.

2.3. Study selection

First, all retrieved publications were uploaded in Rayyan (29) and duplicates were removed. Hereafter, two researchers screened titles and abstracts for eligible studies. Of the studies that were deemed eligible for further inclusion, two researchers (PL and AH) independently assessed the full-text publications to see whether they met the inclusion criteria. Studies that did not meet the criteria were excluded, and the reason for exclusion was listed. In case of disagreement between the two researchers, a discussion took place to reach consensus. If consensus was not reached, a third researcher (DB) was consulted.

2.4. Charting the data

A standardized data extraction form was developed before the data extraction. One researcher extracted data from the included studies. The following data were extracted: Author, country, study design, participants, intervention, and barriers and facilitators for implementation. Two reviewers (PL and AH) discussed the extracted data from all included studies to ensure the reliability of the extraction process.

2.5. Collating, summarizing, and reporting the results

Barriers and facilitators for successful implementation of a combined lifestyle intervention were identified from the results or discussion section of the included studies. Determinants were extracted through thematic analysis and deductively categorized into the constructs of the five main domains of the Consolidated Framework for Implementation Research (CFIR) by two researchers (PL and AH).

The original CFIR was used to categorize the identified barriers and facilitators (23). The CFIR describes implementation determinants from different implementation theories and is composed of five major domains (i.e., intervention characteristics, outer setting, inner setting, characteristics of individuals, and process) that are made up of 39 constructs that influence the implementation of innovations into practice (23). The CFIR domains with their constructs are presented in Appendix 2.

Discrepancies were discussed and, if necessary, consensus about the definitions of the CFIR constructs was reached to categorize identified determinants in the best matching CFIR construct.

2.6. Consultation of key stakeholders

To validate the results of the literature search and to prioritize the relevance of the identified determinants (30), consultation groups with relevant healthcare professionals and interviews with community-dwelling older adults were conducted.

2.6.1. Consultation group with healthcare professionals

Four online consultation groups were conducted with a convenience sample of 13 physical therapists, 3 dieticians, and 2 lifestyle coaches who were interested in implementing the combined lifestyle intervention "ProMuscle." Consultation group participants were recruited in the region of Utrecht and Gelderland (the Netherlands) through local networks and social media. Healthcare professionals were eligible to participate if they had experience in working with older adults (>65 years). A mixed group of healthcare professionals was included in the consultation groups since it was expected to lead to an additional discussion to explore the specific context and to ensure that the results are relevant for daily practice.

The consultation groups were led by an experienced researcher as moderator (BD). A second researcher (AH) observed, took notes, and supported the moderator when necessary.

A semi-structured interview guide was based on the barriers and facilitators identified from the literature and was structured in line with the five domains of the CFIR and corresponding constructs. To ensure a thorough exploration of barriers and facilitators, only two CFIR domains were discussed per consultation group. The CFIR domain "Intervention characteristics" was not discussed in the consultation groups, as participating healthcare professionals were not yet familiar with the combined lifestyle intervention "ProMuscle." Each consultation group started with a short introduction to explain the definition of the CFIR domains and the constructs to be discussed. Participants were first asked to rank the identified determinants of relevance for implementation per domain. Hereafter, a guided discussion took place to operationalize the determinants by providing examples from their daily practice. Finally, participants were asked for missing determinants.

2.6.2. Interviews with community-dwelling older adults

To understand specifically which barriers and facilitators community-dwelling older adults experience when they consider to participate in a combined lifestyle intervention, three older residents, two men, and one woman with a mean age of 70 years, living in Utrecht or Gelderland in the Netherlands were interviewed face-to-face in July 2021. These older residents were recruited by healthcare professionals who participated in the consultation group sessions. A semi-structured interview guide was developed based on the identified barriers and facilitators within the CFIR construct "patient needs."

2.6.3. Data analysis

The consultation groups and interviews were transcribed verbatim. Transcripts were coded following a deductive approach using the Framework method (31). First, two researchers (PL and BD) read the transcripts independently line-by-line to identify emerging concepts and coded the data (32) into the CFIR constructs. Data that did not fit in one of the CFIR constructs were coded as additional codes. The researchers eventually compared the coding and resolved discrepancies through discussion. Nvivo (version 12) was used to analyze transcripts.

3. Results

3.1. Study selection

In total, 12,364 studies were identified in PubMed, Embase, CINAHL, and PsychInfo. After removing duplicates, the title and abstract of 9,379 studies were screened for eligibility. A total of 252 full-text articles were screened for further inclusion. Of the 252 studies, 229 studies were excluded. The main reasons for exclusion were as follows: Participants fell outside the age range of >65 years, implementation was conducted in a population outside the scope of the study, or studies implemented interventions outside the scope of the study, and studies did not assess the implementation of the intervention. No additional studies could be included through citation searching. Ultimately, 23 studies were included in this review (Figure 1).

3.2. Characteristics of the included studies

The characteristics of the 23 included studies are presented in Table 1.

The included studies were published between 2008 and 2021. Seven studies had a qualitative design (18, 35, 38, 42–44, 46), eight a quantitative study design (2, 5, 34, 37, 39, 40, 48, 50), and seven a mixed-methods design (4, 13, 33, 41, 45, 47, 49). One study was a conference abstract (36). Seven studies were conducted in the USA (5, 18, 36, 37, 39, 48, 50), five in Canada (34, 35, 38, 45, 49), two in Taiwan (40, 41), two in Australia (33, 46), two in the Netherlands (4, 13), and one in Finland (42). One multicenter non-randomized study was conducted in Europe (2). One multicenter study was conducted in Canada, UK, and Australia (44). Two studies did not describe the location of their study, the corresponding author of one study was from the USA (47), and for the other study, it was impossible to determine the country in which the study was conducted.

The content of the interventions differed per study. Eight studies evaluated an integrated fall prevention intervention (33–35, 43, 44, 48–50), five studies a nutrition and exercise program (2, 4, 5, 13, 40), four studies evaluated a chronic disease self-management/prevention community-based program (36, 38, 45, 47), one study a successful aging program (41), one study a community-based evidence-based lifestyle program (18), one study a brain training (psycho-education and exercise) (39), one study a health promotion program (37), one study an enhanced primary care program (46), and one study a mental health program (42).

3.3. Barriers and facilitators for the implementation of combined lifestyle interventions in primary care

The studies in this literature review described barriers and facilitators as determinants for the implementation of a combined lifestyle intervention.

In sum, a total of 654 determinants were identified from the literature. The CFIR framework comprises a wide range of contextual factors that could influence implementation. The identified determinants that could influence the implementation of a combined lifestyle intervention for community-dwelling older adults were organized in the constructs of the five CFIR domains. For the 39 constructs of the CFIR framework, determinants influencing the implementation of a combined lifestyle intervention emerged for 32 constructs. An extra six determinants of the CFIR framework were identified from the consultation with healthcare professionals; *tension for change* (implementation climate), *organizational incentives and rewards* (implementation climate), *relative advantage*, *peer pressure*, *self-efficacy*, and *external change agents*. Three determinants emerged from the literature but were not recognized by healthcare

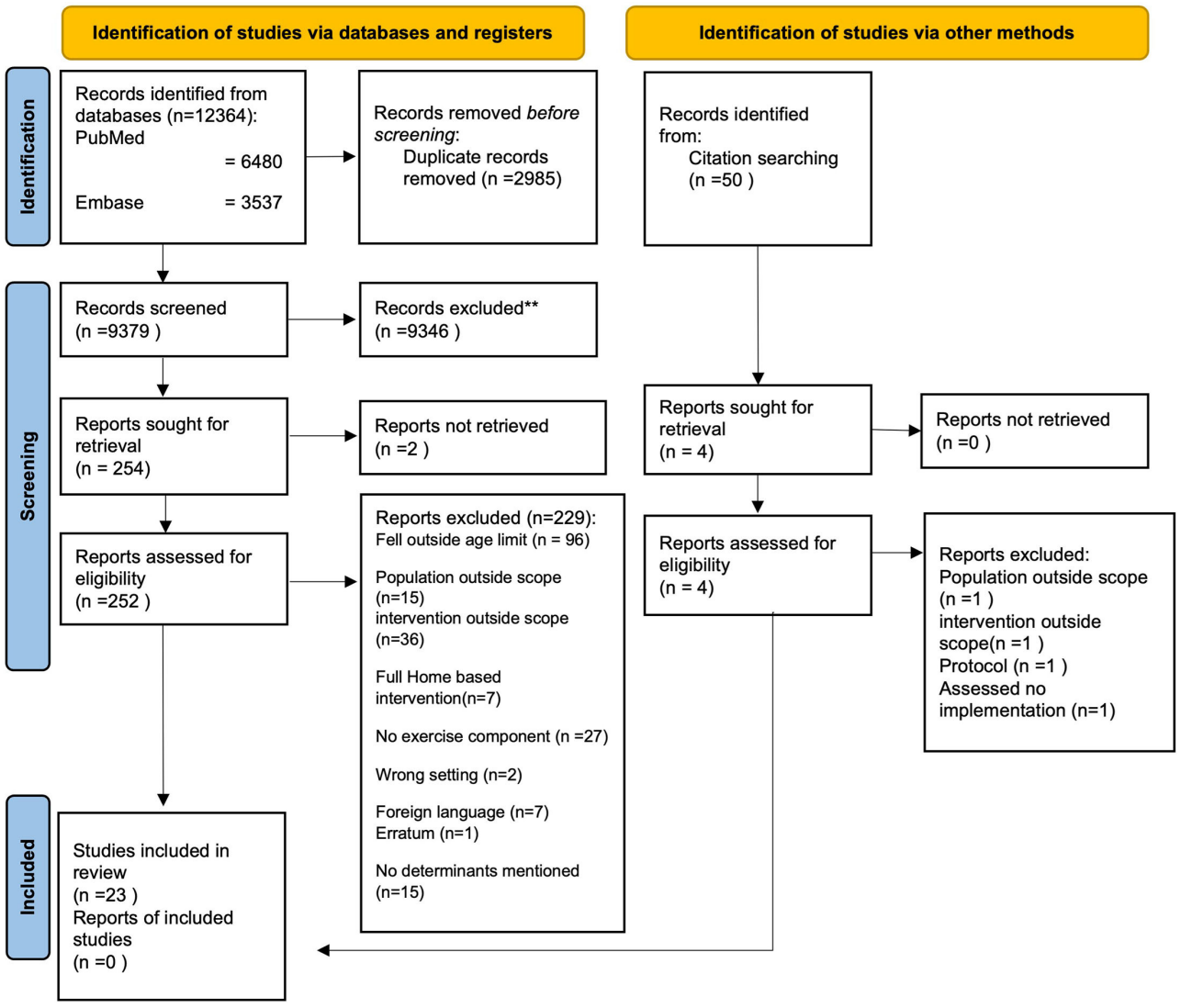


FIGURE 1
PRISMA flowchart. Identification of studies.

professionals (i.e., *Relative priority* (implementation climate), *individual stage of change,* and *reflecting and evaluating*). Determinants that older adults mentioned during the interviews were categorized and described in the domain outer setting (construct *Patients needs & resources*).

Table 2 presents the identified barriers and facilitators from the included studies categorized per CFIR domain and indicates if determinants were mentioned by healthcare professionals including the prioritization during the consultation groups.

For all five CFIR domains, the determinants categorized in the constructs of the CFIR will be described per CFIR domain below.

3.3.1. Intervention characteristics

In the domain intervention characteristics, *costs* and *design quality and packaging* were determinants that were described in most literature. Although not specifically asked during the consultation groups, healthcare professionals suggested that cost could be the most important determinant. In the literature search, 14 studies were included that described *cost* as a determinant for successful implementation, and five studies described *design quality and packaging* as a determinant that could influence the implementation of a combined lifestyle intervention. *Adaptability* and *evidence strength and quality* were identified in seven and six studies, respectively. Other determinants that emerged from the literature search were *relative advantage* and *complexity*. The reason that costs were explicitly mentioned by healthcare professionals is probably because most of the preventive lifestyle interventions are currently not covered by healthcare insurance in the Netherlands. This requires a lot of creativity from healthcare professionals to cover the costs of such an intervention.

TABLE 1 Study characteristics of the included studies.

References	Country	Study design	Participants	Intervention
Ayton et al. (33)	Australia	Mixed methods	Clients of personal alert Victoria	Fall prevention intervention
Banez et al. (34)	Canada	Quantitative non-randomized	Seniors	Fall prevention intervention
Baxter et al. (35)	Canada	Qualitative	Healthcare team members	Fall prevention intervention
Bobitt et al. (18)	USA	Qualitative	Directors of area agencies on aging (AAA) and senior center leader	Community-based EB lifestyle programs
Brown et al. (36)	USA	Qualitative (conference abstract)	Representatives of aging services organizations	Healthy aging and chronic disease prevention and management EBI
Corcoran et al. (5)	USA	Randomized control trial	Facility staff	Exercise and nutritional supplement program
van Dongen et al. (13)	The Netherlands	Mixed methods	Older community living adults and healthcare professionals	Dietary protein and exercise intervention
van Dongen et al. (4)	The Netherlands	Mixed methods	Community-dwelling older adults and healthcare professionals	Intensive support intervention (exercise and dietary protein)
Ford et al. (37)	USA	A cluster-randomized control group design.	Rural county aging unit staff	Implementation strategy for increasing uptake of 2 health promotion programs
Gavarkovs et al. (38)	Canada	Qualitative	Rural program delivery staff	Community-based chronic disease prevention and management program
Horning et al. (39)	USA	Quantitative non-randomized	Community-dwelling older adults	Brain training (psycho-education and exercise)
Hui-Chuan Hsu et al. (40)	Taiwan	Quantitative cohort	Older adults and trainers	Community-based aging intervention (physical activity and nutrition)
Hui-Chuan Hsu et al. (41)	Taiwan	Mixed methods	Unknown	Successful aging program (lecture about successful aging, nutrition, chronic disease, financial security, internet use + physical activity + cognitive function training)
Jyväkorpi et al. (2)	Europe	Quantitative non-randomized	Nutrition interventionists	Physical activity and nutrition intervention
Kulmala et al. (42)	Finland	Qualitative	Healthcare professionals and managers	Mental health intervention
Liddle et al. (43)	Unknown	Qualitative	Allied health professionals	Fall prevention intervention
Mackenzie et al. (44)	Australia, UK, Canada	Qualitative	Health professionals	Fall prevention intervention
Markle-Reid et al. (45)	Canada	Mixed Methods	Providers, peer support volunteers, receivers of diabetes-related services	Community-based program of diabetes self-management
Middlebrook et al. (46)	Australia	Qualitative	Private occupational therapists and physiotherapists	Enhanced primary care program
Paone et al. (47)	Corresponding: USA	Mixed methods	State representatives and organizational representatives	Chronic disease self-management program
Smith et al. (48)	USA	Quantitative	Recipients of funds	Fall prevention intervention
Taing et al. (49)	Canada	Mixed methods	Public health staff and recreation, cultural and facilities service staff, instructors, community-dwelling older adults	Fall prevention intervention
Zachary et al. (50)	USA	Cross-sectional Quantitative	Senior center directors and activities directors	Fall prevention intervention

EB = Evidence-based.

> "I *don't want the implementation to be dependent on money, this happens a lot. Lately I was at a meeting about sports where we design some initiatives. When some ideas emerged, some people yell can we afford that? I believe that a lot of ideas are being excluded because of that, and that is a shame.*"

Moreover, costs affect the possibility to implement a combined lifestyle intervention in healthcare practice in many ways. For example, a program has to be cost-effective to be able to sustain in daily healthcare. Another example healthcare professionals mentioned was that costs can affect the motivation of older adults to engage in a program. On the one hand, if the price is too high

TABLE 2 Barriers and facilitators identified from the included studies and consultation groups with healthcare professionals, categorized per CFIR construct including prioritization from healthcare professionals.

Construct	Sub-component	Barrier/facilitator from literature	References	Emerged from stakeholder consultation?	Ranking of priority by HCP per construct per domain
Intervention characteristics					
Intervention source		No barriers and facilitators		No	Intervention characteristics were not prioritized by HCP
Evidence strength and quality		-		Yes	
		+	(2, 4, 34, 37, 47, 49)		
		+/–			
Relative advantage		No barriers and facilitators		Yes	
Adaptability		-	(18, 36, 42)	Yes	
		+	(2, 4, 46)		
		+/–	(13, 45)		
Trialability		No barriers and facilitators		No	
Complexity		-	(18, 43, 45)	Yes	
		+	(47)		
		+/–			
Design quality and packaging		-	(45, 49)	Yes	
		+	(13, 42)		
		+/–	(4)		
Cost		-	(4, 13, 33, 36, 38, 41, 43, 46, 47, 49)	Yes	
		+	(13, 48)		
		+/–	(18, 40)		
Outer setting					
Patient needs and resources		-	(2, 18, 36, 43, 46, 47)	Yes	1
		+	(38, 45)		
		+/–	(4, 13, 33, 34, 40–42, 44)		
Cosmopolitanism		-	(43, 44)	Yes	2
		+	(4, 13, 18, 40, 42, 47–50)		
		+/–	(46)		
Peer pressure		No barriers and facilitators		Yes	
External policy and incentives		-	(5, 36, 43)	Yes	3
		+	(18, 37, 47–49)		
		+/–	(42)		
Inner setting					
Structural characteristics		-	(5)	Yes	
		+	(48)		

(Continued)

TABLE 2 (Continued)

Construct	Sub-component	Barrier/facilitator from literature	References	Emerged from stakeholder consultation?	Ranking of priority by HCP per construct per domain
		+/–			
Networks and communications		-	(43, 44)	Yes	1
		+	(4, 13, 46, 47)		
		+/–	(35, 49)		
Culture		No barriers and facilitators		No	
Implementation climate		-	(5, 42)	Yes	3
		+	(35)		
		+/–			
	Tension for change	No barriers and facilitators		Yes	
	Compatibility	-	(43)	Yes	
		+	(2, 4, 45, 47)		
		+/–	(13, 18)		
	Relative priority	-	(18, 42, 43)	No	
		+			
		+/–			
	Organizational incentives & rewards	-		No	
		+	(50)		
		+/–			
	Goals and feedback	No barriers and facilitators		No	
	Learning climate	No barriers and facilitators		No	
Readiness for implementation		-	(5)	Yes	2
		+			
		+/–			
	Leadership engagement	-	(50)	Yes	
		+	(47)		
		+/–			
	Available resources	-	(5, 24, 34, 40, 46, 49, 50)	Yes	
		+	(4, 18, 47, 48)		
		+/–	(41, 42, 45)		
	Access to knowledge & information	-	(18)	Yes	
		+	(4, 5, 13, 37, 47)		
		+/–			
Characteristics of individuals					
Knowledge and beliefs about the intervention		-	(5, 18, 42, 50)	Yes	1

(Continued)

10.3389/fpubh.2023.1253267

TABLE 2 (Continued)

Construct	Sub-component	Barrier/facilitator from literature	References	Emerged from stakeholder consultation?	Ranking of priority by HCP per construct per domain
		+	(13, 45)		
		+/–			
Self-efficacy		No barriers and facilitators		Yes	
Individual stage of change		-	(5, 18)	No	
		+	(4, 13)		
		+/–			
Individual identification with organization		No barriers and facilitators		No	
Other personal attributes		-	(35, 40, 46, 47)	Yes	2
		+	(4, 13, 39)		
		+/–	(42, 45)		
Process					
Planning		-		Yes	2
		+	(13)		
		+/–			
Engaging		-	(18)	Yes	1
		+			
		+/–			
	Opinion leaders	-		Yes	
		+	(5)		
		+/–			
	Formally appointed internal implementation leaders	-		Yes	
		+	(42, 50)		
		+/–			
	Champions	-		Yes	
		+	(47)		
		+/–			
	External change agents	No barriers and facilitators		Yes	
	Key stakeholders	-	(34, 36, 46, 47)	No	
		+	(45)		
		+/–			
	Innovation participants	-	(47)	Yes	
		+	(13, 45)		
		+/–	(40)		
Executing		No barriers and facilitators		No	

(Continued)

TABLE 2 (Continued)

Construct	Sub-component	Barrier/facilitator from literature	References	Emerged from stakeholder consultation?	Ranking of priority by HCP per construct per domain
Reflecting & evaluating		-			
		+	(4, 13, 37)	No	
		+/–			

Barriers and facilitators identified from literature are presented as; + = facilitator, − = barrier, +/− = barrier and facilitator.

for something that older adults think they do not need yet, it scares them off. On the other hand, healthcare professionals believe that older adults should pay a small contribution to regain some intrinsic motivation to complete the program.

In addition, healthcare professionals mentioned that people with low socioeconomic status probably benefit most from a lifestyle intervention, but have little to no financial resources to contribute.

> *"I notice that people who are less motivated drop out eventually. So you have to ask yourself, do we need to change everybody? And does everything have to be covered by the healthcare insurance?" "On the other hand, it could be a good thing if the program is covered by the health care insurance or other funding. Because, if you see which group of people have an insufficient intake and are less physically active and have a lot of comorbidities, most of the time they are people with a low social economic status. So yeah."*

In addition, nine included studies described *external policies and incentives* as a determinant for successful implementation. In the consultation groups, healthcare professionals mentioned that a strong collaboration in the community between healthcare professionals and social workers could facilitate the implementation, but also contact with government and healthcare insurers could facilitate the implementation. For example, to explore funding possibilities. However, healthcare professionals also mentioned that it takes a lot of time to make contact, convince the local government about the success of an intervention, and provide the funders with results. The degree of networking also depends on an organization's vision. Some healthcare professionals mentioned that their organization does not prioritize external collaboration.

> *"It is important that healthcare insurers are involved. You always have to prove that the program generates money or that it improves healthcare. But it cannot cost more money. But I believe that you can manage that a little bit, I am convinced of that!"*

3.3.2. Outer setting

In the domain outer setting, the determinants *Cosmopolitanism* (working with external stakeholders) and *patient needs and resources* emerged in most included studies and were ranked as most important determinants by healthcare professionals.

Of the included studies, 16 studies described determinants in the domain outer setting, specifically for the construct "patient needs and resources." Twelve studies described cosmopolitanism as a determinant for successful implementation.

Having the ability to work together with other healthcare professionals outside of the practice is important for the implementation of a combined lifestyle intervention. Moreover, according to the healthcare professionals, the general practitioners can have a major part in referring older adults to the intervention. To make that work, general practitioners should be aware and convinced of the benefits of the intervention.

> *"We work in a health care center. So there are a lot of general practitioners in this building. Here we collaborate a lot and there are many referrals back and forth."*
>
> *"I think there is some kind of hierarchy, older people believe the general practitioner is the boss and take advice from him/her [general practitioner] more seriously. If a nurse practitioner or healthcare professional tells older people that they have discussed it with the general practitioner, they have more influence on peoples' motivation."*

3.3.3. Perspectives of older adults participation in a combined lifestyle intervention

Community-dwelling older adults gave insight into reasons why they would or would not participate in a combined lifestyle intervention. Emerging determinants were categorized in the construct *patient needs and resources.* Most of the barriers and facilitators addressed by community-dwelling older adults are related to the motivation to participate in a lifestyle program. The content of the intervention is a major reason to participate in a program. Older adults mentioned that the social aspect of a program is a facilitator to participate, but that strict rules are a barrier to participate.

> *"It is certainly fun. All are people who have similar difficulties."*
>
> *"If there are too many rules, in short, never mind…For example, if I receive a scheme what says when I have to eat what, it's just going too far."*

Moreover, older people admitted that it is hard to see the benefits of consultations concerning protein-enriched nutrition. In contrast, seeing results and feeling you get healthier is important to people when it comes to the intervention.

> *"I am a bit skeptical about the protein intake. I think it is a bit theoretical. Today you read in the newspaper about protein, the next day about carbs. And the next day, who knows, about something else. It is conflicting, in my opinion. Then I think, just let me do it my way…"*
>
> *"One of the best parts was a rowing machine, where you saw the seconds counting down. And then, yeah, you can see what you are doing."*

Older adults also indicated how much they were willing to pay for the program and how long they wanted to travel. Based on their indications, the mean amount of the costs for the intervention was approximately 50 euros per month. Travel time varied from 10 min by bike to 40 kilometers by car.

Finally, older adults indicated that ways to stimulate and involve people in the program were via email, advertising in a local newspaper, and community centers. A flyer could also work; however, it was mentioned that a flyer needs to be compact and attractive to the eye. In addition, older adults mentioned that the physical therapist or nurse practitioner could also refer people to the program.

> *"Actually you have to see what it [the intervention] is about in a glimpse."*

3.3.4. Inner setting

From the literature search, *readiness for implementation (n = 15)* and *network and communication* ($n = 8$) emerged in most included studies and were ranked to be the most important determinants by healthcare professionals within the domain inner setting. Available resources, a sub-construct of *readiness for implementation*, emerged in most included studies. Having access to knowledge and information, being provided by the organization, and having the available resources to implement a new intervention, for example, time, were facilitators for the implementation according to healthcare professionals. Moreover, having sufficient support within the organization is mentioned as an important determinant for successful implementation. The healthcare professionals indicated that prevention in healthcare for older adults is very important. However, some healthcare professionals doubt if prevention is one of the priorities of their organization, which could affect a successful implementation.

> *"If there is insufficient support, you can do whatever you want, but it is flogging a dead horse."*

Other determinants that emerged from the included studies were *implementation climate*, *leadership engagement*, *structural characteristics*, and *access to knowledge and information*.

3.3.5. Characteristics of individuals

Constructs that emerged in most literature and during the consultation groups, in the domain characteristics of individuals, were *knowledge and beliefs about the intervention* and *other personal attributes*. A total of six studies described *knowledge and beliefs about the intervention* as a determinant for successful implementation, and nine studies described *other personal attributes* as a determinant. Healthcare professionals mentioned being enthusiastic, having the motivation to implement a new intervention, and type of employment were important personal attributes for a successful implementation.

> *"The intention of a healthcare professional is important; you don't want to see it as a business model, but you have to believe in the importance of preventive care."*

Knowledge and beliefs about the intervention was ranked as the most important determinant for implementation by healthcare professionals. Healthcare professionals mentioned that belief in the intervention is important to gain support within and outside the organization. To be able to inspire colleagues and to motivate older adults to start and complete the program are also important for healthcare professionals to believe in the intervention.

Besides having the knowledge and beliefs, healthcare professionals stated that people also have to show initiative in trying to implement the intervention. Other healthcare professionals added that having sufficient support from their organization remains necessary.

> *"When you are an owner of a practice it is easier to convince people of your new idea."*
>
> *"You have to address it positive, not being too persistent just be super enthusiast. Taking initiative to join forces, you don't have to do it alone."*

Four studies described *individual stage of change* as a determinant for successful implementation, but this determinant was not mentioned by healthcare professionals.

3.3.6. Process

The determinant *engaging* within the domain process emerged most frequently in the literature as well as during the consultation group with healthcare professionals. To successfully implement a combined lifestyle intervention, having people who can motivate and stimulate people to change their work process is important. However, being able as a healthcare professional to attract and attach older adults to participate in the program is also important.

The construct *formally appointed internal implementation leaders*, a sub-construct of the construct *engaging*, was ranked as the most important determinant for implementation within the domain process by healthcare professionals.

To engage older adults in the intervention, multiple facilitators and barriers were discussed by healthcare professionals. As mentioned earlier, people have to be aware of the usefulness of the intervention, but professionals should also pay attention to the needs of older adults. Healthcare professionals believe that people should be informed about the importance of the program by healthcare professionals and general practitioners.

To recruit people for participation in a combined lifestyle intervention, multiple sources can be used, such as flyers, word of mouth, and advertising in local newspapers.

In addition, to keep older adults motivated, healthcare professionals should set up the intervention in a creative and patient-centered manner.

> *"I think I stimulate and motivate older people verbally as well as during the therapy sessions. In that way, you make the therapy challenging for them and, yeah, include a bit of creativity."*

In addition to the construct *engaging*, no other determinants emerged from consultation with healthcare professionals. *Planning* and *executing* were determinants described by one and three studies, respectively.

In Figure 2, the determinants for the implementation of a combined lifestyle intervention from the literature and confirmed and prioritized by key stakeholders are visualized. All identified determinants clustered per CFIR domain are presented. The size of each box gives an indication of the frequency of emergence in literature in combination with the relevance according to stakeholders of each CFIR construct. For the domains intervention characteristics, outer setting, inner setting, characteristics of individuals, and process, the most frequently emerged constructs were *costs, cosmopolitanism, readiness for implementation, knowledge and beliefs about the intervention,* and *engaging,* respectively.

4. Discussion

This scoping review identified 654 different barriers and facilitators for the implementation of a combined lifestyle intervention for community-dwelling older adults.

The identified barriers and facilitators cover a broad range of determinants across all domains of the CFIR framework. The five constructs that most frequently emerged from literature and were confirmed by healthcare professionals are *cosmopolitanism* (network with external stakeholders, outer setting), *patient needs & resources* (outer setting), *readiness for implementation* (inner setting), *costs* (innovation characteristics), and *knowledge & beliefs about the intervention* (characteristics of individuals). In addition to the five most frequently emerged constructs, healthcare professionals ranked *network & communication* (inner setting) and *engaging* (process) to be the most relevant determinants for implementation. The determinants indicated by community-dwelling older adults mostly fit in the construct *patient needs and recourses*, whereas costs of the intervention was categorized in the construct *costs* (intervention characteristics). Older adults indicated that engaging and motivating, costs, and transportation to the intervention are determinants that could influence whether they participate in a combined lifestyle intervention or not.

Most identified determinants were categorized in the CFIR domain "outer setting." This can be explained by the multicomponent character of the intervention. With a combined lifestyle intervention in older adults, multiple healthcare professionals are involved in the execution of the intervention. In general, few healthcare professionals work directly together and do not always have a constructive collaboration in the delivery of healthcare. Therefore, first, it is important to develop a collaboration between healthcare professionals to deliver the intervention correctly (51). In addition, to refer community-dwelling older adults to a combined lifestyle intervention, the general practitioner has a major role (9). Healthcare professionals mentioned that older adults would rather follow advice from a general practitioner than from family or a physical therapist. This is comparable with the study by Geense et al. (52), where it is suggested to let general practitioners ask older adults to participate in a lifestyle intervention because of the natural authority (52). However, other studies describe that GPs often do not have sufficient time to inform older adults properly. Moreover, without proper information, the quality of the advice can be affected (9). Similar to the study of Molema et al. (9), healthcare professionals in this review stated that not all general practitioners have a positive attitude toward lifestyle interventions. Therefore, a constructive collaboration with a general practitioner is necessary not only to refer eligible participants but also to inform and convince general practitioners about the benefits of the program so they can correctly pass the information to older adults.

Furthermore, the costs of the intervention emerged as an important determinant for implementation from the majority of the included studies and from the interviews with healthcare professionals and community-dwelling older adults. Not all lifestyle interventions, especially preventive lifestyle interventions, are structurally reimbursed by healthcare insurance in the Netherlands. This means that participants need to (partly) contribute to participate in the intervention. However, only a small percentage of older adults are willing to contribute every month to preventive healthcare. Moreover, not all older adults have the resources to pay for a lifestyle intervention. As a result, the majority of older adults will not benefit from proper preventive care, which ultimately can result in an increased risk of loss of independence and other healthcare-related risks (18). Consequently, the health differences will be preserved and probably increase. Finally, because of the temporality of most reimbursements and lack of structural funding, there is a great chance that a lifestyle intervention stops when funding ends (9).

Overall, the results of this study are in line with the small number of existing reviews reporting barriers and facilitators for combined lifestyle interventions. Belizan et al. (24) found that limited financial resources, lack of support and acceptance by the community, and lack of training were barriers to the implementation of health promotion interventions. In contrast, interventions with sufficient financial resources and support from local authorities and community members had more chance for successful implementation and sustainment of initiatives. This suggests, as also mentioned by the healthcare professionals in the current study, that it is important to have a constructive collaboration in the community with different partners to, for example, explore reimbursement possibilities for the intervention and the implementation process. In addition, studies that evaluated the implementation of combined lifestyle interventions for specific patient groups reported similar results as this study. For example, non-optimal interdisciplinary collaboration, negative attitudes toward the intervention, low literacy of patients, and lack of knowledge from HCP were barriers to the implementation of

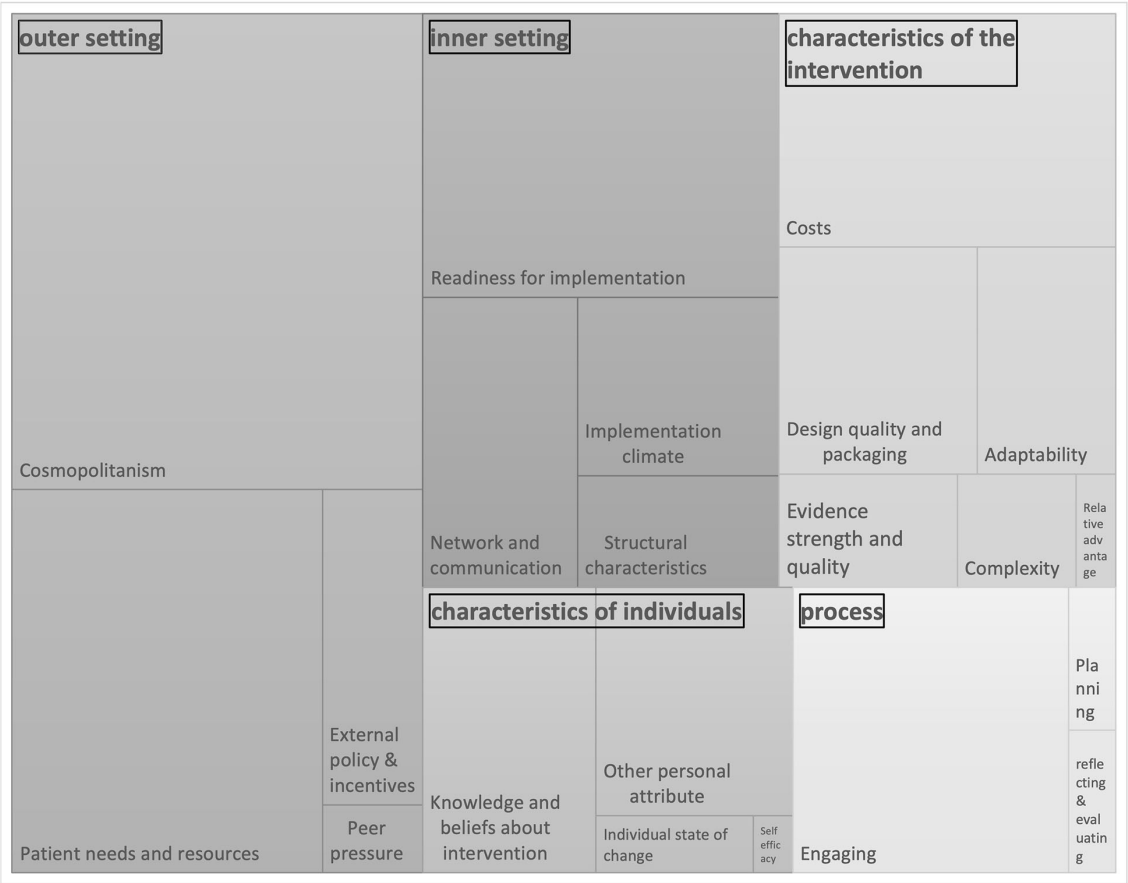


FIGURE 2
Barriers and facilitator for implementing a combined lifestyle intervention. Identified from literature and consultationgroups. The size of the box depends on the frequency of emergence of each CFIR construct.

a combined lifestyle intervention for people with osteoarthritis (25). Moreover, structural funding, good infrastructure, and communication with stakeholders and motivated healthcare professionals were facilitators for the implementation of a combined lifestyle intervention for chronically ill people (9). Lack of time and costs were described as barriers. These barriers and facilitators could be categorized in the most frequently emerged CFIR constructs in this review: *cosmopolitanism*, *knowledge and beliefs about the intervention, patient needs and resources,* and *costs*. The similarities with the results of this review and other research suggest that the identified determinants in this scoping review are applicable for the implementation of an exercise and nutrition intervention such as ProMuscle as well as for other combined lifestyle interventions for older adults in general.

4.1. Strengths and limitations

A strength of this study was that it provides a first overview of the most common determinants in the great pile of possible contextual factors that could influence the implementation of a combined lifestyle intervention. Because of the qualitative explorative design, the validation of the results from the literature by stakeholders strengthens the findings of this study and ensures that the identified determinants influencing implementation fit the context in which the combined lifestyle intervention will be implemented. Another strength of this scoping review is that framework analysis was used to code the data, and three researchers analyzed it to prevent tunnel vision and to prevent new determinants from not being identified. This is amplified by the six extra constructs that were identified from the consultation group with stakeholders. The opposite was true for the determinants *relative priority*, *individual stage of change,* and *reflecting and evaluating*. These determinants were found in the literature but were not mentioned by healthcare professionals. Therefore, the question arises why six extra determinants yielded from the consultation group and another three determinants were not mentioned by healthcare professionals. An explanation could be that some determinants were not coded as the included studies intended. Moreover, in this research, the healthcare professionals were unfamiliar with the intervention and had no experience in implementing a combined lifestyle intervention. This is in contrast with the included studies, where a process evaluation was performed after the implementation of an intervention.

Because healthcare professionals were not experienced in the implementation of a combined lifestyle intervention, they were not questioned about the barriers and facilitators within the domain intervention characteristics. However, some of the identified determinants eventually could be categorized in the domain intervention characteristics as well. Most determinants reflected the general specifications of a combined lifestyle intervention, such as the costs of a preventive intervention (which is almost never reimbursed by healthcare insurance or local government in the Netherlands) or concerning the content of an intervention.

Although this review gives a first overview of determinants that could influence implementation, it was not possible to assess the weight of influence each determinant had on the implementation. This can be seen as a limitation of this study. However, this overview provides guidance in planning for implementation and development of implementation strategies. Another limitation of this study was that articles were excluded that did not describe barriers and facilitators for implementation in their abstracts. Many studies reflect on determinants that influenced the implementation of a combined lifestyle intervention during the trial. However, because the identification of barriers and facilitators is often not the aim of the studies, determinants are often not described in the abstract but mostly are mentioned in the discussion. This could have resulted in the exclusion of studies that did describe determinants for implementation. Despite the possibility that some studies were not included in the analysis, the results from this review correspond to other studies investigating barriers and facilitators for implementation. Therefore, we conclude that the results of this scoping review reflect the contexts where combined lifestyle interventions are implemented.

Finally, a limitation of this study was that only three older adults were interviewed to validate and identify determinants for participation in a combined lifestyle intervention. No distinct saturation was reached; however, most determinants were mentioned by all three older adults. In addition, five of the included studies described determinants from the recipients' perspective. The emerged determinants of this study could, except for one, be categorized in the construct *patient needs*. Furthermore, the identified determinants within the construct *Patient needs and resources* are similar to the results of other studies. For example, Herrema et al. (53) explored the drivers of compliance of older adults to a nutrition and exercise intervention. Support of a physical therapist, social contact, and knowledge about the benefits of the program motivated older adults to continue the program. At last, barriers were the high costs and the lack of an appropriate location. Location is not specifically mentioned by older adults in this scoping review. However, older adults mentioned that the transportation and the content of the intervention must be appealing to start with a lifestyle intervention. Therefore, the results of this scoping review concerning the construct *patient needs and resources* seem to provide an accurate impression of determinants to participate in a combined lifestyle intervention. Healthcare professionals and researchers can take these determinants into account when planning for the development and implementation of a combined lifestyle intervention.

The results of this review indicate that there are multiple determinants that could influence the implementation of a combined lifestyle intervention for older adults. As described in several implementation theories, the determinants found in this review also reflect on multiple levels in the setting where an intervention is implemented (21, 54). Moreover, it is expected that the influencing determinants for implementation are not similar for every setting (55). This review gives an overview of the most common determinants that could influence the implementation of a combined lifestyle intervention for community-dwelling older adults. When planning for the implementation of a combined lifestyle intervention, it is suggested to prioritize the determinants for the specific context to develop appropriate implementation strategies. In addition, the development of implementation strategies to enhance the implementation should focus on different levels and be evaluated to investigate whether strategies were suitable and effective to tackle the identified barriers for the implementation of a combined lifestyle intervention (56).

4.2. Conclusion

This scoping review identified 654 barriers and facilitators for the implementation of a combined lifestyle intervention for community-dwelling older adults. The barriers and facilitators are categorized into the five domains of the CFIR framework. The most frequently emerged determinants influencing implementation are as follows: *cosmopolitanism* (networking with external stakeholders, outer setting), *patient needs and resources* (outer setting), *readiness for implementation* (inner setting), *costs* (innovation characteristics), and *knowledge and beliefs about the intervention* (characteristics of individuals). A further step in the implementation process is the development of implementation strategies aiming at the identified determinants to enhance the implementation of a combined lifestyle intervention in primary care.

Author contributions

BD, AH, and PL collected and analyzed the data from interviews with relevant stakeholders. AH, D-JB, and PL screened included articles for the study. AH and PL analyzed the data from the included studies. PL conducted the literature search, analyzed the qualitative and quantitative data, and wrote the manuscript. BD, AH, D-JB, CV, and LS provided feedback and input for the analysis of the data and critically read and provided feedback for the manuscript. All authors have read and approved the manuscript for submission.

Funding

The research described in this article was financially supported by a grant from the Regio Deal Foodvalley (162135).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships

that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1253267/full#supplementary-material

References

1. WHO europe. WHO healthy aging. Available online at: https://www.euro.who.int/en/health-topics/Life-stages/healthy-ageing (accessed January 17, 2022).

2. Jyväkorpi SK, Ramel A, Strandberg TE, Piotrowicz K, Błaszczyk-Bebenek E, Urtamo A, et al. The sarcopenia and physical frailty in older people: multi-component treatment strategies (SPRINTT) project: description and feasibility of a nutrition intervention in community-dwelling older Europeans. *Eur Geriatr Med.* (2021) 12:303–12. doi: 10.1007/s41999-020-00438-4

3. van der Laag PJ, Arends SAM, Bosma MS, van den Hoogen A. Factors associated with successful rehabilitation in older adults: A systematic review and best evidence synthesis. *Geriatr Nurs.* (2021) 42:83–93. doi: 10.1016/j.gerinurse.2020.11.010

4. Van Dongen EJI, Doets EL, De Groot LCPGM, Dorhout BG, Haveman-Nies A. Process evaluation of a combined lifestyle intervention for community-dwelling older adults: promuscle in practice. *Gerontologist.* (2020) 60:1538–54. doi: 10.1093/geront/gnaa027

5. Corcoran MP, Nelson ME, Sacheck JM, Reid KF, Kirn D, Fielding RA, et al. Efficacy of an exercise and nutritional supplement program on physical performance and nutritional status in older adults with mobility limitations residing at senior living facilities. *J Aging Phys Act.* (2017) 25:453–63. doi: 10.1123/japa.2016-0173

6. National institute of aging. *What Do We Know About Healthy Aging*? (2018). Available online at: https://www.nia.nih.gov/health/what-do-we-know-about-healthy-aging (accessed January 17, 2022).

7. Sharda N, Wong S, White H. The Role of Prevention in Healthy Aging. *Clin Geriatr Med.* (2020) 36:697–711. doi: 10.1016/j.cger.2020.06.011

8. Burgess E, Hassmén P, Pumpa KL. Determinants of adherence to lifestyle intervention in adults with obesity: a systematic review. *Clin Obes.* (2017) 7:123–35. doi: 10.1111/cob.12183

9. Molema CCM, Wendel-Vos GCW, Ter Schegget S, Schuit AJ, Van De Goor LAM. Perceived barriers and facilitators of the implementation of a combined lifestyle intervention with a financial incentive for chronically ill patients. *BMC Fam Pract.* (2019) 20:1–11. doi: 10.1186/s12875-019-1025-5

10. Ory MG, Lee S, Han G, Towne SD, Quinn C, Neher T, et al. Effectiveness of a lifestyle intervention on social support, self-efficacy, and physical activity among older adults: Evaluation of Texercise select. *Int J Environ Res Public Health.* (2018) 15:234. doi: 10.3390/ijerph15020234

11. Rubio-Valera M, Pons-Vigués M, Martínez-Andrés M, Moreno-Peral P, Berenguera A, Fernández A. Barriers and facilitators for the implementation of primary prevention and health promotion activities in primary care: A synthesis through meta-ethnography. *PLoS ONE.* (2014) 9:e89554. doi: 10.1371/journal.pone.0089554

12. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LCPGM, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. *J Am Med Dir Assoc.* (2012) 13:713–9. doi: 10.1016/j.jamda.2012.05.020

13. Van Dongen EJ, Leerlooijer JN, Steijns JM, Tieland M, De Groot LC, Haveman-Nies A. Translation of a tailored nutrition and resistance exercise intervention for elderly people to a real-life setting: adaptation process and pilot study. *BMC Geriatr.* (2017) 17:1–15. doi: 10.1186/s12877-017-0413-8

14. van Dongen EJI, Haveman-Nies A, Doets EL, Dorhout BG, de Groot LCPGM. Effectiveness of a diet and resistance exercise intervention on muscle health in older adults: ProMuscle in practice. *J Am Med Dir Assoc.* (2020) 21:1065–1072.e3. doi: 10.1016/j.jamda.2019.11.026

15. Dorhout BG, de Groot LCPGM, van Dongen EJI, Doets EL, Haveman-Nies A. Effects and contextual factors of a diet and resistance exercise intervention vary across settings: an overview of three successive ProMuscle interventions. *BMC Geriatr.* (2022) 22:1–15. doi: 10.1186/s12877-021-02733-6

16. McKay H, Naylor PJ, Lau E, Gray SM, Wolfenden L, Milat A, et al. Implementation and scale-up of physical activity and behavioural nutrition interventions: An evaluation roadmap. *Int J Behav Nutr Phys Activ.* (2019) 16:104. doi: 10.1186/s12966-019-0868-4

17. Czosnek L, Rankin N, Zopf E, Richards J, Rosenbaum S, Cormie P. Implementing Exercise in Healthcare Settings: The Potential of Implementation Science. *Sports Med.* (2020) 50:1–14. doi: 10.1007/s40279-019-01228-0

18. Bobitt J, Schwingel A. Evidence-based programs for older adults: a disconnect between U. S national strategy and local senior center implementation. *J Aging Soc Policy.* (2017) 29:3–19. doi: 10.1080/08959420.2016.1186465

19. Bajraktari S, Sandlund M, Zingmark M. Health-promoting and preventive interventions for community-dwelling older people published from inception to 2019: a scoping review to guide decision making in a Swedish municipality context. *Arch Public Health.* (2020) 78:97. doi: 10.1186/s13690-020-00480-5

20. Proctor E, Silmere H, Raghavan R, Hovmand P, Aarons G, Bunger A, et al. Outcomes for implementation research: Conceptual distinctions, measurement challenges, and research agenda. Admin Policy Mental Health. *Mental Health Serv Res.* (2011) 38:65–76. doi: 10.1007/s10488-010-0319-7

21. Grol R, Wensing M, Eccles M, Davis D. *Improving Patient Care : The Implementation of Change in Health Care*. London: John Wiley & Sons, Ltd. 374 p.

22. Chaudoir SR, Dugan AG, Hi Barr C. Measuring factors affecting implementation of health innovations: a systematic review of structural, organizational, provider, patient, and innovation level measures. *Implement Sci.* (2013) 8:22. doi: 10.1186/1748-5908-8-22

23. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implement Sci.* (2009) 4:50. doi: 10.1186/1748-5908-4-50

24. Belizan M, Martin Chaparro R, Santero M, Elorriaga N, Kartschmit N, Rubinstein AL, et al. Barriers and facilitators for the implementation and evaluation of community-based interventions to promote physical activity and healthy diet: A mixed methods study in Argentina. *Int J Environ Res Public Health.* (2019) 16:213. doi: 10.3390/ijerph16020213

25. Bouma SE, Van Beek JFE, Diercks RL, Van Der Woude LHV, Stevens M, Van Den Akker-Scheek I. Barriers and facilitators perceived by healthcare professionals for implementing lifestyle interventions in patients with osteoarthritis: A scoping review. *BMJ Open.* (2022) 12:e056831. doi: 10.1136/bmjopen-2021-056831

26. Aromataris E, Munn Z. *JBI Manual for Evidence Synthesis. JBI.* (2020). doi: 10.46658/JBIMES-20-01

27. Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. *Implement Sci.* (2010) 5:1–9. doi: 10.1186/1748-5908-5-69

28. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Ann Intern Med.* (2018) 169:467–73. doi: 10.7326/M18-0850

29. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev.* (2016) 5:210. doi: 10.1186/s13643-016-0384-4

30. Peters MDJ, Marnie C, Colquhoun H, Garritty CM, Hempel S, Horsley T, et al. Scoping reviews: reinforcing and advancing the methodology and application. *Syst Rev.* (2021) 10:1–6. doi: 10.1186/s13643-021-01821-3

31. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol.* (2013) 7:260–1. doi: 10.1186/1471-2288-13-117

32. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res.* (2005) 15:1277–88. doi: 10.1177/1049732305276687

33. Ayton D, Morello R, Natora A, Yallop S, Barker A, Soh SE. Perceptions of falls and falls prevention interventions among Personal Alert Victoria clients. *Health Soc Care Community*. (2018) 26:970–8. doi: 10.1111/hsc.12626

34. Banez C, Tully S, Amaral L, Kwan D, Kung A, Mak K, et al. Development, implementation, and evaluation of an interprofessional falls prevention program for older adults. *J Am Geriatr Soc.* (2008) 56:1549–55. doi: 10.1111/j.1532-5415.2008.01790.x

35. Baxter P, Markle-Reid M. An interprofessional team approach to fall prevention for older home care clients "at risk" of falling: health care providers share their experiences. *Int J Integr Care.* (2009) 9:e15. doi: 10.5334/ijic.317

36. Brown A, Ward K, Kyo T, Ramirez K, Phan Vo L, Vassar S, et al. The use of evidence-based pro-grams for older adults in under-resourced communi-ties in Los Angeles county. In: *Annual Research Meeting The premier forum for health services research*. Boston (2016). Available online at: https://academyhealth.confex.com/academyhealth/2016arm/meetingapp.cgi/Paper/11409 (accessed May 15, 2023).

37. Ford JH, Abramson B, Wise M, Dattalo M, Mahoney JE. Bringing healthy aging to scale: a randomized trial of a quality improvement intervention to increase adoption of evidence-based health promotion programs by community partners. *J Public Health Manag Pract.* (2017) 23:e17–24. doi: 10.1097/PHH.0000000000000503

38. Gavarkovs AG, Burke SM, Reilly KC, Petrella RJ. Barriers to recruiting men into chronic disease prevention and management programs in rural areas: Perspectives of program delivery staff. *Am J Mens Health.* (2016) 10:N155–7. doi: 10.1177/1557988315596226

39. Horning SM, Young S, Myhre JW, Osato S, Wilkins SS, A. multimodal cognitive enhancement program for older adults: a case report of the implementation of brain training. *Act Adapt Aging.* (2016) 40:320–38. doi: 10.1080/01924788.2016.1231487

40. Hsu HC, Wang CH, Chen YC, Chang MC, Wang J. Evaluation of a community-based aging intervention program. *Educ Gerontol.* (2010) 36:547–72. doi: 10.1080/03601270903237713

41. Hsu HC, Kuo T, Lin JP, Hsu WC, Yu CW, Chen YC, et al. A cross-disciplinary successful aging intervention and evaluation: Comparison of person-to-person and digital-assisted approaches. *Int J Environ Res Public Health*. (2018) 15:913. doi: 10.3390/ijerph15050913

42. Kulmala J, Rosenberg A, Ngandu T, Hemiö K, Tenkula T, Hyytiä A, et al. Facilitators and barriers to implementing lifestyle intervention programme to prevent cognitive decline. *Eur J Public Health.* (2021) 31:816–22. doi: 10.1093/eurpub/ckab087

43. Liddle J, Lovarini M, Clemson L, Mackenzie L, Tan A, Pit SW, et al. Making fall prevention routine in primary care practice: Perspectives of allied health professionals. *BMC Health Serv Res.* (2018) 18:598. doi: 10.1186/s12913-018-3414-1

44. MacKenzie L. Perceptions of health professionals about effective practice in falls prevention. *Disabil Rehabil.* (2009) 31:2005–12. doi: 10.3109/09638280902874121

45. Markle-Reid M, Ploeg J, Fisher K, Reimer H, Kaasalainen S, Gafni A, et al. The aging, community and health research unit-community partnership program for older adults with type 2 diabetes and multiple chronic conditions: a feasibility study. *Pilot Feasibility Stud.* (2016) 2:24. doi: 10.1186/s40814-016-0063-1

46. Middlebrook S, Mackenzie L. The Enhanced Primary Care program and falls prevention: Perceptions of private occupational therapists and physiotherapists. *Australas J Ageing.* (2012) 31:72–7. doi: 10.1111/j.1741-6612.2011.00527.x

47. Paone D. Factors supporting implementation among CDSMP organizations. *Front Public Health.* (2015) 2:237. doi: 10.3389/fpubh.2014.00237

48. Smith ML, Durrett NK, Schneider EC, Byers IN, Shubert TE, Wilson AD, et al. Examination of sustainability indicators for fall prevention strategies in three states. *Eval Program Plann.* (2018) 68:194–201. doi: 10.1016/j.evalprogplan.2018.02.001

49. Taing D, McKay K. Better strength, better balance! partnering to deliver a fall prevention program for older adults. *Canadian J Public Health.* (2017) 108:e314–9. doi: 10.17269/CJPH.108.5901

50. Zachary C, Casteel C, Nocera M, Runyan CW. Barriers to senior centre implementation of falls prevention programmes. *Injury Prevention.* (2012) 18:272–6. doi: 10.1136/injuryprev-2011-040204

51. Jenkins GJ, Cooper BR, Funaiole A, Hill LG. Which aspects of coalition functioning are key at different stages of coalition development? A qualitative comparative analysis. *Implement Res Pract.* (2022) 3:263348952211126. doi: 10.1177/26334895221112694

52. Geense WW, Van De Glind IM, Visscher TLS, Van Achterberg T. Barriers, facilitators and attitudes influencing health promotion activities in general practice: An explorative pilot study. *BMC Fam Pract.* (2013) 14:20. doi: 10.1186/1471-2296-14-20

53. Herrema AL, Westerman MJ, Dongen EVJI, Kudla U, Veltkamp M. Combined protein-rich diet with resistance exercise intervention to counteract sarcopenia: a qualitative study on drivers and barriers of compliance. *J Aging Phys Act.* (2018) 26:106–13. doi: 10.1123/japa.2017-0126

54. Nilsen P. Making sense of implementation theories, models and frameworks. *Implement Sci.* (2015) 10:53. doi: 10.1186/s13012-015-0242-0

55. Nilsen P, Bernhardsson S. Context matters in implementation science: A scoping review of determinant frameworks that describe contextual determinants for implementation outcomes. *BMC Health Serv Res.* (2019) 19:189. doi: 10.1186/s12913-019-4015-3

56. Waltz TJ, Powell BJ, Fernández ME, Abadie B, Damschroder LJ. Choosing implementation strategies to address contextual barriers: Diversity in recommendations and future directions. *Implement Sci.* (2019) 14:42. doi: 10.1186/s13012-019-0892-4

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 24 October 2023
DOI 10.3389/fpubh.2023.1257961

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Kenju Shimomura,
Fukushima Medical University, Japan
Sylvia Mwanza Kabaghe,
University of Zambia, Zambia

*CORRESPONDENCE
Paolo Miguel Manalang Vicerra
✉ paolo_vicerra@shu.edu.cn

RECEIVED 13 July 2023
ACCEPTED 09 October 2023
PUBLISHED 24 October 2023

CITATION
Vicerra PMM (2023) Variations in cognition by human capital characteristics: a cross-sectional analysis of Brazilian older adults.
Front. Public Health 11:1257961.
doi: 10.3389/fpubh.2023.1257961

COPYRIGHT
© 2023 Vicerra. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Variations in cognition by human capital characteristics: a cross-sectional analysis of Brazilian older adults

Paolo Miguel Manalang Vicerra*

Asian Demographic Research Institute, Shanghai University, Shanghai, China

Introduction: The productivity of individuals is assumed to decline upon reaching old age when cognitive ability is considered. This assumption is false, especially if the human development characteristics of people are analyzed, which highlights the need to recognize the heterogeneity among subpopulations.

Methods: Using Wave two of the Brazilian Longitudinal Study on Aging, conducted from 2019 to 2021, this study explored the onset and speed of cognitive aging among older individuals aged at least 60 in Brazil, with reference to their education and income levels.

Results: It was observed that although higher human capital characteristics yielded results toward later cognitive decline, women benefited more from having higher educational attainment levels. Such a pattern was similar among men and increased income levels. Disparities in cognitive performance, whether from education or income, were greatest at age 60, and this advantage diminished as age progressed.

Conclusion: Viewing the older population as homogeneous in terms of health function is restrictive. It should be recognized that variations in social status affect individuals' health status into old age and therefore their respective potential for productivity should be maximized.

KEYWORDS

health disparity, socioeconomic characteristics, population heterogeneity, cognitive performance, social determinants of health

1. Introduction

Improvements in social conditions, better living environments, and advances in medical science have resulted in increased life expectancies across countries (1). In conjunction with this, the phenomenon of population aging has been observed in many societies. Brazil is among such cases, where the median age of the population has increased from 16.9 years in 1960 to 32.4 years in 2020 (2). It is estimated to reach 46 by 2060. In terms of proportional distribution in 1960, a little over 4% of Brazil's population were aged 60 and over, while those in the younger age groups of 0 to 14 comprised 38% of the total population. By 2020 and 2060, the older population is estimated to make up about 14 and 33%, respectively, of the total population. During those same periods, the younger age groups will account for almost 21 and 14%, respectively, of the total population.

The onset of ill health is associated with age progression, including declining cognitive performance, notwithstanding dementia (3). There is a biological underpinning in this process as the brain and its functions degenerate in advanced ages (4). Additionally, social disparities can be involved in outcomes pertaining to cognition (5). In 2015, it was estimated that about 5% of the global older population had dementia (3). A higher prevalence of dementia has also been estimated to occur in low- and middle-income countries (LMICs), which constitute around 60% of the global prevalence. In the case of Brazil, dementia is said to be underdiagnosed, with an estimated number of about a million affected individuals (6). Studies at the community level also indicate widely varying prevalence rates between 5 and 19% of the respective communities' older populations (7).

The shift in age structures of societies towards aging has been linked to public health challenges, as there may be issues related to financing healthcare and ensuring a good quality of well-being (1). There are studies that have noted the prospect that such a change in population structure may lead to negative population growth and labor scarcity, with China serving as an example (8). However, recent studies challenge this point of view by delving into the fact that the 'older population' is highly heterogeneous, with individuals having different socioeconomic backgrounds. Therefore, their health and capacity to contribute to society in an economically gainful manner can continue despite old age (9–11). Cognition plays a crucial role in the productivity of the older population, serving as an apt indicator for further social engagement and adaptability in learning and navigating work environments.

This paper employs the previously presented notion of heterogeneity. The entrance to old age should not be defined by chronological age alone, as it does not signify the level of health functioning of individuals. With the increase in life expectancies across societies, the health status and functioning of people today differ significantly from those decades ago. For example, hypothetically, a 60-year-old man today may have the health functioning capacity of a 50-year-old male in the 1980s. This fundamental concept is put forth through the characteristics approach, which is multidimensional and determines the functional capacity of individuals based on chronological age and social characteristics (12). As a hypothetical example, a female aged 65 with no completed schooling may exhibit a cognitive performance level of X, whereas a woman with completed secondary school attainment may exhibit the same level of cognitive functioning X at 70 years old. This implies that individuals with a higher socioeconomic background may experience a later onset of cognitive aging. The characteristics approach has been applied to various health dimensions, including walking speed, handgrip strength, and cognitive status (13–15).

The present study focuses on the differences in cognitive aging among subpopulations in Brazil. As the rate of population aging in the country is increasing, several general social and economic issues have been raised, often overlooking the aspect of cognitive impairment in the discussion (6, 7). As individuals experience ageing differently, this study can provide guidance on which individuals in the population may maintain cognitive productivity. Having an aging population may not only bring social and economic challenges but also offer opportunities when taking a positive perspective and appropriate consideration.

2. Materials and methods

2.1. Data

This study utilized the second wave of the Brazilian Longitudinal Study on Aging (ELSI-Brazil), which includes a total sample of 9,941 participants from whom information was collected between 2019 and 2021. ELSI-Brazil is an ongoing nationally representative cohort study that focuses on individuals aged at least 50 years, with the baseline data collected in 2015–2016. The collected data includes socio-demographic characteristics, self-reported health measures, and anthropometric data. ELSI-Brazil implemented a complex sampling design, and additional details regarding the survey methodology can be found elsewhere (16). The ELSI-Brazil was approved by the Ethics Committee of the Oswaldo Cruz Foundation - Minas Gerais and the process is registered on Plataforma Brasil (CAAE: 34649814.3.0000.5091). Participants signed separate informed consent forms for each of the research procedures and authorized access to corresponding secondary databases.

2.2. Measures

2.2.1. Cognition

A global score was generated from two measures of cognition. The first measure involved immediate and delayed recall. Respondents were presented with a list of 10 words and asked to recite them back to the survey enumerator immediately. After answering other unrelated questions, the respondents were asked again to recite the same 10 words. The second measure of cognition was fluency, specifically involving naming as many animals as possible within a minute. The total number of correct answers was combined to represent the global cognition score, following a similar approach as other studies (17, 18).

2.2.2. Human capital factors

The characteristics focused on in the analyses were socioeconomic factors: education and income. Education was determined based on the survey item that asked about the highest level of education attained by individuals. The categories used were as follows: (a) no education, (b) primary level, (c) secondary level, and (d) postsecondary level. Regardless of completion status, respondents were included in their respective classification. For the characteristics approach analysis, the reference category for comparison was the category of no education.

Income was based on the total household income from various sources reported by the respective older respondents. The total income values were then classified into quartiles. The reference category for income was the lowest quartile.

2.2.3. Other covariates

In previous applications of the characteristics approach, additional health variables that were correlated with the investigated health outcome were included (11, 13). The bases for the selection of the said health

covariates are their observed association with the outcome at hand and also that they are contextualized in the society being investigated. With that said, three medically-diagnosed health status factors were included in the analyses: hypertension, arthritis, diabetes, a cerebral vascular accident or stroke, and chronic obstructive pulmonary disease (COPD). The prevalence of the said diseases has been indicated to be associated with cognitive performance decline among Brazilians over the years (19–21). An advantage of utilizing the characteristics approach as an analytical method is its concise statistical modelling, but the prevalence rates of the previously mentioned diseases were utilized in the present analysis to account for the health status of the analytic sample. The goal was to produce better estimates with regard to the adjusted rates of human capital factors similar to what was done in previous studies involving the characteristics approach (11, 13–15).

2.3. Analysis

The characteristics approach is initiated by creating a schedule of health functions using multiple linear regression models (13, 14). The outcome of these analytical models is cognitive performance, which depends on individual ages and human capital development characteristics. The distribution of cognitive performance characteristics is non-normal, but despite this, the use of the stated regression model analyses is acceptable as violations of the normality assumption occur due to small sample sizes (22). This method of analysis, which yields outcomes with a non-normal distribution, has been utilized in other studies (14, 15). Distinct analytic models were employed for education levels and income quartiles. The model specification for education is:

$$C(k)_i = \beta_0 + \beta_1 \text{age}^2 + \beta_2 \text{Primary} + \beta_3 \text{Secondary} + \beta_4 \text{Postsecondary} + \beta_5 \text{Hypertension} + \beta_6 \text{Arthritis} + \beta_7 \text{Diabetes} + \beta_8 \text{Stroke} + \beta_9 \text{COPD} + \mu_i$$

And the model specification for income quartile analysis was:

$$C(k)_i = \beta_0 + \beta_1 \text{age}^2 + \beta_2 \text{Secondquartile} + \beta_3 \text{Thirdquartile} + \beta_4 \text{High} + \beta_5 \text{Hypertension} + \beta_6 \text{Arthritis} + \beta_7 \text{Diabetes} + \beta_8 \text{Stroke} + \beta_9 \text{COPD} + \mu_i$$

where $C(k)$ stands for the health status k referring to cognition level of person i. Then ε_i is the random error with zero mean and the variance σ^2.

The next step in the characteristics approach is computing α-ages, or alpha ages. These are characteristic-based ages, where individuals showing the same α-age have the same characteristic (13). A standard schedule is established, which serves as the comparative reference for characteristics based on chronological age. In the present analysis, the reference category for education level was individuals with no schooling. As for the income quartile, the reference category was the low-income category. The following equations were for the α-ages of education subgroups:

$$\alpha_{k,\text{Primary}} = \sqrt{age^2_{Noeduc} - \left(\hat{\beta}_2 / \hat{\beta}_1\right)}$$

$$\alpha_{k,\text{Secondary}} = \sqrt{age^2_{Noeduc} - \left(\hat{\beta}_3 / \hat{\beta}_1\right)}$$

$$\alpha_{k,\text{Postsecondary}} = \sqrt{age^2_{Noeduc} - \left(\hat{\beta}_4 / \hat{\beta}_1\right)}$$

For the α-ages of the subpopulations based on income:

$$\alpha_{k,\text{Secondquartile}} = \sqrt{age^2_{Low} - \left(\hat{\beta}_2 / \hat{\beta}_1\right)}$$

$$\alpha_{k,\text{Thirdquartile}} = \sqrt{age^2_{Low} - \left(\hat{\beta}_3 / \hat{\beta}_1\right)}$$

$$\alpha_{k,\text{High}} = \sqrt{age^2_{Low} - \left(\hat{\beta}_4 / \hat{\beta}_1\right)}$$

3. Results

The sample distribution is presented in Table 1. The mean age and cognition levels of men and women in the sample were similar. There were more men at the primary level of education, while there were more women at the other levels. In terms of income quartile, more women were in the lower categories, while men were in the higher levels.

Table 2 presents the differences in average global cognition scores between men and women. It was observed that average cognition scores decrease with older ages. Men with no completed education had an average score of about 15, while women had an average score of 14. For those at the postsecondary level, the average scores for both sexes were almost 23. Similarly, cognition scores increased as human capital development levels increased.

To further explore differences in the trajectories of cognitive performance based on socioeconomic characteristics, the age progression of the health outcome is depicted in Figure 1. There is a significant disparity in average scores based on education levels. Regarding income categories, there are also significant disparities between categories, particularly at age 60. Among men, the differences tend to diminish with older ages. Women in the lower three categories of income showed smaller differences in scores, while the high-income quartile remained notably elevated throughout the age progression.

The results of the characteristics approach analyses by education level are presented in Table 3. Men at the primary level of education have a greater than 1-year advantage over those with no schooling. Higher gains were observed as education levels increased. For example, the level of cognitive performance of a 60-year-old male with no schooling would be attained at age 66 for those at the secondary level and 69 years old for those at the postsecondary

TABLE 1 Descriptive statistics of analytic sample by gender.

	Total (n = 4,099)	Men (n = 1,646)	Women (n = 2,453)
Mean age	69.4	69.5	69.4
Mean cognition	17.4	17.6	17.3
Age group (%)			
60–69	58.8	58.3	59.2
70–79	30.3	29.8	30.8
80 and over	10.9	11.9	10.0
Education level (%)			
No schooling	15.9	14.9	16.7
Primary	51.6	53.3	50.2
Secondary	25.6	25.2	26.0
Postsecondary	6.9	6.6	7.1
Income quartile (%)			
Low	21.3	18.7	23.4
Second	30.6	28.8	32.2
Third	20.3	21.8	19.1
High	27.8	30.8	25.3
Hypertension prevalence (%)	14.6	16.3	13.2
Arthritis prevalence (%)	21.7	14.1	28.1
Diabetes prevalence (%)	20.1	18.3	21.7
Stroke prevalence (%)	4.1	4.7	3.6
Chronic obstructive pulmonary disease prevalence (%)	3.7	3.9	3.5

Source: Brazilian longitudinal study on aging (ELSI-Brazil), 2019–2021.

TABLE 2 Comparison of mean global cognition scores between men and women.

	Men	Women	p-value[+]
Age group			
60–69	18.29	18.08	0.531
70–79	17.10	16.58	0.257
80 and over	15.70	14.75	0.174
Education attainment			
No schooling	14.72	13.85	0.073
Primary	16.55	16.15	0.236
Secondary	20.28	20.16	0.813
Postsecondary	22.83	22.83	0.997
Income quartile			
Low	16.26	15.83	0.393
Second	17.15	16.69	0.264
Third	18.28	17.16	0.081
High	18.44	19.48	0.039

[+]Based on t-test.

level. A similar pattern was observed among women. Another similarity between men and women is that the gains decrease as age progresses. For instance, women with no schooling and those at the postsecondary level had alpha-ages of 60 and 72 years, respectively, resulting in a 12-year difference. At age 80, women with no schooling and women at the postsecondary level may have similar performances at age 89, reducing the difference to 9 years.

The patterns and trends among men and women for α-ages based on income levels were similar to those based on education levels (Table 4). A notably consistent pattern between income and education levels was that women had higher gains than men for the highest categories. Specifically, women in the high-income category, as well as those at the postsecondary level, had approximately 20% higher gains in α-ages than men.

4. Discussion

This study observed the cognitive performance of older Brazilian men and women and identified socioeconomic disparities. Higher levels of education and income were associated with a later onset of cognitive decline, benefiting cognition across the old age spectrum. However, a declining trend was observed upon reaching later ages for both males and females.

In general, socioeconomic factors have shown to have a positive impact on health, particularly in terms of cognition (23, 24). Education has been suggested to enhance cognitive reserves (25) and offer lifelong opportunities that can delay cognitive ageing (24). Greater economic resources are also associated with better healthcare access and social engagement, which can benefit cognitive health (26, 27). The range of activities that people can do

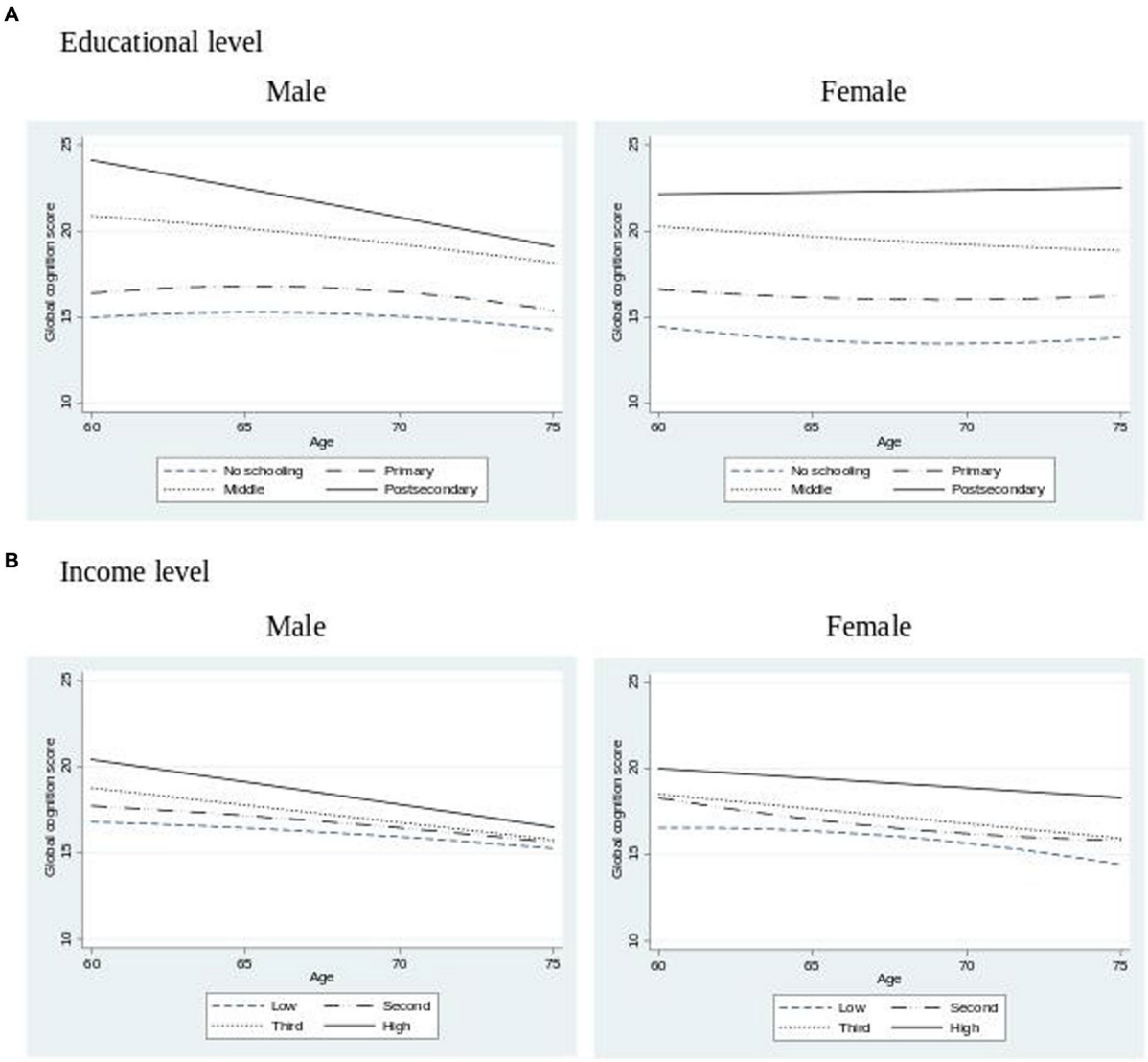


FIGURE 1
Mean cognition score by human capital development factors and gender.

TABLE 3 Alpha-age schedule by educational attainment level of men and women.

	Male			Female		
Age with no schooling	Primary	Secondary	Postsecondary	Primary	Secondary	Postsecondary
60	61.90	66.64	69.09	63.15	68.32	72.11
65	66.76	71.16	73.46	67.91	72.75	76.31
70	71.64	75.76	77.93	72.71	77.24	80.63
75	76.51	80.41	82.45	77.53	81.80	85.00
80	81.42	85.098	87.03	82.39	86.40	89.44

when they have more resources, especially being engaged in community activities.

Similar patterns of better health status related to higher human capital characteristics have been observed in Brazil (28, 29). Illiteracy rates have been declining, but disparities persist among certain subpopulations, including older individuals (30). It has been reported that even within the older population, further disparities are noted. When viewed at the regional level, adults aged 60 and over had illiteracy rates of about 33% in the Northeast, while it is nearly 9% in the Southeast (30). Regarding income, social security

TABLE 4 Alpha-age schedule by income level and gender.

	Male			Female		
Age of low income level	Second	Third	High	Second	Third	High
60	62.93	67.19	68.96	62.87	65.95	71.48
65	67.73	71.67	73.35	67.65	70.53	75.73
70	72.54	76.24	77.82	72.47	75.16	80.07
75	77.36	80.87	82.35	77.31	79.84	84.46
80	82.22	85.51	86.93	82.16	84.55	88.93

schemes have been implemented to promote health and well-being (29). As a result of these programs, about 86% of older individuals in Brazil receive support through social pension schemes. As observed in the present study, the onset of cognitive decline among those with no schooling and low income was much disadvantaged.

Significant differences in the benefits toward cognitive performance were found between genders. Men and women exhibited different degrees of advantage depending on socioeconomic status. Across higher levels of education, women had a greater advantage. These results resemble findings from other LMICs (11, 15). In the context of the current study, women in Brazil have been found to experience inequality in terms of education, labor participation, and income (28, 31). Due to lower returns on income for women, they may compensate through other means (32). This may explain why the higher benefits in the onset of cognitive performance decline are consistently higher for women across all education levels.

There are limitations to this study. The use of cross-sectional data within the panel survey of ELSI-Brazil aligns with selected literature that utilizes the characteristics approach thus far (11). Given the nature of the data used, no causation can be established in the analysis. The results pertaining to the prevalence of cognitive performance also do not indicate a medical diagnosis of dementia. The survey items used are based on established questions for estimating cognitive performance levels. Lastly, the present study focused on the functional differences in the ageing process of the population based on human capital factors. Other studies have explored biomarker-based biological ages (33, 34) but such studies were complex and have extemporized assumptions (13). Furthermore, the present study focused on the general population and estimated the respective trajectories of cognitive performance by human capital development characteristics. Prospective studies may be able to estimate similar trajectories with the inclusion of their health status. It may be utilized as a stratifying characteristic of the analytic sample apart from health status factors as covariates in the statistical modelling analysis in the initial procedure of the characteristics approach.

5. Conclusion

By employing the characteristics approach as a novel analytic method, this study provides a better understanding of the heterogeneity among the older population. The onset and progression of cognitive decline were observed to be associated with human capital development factors. Both education and income levels are preventable risk factors for cognitive impairment. For the current older population, it may be necessary to monitor those with no schooling as they may be at a higher risk of cognitive decline. Healthcare and services should be better aligned with the needs of individuals based on their social and economic backgrounds. Looking toward the long term, measures should be strengthened to improve educational attainment levels for the current younger population. This would lead to increased prospective earnings and better cognitive health outcomes in old age.

Data availability statement

Publicly available datasets were analyzed in this study. The data sets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at https://elsi.cpqrr.fiocruz.br/data-access/.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The ELSI-Brazil was supported by the Brazilian Ministry of Health: DECIT/SCTIE (Grants: 404965/2012-1 and TED 28/2017) and COPID/DECIV/SAPS (Grants: 20836, 22566, 23700, 25560, 25552, and 27510).

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Sander M, Oxlund B, Jespersen A, Krasnik A, Mortensen EL, Westendorp RGJ, et al. The challenges of human population ageing. *Age Ageing*. (2015) 44:185–7. doi: 10.1093/AGEING/AFU189

2. United Nations Population Division (2022). World population prospects 2022. Available at: https://population.un.org/wpp/. (Accessed August 17, 2023).

3. World Health Organization (2017). Global action plan on the public health response to dementia. Geneva: World Health Organization. Available at: http://apps.who.int/bookorders. (Accessed August 17, 2023).

4. Ferrer I. Defining Alzheimer as a common age-related neurodegenerative process not inevitably leading to dementia. *Prog Neurobiol*. (2012) 97:38–51. doi: 10.1016/j.pneurobio.2012.03.005

5. Kleinman A, Estrin GL, Usmani S, Chisholm D, Marquez PV, Evans TG, et al. Time for mental health to come out of the shadows. *Lancet*. (2016) 387:2274–5. doi: 10.1016/S0140-6736(16)30655-9

6. Nakamura AE, Opaleye D, Tani G, Ferri CP. Dementia Underdiagnosis in Brazil. *Lancet*. (2015) 385:418–9. doi: 10.1016/S0140-6736(15)60153-2

7. Fagundes SD, Silva MT, Thees MFRS, Pereira MG. Prevalence of dementia among elderly Brazilians: a systematic review. *Sao Paulo Med J*. (2011) 129:46–50. doi: 10.1590/S1516-31802011000100009

8. Du Y, Yang C. Demographic transition and labour market changes: implications for economic development in China In: I Claus and L Oxley, editors. *China's economy: A collection of surveys*. West Sussex, United Kingdom: John Wiley & Sons (2015). 25–44.

9. Lucero-Prisno III, Don Eliseo MBN, Kouwenhoven PM, Vicerra M, Ma ZF, Méndez MJG, et al. The challenges of the low birth rate in China. *Public Health Challeng*. (2022) 1:e8. doi: 10.1002/PUH2.8

10. Marois G, Gietel-Basten S, Lutz W. China's low fertility may not hinder future prosperity. *Proc Natl Acad Sci U S A*. (2021) 118:e2108900118. doi: 10.1073/PNAS.2108900118/SUPPL_FILE/PNAS.2108900118.SAPP.PDF

11. Vicerra PMM, Estanislao JM. Socioeconomic disparities in cognitive functioning trajectories among older Filipinos: applying the characteristics approach. *J Appl Gerontol*. (2023) 42:1850–8. doi: 10.1177/07334648231159770

12. Sanderson WC, Scherbov S. A unifying framework for the study of population aging. *Vienna Yearb Population Res*. (2016) 1:007–40. doi: 10.1553/populationyearbook2016s007

13. Sanderson WC, Scherbov S. Measuring the speed of aging across population subgroups. *PLoS One*. (2014) 9:e96289. doi: 10.1371/journal.pone.0096289

14. Sanderson WC, Scherbov S, Weber D, Bordone V. Combined measures of upper and lower body strength and subgroup differences in subsequent survival among the older population of England. *J Aging Health*. (2016) 28:1178–93. doi: 10.1177/0898264316656515

15. Vicerra PMM, Pothisiri W. Trajectories of cognitive ageing among Thai later-life adults: the role of education using the characteristics approach. *J Population Soc Stud*. (2020) 28:276–86. doi: 10.25133/JPSSv28n4.019

16. Lima-Costa MF, de Melo Mambrini JV, Bof de Andrade F, de Souza PRB Jr, de Vasconcellos MTL, Neri AL, et al. Cohort profile: the Brazilian longitudinal study of ageing (ELSI-Brazil). *Int J Epidemiol*. (2023) 52:e57–65. doi: 10.1093/ije/dyac132

17. Cardoso BR, Hare DJ, Macpherson H. Sex-dependent association between selenium status and cognitive performance in older adults. *Eur J Nutr*. (2021) 60:1153–9. doi: 10.1007/s00394-020-02384-0

18. Veronese N, Koyanagi A, Solmi M, Thompson T, Maggi S, Schofield P, et al. Pain is not associated with cognitive decline in older adults: a four-year longitudinal study. *Maturitas*. (2018) 115:92–6. doi: 10.1016/j.maturitas.2018.07.001

19. Lopes MA, Ferrioli E, Nakano EY, Litvoc J, Bottino CM. High prevalence of dementia in a community-based survey of older people from Brazil: association with intellectual activity rather than education. *J Alzheimers Dis*. (2012) 32:307–16. doi: 10.3233/JAD-2012-120847

20. Lopes MA, Xavier AJ, D'Orsi E. Cognitive and functional impairment in an older community population from Brazil: the intriguing association with frequent pain. *Arch Gerontol Geriatr*. (2016) 66:134–9. doi: 10.1016/j.archger.2016.05.010

21. Teixeira MM, Passos VMA, Barreto SM, Schmidt MI, Duncan BB, Beleigoli AMR, et al. Association between diabetes and cognitive function at baseline in the Brazilian longitudinal study of adult health (ELSA- Brasil). *Sci Rep*. (2020) 10:1596. doi: 10.1038/s41598-020-58332-9

22. Sainani KL. Dealing with non-normal data. *PMR*. (2012) 4:1001–5. doi: 10.1016/J.PMRJ.2012.10.013

23. Demakakos P, Biddulph JP, Bobak M, Marmot MG. Wealth and mortality at older ages: a prospective cohort study. *J Epidemiol Community Health*. (2016) 70:346–53. doi: 10.1136/JECH-2015-206173

24. Zahodne LB, Stern Y, Manly JJ. Differing effects of education on cognitive decline in diverse elders with low versus high educational attainment. *Neuropsychology*. (2015) 29:649–57. doi: 10.1515/jci-2013-0007

25. Stern Y. The concept of cognitive reserve: a catalyst for research. *J Clin Exp Neuropsychol*. (2003) 25:589–93. doi: 10.1076/jcen.25.5.589.14571

26. Yaffe K, Falvey C, Harris TB, Newman A, Satterfield S, Koster A, et al. Effect of socioeconomic disparities on incidence of dementia among biracial older adults: prospective study. *BMJ*. (2013) 347:f7051. doi: 10.1136/bmj.f7051

27. Yochim BP, Mueller AE, Segal DL. Late life anxiety is associated with decreased memory and executive functioning in community dwelling older adults. *J Anxiety Disord*. (2013) 27:567–75. doi: 10.1016/J.JANXDIS.2012.10.010

28. Borelli WV, Leotti VB, Strelow MZ, Chaves MLF, Castilhos RM. Preventable risk factors of dementia: population attributable fractions in a Brazilian population-based study. *Lancet Reg Health*. (2022) 11:100256. doi: 10.1016/j.lana.2022.100256

29. Freeman T, Gesesew HA, Bambra C, Giugliani ERJ, Popay J, Sanders D, et al. Why do some countries do better or worse in life expectancy relative to income? An analysis of Brazil, Ethiopia, and the United States of America. *Int J Equity Health*. (2020) 19:1–19. doi: 10.1186/S12939-020-01315-Z/TABLES/2

30. Instituto Brasileiro de Geografiae Estatıstica. (2023). "Illiteracy rate is lower in 2022, but remains high among the elderly, black and Brown persons and in the northeast region. Available at: https://agenciadenoticias.ibge.gov.br/en/agencia-news/2184-news-agency/news/37103-illiteracy-rate-is-lower-in-2022-but-remains-high-among-the-elderly-black-and-brown-persons-and-in-the-northeast-regioneste-2 [Accessed June 9, 2023].

31. Codazzi K, Pero V, Sant'Anna AA. Social norms and female labor participation in Brazil. *Rev Dev Econ*. (2018) 22:1513–35. doi: 10.1111/RODE.12515

32. Ross CE, Mirowsky J. Gender and the health benefits of education. *Sociol Q*. (2010) 51:1–19. doi: 10.1111/j.1533-8525.2009.01164.x

33. Klemera P, Doubal S. A new approach to the concept and computation of biological age. *Mech Ageing Dev*. (2006) 127:240–8. doi: 10.1016/j.mad.2005.10.004

34. Levine ME. Modeling the rate of senescence: can estimated biological age predict mortality more accurately than chronological age? *J Gerontol Ser A*. (2013) 68:667–74. doi: 10.1093/gerona/gls233

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 03 November 2023
DOI 10.3389/fpubh.2023.1223382

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Shemsu Kedir,
Werabe University, Ethiopia
Sapna Langyan,
Indian Council of Agricultural Research (ICAR), India

*CORRESPONDENCE
Xiaoguang Xu
✉ xuxg2007@sina.com
Xiaofeng Li
✉ lxf_chen@dmu.edu.cn

†These authors have contributed equally to this work

RECEIVED 16 May 2023
ACCEPTED 23 October 2023
PUBLISHED 03 November 2023

CITATION
Cui J, Nima O, Zhaxi D, Jin C, Wang R, Diao Y, Chen Y, Xu X and Li X (2023) Health status of the population in Naqu, Tibet and its latent class analysis: a cross-sectional survey. *Front. Public Health* 11:1223382. doi: 10.3389/fpubh.2023.1223382

COPYRIGHT
© 2023 Cui, Nima, Zhaxi, Jin, Wang, Diao, Chen, Xu and Li. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Health status of the population in Naqu, Tibet and its latent class analysis: a cross-sectional survey

Jiaxue Cui[1†], Ouzhu Nima[2†], Duoji Zhaxi[2], Chenxin Jin[1], Ruiqi Wang[1], Yizhuo Diao[1], Yongxing Chen[1], Xiaoguang Xu[2,3*] and Xiaofeng Li[1*]

[1]Department of Epidemiology and Health Statistics, Dalian Medical University, Dalian, China, [2]Institute of High Altitude Medicine, People's Hospital of Naqu Affiliated to Dalian Medical University, Naqu, China, [3]Department of Neurosurgery, Second Affiliated Hospital of Dalian Medical University, Dalian, China

Background: Through a survey and analysis of the population's present state of health, it is possible to give data support for improving the health status of inhabitants in Naqu, Tibet. Additionally, it is possible to provide specific recommendations for the development of medical and healthcare facilities in Tibet.

Methods: The health scores of the participants were based on their responses to the four main sections of the questionnaire: dietary habits, living habits, health knowledge, and clinical disease history, and the variability of health status among groups with different characteristics was analyzed based on the scores. The four major sections were used to create classes of participants using latent class analysis (LCA). Using logistic regression, the factors influencing the classification of latent classes of health status were investigated.

Results: A total of 995 residents from 10 counties in Naqu were selected as the study subjects. And their demographic characteristics were described. The mean health score of residents after standardization was 81.59 ± 4.68. With the exception of gender, health scores differed between groups by age, education level, different occupations, marital status, and monthly income. The health status in Naqu, Tibet, was divided into two groups (entropy = 0.29, BLRT = 0.001, LMRT = 0.001) defined as the "good health group" and the "general health group." A monthly income of more than ¥5000 adverse to good health in Naqu, Tibet.

Discussion: Single, well-educated young adults in Naqu, Tibet, have outstanding health. The vast majority of people in Tibet's Naqu region were in good health. Furthermore, the population's latent health status was divided into two classes, each with good dietary and living habits choices, low health knowledge, and a history of several clinical diseases. Univariate and multivariate logistic regression analysis showed that monthly income more than ¥5000 was an independent risk factor for poor health status.

KEYWORDS

Tibet, population health, latent class analysis, cross-sectional survey, herders and farmers, health knowledge

1. Introduction

Naqu is located in the northern part of Tibet Autonomous Region, at an elevation of more than 4,500 meters. People in this area have long been subjected to the harsh environment of hypobaric hypoxia, high altitude, low temperature, and high UV rays (1). Because of its high altitude and harsh weather, Tibet is inaccessible, and its social and economic development lags

behind that of the rest of China. With the development of China's economy and transportation system in recent years, Tibetan people's living conditions have improved to some extent. However, Tibet's medical and health levels remain lower than in other developed areas of China. There have been few surveys and analyses of the Tibetan population's health so far.

Currently, knowledge-attitude-practice (KAP) questions are used in the majority of population health surveys undertaken by local and international experts. Some researches use the content of questionnaires to evaluate participants' responses and examine their health condition based on their results. Despite the fact that there are more surveys on population health status in the United States and elsewhere, there is no study of population health status in Naqu, Tibet. In addition to the traditional use of descriptive statistical analysis, several research have added latent class analysis, which is widespread in psychology and sociology, into the study of health status analysis (2–4). Our study assessed the present health status of the population in Naqu, Tibet using descriptive statistical analysis. The latent classes of health status in Naqu, Tibet were analyzed by merging the idea of health quotient (HQ) introduced by Canadian medical expert Dr.Wah Jun Tze. The health quotient can correctly reflect a person's health wisdom and can be used to gauge a person's attitude toward health (5). It consists of the following five components: self-care, health knowledge, living habits, mental health, and life skills. The term "health quotient" focuses on health and encompasses a wide range of topics such as culture and awareness (6). The latent class analysis of the health status of the population in Naqu of Tibet, when combined with the five elements of the health quotient, can more comprehensively show the health characteristics of the population in Naqu of Tibet.

At the National Health and Health Conference in 2016, China presented the "Healthy China 2030" plan, elevating the construction of "Healthy China" to a national strategy. Health has emerged as a "key word" in China's future development strategy (7). The development of all aspects of society is connected to population health. Through the survey and analysis of the current health condition of the population in Naqu, Tibet, and the provision of targeted suggestions for the construction of medical and health care in Tibet, the investigation and analysis of the health status of the population here can provide data support for improving the health level of the population.

2. Materials and methods

2.1. Subjects

This was a cross-sectional survey, with data collected via questionnaires. As the study object, residents from 10 counties in Naqu, Tibet, were selected at random using the random sampling method. Following the principle of informed consent, qualified investigators conducted a face-to-face survey in the local language using a structured questionnaire. All participants of the study provided signed informed consent.

Subject inclusion criteria were as follows: (1) residents of Naqu, Tibet; (2) adults over 18 years of age; (3) good mental status and able to cooperate with the investigators to complete the questionnaire; (4) able to complete the physical index measurement.

Subjects were excluded based on the following criteria: (1) refusing to continue participating or collaborating in the process; (2) refusal to give informed consent.

The following formula was used to calculate the sample size of the study subjects:

$$n = \left(\frac{t_{\alpha/2}}{\delta} \right)^2 p(1-p)$$

n: The minimum sample size required; p: The estimated proportion of the target volume; δ: maximum allowable error.

The sample size is 897 when $\alpha = 0.05$, $p = 0.3$. In previous studies, the allowable error was generally 5% (8, 9). However, the subjects of our study were residents in plateau areas, and their occupation and physical indicators may be limited by regional influence. Therefore, δ was taken to 3% in our study in the hope of achieving a more accurate description of the health status of the inhabitants of this area.

995 people were finally determined and collected based on the calculation of the sample size of the research object and the inclusion and exclusion criteria, and all 995 people were investigated using the Questionnaire on the Health Status and Health Needs of People in Highland Areas.

2.2. Content of the questionnaire

(1) We used a validated questionnaire on Highland People's Health Status and Health Needs (10). The questionnaire was divided into five sections: "basic personal information," "dietary habits," "living habits," "health knowledge" and "clinical disease history."

According to the previous research, the degree to which each option represented in the sections "dietary habits," "living habits" and "health knowledge" was assigned a score of 1–5 (Supplementary material 1). No related diseases were given 5 points in the section on "history of clinical diseases," and the number of related diseases was taken into account when deducting the corresponding score (1–5 points) from the maximum score of 5. People who had not had any common illnesses in the previous 2 weeks receive 5 points. The maximum score of 5 points was deducted from the appropriate number based on the number of common diseases they have experienced (1–5). Those with no recent hospitalization experience received 10 points, while those with hospitalization experience received the corresponding number (1–10 points) subtracted from the maximum score of 10 points based on the number of hospitalization experiences.

To obtain a health score for the residents of the area, scores were calculated based on the responses of the participants. With a maximum score of 133 points and a maximum score of 100 points after score standardization, higher scores represent better health.

(2) According to some questions in "health knowledge," the current situation and demand of local residents for daily physical examination, disease screening activities and health promotion activities were analyzed, and the influence of health status score on health knowledge was analyzed.

2.3. Questionnaire quality control

(1) The first draft of the questionnaire was created after referring to a large number of research materials, and then revised after contacting experts and conducting a pre-survey before forming the final questionnaire for this survey and creating a survey guide.
(2) The questionnaire's content was kept confidential to avoid respondents from not filling out the actual scenario out of fear of personal information leakage.

2.4. Statistical analysis

A database was created using the EpiData3.1 program. The data was sorted using Excel2016, and the statistical analysis was performed using SPSS26.0 software. Values for regularly distributed measurement data and categorical variables are expressed as mean standard deviation (SD) and number/percentage (n/%). The t-test and ANOVA were used to describe differences in participant characteristics. All variables were included in univariate and multivariate logistic regression models for analysis. The difference was considered statistically significant when $p < 0.05$ and the test level $\alpha = 0.05$. The representative meaning of categories was investigated using latent class analysis (LCA), which was used to establish classes of participants based on their answers to the four primary sections. The explicit variables of latent class analysis were dietary habits score, living habits score, health knowledge score and clinical disease history score. Before the standardized score, a dietary habits score ≥ 23 was defined as having good dietary habits. The score of living habits ≥ 19 was defined as having good living habits. Good health knowledge was defined as health knowledge score ≥ 10; the clinical disease history score ≥ 55 was defined as no clinical disease history. Before performing latent class analysis, univariate and multivariate logistic regression analyses were performed in SPSS26.0 software to compare the scores of the four sections. The high and low score groups were divided according to the above. Models with 1–4 classes were examined, and model selection was based on improvements in test statistics including chi-square goodness of fit, Bayesian information criterion (BIC), Akaike information criterion (AIC), entropy, Bootstrap likelihood ratio test (BLRT) and Vuong-lo–mendell–rubin test (LMRT). Mplus8.3 software was used to do the Latent class analysis. In SPSS26.0 software, logistic regression was utilized to investigate the contributing factors of latent classes of health status.

3. Results

3.1. Participant characteristics

This study collected a total of 995 valid questionnaires (Table 1), including 586 males (58.9%). There were 409 females, accounting for 41.1% of the total. The average age was 34.16 ± 13.04 years old. 54.5% were illiterate, 20.2% had completed primary or junior high school,

TABLE 1 Participant characteristic.

Characteristic	*n* (%)	Mean total score (Mean ± SD)	Value of statistics	*p* value
Gender				
Male	586 (58.9)	81.69 ± 4.69	0.85	0.397
Female	409 (41.1)	81.44 ± 4.67		
Age groups, years				
18 ~ 30	491 (49.3)	82.16 ± 4.81	10.57	<0.001
31 ~ 50	381 (38.3)	81.33 ± 4.38		
51~	123 (12.4)	80.10 ± 4.70		
Education				
Illiteracy	542 (54.5)	81.03 ± 4.39	21.97	<0.001
Primary and Junior High schools	201 (20.2)	81.01 ± 4.72		
High school and above	252 (25.3)	83.24 ± 4.88		
Occupations				
Herdsmen and farmer	630 (63.3)	80.82 ± 4.63	−6.95	<0.001
other	365 (36.7)	84.12 ± 4.52		
Marital status				
Married	697 (70.1)	81.13 ± 4.38	−4.42	<0.001
Unmarried	298 (29.9)	82.65 ± 5.16		
Monthly income (RMB)				
Below 2000	312 (31.4)	81.15 ± 4.95	4.00	0.019
2001 ~ 5,000	358 (36.0)	82.13 ± 4.69		
More than 5,000	325 (32.7)	81.41 ± 4.68		

and 25.3% had completed high school or higher. And herders and farmers made up 63.3% of the participants. Furthermore, in this study, 70.1% were married.

3.2. Differences in total health scores between groups of people with various characteristics

The health of the population was graded based on the questionnaire responses of the participants. Following standardization, the participants' health status could be assessed up to 100 points, with a higher score indicating better health.

We used *t*-test and ANOVA to compare the health scores of people of different genders, ages, education levels, occupations, marital status, and monthly income (Table 1). And the results revealed that there were differences in the total health score in terms of age, education, occupations, marriage, and monthly income in addition to gender. The higher the health score, the younger the age. People with a high school education or higher had a considerably higher health score (83.24 ± 4.88) than those with lower education levels. Herdsmen's and farmers' health scores (80.82 ± 4.63) were lower than other occupations. Unmarried people had a higher health score (82.65 ± 5.16) than who were married. People with a monthly income of ¥2001–5,000 could have a higher health score.

3.3. Differences in the four sections' health scores between groups of persons with various characteristics

Following the comparison of the overall score, the standardized scores for the different sections were compared (Table 2).

In terms of dietary habits, we questioned about Eating on time; Eating speed; The temperature of food; A few meals a day; The number of breakfast times per week; How many times a week you eat leftovers; Whether the food has a strong sour taste; How to deal with moldy ingredients. There were differences among groups with different education levels, different occupations, marital status and monthly income. Those with primary and junior high school education performed worse than those with other qualifications. The scores of dietary habits of herdsmen and farmers were significantly lower than other occupations. The score of dietary habits of married group was significantly higher than that of the unmarried groups. People with monthly income from ¥2001 to ¥5,000 had higher dietary habits scores than those with other income levels. Univariate logistic regression analysis of dietary habits showed that education level of primary and junior high school and being unmarried were associated with lower scores in this section (Table 3). On the basis of single factor regression analysis, the multivariate logistic regression further found that other occupations were 2.01 times more likely to get high scores in terms of dietary habits than herdsmen and farmers.

TABLE 2 Comparison of average scores of health scores in each section.

Characteristic	Dietary habits	*p*	Living habits	*p*	Health knowledge	*p*	Clinical disease history	*p*
Gender								
Male	19.21 ± 1.80	0.736	16.71 ± 2.01	0.001	6.25 ± 1.61	0.293	39.52 ± 2.15	<0.001
Female	19.25 ± 1.64		17.11 ± 1.86		6.14 ± 1.69		39.28 ± 2.36	
Age groups, years								
18 ~ 30	19.17 ± 1.86	0.474	17.14 ± 2.06	<0.001	6.31 ± 1.68	0.138	39.53 ± 2.11	<0.001
31 ~ 50	19.31 ± 1.59		16.62 ± 1.79		6.12 ± 1.61		39.28 ± 2.37	
51~	19.19 ± 1.74		16.58 ± 1.88		6.08 ± 1.57		38.25 ± 2.98	
Education								
Illiteracy	19.30 ± 1.58	<0.001	16.57 ± 1.86	<0.028	6.00 ± 1.55	<0.001	39.16 ± 2.51	0.070
Primary and Junior High schools	18.94 ± 1.94		16.69 ± 1.85		6.15 ± 1.64		39.24 ± 2.15	
High school and above	19.30 ± 1.85		17.66 ± 2.02		6.71 ± 1.73		39.57 ± 2.19	
Occupations								
Herdsmen and farmer	19.10 ± 1.74	0.003	16.63 ± 1.86	<0.001	5.91 ± 1.59	<0.001	39.18 ± 2.46	0.093
other	19.44 ± 1.71		17.29 ± 2.04		6.73 ± 1.60		39.44 ± 2.18	
Marital status								
Married	19.34 ± 1.57	0.005	16.57 ± 1.86	<0.001	6.10 ± 1.60	0.003	39.12 ± 2.39	0.001
Unmarried	18.96 ± 2.04		17.58 ± 1.98		6.45 ± 1.72		39.64 ± 2.27	
Monthly income (RMB)								
Below 2000	19.31 ± 1.61	0.020	16.71 ± 1.91	0.063	5.94 ± 1.69	0.001	39.19 ± 2.57	0.252
2001 ~ 5,000	19.36 ± 1.69		17.06 ± 2.07		6.27 ± 1.60		39.44 ± 2.32	
More than 5,000	19.01 ± 1.88		16.82 ± 1.86		6.40 ± 1.61		39.18 ± 2.19	

TABLE 3 Univariate and multivariate logistic regression analysis of the scores of each section.

Characteristic	Dietary habits				Living habits				Health knowledge				Clinical disease history			
	Crude		Adjusted		Crude		Adjusted		Crude		Adjusted		Crude		Adjusted	
	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*
Gender																
Male																
Female	1.03 (0.677–1.576)	0.881	1.13 (0.721–1.762)	0.600	2.24 (1.232–4.065)	0.008	2.14 (1.156–3.950)	0.015	0.85 (0.636–1.137)	0.274	0.80 (0.588–1.090)	0.158	0.77 (0.572–1.042)	0.091	0.74 (0.538–1.009)	0.057
Age groups, years																
18 ~ 30																
31 ~ 50	1.34 (0.839–2.131)	0.222	0.99 (0.557–1.745)	0.961	0.80 (0.452–1.402)	0.430	1.22 (0.645–2.318)	0.538	0.79 (0.585–1.080)	0.142	1.11 (0.759–1.628)	0.586	0.96 (0.701–1.303)	0.775	1.20 (0.816–1.755)	0.359
51~	0.79 (0.436–1.442)	0.446	0.57 (0.286–1.135)	0.109	0.63 (0.296–1.348)	0.235	1.93(0.412–2.090)	0.856	0.78 (0.493–1.28)	0.293	1.18 (0.707–1.983)	0.521	0.64 (0.390–1.067)	0.088	0.76 (0.438–1.324)	0.335
Education																
Illiteracy																
Primary and Junior High schools	0.52 (0.318–0.864)	0.011	0.60 (0.348–1.043)	0.070	1.01 (0.534–1.900)	0.983	1.05 (0.535–2.045)	0.894	1.41 (0.969–2.051)	0.072	1.38 (0.924–2.054)	0.116	0.83 (0.558–1.232)	0.353	0.77 (0.505–1.185)	0.24
High school and above	0.77 (0.462–1.279)	0.310	0.95 (0.443–2.031)	0.892	2.03 (0.969–4.274)	0.061	1.97 (0.740–5.242)	0.175	2.24 (1.61–3.119)	<0.001	1.78 (1.093–2.886)	0.02	1.24 (0.886–1.746)	0.208	1.00 (0.596–1.665)	0.99
Occupations																
Herdsmen and farmer																
Other	1.24 (0.796–1.927)	0.344	2.02 (1.118–3.634)	0.020	1.03 (0.600–1.764)	0.918	1.61 (0.319–1.171)	0.138	2.29 (1.716–3.058)	<0.001	1.93 (1.337–2.795)	<0.001	1.19 (0.889–1.600)	0.26	0.93 (0.630–1.384)	0.734
Marital status																
Married																
Unmarried	0.47 (0.310–0.720)	<0.001	0.34 (0.200–0.575)	<0.001	2.02 (1.034–3.927)	0.040	1.68 (0.757–3.750)	0.202	1.49 (1.100–2.005)	0.009	0.91 (0.610–1.348)	0.628	1.80 (1.324–2.436)	<0.001	2.06 (1.387–3.070)	<0.001
Monthly income (RMB)																
Below 2000																
2001 ~ 5,000	1.21 (0.690–2.120)	0.506	1.19 (0.670–2.119)	0.551	1.67 (0.881–3.170)	0.116	1.93 (0.993–3.756)	0.053	1.15 (0.806–1.627)	0.450	0.99 (0.687–1.428)	0.960	1.30 (0.918–1.837)	0.140	1.20 (0.841–1.722)	0.311
More than 5,000	0.58 (0.348–0.951)	0.031	0.53 (0.310–0.890)	0.017	1.27 (0.687–2.349)	0.445	1.32 (0.679–2.552)	0.415	1.25 (0.876–1.785)	0.218	0.91 (0.623–1.335)	0.636	0.76 (0.519–1.109)	0.154	0.70 (0.471–1.045)	0.081

10.3389/fpubh.2023.1223382

In terms of living habits, we inquired about the following: The quality of sleep; Whether you have the habit of napping; Whether there is a habit of drinking more water; Smoking status; Secondhand smoke exposure in the last year; Alcohol consumption; Do you usually do physical exercise? There were differences between groups with different genders, ages, education levels, different occupations and marital status. Female's living habits are better than males. Univariate and multivariate logistic regression analysis showed that women were more than twice as likely to have better lifestyle habits than men (Table 3). In addition, the younger the age, the higher the average score of living habits. The higher the level of education, the higher the average living habits score. Herdsmen and farmers score lower than other occupations on living habits. And the unmarried group outperformed the married groups in terms of living habits.

We questioned health knowledge by asking Whether visiting the hospital regularly for physical examination; Whether participated in disease screening activities; Whether participated in health education activities; Knowledge of health; Psychological knowledge. There were differences in average health knowledge scores across education levels, different occupations, marital status, and monthly income categories. The higher the level of education, the higher the average health knowledge score. Herdsmen and farmers had a lower health knowledge score than the other occupations. Unmarried people had higher health knowledge scores than married people. The higher the monthly income, the higher the level of health knowledge. Logistic regression analysis showed that high school and above education and being unmarried increased the likelihood of getting high scores in the health knowledge part, while being a herdsman or farmer reduced the likelihood of getting high scores. However, the effect of being unmarried on health knowledge was not significant in the results of multifactor logistic regression analysis (Table 3).

In terms of clinical history, we asked whether were any hypoxic symptoms such as tinnitus, dizziness, limb weakness, and shortness of breath. History of intestinal disease, cardiovascular disease, cerebrovascular disease, blood and stomach disease, lung disease, altitude disease, cancer; Whether they suffered from other common diseases in the past 2 weeks; The number of hospitalizations in the last 2 weeks. Gender, age, and marital status all differed significantly between groups. Male clinical disease history scores were higher than female clinical disease history scores. The older the person, the lower the clinical disease history score. The unmarried group outperformed the married groups in terms of clinical disease history. Both univariate and multivariate logistic regression analyses showed less clinical disease history among unmarried people. And more clinical disease history among those with a monthly income of more than ¥5,000 in multivariate logistic regression analysis.

3.4. Health knowledge analysis

In addition, a separate analysis of the health knowledge section showed that 390 (39.2%) of the population visited the hospital regularly for physical examination, while 605 did not. There were 527 people who responded to the question about why they did not visit the hospital regularly. Of the 527 respondents, 429 cited lacks of time as a cause, 175 cited continual transit as a reason, 48 deemed regular physical examination unnecessary, and 87 cited economic reasons for not having regular health examinations (Figure 1).

374 (37.6%) people participated in disease screening activities. A total of 363 people answered the question whether participating in disease screening activities would affect their health behavior, and 82 people thought that it had no effect. 136 thought that the impact was general; 144 thought that the impact was significant; One person thought that the impact was extremely obvious (Figure 2).

278 (27.9%) of the participants had participated in health education activities. 275 people answered the question of the access to participate in health education activities, 69 people took the hospital as the channel; 87 used community as the channel; 64 of them had their work unit as the channel; 35 people use internet media such as television and radio as channels. Among the questions about the number of times they participated in health education activities in the past 2 years, 63 people had participated one or two times; 40 people participated 3–5 times; 10 participated in more than five health promotion sessions. 96 people thought that health promotion activities did not affect their health behavior; 97 people thought that participating in health activities had a general effect on their health behavior, 71 people thought that participating in health promotion activities had a significant effect on their health behavior. Three people thought that the influence on themselves was very obvious.

741 people did not participate in health education activities due to a lack of time; 332 people did not participate in health education activities due to inconvenient transportation; and 68 people did not participate in health education activities because they believed the content was irrelevant to them (Figure 3). 275 persons were able to master three or more types of health knowledge; 207 people were able to master the knowledge of high altitude disease prevention and control, as well as high altitude environment and health care. 772 persons could master two or more types of mental health knowledge, and 161 could master mental response and adaptation at high altitude knowledge.

3.5. Latent class analysis of population health status

Based on the five elements of self-care, health knowledge, living habits, mental health, and life skills of "health quotient," combined with the corresponding items in the questionnaire, dietary habits, living habits, health knowledge, and clinical disease history were taken as the explicit variables, which were divided into 1 to 4 classes in order for model fitting and estimation of latent class analysis to classify the potential types of health status of the population in Naqu, Tibet. The relationship between latent health categories and gender, age, different occupations, education level, marital status and monthly income were analyzed.

The results revealed that the AIC, BIC, and aBIC values of the two-class model are the smallest (Table 4), while the Entropy value was the highest, and LMRT and BLRT both approach the significant threshold. As a result, the two-class model was chosen as the best model, and the conditional probability distributions for each class were illustrated in Figure 4; Table 5. The results showed that the likelihood of the four characteristics of category 1 was higher than that of category 2, therefore they were dubbed the "good health group," with a total of 851 cases (86.0%) being assigned to this category. Category 2 was dubbed the "general health group," with 144 cases (14.0%) falling into this category. The two latent classes also shared

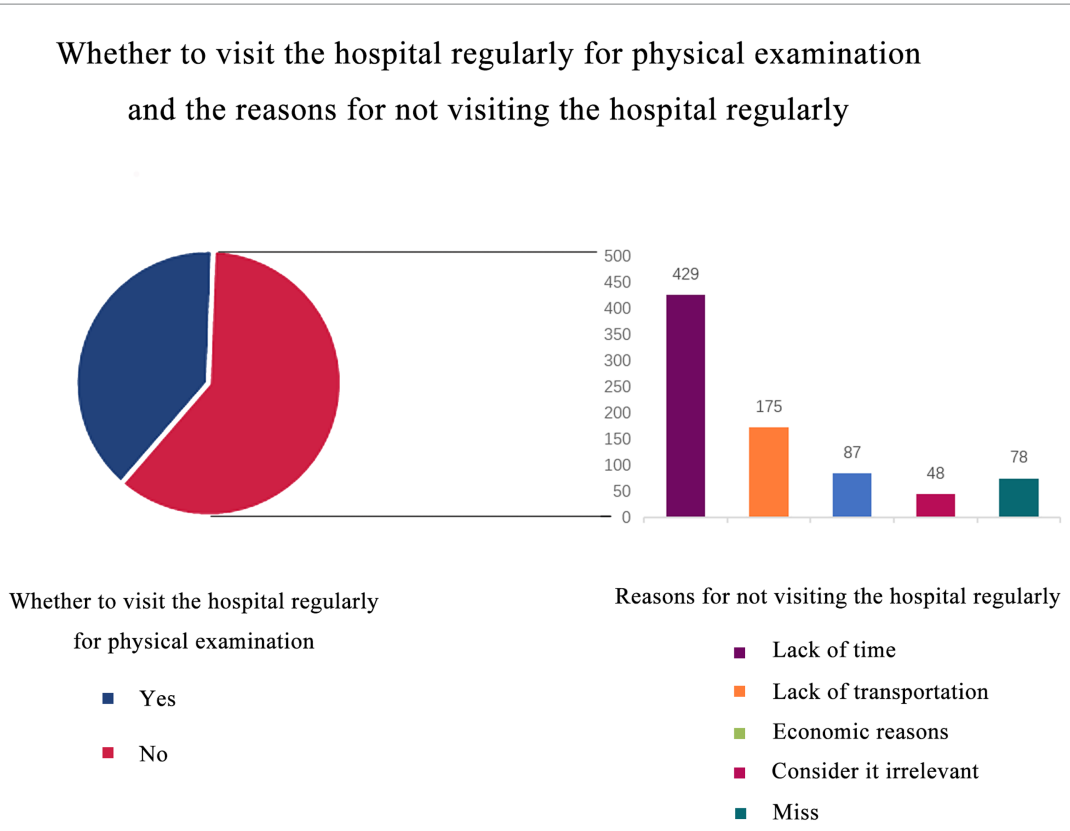


FIGURE 1
Whether to visit the hospital regularly for physical examination and the reasons for not visiting the hospital regularly. 39.2% of them would go to the hospital regularly for physical examination, while 60.8% of them would not. We used the bar chart to analyze the reasons for not going to the hospital regularly, and the most common reason was lack of time.

several characteristics: high scores in dietary habits and living habits, and low scores in both.

3.6. Influencing factors of latent classes of population health status in Naqu, Tibet

Combined with the existing researches, the relationship between gender, age, education level, different occupations, marital status, and monthly income and the latent health classes of the population in Naqu area of Tibet was analyzed as independent variables. Univariate logistic regression analysis (Table 6) showed that Monthly income of more than ¥5,000 was related to the grouping of latent health classes of the population in Naqu, Tibet. After adjusting for other factors, the results of the multivariate logistic regression analysis still showed that the health of those monthly income more than ¥5,000 was poor than others (Table 6). Univariate and multivariate logistic regression analysis showed that monthly income more than ¥5,000 was an independent risk factor for poor health status.

4. Discussion

The Tibetan region of China has a unique alpine climate and hypoxic environment. The duration of sunlight in Tibetan highlands is long, and UV radiation is substantially higher than in lower altitude areas. In this extreme environment, Tibetan living habits and diets are strongly influenced by regional biogeography, indigenous traditions, popular religious beliefs and dietary taboos (11, 12). It is characterized by beef and mutton meat, dairy products, and fewer fruits and vegetables, and its vitamin C intake is much lower than that in plain areas. Their daily staple food is zanba, and a common drink is buttered tea (10, 13). Therefore, the diet of high-altitude residents is high in fat, high in cholesterol, and low in vitamins (14). Plains, low oxygen stress has a major impact on the physiological functions of people who have lived on the plains for generations and have recently moved to the plateau. However, the indigenous Tibetans have a strong adaptability to the plateau (15), and it has been confirmed that this adaptability to high altitude may be related to the genes of the Tibetan people (16, 17).

It has been reported that 1.2–33% of the population at high altitude are not adapted to the hypoxic environment, and are prone to hypercellularity of high altitude polycythemia (HAPC), which results in increased blood viscosity, slow blood flow, increased blood volume, aggravated ischemia and hypoxia, microcirculatory disturbances, and affected systemic tissues and organs. Patients are prone to dizziness, headache, dyspnea, palpitations, sleep disturbances and other symptoms, and are susceptible to stroke and myocardial ischemia (18). A cross-sectional study in 2015 showed that the prevalence of hypertension, diabetes, overweight/obesity, dyslipidemia, and current smoking in Tibetan adults were 62.4, 6.4, 34.3, 42.7, and 6.1%,

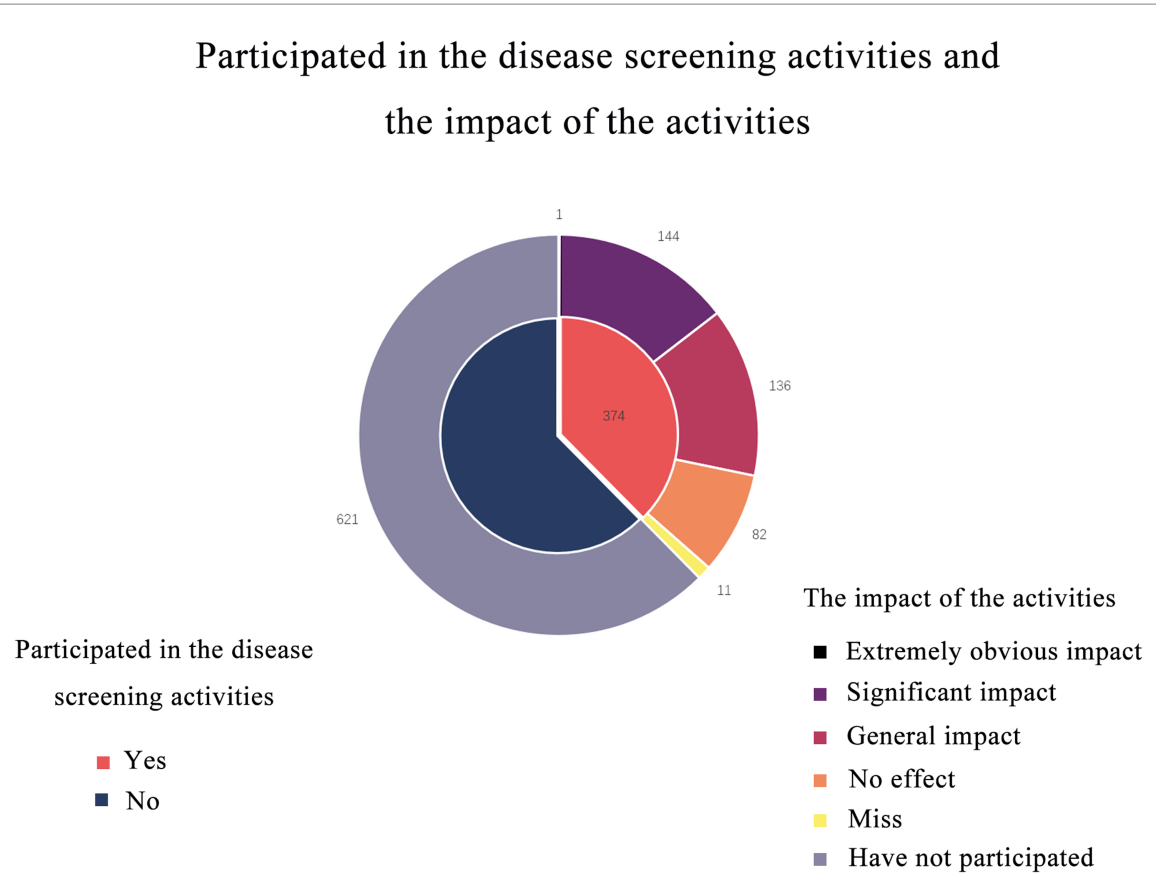


FIGURE 2
Double-layer pie chart shows participation in screening activities and the impact of the activities. 374 (37.6%) people participated in disease screening activities. Most people believed that the screening program had an impact on their health behavior.

respectively. A previous study showed that the age-standardized prevalence rates of dyslipidemia, hypertension, diabetes, current smoking, and overweight in Chinese adults aged 35–74 years were 53.6, 26.1, 5.2, 34.4, and 28.2%, respectively, and that the prevalence rates of dyslipidemia were higher in those who did not consume butter tea (19).

The four sections included in our health score were: dietary habits, living habits, health knowledge, and clinical disease history. The *t*-test and ANOVA results of the total health score of different groups revealed that the older the age, the lower the health score; people with a high school education or higher had significantly higher health scores than those with lower education levels. Unemployed, herdsmen, and farmers had worse health scores than the general population, whereas students and other occupational categories had higher health scores than the general population. Unmarried people had better health than those in other marital status groups. The higher the monthly *per capita* income, the better the health. Single young people with higher education and higher income have higher health scores and better physical health status. The results were similar to those in other regions of China (20–22).

Taking dietary habits, living habits, health knowledge and clinical disease history as explicit variables, the potential groups of health status of the population in Naqu, Tibet were classified. The subjects were divided into two classes. The probability of the four dimensions of class 1 was higher than that of class2, so it was named as "good health group" and "general health group." The relationship between latent health classes and gender, age, different occupations, education, marital status, monthly income was analyzed.

The results showed that the probability of four dimensions was higher in the "good health group" than in the "general health group," and the two latent classes also shared some common characteristics: high scores in dietary habits and living habits, and low scores in both health knowledge and clinical disease history. According to univariate and multivariate logistic regression analysis, monthly income higher than 5,000 was an independent risk factor for influencing the study participants to be classified in the group with poor health status.

The total score did not differ significantly between genders, although there were significant difference in living habits and clinical disease history. Women's living habits scores were higher than men's, but their clinical disease history scores were lower. Gender has been identified as a major factor influencing living habits (23). In addition, according to the 2018 National Health Service Survey, the two-week prevalence rate of women in Tibet was much greater than that of men. The two-week prevalence rate was positively related to age and economic level, but negatively related to education (24). The health of Tibetan women demands our concern due to their physiological constitution and the stress of living.



FIGURE 3
The participation and effect of health education activities. Each question accounted for an average of one quarter of the inner circle, and the corresponding response to each question was distributed according to the proportion within the inner quarter circle.

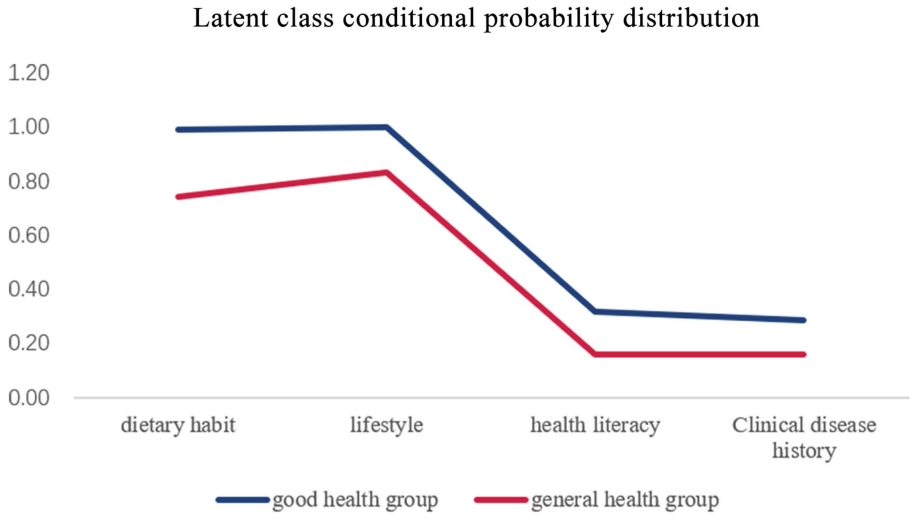


FIGURE 4
Latent class conditional probability distribution. Latent class analysis divided the population into two groups: good health group and general health group. The line graph shows how high or low each group scored on the four dimensions, representing each type of feature.

TABLE 4 Latent class model fitting index of health status.

Model	K	Log(L)	AIC	BIC	aBIC	Entropy	BLRT(*p*)	LMRT(*p*)
1	4	−2615.82	5239.65	5259.26	5246.56			
2	9	−1656.51	3331.03	3375.15	3346.57	0.29	<0.001	<0.001
3	14	−1654.98	3337.95	3406.59	3362.13	0.63	0.67	0.36
4	19	−1654.27	3346.55	3439.70	3379.35	0.69	0.67	0.59

TABLE 5 Latent class conditional probability distribution.

Class	*n*(%)	Dietary habits	Lifestyle	Health literacy	Clinical disease history
Good health group	851 (0.86)	0.99	1.00	0.32	0.29
General health group	144 (0.14)	0.74	0.83	0.16	0.16

At the same time, differences in health scores between age groups in terms of living habits and clinical disease history were statistically significant. The younger the age, the healthier the living habits and the fewer clinical disease history. This could be due to the fact that they live less stressful lives, have better sleep habits, can maintain exercise habits, and may smoke and drink less. The older you get, the worse your physical function becomes and the more clinical disease history you have. In addition to our conventional notions of undesirable habits such as smoking and drinking. In recent years, an increasing number of studies have discovered that sleep quality is closely associated to health. Sleep difficulties have been linked to inflammatory responses in the body, psychological issues, and even increased mortality in adults (25–27). As a result, excellent sleep habits, regular exercise, and quitting smoking and drinking can all help to improve physical health.

In terms of dietary habits, living habits, and health knowledge, our study discovered that differences in health scores of different education levels and different occupations were statistically significant. There were also statistical differences in clinical disease history scores between different occupations. The higher the educational level, the higher the social position, the more the emphasis on health, the greater the social contact, and the more hopeful mental state, which influences living habits (28). According to research studies, highly educated people have a high level of health information literacy (29). As for the fact that people with primary and junior high school education have lower dietary habits than the other two groups, we speculate that this is because people with this education level are mostly herdsmen and farmers in the Naqu. They cannot ensure a regular three meals a day during their occupations.

Animal husbandry is the pillar industry of Tibet, and the Tibetan people have a profound historical tradition and rich practical experience in animal husbandry since ancient times (30). 63.3% of our participants were herders or farmers. Herdsmen's and farmers eat fewer fresh vegetables and fruits all year because of their nomadic living habits, and herders and farmers' domicile and access to medical institutions could be better (24). And they have limited access to health care and a poor understanding of health information (31). As a result, herders and farmers performed poorly in all four components. Students performed better in all four parts, most likely because they were younger, had a normal school schedule, ate three meals per day, and were given more health information. Thus, herdsmen and farmers performed poorly in all four sections.

In all four sections, the differences in health scores by marital status were statistically significant. Marriage can greatly increase income and happiness, as well as promote physical and mental health. Marriage also brings greater happiness to men than to women (32, 33). However, the results of our *t*-test, ANOVA, logistic regression analysis, and subsequent analysis of latent categories showed that the unmarried group scored lower than the married group only in terms of dietary habits. Married people are more likely to have a regular family life and therefore better dietary habits than the unmarried group. Unmarried people had a higher average living habits score than the married group, probably because their lives were freer and more flexible. Although the results of some studies are contrary to our results, according to our survey on the living conditions of local residents, the married people may bear more social, family and work pressure than the unmarried people. These hidden pressures cannot be revealed through existing indicators. Our study also did not examine life well-being, which may be one of the reasons why unmarried people in this paper have better health than married people.

People with a monthly income of between ¥2001 and ¥5,000 were considered to be well-off, as they could afford three meals a day and regular work and rest, and their life pressures were moderate, so their dietary habits score was higher than other income groups. As a result, their dietary habits, living habits and clinical disease history scores were higher than those of other income groups. The higher the level of education, the higher the health knowledge score; and the higher the monthly *per capita* income, the higher the health knowledge score. People with higher monthly incomes pay more attention to health issues and therefore have more comprehensive health and psychological knowledge. Higher monthly income contributes to the acceptance of health knowledge (34), but the work stress and adverse health outcomes associated with higher income cannot be ignored (35).

In a separate analysis of health information literacy, it is not difficult to see that many people are in the habit of having frequent physical examinations at the hospital, as well as participating in disease screening and health promotion activities. However, transport and income constraints prevent people from having regular health checks. According to the results of our study, more than half of the participants believed that "whether participating in health screening

TABLE 6 Univariate and multivariate logistic regression analysis were performed after latent class analysis.

Characteristic	Class1(%)	Class2(%)	Crude			Adjusted		
			OR	95%CI	*p*	OR	95%CI	*p*
Gender								
Male	492 (57.8)	94 (65.3)						
Female	359 (42.2)	50 (34.7)	1.37	0.948–1.983	0.093	1.43	0.975–2.103	0.067
Age groups, years								
18 ~ 30	421 (49.5)	70 (48.6)						
31 ~ 50	329 (38.7)	52 (36.1)	1.052	0.715–1.548	0.797	1.091	0.689–1.727	0.711
51~	101 (11.9)	22 (15.3)	0.764	0.451–1.292	0.315	0.759	0.423–1.357	0.351
Education								
Illiteracy	468 (55.0)	74 (51.4)						
Primary and Junior High schools	164 (19.3)	37 (25.7)	0.701	0.455–1.081	0.108	0.790	0.498–1.256	0.319
High school and above	219 (25.7)	33 (22.9)	1.050	0.676–1.630	0.830	1.287	0.682–2.43	0.437
Occupations								
Herdsmen and farmer	537 (63.1)	93 (64.6)						
Other	314 (36.9)	51 (35.4)	1.07	0.738–1.541	0.733	1.167	0.730–1.866	0.517
Marital status								
Married	601 (70.6)	96 (66.7)						
Unmarried	250(29.4)	48(33.3)	0.8321	0.571–1.212	0.338	0.676	0.423–1.080	0.102
Monthly income (RMB)								
Below 2000	271 (31.8)	41 (28.5)						
2001 ~ 5,000	318 (37.4)	40 (27.8)	1.203	0.756–1.914	0.43	1.242	0.772–1.996	0.372
More than 5,000	262 (30.8)	63 (43.8)	0.630	0.410–0.966	0.034	0.596	0.381–0.933	0.024

activities will affect their health behavior" and "whether participating in health promotion activities will affect their health behavior" had a moderate or no effect on their health behavior.

On the one hand, we can find answers to the health education channels; however, the intrinsic education activities through community and hospital channels are unable to attract more people to participate in the form of a single, and its influence is also unimpressive; on the other hand, the educational level of our subjects is relatively low; the majority of them are illiterate or have just completed primary and junior high school. According to a 2021 study conducted in Nanjing, China, current health education and promotion intervention tactics are ineffective for people with low education levels (29). As a result, it is essential to develop diverse and highly targeted personalized health education approaches to reduce the difficulty of absorbing health education information among low-educated groups.

In general, the people of Naqu, Tibet, have healthy dietary habits and living habits, but they have lower health knowledge and a higher prevalence of clinical diseases. Disease screening and health education should be improved. Tibet's economy has grown dramatically in recent years, and living conditions have improved.

However, there is still a need to continue to improve the level of medical and health care in the Naqu, with particular attention to the health level of herders and farmers and the dissemination of health knowledge for this population, introduce medical and health professionals, provide free medical care, and carry out other activities to promote the health of people in Naqu.

5. Conclusion

Single, well-educated young adults in Naqu, Tibet, have outstanding physical and mental health. The vast majority of people in Tibet's Naqu region were in good health. Furthermore, the population's latent health status was divided into two classes, each with good dietary and living habits choices, low health knowledge, and a history of several clinical diseases. Univariate and multivariate logistic regression analysis showed that monthly income more than ¥5,000 was an independent risk factor for poor health status.

6. Limitations

There are several limitations that must be addressed. This is a cross-sectional study, so the conclusion of causality is weak. Alternatively, some of the items in our questionnaire may cause respondents to have a recall bias. Our judgments of the participants' health were based on past research and conventional knowledge, which may have been skewed.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Naqu People's Hospital Medical research and New technology Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JC: original draft preparation, methodology, software analysis, formal analysis, and data curation. ON: investigation, resources, manuscript review, and editing. DZ, CJ, RW, YC, and YD: investigation, data entry, and data curation. XX and XL: investigation, resources, manuscript review, editing, and supervision. All authors contributed to the article and approved the submitted version.

Funding

This study was supported by the 2021 Regional Science and Technology Collaborative Innovation Special Project (Project No. QYXTZX-NQ2022-03), Science and Technology Program of Tibet Autonomous Region (Project No. XZ202301YD0038C) and the general program of the Liaoning Provincial Department of Education (Project No. LJKZ0849).

Acknowledgments

We would like to thank the research subjects for their willingness to participate and the people who participated in this research and provided assistance.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1223382/full#supplementary-material

References

1. Ma Y, Zhu L, Ma Z, Gao Z, Wei Y, Shen Y, et al. Distinguishing feature of gut microbiota in Tibetan highland coronary artery disease patients and its link with diet. *Sci Rep*. (2021) 11:18486. doi: 10.1038/s41598-021-98075-9

2. Dougherty L, Bellows N, Dadi C. Creating reproductive health behavioral profiles for women of reproductive age in Niger using cross-sectional survey data: a latent class analysis. *Int J Public Health*. (2023) 68:1605247. doi: 10.3389/ijph.2023.1605247

3. Daignault I, Deslauriers-Varin N, Parent S. Profiles of teenage Athletes' exposure to violence in sport: an analysis of their sport practice, athletic behaviors, and mental health. *J Interpers Violence*. (2023) 38:7754–79. doi: 10.1177/08862605221148216

4. Shi J, Tao Y, Yan C, Zhao X, Wu X, Zhang T, et al. A study on the correlation between family dynamic factors and depression in adolescents. *Front Psych*. (2022) 13:1025168. doi: 10.3389/fpsyt.2022.1025168

5. Yin Y, Zhang J, Chen Y. Research progress on dialectical catering management of traditional Chinese medicine for the older adults based on health quotient theory. *J Nurs Sci*. (2020) 35:111–2. doi: 10.3870/j.issn.1001-4152.2020.06.111

6. Li H, Chen F. A three-factor structural equation model of health quotient, mobility quotient and well-being index of the older adults under the background of successful aging. *Chin J Gerontol*. (2021) 41:4404–8. doi: 10.3969/j.issn.1005-9202.2021.19.072

7. Han Y, Liu Y, Chen S, Li Q, Yang J, Zhang J. Health status of health check-up population in Beijing in 2020. *J Health Exam Manag*. (2022) 3:111–7.

8. Al-Balas M, Al-Balas HI, Jaber HM, Obeidat K, Al-Balas H, Aborajooh EA, et al. Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: current situation, challenges, and perspectives. *BMC Med Educ*. (2020) 20:513. doi: 10.1186/s12909-020-02257-4

9. Tao B, Lu T, Chen H, Yan J. The relationship between psychological stress and emotional state in Chinese university students during COVID-19: the moderating role of physical exercise. *Healthcare*. (2023) 11:11050695. doi: 10.3390/healthcare11050695

10. Xiao Z, Sun X, Zhaxi D, Zhang F, Ji Y, Cheng T, et al. Distinct nutrient intake style in inhabitants of ultra-high-altitude areas in north of Tibet, China: a cross-sectional study based on newly developed Tibetan food frequency questionnaires. *Front Nutr*. (2021) 8:743896. doi: 10.3389/fnut.2021.743896

11. Zhou C, Li M, Liu L, Zhao F, Cong W, Zhang F. Food consumption and dietary patterns of local adults living on the Tibetan plateau: results from 14 countries along the Yarlung Tsangpo River. *Nutrients*. (2021) 13:2444. doi: 10.3390/nu13072444

12. Zhou CN, Li M, Xiao R, Zhao FJ, Zhang FS. Significant nutritional gaps in Tibetan adults living in agricultural counties along Yarlung Zangbo River. *Front Nutr*. (2022) 9:845026. doi: 10.3389/fnut.2022.845026

13. Lv J, Qi P, Bai LH, Yan XD, Zhang L. Review of the relationship and underlying mechanisms between the Qinghai-Tibet plateau and host intestinal flora. *Front Microbiol*. (2022) 13:1055632. doi: 10.3389/fmicb.2022.1055632

14. Liu M, Yan M, Guo Y, Xie Z, Li R, Li J, et al. Acute ischemic stroke at high altitudes in China: early onset and severe manifestations. *Cells*. (2021) 10:809. doi: 10.3390/cells10040809

15. Li C, Li X, Liu J, Fan X, You G, Zhao L, et al. Investigation of the differences between the Tibetan and Han populations in the hemoglobin-oxygen affinity of red blood cells and in the adaptation to high-altitude environments. *Hematology*. (2018) 23:309–13. doi: 10.1080/10245332.2017.1396046

16. Sanchez K, Ballaz SJ. Might a high hemoglobin mass be involved in non-cardiogenic pulmonary edema? The case of the chronic maladaptation to high-altitude in the Andes. *Med Hypotheses*. (2021) 146:110418. doi: 10.1016/j.mehy.2020.110418

17. Simonson TS, McClain DA, Jorde LB, Prchal JT. Genetic determinants of Tibetan high-altitude adaptation. *Hum Genet*. (2012) 131:527–33. doi: 10.1007/s00439-011-1109-3

18. Dong Z, Hao Y, Zhang Y. Research advances in the treatment of metaplastic erythrocytosis. *J Mod Med Health*. (2021) 37:1309–12. doi: 10.3969/j.issn.1009-5519.2021.08.014

19. Xu S, Jiayong Z, Li B, Zhu H, Chang H, Shi W, et al. Prevalence and clustering of cardiovascular disease risk factors among Tibetan adults in China: a population-based study. *PLoS One*. (2015) 10:e0129966. doi: 10.1371/journal.pone.0129966

20. Wang H, Jiang F, Xu L, Liu Y, Qin Y, Gu X. High-risk status and influencing factors of chronic diseases among healthy people aged ≥18 years in Zhenjiang city. *Prev med Jiangsu Province*. (2022) 33:301–3. doi: 10.13668/j.issn.1006-9070.2022.03.016

21. Chen D. *Survey on health literacy and its influencing factors among general population in Hubei province*. China: Wuhan University (2017).

22. Zhang N, Yu J, Xu J, Wang Z. A cross-sectional study on the health literacy of four occupational groups in Xuanwu district of Beijing. *Chin J Health Educ*. (2012) 28:33–5.

23. Varì R, Scazzocchio B, D'Amore A, Giovannini C, Gessani S, Masella R. Gender-related differences in lifestyle may affect health status. *Ann Ist Super Sanita*. (2016) 52:158–66. doi: 10.4415/ANN_16_02_06

24. Deng R, Labasangzhu , Zhaxideji , Wang G, Hong P, Li J, et al. Illness prevalence rate in Tibet, China: data from the 2018 National Health Service Survey. *BMC Public Health*. (2020) 20:955. doi: 10.1186/s12889-020-08960-7

25. Mahon N, Glennon JC. The bi-directional relationship between sleep and inflammation in muscular dystrophies: a narrative review. *Neurosci Biobehav Rev*. (2023) 150:105116. doi: 10.1016/j.neubiorev.2023.105116

26. Hou X, Hu J, Wang E, Wang J, Song Z, Hu J, et al. Self-reported sleep disturbance is an independent predictor of all-cause mortality and respiratory disease mortality in US adults: a population-based prospective cohort study. *Int J Public Health*. (2023) 68:1605538. doi: 10.3389/ijph.2023.1605538

27. Qu G, Liu H, Han T, Zhang H, Ma S, Sun L, et al. Association between adverse childhood experiences and sleep quality, emotional and behavioral problems and academic achievement of children and adolescents. *Eur Child Adolesc Psychiatry*. (2023) 4:1–12. doi: 10.1007/s00787-023-02185-w

28. Gu L. An empirical analysis of educational attainment and health status of the older adults. In: *Forum On Contemporary Education*, vol. 6 (2010). 45–7. doi: 10.3969/j.issn.1671-8305.2010.06.0172

29. Shi C, Chen X, Wang N, Ynag F. *To analyze the trend of health literacy in people with different educational levels in Nanjing from 2014 to 2019 preventive medicine in Jiangsu Province*. (2021) 32:771–3+6. doi: 10.13668/j.issn.1006-9070.2021.06.045

30. Wang X. *Tibetan Momad's lifeway in social change and infulence factors: sociologyical interpretation of the Tridu country*. China: Northwest University for Nationalities (2011).

31. Wang Y, Dacherstein S, Wang S, Yao H. Relationship between life and dietary habits and health literacy level of Kazak herdmen. *Occup health*. (2021) 37:359–62+66.

32. Wang L. *Marital status and individual health—An empirical study based on Chinese household tracking survey data*. Shanghai Academy of Social Sciences (2019). Available at: https://kns.cnki.net/kcms2/article/abstract?v=A67obWUfw0mp0iP8PG30CrNIlhHz9LCzroyoF9_BL7RA3ILG-o3QGbxbYrcHGrlhSDPzLO1MYaFA6PrfJuLpavcA4xkC9-q_Gi5tsAl9dzaOyIGIL9XaoOIeDkYA15yHqtmqJw1FwXs=&uniplatform=NZKPT&language=CHS

33. Chen S. *Does marriage promote health*. East China Normal University (2019).

34. Wang WC, Zou SM, Ding Z, Fang JY. Nutritional knowledge, attitude and practices among pregnant females in 2020 Shenzhen China: a cross-sectional study. *Prev Med Rep*. (2023) 32:102155. doi: 10.1016/j.pmedr.2023.102155

35. Hiyoshi A, Honjo K, Platts LG, Suzuki Y, Shipley MJ, Iso H, et al. Trends in health and health inequality during the Japanese economic stagnation: implications for a healthy planet. *SSM Popul Health*. (2023) 22:101356. doi: 10.1016/j.ssmph.2023.101356

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 November 2023
DOI 10.3389/fpubh.2023.1238842

Check for updates

OPEN ACCESS

EDITED BY
Katherine Simone McGilton,
University Health Network, Canada

REVIEWED BY
Garyfallia Pepera,
University of Thessaly, Greece
Huaide Qiu,
Nanjing Normal University of Special Education, China

*CORRESPONDENCE
Filipa Alves da Costa
✉ alvesdacosta.f@gmail.com

RECEIVED 14 June 2023
ACCEPTED 23 October 2023
PUBLISHED 16 November 2023

CITATION
Viegas R, Alves da Costa F, Mendes R, Deidda M, McIntosh E, Sansano-Nadal O, Magaña JC, Rothenbacher D, Denkinger M, Caserotti P, Tully MA, Roqué-Figuls M and Giné-Garriga M (2023) Relationship of the SITLESS intervention on medication use in community-dwelling older adults: an exploratory study.
Front. Public Health 11:1238842.
doi: 10.3389/fpubh.2023.1238842

COPYRIGHT
© 2023 Viegas, Alves da Costa, Mendes, Deidda, McIntosh, Sansano-Nadal, Magaña, Rothenbacher, Denkinger, Caserotti, Tully, Roqué-Figuls and Giné-Garriga. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Relationship of the SITLESS intervention on medication use in community-dwelling older adults: an exploratory study

Ruben Viegas[1], Filipa Alves da Costa[1,2]*, Romeu Mendes[3,4], Manuela Deidda[5], Emma McIntosh[5], Oriol Sansano-Nadal[6,7], Juan Carlos Magaña[6], Dietrich Rothenbacher[8], Michael Denkinger[9], Paolo Caserotti[10], Mark A. Tully[11], Marta Roqué-Figuls[12] and Maria Giné-Garriga[6,13]

[1]Faculty of Pharmacy, iMED, Research Institute for Medicines, University of Lisbon, Lisbon, Portugal, [2]Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health and Science, Almada, Portugal, [3]EPIUnit - Instituto de Saúde Pública, Universidade do Porto, Porto, Portugal, [4]ACES Douro I – Marão e Douro Norte, Administração Regional de Saúde do Norte, Vila Real, Portugal, [5]Health Economics and Health Technology Assessment (HEHTA), Institute of Health and Wellbeing (IHW), University of Glasgow, Glasgow, United Kingdom, [6]Faculty of Psychology, Education and Sport Sciences Blanquerna, Universitat Ramon Llull, Barcelona, Spain, [7]School of Health and Sport Sciences (EUSES), Rovira i Virgili University, Tarragona, Spain, [8]Institute of Epidemiology and Medical Biometry, Ulm University, Ulm, Germany, [9]Institute for Geriatric Research at Agaplesion Bethesda Clinic and Geriatric Centre, Ulm University Medical Centre, Ulm, Germany, [10]Department of Sports Science and Clinical Biomechanics, Center for Active and Healthy Ageing, University of Southern Denmark, Odense, Denmark, [11]School of Medicine, University of Ulster, Londonderry, United Kingdom, [12]Iberoamerican Cochrane Centre, Biomedical Research Institute Sant Pau (IIB Sant Pau), CIBER Epidemiología y Salud Pública (CIBERESP), Barcelona, Spain, [13]Faculty of Health Sciences Blanquerna, Universitat Ramon Llull, Barcelona, Spain

Background: Sedentary behavior (SB) and physical activity (PA) interventions in older adults can improve health outcomes. Problems related with aging include prevalent comorbidity, multiple non-communicable diseases, complaints, and resulting polypharmacy. This manuscript examines the relationship between an intervention aiming at reducing SB on medication patterns.

Method: This manuscript presents a local sub-analysis of the SITLESS trial data on medication use. SITLESS was an exercise referral scheme (ERS) enhanced by self-management strategies (SMS) to reduce SB in community-dwelling older adults. We analyzed data from the ERS + SMS, ERS and usual care (UC) groups. Patient medication records were available at baseline and at the end of the intervention (4-month period) and were analyzed to explore the effect of SITLESS on medication patterns of use.

Result: A sample of 75 participants was analyzed, mostly older overweight women with poor body composition scores and mobility limitations. There was a significant reduction of 1.6 medicines (SD = 2.7) in the ERS group ($p < 0.01$), but not in the UC or ERS + SMS groups. Differences were more evident in medicines used for short periods of time.

Conclusion: The findings suggest that an exercise-based program enhanced by SMS to reduce SB might influence medication use for acute conditions but there is a need to further investigate effects on long-term medicine use in older adults.

KEYWORDS

physical activity, older adults, medication use, intervention, sedentary behavior, primary health care

1. Introduction

Increased longevity and improved health at older ages seen globally present significant challenges such as older adults having a higher prevalence of multimorbidity that often results in simultaneous treatment with multiple drugs (1). Polypharmacy (i.e., using five or more medications) (2) may increase the number of drug-related problems such as adverse effects and interactions, and is frequently associated with an increased use of potentially inappropriate medications (PIMs). Polypharmacy could have negative associations on long-term physical and cognitive functions (3–5).

Higher levels of physical activity (PA; occupational, commuting, leisure-time and household chores) have been significantly associated with a decreased risk of medicine use even after adjusting for sex, age, and economic status (6, 7). In a previous study, both medication use, and lack of PA were strongly associated with poor self-reported health status in older adults (8). More recently, sedentary behavior (SB; any waking activity in a sitting, reclining, or lying posture where energy expenditure is <1.5 metabolic equivalents) has been also considered an important determinant of health-related quality of life in older adults (9). Other studies conducted in a similar population showed that the likelihood of being categorized as highly sedentary increased with poor self-rated health, being overweight or obese, having a history of smoking, and multiple medication use (10, 11). An association between both sedentary time and cardiometabolic risk factors (such as metabolic syndrome and obesity) in older adults and between sedentary time and increased medication use have also been suggested (12).

However, evidence on whether a program aimed at reducing SB and increasing PA may help decrease medication use is yet to be established. This sub-study within the SITLESS Trial evaluated the relationship of an exercise referral scheme (ERS) enhanced by self-management strategies (SMS) aimed at reducing SB—SITLESS intervention- (13) and targeting community-dwelling older adults, on medication use compared to the ERS alone and usual care (UC) in a subsample of the population. Therefore, this study aims to understand how PA interventions in older adults can influence medication use. The main hypothesis established was that increased physical activity is associated with decreased medication needs. A secondary hypothesis was that the medication group that could potentially be reduced would be the medicines that affected the Central Nervous System.

2. Materials and methods

2.1. Participants

This research is a sub analysis of the SITLESS trial data. Briefly, SITLESS was a multi-center pragmatic three-armed randomized controlled trial conducted in 4 European countries. The purpose of the initial study was to assess the short and long-term effectiveness (and cost-effectiveness) of ERS program enhanced by SMS to reduce SB and increase PA and other health outcomes in community-dwelling European older adults (≥65 years old). The original SITLESS study was designed as RCT, where participants were randomly allocated into a usual care group (UC), a physical activity program alone (ERS), and the same physical activity program + Self-Management Strategies (ERS + SMS). Participants were recruited through primary care centers and posters, flyers, newspapers, radio broadcasts and social media outlets were also used to advertise the study as additional recruitment strategies, considering as eligibility criteria (1) aged 65 years or above; (2) community-dwelling; (3) able to walk without the help of another person for at least 2 min with or without a walking aid; (4) have no major physical limitations as shown by a score on the Short Physical Performance Battery (SPPB) of 4 or above [35]; (5) insufficiently active as determined by the following screening question: "Do you perform regular physical activity (PA) for at least 30 min five or more days of the week (referring only to PA that makes the participant become out of breath while doing it or such that it does not allow him/her to maintain a conversation while doing the activity; do not count regular walking)"; and/ or (6) report spending long periods of time in SB by answering affirmatively to the question: "For most days, do you feel you sit for too long (6–8 h or more a day)? Some examples might include when watching TV, working at the computer/laptop or when doing sitting-based hobbies such as sewing." The sample was estimated aiming to detect a moderate effect size of 30 daily counts per minute (CPM) in a two-sided test, at a power of 80% and an α of 0.05, a common standard deviation of 139 of the mean and a 24% dropout rate. Included participants were insufficiently active (<150 min/week) and/or reported being highly sedentary (>6 h in SB). More information about the SITLESS study can be found elsewhere (13).

The ERS was a 16-week program with two 60-min sessions per week, including aerobic, balance and resistance training. The ERS + SMS participants received, concurrently to the 16-week PA program offered to ERS participants, a face-to-face visit, six-group sessions and four telephone calls. Participants allocated to the usual UC were offered two health advice meetings with general recommendations on healthy lifestyle.

For this sub-study, we used a convenience sample of 75 of 337 older adults from Barcelona, who had information on the number of medicines at baseline and post-intervention (month 4) and further explored a sub-sample of 20, who had specific information on the active ingredients being used on both these periods. For this analysis, besides analyzing the 3 groups separately, we explored possible combinations of the groups to identify relationships: (UC + ERS) and [ERS + (ERS + SMS)].

2.2. Data collection

The current study complements previous research by exploring whether the SITLESS intervention led to a change in overall medication use after the intervention (4-month follow up). All data were collected between 2016 and 2017. Medicines were identified from the medication database available and described using International Nonproprietary Names (INN). Besides prescription medicines, over the counter medicines and supplements, such as vitamins, were also considered for this analysis. The number and type of current medications were obtained through an individual interview. Information about medicines included the medicine brand name that was translated to INN, dosage, and daily frequency.

2.3. Statistical analysis

The main participant characteristics are presented descriptively as mean and standard deviation (SD) for continuous variables or number and percentage for categorical variables. Covariates used to describe the sample included sex, age, Body Mass Index (BMI), waist and hip circumferences (WC and HC) and the Short Physical Performance Battery (SPPB) score. *T*-tests are used to identify changes in continuous variables from different groups between baseline and post-intervention. Other statistical methods such as a linear regression could not be employed due to the limited sample available for this sub-study.

In addition, a mixed-method approach was used to explore in more detail the pharmacotherapeutic groups whose consumption decreased following the SITLESS intervention. These are presented descriptively, and changes explained using as framework the mechanistic mode of action of each class and focusing on common characteristics.

All statistical analyses were performed using IBM SPSS Statistics 26 (SPSS, Inc., an IBM Company, Chicago, IL, United States) and the significance level was set at $p < 0.05$.

3. Results

Participants' characteristics at baseline are presented in Table 1. The sample was composed mostly of older overweight adults (77% female). The waist to hip ratio was on average 0.91 (SD = 0.09) which indicates a high health risk. Participants presented in average 3.2 (SD = 2.1) comorbidities: 52% had high blood pressure (UC 61%; ERS 46%; ERS + SMS 50%), 50% had arthritis (UC 48%; ERS 58%; ERS + SMS 42%), 31% had obesity (UC 13%; ERS 39%; ERS + SMS 39%), 20% chronic pain (UC 17%; ERS 19%; ERS + SMS 23%), 19% diabetes (UC 4%; ERS 19%; ERS + SMS 31%), 15% depressive disorders (UC 26%; ERS 12%; ERS + SMS 8%) and 12% anxiety disorders (UC 9%; ERS 12%; ERS + SMS 15%). The average blood pressure for the sample was 134.4 (SD = 15.9)/80.0 (SD = 12.0). Regarding smoking habits, 10% were active smokers, 23% ex-smokers and 67% non-smokers. Smokers had been smoking for 30.6 years (SD = 17.7) with an average of 13.4 (SD = 7.9) cigarettes per day. The SPPB score indicates that the sample had one or more mobility limitations.

Differences in medicine use were observed in the entire sample and in all subgroups (Table 2) between baseline and after the intervention. However, significant reductions in medicine use were most visible and significant only in the ERS alone group or when collapsing this group with the ERS + SMS group.

The subgroup of patients that had a complete medication record ($n = 20$) including active ingredients and dosages was analyzed to better understand the type of changes that might have happened (Table 3). Most changes occurred in medicines that were used for acute situations (e.g., vitamins, eye drops or anti-inflammatories).

4. Discussion

This study contributes to the evidence base on medication use impacts of interventions aimed at reducing SB and promoting PA in community-dwelling older adults. It was hypothesized that the SITLESS intervention would contribute to a change in medication use patterns. We could observe a reduction for the whole sample and for the ERS groups but could not fully explain all the causes for this reduction. The reduction of medicine burden in older adults can be one solution for the growing problem of polypharmacy, that could have negative associations on long-term physical and cognitive functions (3–5). Exercise interventions could provide a solution for better health outcomes while providing older adults with a longer life and lower medicine burden.

The sample included in this sub analysis showed poor values of body composition (BMI = 29; waist to hip ratio = 0.91; daily step count around 5,000 steps). Interventions targeting SB and PA can lead to improved body composition and might prevent the development of chronic diseases, leading ultimately to lower use of medication by older adults (14, 15). In order to explore this relationship in further detail, more studies should aim to collect movement behavior in different timepoints (preferably with accelerometry), body composition and medication outcomes, and also analyze the interaction between these variables.

The difference in the number of medicines at baseline and after intervention seems to follow a trend of reduction in overall number of medicines taken, as seen in other studies (6). Even though the reduction was seen in the overall sample and in the subgroup ERS alone, the ERS + SMS group did not show a significant reduction. However, when combining these two subgroups [ERS alone +

TABLE 1 Sample demographic and descriptive characteristics at baseline.

	Total sample ($n = 75$) (77.3% female)	UC ($n = 23$) (82.6% female)	ERS ($n = 26$) (76.9% female)	ERS + SMS ($n = 26$) (73.1% female)	(UC + ERS) ($n = 49$) (79.6% female)	[ERS + (ERS + SMS)] ($n = 52$) (75.0% female)
Age	75.7 (SD = 6.5)	75.5 (SD = 6.7)	76.6 (SD = 7.0)	75.5 (SD = 6.7)	75.9 (SD = 6.5)	76.0 (SD = 6.8)
BMI	29.6 (SD = 5.2)	28.6 (SD = 4.1)	30.2 (SD = 4.5)	29.8 (SD = 6.6)	29.5 (SD = 4.3)	30.0 (SD = 5.6)
W/H ratio	0.9 (SD = 0.1)	0.9 (SD = 0.1)	0.9 (SD = 0.1)	0.9 (SD = 0.1)	0.9 (SD = 0.1)	0.9 (SD = 0.1)
SPPB	8.8 (SD = 2.5)	8.7 (SD = 2.6)	8.1 (SD = 2.9)	8.7 (SD = 2.6)	8.9 (SD = 2.4)	8.4 (SD = 2.7)
Comorbidities	3.2 (SD = 2.1)	3.3 (SD = 2.0)	3.3 (SD = 2.3)	3.1 (SD =1.9)	3.3 (SD = 2.2)	3.2 (SD = 2.1)
Daily step count	4716.9 (SD = 1960.3)	5262.4 (SD = 1998.9)	4175.3 (SD = 1903.8)	4756.9 (SD = 1921.7)	4694.1 (SD = 2003.6)	4478.2 (SD = 1915.3)

UC, Usual care; ERS, Exercise Referral Scheme; ERS + SMS, Exercise Referral Schemes and Self-Management Strategies; BMI, Body Mass Index; WC, Waist circumference; W/H ratio, Waist to hip ratio; SPPB, Short Physical Performance Battery.

TABLE 2 Changes in medicine use in the different groups.

Number of medicines	Baseline	End of intervention	Observed change
Total sample ($n = 75$)	5.7 (SD = 3.8)	4.6 (SD = 3.2)	−1.1 (SD = 2.7), $p < 0.01$
UC ($n = 23$)	4.8 (SD = 3.8)	3.7 (SD = 2.7)	−1.1 (SD = 2.8), $p = 0.08$
ERS alone ($n = 26$)	6.3 (SD = 4.1)	4.7 (SD = 3.5)	−1.6 (SD = 2.7), $p < 0.01$
ERS + SMS ($n = 26$)	5.9 (SD = 3.5)	5.4 (SD = 3.3)	−0.5 (SD = 2.7), $p = 0.30$
(UC + ERS) ($n = 49$)	5.5 (SD = 4.0)	4.2 (SD = 3.2)	−1.3 (SD = 2.7), $p < 0.01$
[ERS + (ERS + SMS)] ($n = 52$)	6.1 (SD = 3.8)	5.0 (SD = 3.4)	−1.1 (SD = 2.7), $p < 0.01$

UC, Usual care; ERS, Exercise Referral Scheme; ERS + SMS, Exercise Referral Schemes and Self-Management Strategies.

(ERS + SMS)] the change became significant also, suggesting the inability to detect a significant change in all subgroups receiving the main intervention (ERS) could result mainly from the small sample size and not from the intervention *per se*. It is also reasonable to expect longer-term effects of the SMS sessions enhancing the effects of the ERS, thus only captured later. SMS had been shown to be effective in changing behavior (16), thus to evaluate the effects of the SITLESS intervention in medication use, particularly the enhanced approach using SMS, compared to ERS alone or UC we may need a longer follow up. This gains relevance when the average number at baseline indicates polypharmacy (> 5 medicines) in most groups, which follows a growing trend of polypharmacy in the last years (17). Future studies should aim for obtaining medication use data and whenever possible supplement patient-reported information with electronic health records (18, 19).

Due to the limited sample, we could not explore in detail the causes for the change in medicine use. A more robust sample would have allowed to use a regression model that could provide some clues on the reason for the change in medicine use. Medication management is a complex process that involves multiple healthcare professionals and the patient as the main player. Multiple challenges are known to arise when managing polypharmacy (e.g., transition of care, duplication of therapy, etc.) (20). Future studies could consider the continuum in patient centered care and whenever full integration of electronic records is not possible, increasing the number of contact points with the healthcare system, including with the local pharmacy. This could lead to more detailed and robust information to explore the effects of any intervention on medication patterns (21).

Lastly, the mixed-methods approach taken to explore qualitatively the medication classes most associated with decreases in the overall number of medicines can provide some clues on possible short-term effects of interventions targeting SB. We observed that medications used for acute conditions were those more frequently removed, including painkillers. However, to a lower extent, there was also removal of medications whose effectiveness is questionable (e.g., vitamins) or removal of potentially unsafe medications, including interactions (e.g., acenocumarol + aspirin) or potentially inappropriate medications (e.g., antidepressants with fall-inducing potential). Exercise interventions can support older adults in the prevention of falls and fall-related injuries (22, 23). Considering this, paying special attention to medicines that can affect balance or have a fall-inducing potential can have a protective effect on older adults and ultimately reduce fall risk and improve quality of life. In the current study, we could not fully explore changes in therapeutic subgroups, where changes could be expected, such as fall-risk increasing drugs (FRIDs, which include, e.g., drugs causing sedation, e.g., antipsychotics, drugs causing hypotension, e.g., loop diuretics, drugs with anticholinergic effects, e.g., tricyclic antidepressants, drugs causing bradycardia, e.g., antiarrhythmics, and other associated classes), mostly because of the limited sample size of the sub-analysis but also because of the pitfalls in recording of medication data. However, it has been shown that exercise is the single intervention demonstrated to significantly reduce the rate of falls in community-dwelling individuals (24), which is often associated to deprescribing following medication review in multifactorial interventions (25).

In general, the total quantitative difference might be low; however, qualitatively, the changes observed are aligned with pharmaceutical care principles, by focusing on necessity (e.g., pain-killers patient #11 and #4), effectiveness (e.g., supplements patient #8) and safety (e.g., CNS-acting medicine—patient #15 and #16; or interactions—patient #6). These findings suggest that for exploring the full potential of SB interventions on medication patterns, mixed methods are particularly useful as a change in number might not be clinically significant (26). The full potential of such analysis was however not reached as additional information on indication and duration of exposure would be needed for type 2 medication review. In such reviews, it would be possible to identify according to well established criteria, e.g., if removal of proton-pump inhibitors (patient #18) could also be justified by excessive duration. The benefits of type 3 medication review are even higher, but would also imply having additional information on comorbidities and laboratory values; these would allow judging if, e.g., removal of statins (patient #8 and #15) could be justified by effectiveness, as the most recent criteria consider there is no evidence to support the use of statins for primary prevention of cardiovascular disease in diabetes mellitus (27).

5. Conclusion

Many of the alterations in medication may be justified not only by the intervention but also by changes in the clinical condition, for which access to biochemical values would be valuable (e.g., to judge if the use of painkillers is done in the absence of tissue damage) and their absence constitutes one of the limitations of this study. A multidisciplinary approach to medication tracking using both data registries from physicians and pharmacists, and information from caregivers could add more accuracy to the reasons for changes in medication use. Another limitation of this study is the limited sample size with information on medicines used compared to the original sample ($n = 446$). This difference in sample size does not allow for a robust interpretation of the available data and only allows this study to provide an exploratory view of this topic. The reduction in the number of medicines could also be biased by the collection of data, as participants might not have recalled all the medicines after the

10.3389/fpubh.2023.1238842

TABLE 3 Detailed medication analysis ($n = 20$).

Patient ID	Group*	Initial medicine use (and number of medicines)	Post-intervention medication use (and number of medicines)	Difference in medicine number	Detail of difference in medicines
1	1	Brimonidine eye drops 1,5 g 1D; Dexamethasone eye drops 1 g 1D; Enalapril 20 mg 2D; Vitamin E 5,000 UI/10 mg 1D (n = 4)	Enalapril 20 mg 2D (n = 1)	−3	Two formulations removed were eye drops and another was a vitamin supplement.
2	1	Tramadol 50 mg 1D (n = 1)	Bisoprolol 2,5 mg; Omeprazole 20 mg 1D; Tramadol 50 mg 1D (n = 3)	+2	Inclusion of Bisoprolol and Omeprazole.
3	1	Bisoprolol 5 mg 1D; Losartan 50 mg 1D (n = 2)	Dabigatran 150 mg 1D; Omeprazole 20 mg 1D (n = 2)	0	Hypertension medication was removed, and dabigatran and omeprazole added.
4	2	Lisinopril 20 mg 1D; Metamizole 5 mg 0,5D; Verapamil 240 mg 1D; Vitamin D 1.5 mL 1D (n = 4)	Lisinopril 20 mg 1D; Verapamil 240 mg 1D; Vitamin D 1.5 mL 1D (n = 3)	−1	Metamizole was removed.
5	3	Acenocumarol20 mg 1D; Atorvastatin 20 mg1D; Bisoprolol 2.5 mg 3D; Budesonide/formoterol 80/4,5 mcg 4D; Exenatide 10 mcg 2D; Furosemida40mg 1D; Linagliptin 5 mg 1D; Omeprazole 20 mg 1D; Spironolactone 60 mg 2D (n = 9)	Acenocoumarin 4 mg 1D; Atorvastatin 20 mg 1D; Bisoprolol 2,5 mg 3D; Budesonide/formoterol 80/4,5 mcg 4D; Diltiazem 60 mg 2D; Exenatide 10 mcg 2D; Furosemide 40 mg 2D; Insulin 3 mL 10 units 1D; Linagliptin 5 mg 1D; Omeprazole 20 mg 1D; Paracetamol 1 g 1D (n = 11)	+2	Paracetamol and insulin were added to diabetes therapy. Spironolactone was removed and diltiazem was added.
6	3	Acenocoumarin 4 mg 1D; Acetylsalicylic acid 100 mg 1D; Amiodarone 200 mg 1D; Atorvastatin 40 mg 1D; Enalapril 5 mg 1D; Tiotropium 18 mcg 1D (n = 6)	Amiodarone 200 mg 1D; Atorvastatin 40 mg 1D; Enalapril 5 mg 1D; Tiotropium 18 mcg 1D (n = 4)	−2	Removal of aspirin and acenocoumarin.
7	2	Calcifediol 0,266 mg 30D; Calcium carbonate 500 mg 2D; Amiloride 5 mg 1D; Hydrochlorothiazide 50 mg 1D (n = 4)	Calcium carbonate 500 mg 2D; Calcifediol 0,266 mg 30D; Amiloride 5 mg 1D; Hydrochlorothiazide 50 mg 1D (n = 4)	0	No changes.
8	2	Acetylsalicylic acid 100 mg 1D; Bimatoprost eye drops 0.3 mg 1D; Bisoprolol 5 mg 1D; Glycerol trinitrate 5 mg 1D; Olmesartan 40 mg 1D; Omeprazole 20 mg 1D; *Serenoa repens* 160 mg 2D; Simvastatin 20 mg 1D; Vitamin D 0.3 mg 30D (n = 9)	Acetylsalicylic acid 100 mg 1D; Bisoprolol 5 mg 1D; Glycerol trinitrate 5 mg 1D; Olmesartan 40 mg 1D (n = 4)	−5	Stopped omeprazole, a natural supplement of "*Serenoa repens*," vitamin D, simvastatin and bimatoprost eye drops.
9	3	Acetylsalicylic acid 100 mg 1D; Alopurinol 300 mg 1D; Atenolol 100 mg 1D; Atorvastatin 40 mg 1D; Fesoterodine 8 mg 1D; Metformin 850 mg 1D; Omeprazole 20 mg 0,5D; Paracetamol 500 mg 4D; Pioglitazone 30 mg 1D; Pregabalin 150 mg 1D; Valsartan 320 mg 1D; Vitamin D 0,266 mg 30D (n = 12)	Acetylsalicylic acid 100 mg 1D; Alopurinol 300 mg 1D; Alprazolam 0,25 mg 2D; Atenolol 100 mg 1D; Atorvastatin 40 mg 1D; Fesoterodine 8 mg 1D; Metformin 850 mg 3D; Omeprazole 20 mg 0,5D; Pioglitazone 30 mg 1D; Pregabalin 150 mg 1D; Valsartan 320 mg 1D; Vitamin D 0,266 mg 30D (n = 12)	0	Stopped paracetamol but alprazolam was added.
10	3	Enalapril 20 mg 1D; Hydrochlorothiazide 12,5 mg 1D; Omeprazole 20 mg 1D (n = 3)	Enalapril 20 mg 1D; Lorazepam 1 mg 1D; Omeprazole 20 mg 1D; Sertraline 100 mg 1D; Vitamin D 2,5 mL 30D (n = 5)	+2	Addition of sertraline, lorazepam, and vitamin D. Removal of hydrochlorothiazide.
11	2	Enalapril 5 mg 1D; Paracetamol 500 mg 3D; Tamsulosin 0,4 mg 1D; Vitamin B 1,000 mcg 30D (n = 4)	Enalapril 5 mg 1D; Tamsulosin 0,4 mg 1D; Vitamin B 1,000 mcg 30D (n = 3)	−1	Stopped paracetamol.

(Continued)

10.3389/fpubh.2023.1238842

TABLE 3 (Continued)

Patient ID	Group*	Initial medicine use (and number of medicines)	Post-intervention medication use (and number of medicines)	Difference in medicine number	Detail of difference in medicines
12	1	Atorvastatin 20 mg 1D; Dorzolamide 20 mg/mL 2D; Latanoprost 50 mcg/mL 1D; Timolol 5 mg 7 mL 2D (n = 4)	Atorvastatin 20 mg 1D; Dorzolamide 20 mg/mL 2D; Latanoprost 50 mcg/mL 1D (n = 3)	−1	Timolol (eye drops) was removed.
13	3	Alopurinol 300 mg 1D; Digoxin 0,25 mg 1D; Enalapril 5 mg 0,5D; Ferro glycine 100 mg 1D; Furosemide 40 mg 1D; Hydroxycarbamide 500 mg 2D; Ketoconazole 100 mL 3D; Paracetamol 1 g 2D; Salmeterol 25 mcg 2D; Spironolactone 25 mg 1D; Vitamin B 1,000 mcg 30D (n = 11)	Alopurinol 300 mg 1D; Digoxin 0,25 mg 1D; Enalapril 5 mg 0,5D; Ferro glycine 100 mg 1D; Furosemide 40 mg 1D; Hydroxycarbamide 500 mg 2D; Ketoconazole 100 mL 3D; Omeprazole 20 mg 1D; Paracetamol 1 g 2D; Salmeterol 25mcg 2D; Spironolactone 25 mg 1D; Vitamin B 1,000 mcg 30D (n = 12)	+1	Omeprazole was added.
14	1	Acetylsalicylic acid 100 mg 1D; Budesonide 200 mcg 4D; Calcium Carbonate 500 mg 2D; Galantamine 16 mg 1D; Hydrochlorothiazide 12,5 mg 1D; Lormetazepam 2 mg 1D; Losartan 50 mg 1D; Omeprazole 20 mg 1D; Paracetamol 1 g 1D; Salmeterol 50 mcg 2D; Simvastatin 10 mg 1D; Vitamin D 400ui 1D (n = 12)	Acetylsalicylic acid 100 mg 1D; Lormetazepam 2 mg 1D; Losartan 50 mg 1D; Omeprazole 20 mg 1D; Paracetamol 1 g 1D; Salmeterol 50 mcg 2D; Simvastatin 10 mg 1D (n = 7)	−5	Budesonide, Galantamine, Calcium, Vitamin D and Hydrochlorothiazide were removed.
15	2	Atorvastatin 10 mg 1D; Bisoprolol 2,5 mg 1D; Citalopram 10 mg 1D; Diazepam 2,5 mg 1D; Hydrochlorothiazide 12,5 mg 1D; Lisinopril 20 mg 1D; Pantoprazole 20 mg 1D; Warfarin 1 mg 1D (n = 8)	Atorvastatin 10 mg 1D; Bisoprolol 2,5 mg 1D; Diazepam 2,5 mg 1D; Lisinopril 20 mg 1D; Pantoprazole 20 mg 1D; Warfarin 1 mg 1D (n = 6)	−2	Hydrochlorothiazide and Citalopram were removed.
16	3	Acetylsalicylic acid 150 mg 1D; Amitriptyline 25 mg 1D; Bisoprolol 5 mg 1D; Fluoxetine 20 mg 1D; Flupenthixol + Melitracen 0,5 + 3 mg 1D; Hydrochlorothiazide 12,5 mg 1D; Ezetimibe 10 mg 1D; Metformin 850 mg 1D; Omeprazole 20 mg 1D; Quetiapine 25 mg 1D; Rosuvastatin 20 mg 1D; Valsartan 320 mg 1D (n = 12)	Acetylsalicylic acid 150 mg 1D; Amitriptyline 25 mg 1D; Bisoprolol 5 mg 1D; Clonazepam 2,5 mg/mL 1D; Duloxetine 60 mg 1D; Ezetimibe 10 mg 1D; Levodopa 200/50 mg 3D; Metformin 850 mg 1D; Omeprazole 20 mg 1D; Rosuvastatin 20 mg 1D; Valsartan 320 mg 1D (n = 11)	−1	Levodopa and Duloxetine were added. Flupentixol, Fluoxetine and Hydrochlorothiazide were removed.
17	2	Duloxetin 100 mg 1D; Lorazepam 0,5D; Otilonium bromide 40 mg 1D; Paracetamol 650 mg 1D (n = 4)	Duloxetin 100 mg 1D; Lorazepam 0,5D; Paracetamol 650 mg 1D; Vitamins 1D (n = 4)	0	Otilonium bromide was removed and vitamins were added.
18	2	Enalapril 50 mg 1D; Omeprazole 20 mg 1D (n = 2)	Enalapril 50 mg 1D (n = 1)	−1	Omeprazole was removed.
19	3	Lisinopril 5 mg 1D (n = 1)	Lisinopril 5 mg 1D; Sulpiride 200 mg 2D (n = 2)	+1	Sulpiride was added.
20	1	Acetylsalicylic acid 100 mg 1D; Omeprazole 20 mg 1D (n = 2)	Acetylsalicylic acid 100 mg 1D; Omeprazole 20 mg 1D; Paracetamol 500 mg 3D (n = 3)	+1	Paracetamol was added.

*Group 1=Usual Care; Group 2=Exercise Referral Scheme only; Group 3=Exercise Referral Schemes and Self-Management Strategies.

intervention. A thorough data collection for medicines, including those as main variables of the study, could be a first step into increasing accuracy and more associations between exercise and medication use.

Although this retrospective post-hoc analysis showed possible relationships between lifestyle interventions and medication use, the hypothesis established could not be confirmed. We have identified that

exercise interventions can have a modest impact in medication use (i.e., number) and identified some potential medicine groups that can be highlighted in future research (e.g., FRIDs, namely those causing sedation, causing hypotension, or with anticholinergic effects). More robust and exhaustive health information systems, strengthened by interprofessional efforts are needed to better capture the impact of lifestyle interventions on medication use patterns.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: dataset owned by the original article owner. Requests to access these datasets should be directed to MG-G, mariagg@blanquerna.url.edu.

Ethics statement

The studies involving humans were approved by the Ethics and Research Committee of Ramon Llull University (Fundació Blanquerna, Spain; reference number: 131400IP). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RV, FAC, RM, and MG-G: conceptualization and writing — original draft preparation. RV, FAC, MG-G, MR-F, MaD, MiD, and EM: methodology. OS-N, JCM, DR, MaD, MiD, PC, MT, and MG-G: data collection. RV, FAC, and RM: formal analysis. RV, FAC, RM, MaD, EM, OS-N, JCM, DR, MiD, PC, MT, MR-F, and MG-G: writing — review and editing. FAC, RM, and MG-G: supervision. All authors contributed to the article and approved the submitted version.

Funding

The SITLESS project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 634270. RV is a PhD scholar of Fundação para a Ciência e Tecnologia, I.P. (FCT), Ministério da Ciência e Tecnologia, Portugal (Grant number: SFRH/BD/13164/2022).

Acknowledgments

The authors thank all participants that volunteered to take part in the study and all primary health care professionals in charge of the recruitment and medication use data collection.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Maresova P, Javanmardi E, Barakovic S, Barakovic Husic J, Tomsone S, Krejcar O, et al. Consequences of chronic diseases and other limitations associated with old age – a scoping review. *BMC Public Health*. (2019) 19:1431. doi: 10.1186/s12889-019-7762-5

2. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. *BMC Geriatr*. (2017) 17:230. doi: 10.1186/s12877-017-0621-2

3. Jyrkkä J, Enlund H, Lavikainen P, Sulkava R, Hartikainen S. Association of polypharmacy with nutritional status, functional ability and cognitive capacity over a three-year period in an elderly population. *Pharmacoepidemiol Drug Saf*. (2011) 20:514–22. doi: 10.1002/pds.2116

4. Koyama A, Steinman M, Ensrud K, Hillier TA, Yaffe K. Long-term cognitive and functional effects of potentially inappropriate medications in older women. *J Gerontol A Biol Sci Med Sci*. (2014) 69:423–9. doi: 10.1093/gerona/glt192

5. Maher RL, Hanlon J, Hajjar ER. Clinical consequences of polypharmacy in elderly. *Expert Opin Drug Saf*. (2014) 13:57–65. doi: 10.1517/14740338.2013.827660

6. Bertoldi AD, Hallal PC, Barros AJD. Physical activity and medicine use: evidence from a population-based study. *BMC Public Health*. (2006) 6:224. doi: 10.1186/1471-2458-6-224

7. Pepera G, Mpea C, Krinta K, Peristeropoulos A, Antoniou V. Effects of multicomponent exercise training intervention on hemodynamic and physical function in older residents of long-term care facilities: a multicenter randomized clinical controlled trial. *J Bodyw Mov Ther*. (2021) 28:231–7. doi: 10.1016/j.jbmt.2021.07.009

8. Bertoldi AD, Barros AJ, Hallal PC, Lima RC. Drug utilization in adults: prevalence and individuals determinants. *Rev Saude Publica*. (2004) 38:228–38. doi: 10.1590/S0034-89102004000200012

9. Kim Y, Lee E. The association between elderly people's sedentary behaviors and their health-related quality of life: focusing on comparing the young-old and the old-old. *Health Qual Life Outcomes*. (2019) 17:131. doi: 10.1186/s12955-019-1191-0

10. Heseltine R, Skelton DA, Kendrick D, Morris RW, Griffin M, Haworth D, et al. "Keeping moving": factors associated with sedentary behaviour among older people recruited to an exercise promotion trial in general practice. *BMC Fam Pract*. (2015) 16:67. doi: 10.1186/s12875-015-0284-z

11. Mitchell RJ, Lord SR, Harvey LA, Close JC. Obesity and falls in older people: mediating effects of disease, sedentary behavior, mood, pain and medication use. *Arch Gerontol Geriatr*. (2015) 60:52–8. doi: 10.1016/j.archger.2014.09.006

12. Rezende LFM, Rey-López JP, Matsudo VKR, Luiz OC. Sedentary behavior and health outcomes among older adults: a systematic review. *BMC Public Health*. (2014) 14:333. doi: 10.1186/1471-2458-14-333

13. Giné-Garriga M, Coll-Planas L, Guerra M, Domingo À, Roqué M, Caserotti P, et al. The SITLESS project: exercise referral schemes enhanced by self-management strategies to battle sedentary behaviour in older adults: study protocol for a randomised controlled trial. *Trials*. (2017) 18:221. doi: 10.1186/s13063-017-1956-x

14. Deenik J, Tenback DE, Tak EC, Rutters F, Hendriksen IJ, van Harten PN. Changes in physical and psychiatric health after a multidisciplinary lifestyle enhancing treatment for inpatients with severe mental illness: the MULTI study I. *Schizophr Res*. (2019) 204:360–7. doi: 10.1016/j.schres.2018.07.033

15. Spiteri K, Broom D, Hassan Bekhet A, Xerri de Caro J, Laventure B, Grafton K. Barriers and motivators of physical activity participation in middle-aged and older

adults—a systematic review. *J Aging Phys Act*. (2019) 27:929–44. doi: 10.1123/japa.2018-0343

16. Lachman ME, Lipsitz L, Lubben J, Castaneda-Sceppa C, Jette AM. When adults Don't exercise: Behavioral strategies to increase physical activity in sedentary middle-aged and older adults. *Innov Aging*. (2018) 2:igy007. doi: 10.1093/geroni/igy007

17. Midão L, Giardini A, Menditto E, Kardas P, Costa E. Polypharmacy prevalence among older adults based on the survey of health, ageing and retirement in Europe. *Arch Gerontol Geriatr*. (2018) 78:213–20. doi: 10.1016/j.archger.2018.06.018

18. Grzeskowiak LE, Gilbert AL, Morrison JL. Methodological challenges in using routinely collected health data to investigate long-term effects of medication use during pregnancy. *Ther Adv Drug Saf*. (2013) 4:27–37. doi: 10.1177/2042098612470389

19. Lockery JE, Rigby J, Collyer TA, Stewart AC, Woods RL, McNeil JJ, et al. Optimising medication data collection in a large-scale clinical trial. *PLoS One*. (2019) 14:e0226868. doi: 10.1371/journal.pone.0226868

20. Ferreri SP, Hughes TD, Snyder ME. Medication therapy management: current challenges. *Integrat Pharmacy Res Pract*. (2020) 9:71–81. doi: 10.2147/IPRP.S179628

21. Liddy C, Blazkho V, Mill K. Challenges of self-management when living with multiple chronic conditions: systematic review of the qualitative literature. *Can Fam Physician*. (2014) 60:1123–33.

22. Pepera G, Krinta K, Mpea C, Antoniou V, Peristeropoulos A, Dimitriadis Z. Randomized controlled trial of group exercise intervention for fall risk factors reduction in nursing home residents. *Can J Aging*. (2023) 42:328–36. doi: 10.1017/S0714980822000265

23. Zhang Q, Liu Y, Li D, Jia Y, Zhang W, Chen B, et al. Exercise intervention for the risk of falls in older adults: a protocol for systematic review and meta-analysis. *Medicine*. (2021) 100:e24548. doi: 10.1097/MD.0000000000024548

24. Dautzenberg L, Beglinger S, Tsokani S, Zevgiti S, Raijmann R, Rodondi N, et al. Interventions for preventing falls and fall-related fractures in community-dwelling older adults: a systematic review and network meta-analysis. *J Am Geriatr Soc*. (2021) 69:2973–84. doi: 10.1111/jgs.17375

25. Seppala LJ, Kamkar N, van Poelgeest EP, Thomsen K, Daams JG, Ryg J, et al. Medication reviews and deprescribing as a single intervention in falls prevention: a systematic review and meta-analysis. *Age Ageing*. (2022) 51:afac191. doi: 10.1093/ageing/afac191

26. Pound P, Britten N, Morgan M, Yardley L, Pope C, Daker-White G, et al. Resisting medicines: a synthesis of qualitative studies of medicine taking. *Soc Sci Med*. (2005) 61:133–55. doi: 10.1016/j.socscimed.2004.11.063

27. O'Mahony D, O'Sullivan D, Byrne S, O'Connor MN, Ryan C, Gallagher P. STOPP/START criteria for potentially inappropriate prescribing in older people: version 2. *Age Ageing*. (2015) 44:213–8. doi: 10.1093/ageing/afu145

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 22 November 2023
DOI 10.3389/fpubh.2023.1289552

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Shinichi Tanihara,
Kurume University, Japan
Carlo Lazzari,
International Centre for Healthcare and Medical Education, Bristol, United Kingdom
Andrew Joyce,
Swinburne University of Technology, Australia

*CORRESPONDENCE
Hiroaki Saito
h.saito0515@gmail.com

RECEIVED 06 September 2023
ACCEPTED 02 November 2023
PUBLISHED 22 November 2023

CITATION
Abe T, Saito H, Moriyama N, Ito N, Takita M, Kinoshita Y, Ozaki A, Nishikawa Y, Yamamoto C, Zhao T, Sato M and Tsubokura M (2023) *Idobata-Nagaya*: a community housing solution for socially isolated older adults following the great East Japan earthquake. *Front. Public Health* 11:1289552. doi: 10.3389/fpubh.2023.1289552

COPYRIGHT
© 2023 Abe, Saito, Moriyama, Ito, Takita, Kinoshita, Ozaki, Nishikawa, Yamamoto, Zhao, Sato and Tsubokura. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Idobata-Nagaya: a community housing solution for socially isolated older adults following the great East Japan earthquake

Toshiki Abe[1], Hiroaki Saito[1,2]*, Nobuaki Moriyama[3], Naomi Ito[1], Morihito Takita[4], Yuri Kinoshita[3,5], Akihiko Ozaki[6], Yoshitaka Nishikawa[2,7], Chika Yamamoto[1], Tianchen Zhao[1], Mika Sato[8] and Masaharu Tsubokura[1]

[1]Department of Radiation Health Management, Fukushima Medical University School of Medicine, Fukushima, Japan, [2]Department of Internal Medicine, Soma Central Hospital, Fukushima, Japan, [3]Department of Public Health, Fukushima Medical University School of Medicine, Fukushima, Japan, [4]Research Division, Medical Governance Research Institute, Tokyo, Japan, [5]Division of Food Science and Nutrition, Tohoku Seikatsu Bunka Junior College, Sendai, Miyagi, Japan, [6]Department of Breast Surgery, Jyoban Hospital of Tokiwa Foundation, Fukushima, Japan, [7]Department of Internal Medicine, Hirata Central Hospital, Fukushima, Japan, [8]Department of Health Nursing of International Radiation Exposure, School of Medicine, Fukushima Medical University, Fukushima, Japan

Introduction: Following the Great East Japan Earthquake, the living environment of socially isolated older adults has become a pressing concern. In response, *Nagaya*, a collective housing program, was established in Soma City, Fukushima, Japan to address social isolation among older adults and support their long-term health. This study aimed to identify characteristics of individuals in Nagaya and examine the sustainability of this initiative.

Methods: We conducted a retrospective analysis of residents who were relocated to *Nagaya*, emphasizing their characteristics, the continuity of their stay in *Nagaya*, and their care certification levels, using data up to December 31, 2022. We employed Kaplan–Meier curves to analyze the duration for which residents continued to reside in *Nagaya* and the time leading up to the requiring care-level certification.

Results: Of 65 people who moved to *Nagaya* after the disaster, 30 people (46.2%) continued to live there, 21 (32.3%) died during their stay, and 14 (21.5%) moved out. The overall duration of occupancy averaged 6.39 years (SD 3.83 years). The proportion of requiring care-level certification occurrences per person-year was 0.0577 for those without care certification and 0.3358 for those with requiring support level at the time of moving in.

Conclusion: In summary, *Nagaya*-style communal housing may offer suitable living environments for older adults with diverse needs during disasters and serve as a valuable tool for developing public policies in aging societies.

KEYWORDS

social isolation, disaster, collective housing, long-term care, preventive care

1 Introduction

Promoting a longer, healthier life expectancy for older people is becoming increasingly important in regions with rapidly aging populations (1). In addition to various factors, including healthy diets, regular physical activity (2, 3), and economic stability (4), social factors, such as social interaction (5), community involvement (6), and the environment to live according to their own will (7), contribute to healthy living. However, older adults at high risk of social isolation might struggle to create such environments independently. Consequently, families and local governments need to provide supportive environments for older adults (8, 9).

In developed countries with rapidly aging populations, addressing the health, housing, and caregiving concerns of socially isolated older adults is becoming a critical public health issue. In 2020, Japan had an aging rate of 28.6%, with 15.0% of older men and 22.1% of older women living alone (10). China is also undergoing unprecedented rapid aging among developed nations (11). Along with population aging, social isolation and loneliness are increasingly recognized as significant health problems (12). Numerous studies have demonstrated that social isolation and loneliness can worsen the prognosis of affected individuals and increase the risk of early death and frailty, making it an urgent issue to address (13, 14). Consequently, addressing the needs of isolated older adults who struggle to receive family support is a substantial global challenge, and its importance is expected to grow.

In this context, learning from approaches employed to support isolated older people after the Great East Japan Earthquake provides insights for addressing challenges in rapidly aging regions. Prolonged evacuations following the 2011 Great East Japan Earthquake, tsunami, and nuclear accident exacerbated the isolation among older people, adversely affecting their health. There was a subsequent rise in the occurrence of chronic diseases and an elevated risk of receiving care certification (15–17). As the care demands increased, many older people, particularly those without supportive family members, often needed to be placed in managed care facilities, because it is more difficult for them to continue living in their original homes. This concern became especially relevant in areas affected by the 2011 disaster. Therefore, identifying a suitable living environment for isolated older people with or without the need for caregiver assistance remains a persistent issue in the aftermath of long-term evacuation scenarios.

One initiative aimed at addressing the long-term living needs of isolated older people following the Great East Japan Earthquake was the establishment of *Idobata-Nagaya*, a shared living housing model in Soma City. Soma City, which is located 40–50 kilometers from the Fukushima Daiichi Nuclear Power Plant, had a notably high aging rate in 2010, with 25.3% of its population aged over 65 years. The earthquake and subsequent tsunami resulted in 486 deaths in the area, leading more than 2000 people to evacuate to temporary housing (18). The region's infrastructure and medical system were vulnerable, and the working population later flowed to other regions (19). Older individuals who were self-reliant but had difficulty receiving family support, as well as those who experienced physical decline due to evacuation, wished to stay and continue living in the Soma region. They lived in temporary housing, but their long-term living environment was challenging because it was difficult to obtain support from the community and their families. In 2012, Soma City opened *Idobata-Nagaya*. "*Nagaya*" refers to a traditional architectural style of old Japanese houses (20). "*Idobata*" is a term used to denote a place for socializing. The amalgamation of these two terms led to the creation of "*Idobata Nagaya*" (hereafter *Nagaya*), which was designed as a hub for daily social interaction (21).Within *Nagaya*, residents convene for communal meals, participate in group exercise, monitor each other's health, and engage in spontaneous interactions (15, 21). The overarching vision of *Nagaya* was to cultivate a community wherein independent older individuals could either delay the need for assisted care or remain even if their health deteriorated. Evaluating the long-term impact of *Nagaya* can contribute to addressing housing issues for older individuals in the context of future disasters.

In this study, we aimed to elucidate characteristics of individuals who were deemed suitable to reside in *Nagaya*, a pioneering collective housing model, following the Great East Japan Earthquake. We also aimed to examine the sustainability of their residency and changes in their care needs over time. We hypothesized that the environment of *Nagaya* reduces the necessity for care for its residents, thus promoting longer durations of stay. By assessing the length of stay and care requirements, this research provides insights into how such housing models can address social isolation, particularly after disasters. Ultimately, we strived to contribute to the broader efforts of mitigating social isolation and enhancing the well-being of the older adult in our aged society.

2 Materials and method

2.1 Background and participants of *Nagaya*

This was a retrospective cohort study. The participants were those who moved to *Nagaya* in Soma City, Fukushima Prefecture, between May 2012 and December 2022. Between May 2012 and May 2013, five row houses were successively inaugurated, yielding 58 living spaces. At the time of admission, the residents had to be able to live independently and were unable to continue living elsewhere because of the earthquake's aftermath. To decide who will live in *Nagaya*, city employees conducted individual interviews with each potential inhabitant. The criteria used to determine who should reside in *Nagaya* were their chances of rebuilding their lives, the presence of family support, financial situation, age, any underlying illnesses, and the level of care needs (22).

2.2 Services provided in *Nagaya*

Nagaya was designed based on the assumption that independent older adults live together. The design of the building is a row house (Supplementary Figures S1, S2). In addition to two bedrooms and an eat-in kitchen room for everyone, a communal bath was installed, and a shared washing machine was provided. The city provides the following services to support daily life: (1) Lunch delivery: an external service delivers lunch boxes daily; (2) a health center nurse checks the residents' health status every 1–2 months; (3) a transportation service to nearby commercial facilities is provided regularly by bus for shopping purposes; and (4) a contracted caretaker monitors *Nagaya* regularly. Each *Nagaya* elects a delegate to oversee and maintain it autonomously. The representative coordinates lunch with the city's health department and monitors people's health.

2.3 Data used for analysis

The data used in this study were obtained from Soma City. The anonymized data included information on the residents' sex, age, underlying diseases, moving-in period, reasons for leaving *Nagaya*, and long-term care insurance system-determined care levels at the start of living and during their stay. In Japan's long-term care insurance system, care levels are determined based on activities of daily living and physical function. Requiring Long-term care certification starts with requiring support levels 1 and 2 (mild disability) and requiring long-term care levels 1 and 2 (moderate disability) and goes up to requiring long-term care levels 3–5 (severe disability), with a total of 7 stages (23). Older people certified as requiring support levels 1 or 2 can live independently but require some daily living assistance, whereas those certified as requiring long-term care levels 1 or 2 require more assistance. Furthermore, older people with a requiring long-term care level of 3 or higher require constant care and need to move to facilities such as nursing homes.

2.4 Statistical analysis

We investigated (1) residents' characteristics; (2) retention status in *Nagaya* after moving in, including the timing and reasons for leaving; and (3) changes in requiring support/long-term care levels over time. To assess retention, the number of years from moving in to a departure event was calculated by Kaplan–Meier curves. Regarding care level changes, residents without care level certification and those with certified requiring support levels at the time of moving in were targeted. Kaplan–Meier curves were calculated using years until a requiring long-term care level of 1 or higher certification event. Censorship occurred when residents died or left *Nagaya*. Only those who turned 65 years of age during the study period were included in the care-level change analysis since those under 65 years of age have different care certification requirements. This study was approved by the Ethics Review Committee of the Fukushima Medical University (approval number 2022-208). As this was an anonymized, information-based study, research consent was obtained using an opt-out approach.

TABLE 1 Characteristics of the residents.

Characteristic	Cohort (n = 65)
Age at starting residence, mean (SD)	76.2 (12.0)
Age at starting residence, *n* %	
<50 years	1 (1.5)
50–59 years	6 (9.2)
60–69 years	7 (10.8)
70–79 years	18 (27.7)
80–89 years	29 (44.6)
>90 years	4 (6.2)
Female, *n* %	46 (70.8)
Year at starting residence, *n* %	
2012	21 (32.3)
2013	27 (41.5)
2014	7 (10.8)
2015	8 (12.3)
2016	1 (1.5)
2017	0 (0)
2018	0 (0)
2019	1 (1.5)
Certification for requiring long-term care/support needs at starting residence, *n* %	
Without certification	43 (66.2)
Requiring support level 1	6 (9.2)
Requiring support level 2	4 (6.2)
Requiring long-term care level 1	3 (4.6)
Requiring long-term care level 2	4 (6.2)
Requiring long-term care level 3	2 (3.1)
Requiring long-term care level 4	2 (3.1)
Requiring long-term care level 5	1 (1.5)
Residence years, mean (SD)	6.39 (3.83)

SD, standard deviation.

3 Results

3.1 Background of the residents

After *Nagaya* began operations in April 2012, 65 people moved into *Nagaya* (Table 1). The average age at the time of moving in was 76.2 years (standard deviation [SD]: 12.0 years), with one person (1.5%) in their teens, six (9.2%) in their 50s, seven (10.8%) in their 60s, 18 (27.7%) aged 70 or older, 29 (44.6%) aged 80 or older, and four (6.2%) aged 90 or older.

3.2 Follow-up results: duration of stay and outcomes

Of the 65 people, 30 (46.2%) continued to reside in *Nagaya* until December 31, 2022; 21 (32.3%) died during their stay; and the remaining 14 (21.5%) left *Nagaya*. The main reason for leaving was moving to live with relatives (eight people), followed by health-related hospitalization or relocation to a facility (five people). The average overall duration of stay was 6.39 years (SD: 3.83 years), with a median of 7.04 years (interquartile range [IQR]: 3.82–9.08 years), ranging from 21 days to 10.7 years. Regarding the duration of stay, five people left within one year; four people died during the period, and one person left for admission to another facility. Six people left within three years, four people died during this period, and two people moved to live with relatives. Eleven people left within 5 years, with four dying during the study period, four moving to live with relatives, and three leaving for facility admission. The remaining 39 individuals continued to reside for over 5 years. Figure 1A depicts the Kaplan–Meier curve for residence discontinuation. The retention rate declined steadily. Figure 1B shows the Kaplan–Meier curve for residence discontinuation by requiring support/long-term care level at move-in. Details for each age group are provided in the Supplementary material.

3.3 Changes in requiring support and long-term care levels

At admission, 40 of the 62 people who were 65 years and older during the observation period had no requiring support/care

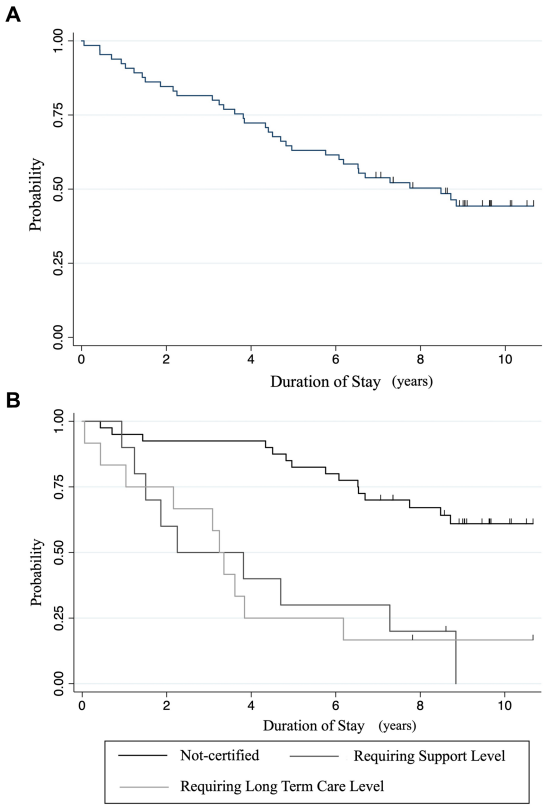


FIGURE 1
(A) Residence retention rates: a Kaplan–Meier survival analysis. **(B)** Residence retention rates by initial care level requirement: a Kaplan–Meier survival analysis. Discontinuation of residence occurred in cases of death, admission to other facilities, relocation to a family member's home, or departure. Censoring was only performed at the end of the observation period. "Support levels" means "requiring support levels." "Care levels" means "requiring long-term care levels."

certification, 10 had a requiring support level, and 12 had a requiring long-term care level (three with requiring long-term care level 1, four with level 2, two with level 3, two with level 4, and one with level 5) (Table 2). The annual rate of requiring long-term care-level certification was 0.0577 per person-year for the group without requiring support/care certification and 0.3358 per person-year for the group with requiring support-level certification at admission. Figure 2 shows the Kaplan–Meier curve for care-level certification by requiring support/long-term care level at move-in.

Supplementary Tables S1A–C summarize the status of long-term care certifications at 1, 3, and 5 years after admission. Although requiring support/long-term care levels generally increased over time, three people improved their care level during their stay in *Nagaya*; one resident started at requiring long-term care level 3 but improved to requiring long-term care level 2 after 2 years. One individual was certified as requiring long-term care level 2 at move-in, requiring long-term care level 1 a year later, and requiring support level 2 after 2 years. At move-in, the last person had requiring long-term care level 2 but was certified as requiring long-term care level 1 a year later.

4 Discussion

We observed a cohort of residents in *Nagaya,* disaster collective housing, 11 years after the community was established. The community welcomed not only independent older people but also those who needed care or were very old and struggling to live alone. Many residents continued living in the community for a long period, and the duration from moving to requiring care was maintained for an extended period. The study suggests that the *Nagaya* environment encourages residents to interact with the community, enabling many residents to maintain their health and continue their independent daily lives. The insights gained in this study can be applied to housing issues for isolated older individuals after other disasters and may also

TABLE 2 Characteristics regarding requiring long-term care/support levels at the time of starting the residence.

	Total (*n* = 62)	Requiring long-term care/support level at starting residence		
		Not-certified (*n* = 40)	Support level 1 or 2 (*n* = 10)	Long-term care level 1 to 5 (*n* = 12)
Age at starting residence, mean (SD)	77.8 (8.9)	75.9 (8.7)	83.6 (5.1)	79.3 (9.8)
Age at moving out, mean (SD)	84.1 (8.4)	83.4 (8.3)	87.8 (5.0)	83.2 (9.7)
Female, *n* %	45 (72.6)	30 (48.4)	8 (80.0)	7 (58.3)
Residence years, mean (SD)	6.32 (3.28)	7.70 (2.62)	4.10 (2.95)	3.79 (3.0)
Incidence rate for requiring long-term care level 1 or above (per person-years)	–	0.0577	0.3358	–
Current status of the residents[a], *n* %				
Continued occupancy	28 (45.2)	25 (62.5)	1 (10.0)	2 (16.7)
Deceased	21 (33.4)	9 (22.5)	6 (60.0)	6 (50.0)
Relocation	8 (12.9)	5 (12.5)	2 (20.0)	1 (8.3)
Admitted to another facility	5 (8.1)	1 (2.5)	1 (10.0)	3 (25.0)

SD, standard deviation.[a]Status as of December 31, 2022.

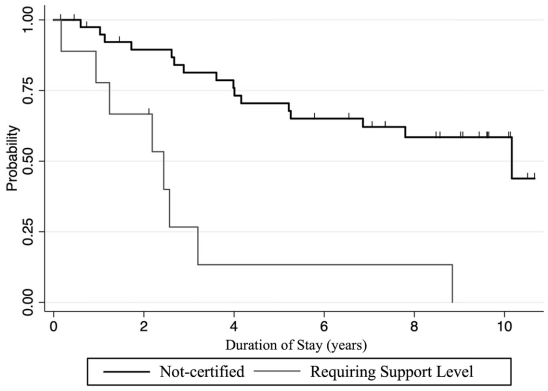


FIGURE 2
Kaplan–Meier survival analysis of transition to requiring long-term care levels after starting the residence. An event was defined as a newly certified event requiring long-term care after moving in. Censoring was performed at the end of the observation period or at discontinuation of residence.

be relevant to housing issues for older isolated individuals in aging societies.

The public housing community initiative contributed to the continued living of older individuals from diverse backgrounds in the Soma region following the disaster. A characteristic challenge in disaster-stricken areas, including the Soma region, is the emergence of diverse housing needs for a wide range of older individuals in terms of age, daily life independence, and frailty. This study revealed variations in age and independence levels among the residents, highlighting the importance of accommodating a diverse older population. Unlike traditional residential facilities with constant professional supervision, such as nursing homes, *Nagaya* fostered an environment for residents to interact and support each other (21). Unlike facilities with strict admission conditions based on care needs (24, 25), *Nagaya* embraced residents with varying levels of frailty and care requirements. While initially designed for independent older individuals, *Nagaya* unintendedly accommodated those requiring mild care, enhancing their quality of life. Although this study did not evaluate social formations among the residents themselves, by creating a supportive environment and promoting social interactions, *Nagaya* may have catered to the needs of older individuals with diverse backgrounds and contributed to their continued living arrangements in the region. The success of *Nagaya* demonstrates the potential of community-based solutions to address the complex care needs of older adults, especially in post-disaster scenarios.

Residents of *Nagaya* have demonstrated the ability to maintain their physical health and reside in the community for extended periods. While direct comparisons with previous studies are challenging, the outcomes appear favorable. For example, in a Japanese cohort study, 44.5% of 746 individuals requiring support level received care level certification within 2 years (26). In another Japanese cohort study, 4.1–4.3% of those requiring support levels transitioned to requiring long-term care level 3 or higher within 3 years, which aligns with the results of this study (27). Notably, given that more than 50% of the residents were aged 80 years or older, the results may be even more promising than those of previous studies. Interestingly, three of the residents in this cohort also showed improvement in their requiring support/long-term care level during their stay, suggesting that the environment in *Nagaya* contributed to reducing the level of care. The presence of a supportive community might have contributed to residents maintaining their independence and preventing the deterioration of care needs (15). Older people participating in social activities have a lower risk of functional disability and death (28, 29), and promoting social activities, including friend interactions, has been suggested to prevent the worsening of care levels (26). Additionally, prioritizing the independence of older adults can have positive impacts on their physical health (7, 30). Communities like *Nagaya* have the potential to uphold physical well-being and delay the transition from frailty to the need for extensive care for independent older individuals.

A notable finding of this study is that many older residents, including those who were very old or certified in care, were able to continue living in *Nagaya* for an extended period. Socially and physically vulnerable individuals may particularly benefit from living in *Nagaya*. After the disaster, those with higher care needs and those living alone are more likely to be negatively affected by changes in their living environment (17). Many residents of *Nagaya* did not have close family members to support them; therefore, their health conditions might have deteriorated more if they had lived alone outside *Nagaya*. On the other side, there were also cases for which *Nagaya* was not well-suited for residents. Five residents left *Nagaya* within a year owing to disease, suggesting that people at high risk for disease exacerbation should consider that *Nagaya*-style facilities are not suitable for them and that they need more specialized care.

Housing facilities such as those in *Nagaya* may become increasingly necessary in the aftermath of large-scale disasters. Problems that may arise after such disasters include the disappearance of living areas for older people living alone and difficulties maintaining a healthy life expectancy. In Hurricane Katrina, those who needed social and medical support had higher mortality rates, and there were reports of increased mental health problems after the disaster (31, 32). Establishing collective housing like *Nagaya* in disaster-stricken areas could help address these problems. Additionally, providing a suitable living environment for older people after a large-scale disaster is essential for facilitating the return of victims to affected areas. In regions hit by the 2011 disaster, there were cases in which returning to residential areas was difficult because of a lack of appropriate care facilities for older people (33). In Katsurao Village, located 20–30 km from the nuclear power plant, difficulty in accessing continuous long-term care insurance services made settling challenging (34). By contrast, in Kawauchi Village, also 20–30 km from the nuclear power plant, the presence of a special nursing home for older adults allowed residents and their families to return to their original homes (35). In one case, a school building was renovated into a care facility to fill its shortage (36). The widespread availability of adequate care facilities in these areas may contribute to the return of the evacuees.

4.1 Future implications

Further research is needed to determine the applicability of *Nagaya*-style housing in other disaster scenarios. This study primarily focused on residents' continuity of residence and care progression. Ongoing interviews and health surveys with residents are crucial for understanding the specific advantages of this housing model.

We assume that the results presented herein are due to the formation of social networks by residents. However, it is also important to measure actual participation in social activities. While *Nagaya* showcases potential for broader application in aging communities, further investigation is required. Some residents showed improvement in their level of care during their stay; however, there were scattered cases of rapid progress in the level of care. Future work is needed to determine what factors are associated with maintaining or improving the level of care in a *Nagaya*-like setting. Given the diverse needs arising from different disasters and regions, the universal effectiveness of this housing approach may vary. Examining cases in different cultural contexts is essential to assess the suitability of *Nagaya*-style projects.

4.2 Limitation

This study has several limitations. First, it is based on a single case study, which may limit the generalizability of the findings to other contexts or types of disasters. In addition, to highlight the benefits provided by *Nagaya*, comparisons with residents residing in other facilities are desirable. Second, the study primarily focused on the continuity of residence and progression of care needs without considering other factors that might influence the overall well-being and satisfaction of older residents in *Nagaya*-style housing. Third, residents who died during the occupation of *Nagaya* are separated into two groups: those who died in *Nagaya* and those who died in the hospital, the details of which remain unclear. Lastly, this study did not measure individual-specific factors, such as physical activity levels, functional abilities, or detailed medical histories of older residents. It should be noted that this is a data-based analysis and does not directly measure indicators of health.

5 Conclusion

Soma *Nagaya* initiatives showed the potential to provide a suitable living environment for older individuals with diverse needs in the aftermath of disasters. These findings suggest that *Nagaya*-style housing could be a useful tool for solving the housing concerns of isolated older individuals in disaster-prone areas.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

The studies involving humans were approved by Fukushima Medical University Ethics Review Committee Chair, Clinical Research Review Committee for Guidelines Chair, General Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

TA: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. HS: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. NM: Writing – review & editing. NI: Writing – review & editing. MoT: Writing – review & editing. YK: Writing – review & editing. AO: Writing – review & editing. YN: Writing – review & editing. CY: Writing – review & editing. TZ: Writing – review & editing. MS: Writing – review & editing. MaT: Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Research Project on the Health Effects of Radiation organized by the Ministry of Environment, Japan.

Acknowledgments

We would like to express our gratitude to the staff of Soma City who provided us with the data for this study, particularly the staff of the Soma Health Center, Mr. Hidehiko Yokoyama, Mr. Tetsuya Yokoyama, and Ms. Miki Sato of Soma Central Hospital. We would like to thank Editage (www.editage.com) for English language editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1289552/full#supplementary-material

References

1. Chatterji S, Byles J, Cutler D, Seeman T, Verdes E. Health, functioning, and disability in older adults--present status and future implications. *Lancet*. (2015) 385:563–75. doi: 10.1016/S0140-6736(14)61462-8

2. Zhang S, Tomata Y, Discacciati A, Otsuka T, Sugawara Y, Tanji F, et al. Combined healthy lifestyle behaviors and disability-free survival: the Ohsaki cohort 2006 study. *J Gen Intern Med*. (2019) 34:1724–9. doi: 10.1007/s11606-019-05061-z

3. Marengoni A, Angleman S, Melis R, Mangialasche F, Karp A, Garmen A, et al. Aging with multimorbidity: a systematic review of the literature. *Ageing Res Rev*. (2011) 10:430–9. doi: 10.1016/j.arr.2011.03.003

4. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology*. (2016) 17:567–80. doi: 10.1007/s10522-016-9641-0

5. England S. (2006). *Understanding participation in sport: what determines sports participation among recently retired people?* Available at: http://www.sportengland.org/media/39497/understanding-participation-among-recently-retired-people.pdf.

6. Koeneman MA, Verheijden MW, Chinapaw MJ, Hopman-Rock M. Determinants of physical activity and exercise in healthy older adults: a systematic review. *Int J Behav Nutr Phys Act*. (2011) 8:142. doi: 10.1186/1479-5868-8-142

7. Welford C, Murphy K, Wallace M, Casey D. A concept analysis of autonomy for older people in residential care. *J Clin Nurs*. (2010) 19:1226–35. doi: 10.1111/j.1365-2702.2009.03185.x

8. Lubben J, Blozik E, Gillmann G, Iliffe S, von Renteln KW, Beck JC, et al. Performance of an abbreviated version of the Lubben social network scale among three European community-dwelling older adult populations. *Gerontologist*. (2006) 46:503–13. doi: 10.1093/geront/46.4.503

9. Grenade L, Boldy D. Social isolation and loneliness among older people: issues and future challenges in community and residential settings. *Aust Health Rev*. (2008) 32:468–78. doi: 10.1071/AH080468

10. 2020 Populaation Census. (2022). Available at: https://www.stat.go.jp/english/data/kokusei/2020/summary.html.

11. The L. Population ageing in China: crisis or opportunity? *Lancet*. (2022) 400:1821. doi: 10.1016/S0140-6736(22)02410-2

12. Holt-Lunstad J, Perissinotto C. Social isolation and loneliness as medical issues. *N Engl J Med*. (2023) 388:193–5. doi: 10.1056/NEJMp2208029

13. Gale CR, Westbury L, Cooper C. Social isolation and loneliness as risk factors for the progression of frailty: the English longitudinal study of ageing. *Age Ageing*. (2018) 47:392–7. doi: 10.1093/ageing/afx188

14. Holt-Lunstad J. Social connection as a public health issue: the evidence and a systemic framework for prioritizing the "social" in social determinants of health. *Annu Rev Public Health*. (2022) 43:193–213. doi: 10.1146/annurev-publhealth-052020-110732

15. Yoshida I, Morita T, Ishii T, Leppold C, Tsubokura M. Minimizing isolation of the elderly following the Fukushima nuclear power plant disaster. *Disaster Med Public Health Prep*. (2021) 15:140–2. doi: 10.1017/dmp.2020.36

16. Ishikawa K, Kanazawa Y, Morimoto S, Takahashi T. Depopulation with rapid aging in Minamisoma City after the Fukushima Daiichi nuclear power plant accident. *J Am Geriatr Soc*. (2012) 60:2357–8. doi: 10.1111/jgs.12012

17. Moriyama N, Morita T, Nishikawa Y, Kobashi Y, Murakami M, Ozaki A, et al. Association of living in evacuation areas with long-term care need after the Fukushima accident. *J Am Med Dir Assoc*. (2022) 23:111–116.e1. doi: 10.1016/j.jamda.2021.05.030

18. About Great East Earthquake: Soma Regional Wide-Area Municipalities Association. Available at: https://www.soma-area.jp/shinsai.html.

19. Census 2015 Survey Results. (2015). Statistics Bureau, Ministry of Internal Affairs. Available at: https://www.stat.go.jp/data/kokusei/2015/kekka.html.

20. Jonas M. Private use of public open space in Tokyo a study of the hybrid landscape of Tokyo's informal gardens. *J Landsc Archit*. (2007) 2:18–29. doi: 10.1080/18626033.2007.9723385

21. Ito N, Kinoshita Y, Morita T, Tsubokura M. Promoting independent living and preventing lonely death in an older adult: Soma Idobata-Nagaya after the 2011 Fukushima disaster. *BMJ Case Rep*. (2022) 15:e243117. doi: 10.1136/bcr-2021-243117

22. Tachiya H. *Personal account of mayors from disaster-struck*. Municipalities: Kindai Shoubo (2018).

23. Matsuda S. The health and social system for the aged in Japan. *Aging Clin Exp Res*. (2002) 14:265–70. doi: 10.1007/BF03324449

24. Unwin BK, Porvaznik M, Spoelhof GD. Nursing home care: part I. Principles and pitfalls of practice. *Am Fam Physician*. (2010) 81:1219–27.

25. Japan OoHPCSGo. *Nursing care in Japan 2023*. Available at: https://www.kantei.go.jp/jp/singi/kenkouiryou/en/pdf/nursing_care.pdf.

26. Noguchi T, Nakagawa T, Komatsu A, Ishihara M, Shindo Y, Otani T, et al. Social functions and adverse outcome onset in older adults with mild long-term care needs: a two-year longitudinal study. *Arch Gerontol Geriatr*. (2022) 100:104631. doi: 10.1016/j.archger.2022.104631

27. Kamiya K, Adachi T, Sasou K, Suzuki T, Yamada S. Risk factors for disability progression among Japanese long-term care service users: a 3-year prospective cohort study. *Geriatr Gerontol Int*. (2017) 17:568–74. doi: 10.1111/ggi.12756

28. Sone T, Nakaya N, Sugawara Y, Matsuyama S, Tsuji I. Effect of social participation on the association between frailty and disability. *Arch Gerontol Geriatr*. (2023) 110:104989. doi: 10.1016/j.archger.2023.104989

29. Abe N, Ide K, Watanabe R, Hayashi T, Iizuka G, Kondo K. Social participation and incident disability and mortality among frail older adults: a JAGES longitudinal study. *J Am Geriatr Soc*. (2023) 71:1881–90. doi: 10.1111/jgs.18269

30. Moilanen T, Kangasniemi M, Papinaho O, Mynttinen M, Siipi H, Suominen S, et al. Older people's perceived autonomy in residential care: an integrative review. *Nurs Ethics*. (2021) 28:414–34. doi: 10.1177/0969733020948115

31. Engelman A, Guzzardo MT, Antolin Muñiz M, Arenas L, Gomez A. Assessing the emergency response role of community-based organizations (CBOs) serving people with disabilities and older adults in Puerto Rico post-hurricane María and during the COVID-19 pandemic. *Int J Environ Res Public Health*. (2022) 19:2156. doi: 10.3390/ijerph19042156

32. Chandra A, Marsh T, Madrigano J, Simmons MM, Abir M, Chan EW, et al. Health and social services in Puerto Rico before and after Hurricane Maria: Predisaster conditions, hurricane damage, and themes for recovery. *Rand Health Q*. (2021) 9:10.

33. Tanigawa K. Health issues today in affected areas near Fukushima Daiichi nuclear power plant. *Ann ICRP*. (2021) 50:90–4. doi: 10.1177/01466453211006807

34. Ito N, Moriyama N, Furuyama A, Saito H, Sawano T, Amir I, et al. Why do they not come home? Three cases of Fukushima nuclear accident evacuees. *Int J Environ Res Public Health*. (2023) 20:4027. doi: 10.3390/ijerph20054027

35. Kobashi Y, Nishikawa Y, Morita T, Omata F, Ito N, Tsubokura M. Demographic change of the Kawauchi special nursing home occupants in a former evacuation area after the nuclear power plant accident: a retrospective observational study. *Disaster Med Public Health Prep*. (2022) 17:e204. doi: 10.1017/dmp.2022.191

36. Nishikawa Y, Ozaki A, Tsubokura M. Successful renovation of a closed school into a long-term Care Facility in the Affected Area after the 2011 Fukushima disaster. *Disaster Med Public Health Prep*. (2019) 13:107–8. doi: 10.1017/dmp.2018.107

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 23 November 2023
DOI 10.3389/fpubh.2023.1284959

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Wei-Chih Lien,
National Cheng Kung University, Taiwan
Eric Lichtenstein,
University of Basel, Switzerland

*CORRESPONDENCE
Jing Pang
✉ pangjing314@163.com
Tiemei Zhang
✉ tmzhang126@126.com

RECEIVED 29 August 2023
ACCEPTED 13 November 2023
PUBLISHED 23 November 2023

CITATION
Pang J, Tu F, Han Y, Zhang E, Zhang Y and Zhang T (2023) Age-related change in muscle strength, muscle mass, and fat mass between the dominant and non-dominant upper limbs. *Front. Public Health* 11:1284959. doi: 10.3389/fpubh.2023.1284959

COPYRIGHT
© 2023 Pang, Tu, Han, Zhang, Zhang and Zhang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Age-related change in muscle strength, muscle mass, and fat mass between the dominant and non-dominant upper limbs

Jing Pang[1]*, Fuyi Tu[2], Yiwen Han[1], Enyi Zhang[1], Yan Zhang[1] and Tiemei Zhang[1]*

[1]The Key Laboratory of Geriatrics, Beijing Institute of Geriatrics, Institute of Geriatric Medicine, Chinese Academy of Medical Sciences, Beijing Hospital, National Center of Gerontology of National Health Commission, Beijing, China, [2]School of Science, Chongqing University of Posts and Telecommunications, Chongqing, China

Background: Any form of physical activity is recommended for the older adults to maintain their physical function; however, the effect of daily activities on muscle function still needs to be investigated. Humans always use one dominant hand to perform tasks, providing a natural situation for research on the effect of daily activities on muscle function.

Methods: Five hundred and twenty-six healthy adults were recruited from the community in Beijing. Muscle strength was assessed using a handgrip dynamometer, lean mass, fat mass, bone area and bone mineral content of upper limbs were assessed using dual-energy X ray-absorptiometry. The results were compared between the dominant and non-dominant upper limbs.

Results: The dominant upper limb had better muscle strength, lean mass, bone area and bone mineral content than the non-dominant side. The difference in muscle strength and lean mass between the two upper limbs decreased with the advanced age. In older age, fat mass of upper limbs increased in men, but not in women.

Conclusion: Daily activities can maintain better muscle function in the dominant upper limb than in the non-dominant side; however, the delaying effect on age-related decline in muscle function was limited.

KEYWORDS

upper limbs, muscle strength, lean mass, fat mass, bone mineral content

Introduction

Sarcopenia is an adverse change in muscle across the whole lifetime, especially in older age. It is defined by the loss of muscle mass, and decreases in muscle strength and physical performance (1, 2). Older adults people with less muscle might have a higher risk of disability. Walking is a basic requirement for independent living, thus most studies have focused on the change of lower limbs with aging (3). There have been relatively fewer studies about the age-related decline in the upper limbs.

The upper limbs play important roles in everyday living, such as feeding, dressing, and grooming, which are critical tasks for independent living. The decline in upper limb strength

may impact these activities and reduce quality of life (4, 5). In the Asian Working Group for Sarcopenia 2019 consensus, low muscle strength is defined as handgrip strength <28 kg for men and < 18 kg for women (6). Low handgrip strength is a simple and powerful predictor for future disability (7, 8) and falls (9–11). Similar to lower limb function, upper limb function also involves several physiological domains. A previous study demonstrated that performance in muscle strength, arm stability, dexterity, and coordination of the upper limbs significantly decreased with age (12). To study the upper limbs, handgrip strength is the most popular indicator for muscle function assessment (13). However, muscle strength is only one part of muscle performance, and how other muscle indicators change in the upper limbs with aging are unknown.

In contrast to the lower limbs, people usually have a dominant side when performing tasks using the upper limbs. The dominant side always has greater muscle strength than the non-dominant side (14). Several physical activities, such as doing housework and playing with balls, usually practice only one side of the upper limbs. Therefore, the comparison of muscle performance between the two upper limbs might provide guidance to evaluate the effect of daily activities on muscle function maintenance.

Muscle performance is a loosely defined concept that broadly includes muscle mass, muscle strength, and muscle composition (15). Herein, we compared several muscle indicators between the two upper limbs and observed the age-related changes in them. The results might help us to realize the relationship among daily activities, muscle function and aging, and give us a clue to determine which kind of muscle indicators could be used for early recognition and intervention in motor function decline. This can help us to optimize the intervention strategies for healthy aging.

Methods

Subjects

The healthy subjects were volunteers to participant in this study. 538 Chinese adults (526 right-hand dominant and 12 left-hand dominant) aged 25–89 years were recruited from the community of Beijing in 2015. The proportion of left-dominant and right-dominant participants was imbalance; therefore we only analyzed the data of right-hand dominant participants (Table 1). A brief questionnaire, including basic demographic details, physical status, exercise, and medical history information was completed. Subjects who participated in regular strength training of the upper limbs (>1 time/week and > 10 min/time training) were excluded. The subjects' informed consent was obtained to use their information in this study; and the study was approved by the Ethics Committee of Beijing Hospital (approval No. 2012BJYYEC-052-02).

Muscle strength

Handgrip strength (HS) was assessed in each hand using a JAMAR digital dynamometer (Sammons Preston, Chicago, IL, United States), which was measured twice for each hand and the higher value was used in the analysis.

TABLE 1 Parameters of the dominant and non-dominant upper limbs in muscle performance between men and women (mean ± SD).

Group	Total (n = 526)	Men (n = 284)	Women (n = 242)
Age (years)	62.47 ± 14.36	62.56 ± 14.25	62.37 ± 14.52
Weight (kg)	64.73 ± 10.86	69.91 ± 9.72	58.65 ± 8.78
Height (cm)	164.21 ± 8.06	169.57 ± 5.69	157.92 ± 5.46
BMI (kg/cm^2)	23.92 ± 3.04	24.28 ± 2.80	23.51 ± 3.26
Muscle strength (kg)			
Non-dominant	31.80 ± 9.96	37.33 ± 8.63	25.30 ± 7.08
Dominant	36.72 ± 12.26	42.89 ± 10.62	29.47 ± 9.87
p-Value	<0.001	<0.001	<0.001
Cohen's d	0.88	0.87	0.94
Bone Area (cm^2)			
Non-dominant	187.99 ± 30.93	208.35 ± 23.03	164.09 ± 19.99
Dominant	209.88 ± 36.71	231.23 ± 31.05	184.84 ± 25.22
p-Value	<0.001	<0.001	<0.001
Cohen's d	1.19	1.20	1.18
Bone Mineral Content (g)			
Non-dominant	141.97 ± 43.51	170.7 ± 33.18	108.25 ± 26.78
Dominant	153.18 ± 44.26	184.21 ± 32.48	116.76 ± 23.72
p-Value	<0.001	<0.001	<0.001
Cohen's d	0.47	0.50	0.45
Lean Mass (g)			
Non-dominant	2139.54 ± 614.96	2564.47 ± 463.60	1640.87 ± 330.08
Dominant	2293.31 ± 684.15	2777.51 ± 508.55	1725.08 ± 339.74
p-Value	<0.001	<0.001	<0.001
Cohen's d	0.57	0.75	0.36
Fat Mass (g)			
Non-dominant	1275.74 ± 416.87	1196.39 ± 354.94	1368.87 ± 463.13
Dominant	1309.93 ± 387.88	1189.41 ± 315.32	1451.38 ± 416.87
p-Value	<0.001	0.466	<0.001
Cohen's d	0.18	0.04	0.38

p-Value: differences between the dominant and the non-dominant upper limbs. Cohen's d: the difference between the means of the dominant and the non-dominant upper limbs divided by the standard deviation.

Muscle mass and muscle composition

All the participants completed the dual-energy X ray-absorptiometry (DEXA, Hologic QDR 4500A, Hologic) measurement in Beijing hospital. A standardized procedure for body composition detection and QDR software analysis were used. From DEXA scans, lean mass, fat mass, bone area and bone mineral content (BMC) of two upper limbs were evaluated.

Statistical analysis

Descriptive statistics were used to characterize the demographics and the measured variables of the subjects. All values

are shown as the mean ± SD. The differences between the two upper limbs were compared using a paired *t*-test. A sample size of 29 achieves 90% power to detect a mean of paired differences of 3.0 with an estimated standard deviation of differences of 5.0 and with a significance level (alpha) of 0.05 using a two-sided paired t-test. The statistical analyses were carried out using SPSS 21.0 (IBM Corp., Armonk, NY, United States), and $p < 0.05$ was considered statistically significant.

For analysis the age-related patterns of muscle performance in two upper limbs, we employed the restricted cubic spline (RCS) to flexibly model and visualize the relationships between age and each indicator. RCS fitted a smooth and continuous curve for each indicator across the range of ages, allowing for cubic form changes in function at specific age points - 45, 55, 65 and 75 years - referred to as knot points. The curves obtained by RCS reflect the overall age-related changes of each indicator, and we further identified the change points at which abrupt changes occur in each indicator during ageing based on the fitted RCS curves. The segmented regression is a common choice for change point detection (16, 17). Given an initial guess for the change point, the segment regression fitted a piecewise linear function and updated the change point to minimize the gap between the two fitted intersecting lines. The process iterated until convergence is reached, ultimately yielding the optimal change point. The left and right slopes are calculated together with the estimated change point. The analyses of this part were performed using R (Version 4.3.1).

Results

The difference in muscle performance between the two upper limbs

All the muscle performance indicators (muscle strength, lean mass, fat mass, bone area and bone mineral content) were exhibited significantly differences between the two upper limbs ($p < 0.05$, Table 1). The muscle strength, lean mass, bone area, and bone mineral content of the dominant upper limb were much higher than those of the non-dominant side both in male and female participants ($p < 0.05$, Table 1). In women, the dominant upper limb had more fat mass than the non-dominant one ($p < 0.05$); however, there was no difference in fat mass between the two sides in men.

Comparison of muscle performance between the two upper limbs among age groups

In females, the dominant upper limb exhibited higher muscle strength, lean mass, fat mass, bone area, and bone mineral content than the non-dominant upper limb in each age group (Table 2). In males, the muscle strength, lean mass and bone area showed significant differences between the two upper limbs in each age group; however, there was no difference of bone mineral content and fat mass between the two sides in older group. We calculated the value of the dominant upper limb minus the non-dominant upper limb (D-value). The difference in muscle strength and lean mass between the two upper limbs decreased significantly with age both in male and female participants. Compared with those in 25–59 years old group, D-value for muscle strength in 75+ years old group decreased by 54% for males and 55% for females; D-value for lean mass in 75+ years old group decreased by 58% for males and 59% for females.

Comparison of age-related changes in muscle performance between the two upper limbs

We observed the trend of muscle performance indicators changed with age (Figure 1), analyzed the cutoff point of each indicator (Figure 2) and calculated the slope of them (Table 3). After 50 years old, the slope of muscle strength and lean mass in the dominant upper limb declined more significantly than those in the non-dominant upper limb both in males and females participants. The change of fat mass showed a sexual difference. After 50 years old, the fat mass of both upper limbs increased significantly in males, but decreased in females. In males, the slope of bone mineral content changed more significantly in the dominant upper limb than that in the non-dominant upper limb after 65 years old. In females, the age-related trend of bone mineral content was similar between the two upper limbs.

Discussion

Physical activity is important for physical function maintenance. People always have one dominant hand for carrying out daily tasks. The dominant hand is usually involved in more physical activity than the non-dominant hand, which might lead to different muscle performance between them. In this study, we compared several muscle performance indicators of the two upper limbs and found that the dominant upper limb maintained the better muscle performance than the non-dominant side, but the difference between the two sides decreased with the advanced age.

In this study, the handgrip strength of the dominant upper limb declined faster than that of the non-dominant upper limb in older age. Consistent with this, men had stronger handgrip strength than women, but the strength of men declined faster than that of women during aging (18, 19). Daily activities can increase muscle strength, but cannot prevent muscle aging. There may be two ways for muscle function maintenance: (1) doing more activities from young age to reserve high intrinsic ability; (2) engaging in more activities in old age for anti-aging.

Muscle strength and muscle mass are two important indicators for motor function assessment (1, 2); however, which indicator is more sensitive for sarcopenia early recognition still need to be investigated. In this study, both muscle strength and lean mass of upper limbs showed significant differences between the two sides and declined with age. In addition, we observed that muscle strength began to decline significantly at age 55 in men and age 50 in women, which was earlier than lean mass declined at age 61 in men and age 57 in women. This result supported the European consensus on Sarcopenia diagnosis revised in 2019, in which muscle strength detection was

10.3389/fpubh.2023.1284959

TABLE 2 Parameters of the dominant and non-dominant upper limbs in muscle performance within different age groups (mean ± SD).

Group	Men			Women		
	25–59 years	60–74 years	75+ years	25–59 years	60–74 years	75+ years
n	103	122	59	89	100	53
Height (cm)	171.42 ± 5.42	168.93 ± 5.80	167.66 ± 5.04	159.13 ± 5.36	158.31 ± 4.74	155.13 ± 5.99
Weight (kg)	71.91 ± 10.43	69.64 ± 9.60	67.00 ± 7.85	58.57 ± 8.68	59.53 ± 9.01	57.13 ± 8.45
BMI (kg/cm^2)	24.42 ± 2.84	24.37 ± 2.83	23.84 ± 2.68	23.13 ± 3.27	23.75 ± 3.44	23.70 ± 2.85
Muscle strength (kg)						
Non-dominant	42.50 ± 8.48	36.28 ± 6.98	30.49 ± 6.13	29.24 ± 6.92	24.61 ± 6.10	20.00 ± 4.91
Dominant	49.75 ± 10.20	41.51 ± 8.50	33.80 ± 6.70	34.72 ± 10.23	28.52 ± 8.77	22.45 ± 5.43
p-Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cohen's *d*	0.98	0.97	0.60	1.15	0.92	0.68
Bone area (cm^2)						
Non-dominant	207.59 ± 23.49	210.30 ± 22.65	205.66 ± 23.04	168.78 ± 21.32	164.86 ± 17.64	154.77 ± 19.05
Dominant	231.46 ± 33.49	234.53 ± 28.79	224.00 ± 30.47	188.48 ± 25.33	184.94 ± 24.99	178.52 ± 24.68
p-Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cohen's *d*	1.12	1.47	0.92	1.01	1.24	1.46
Bone mineral content (g)						
Non-dominant	176.61 ± 27.06	168.88 ± 27.19	164.14 ± 49.27	118.33 ± 19.44	108.21 ± 31.48	91.40 ± 18.30
Dominant	192.66 ± 33.06	183.81 ± 28.94	170.31 ± 33.96	127.86 ± 19.36	114.84 ± 21.84	101.76 ± 24.85
p-Value	<0.001	<0.001	0.182	<0.001	0.013	<0.001
Cohen's *d*	0.59	0.68	0.18	0.94	0.25	0.79
Lean mass (g)						
Non-dominant	2664.80 ± 527.32	2584.63 ± 425.97	2347.61 ± 338.48	1619.62 ± 370.59	1697.64 ± 285.27	1569.42 ± 324.73
Dominant	2965.60 ± 520.36	2765.62 ± 488.69	2473.75 ± 361.20	1748.28 ± 364.33	1758.98 ± 325.86	1622.15 ± 306.95
p-Value	<0.001	<0.001	<0.001	<0.001	<0.001	0.017
Cohen's *d*	0.86	0.76	0.62	0.40	0.40	0.34
Fat mass (g)						
Non-dominant	1184.89 ± 388.73	1200.59 ± 347.64	1207.77 ± 310.52	1344.98 ± 501.49	1391.80 ± 475.64	1365.73 ± 368.48
Dominant	1148.46 ± 322.15	1202.69 ± 318.99	1233.43 ± 291.57	1407.08 ± 469.03	1486.92 ± 395.03	1458.70 ± 360.81
p-Value	0.031	0.887	0.153	0.029	<0.001	<0.001
Cohen's *d*	0.22	0.01	0.19	0.23	0.46	0.62

p-Value: differences between the dominant and the non-dominant upper limbs; Cohen's d: the difference between the means of the dominant and the non-dominant upper limbs divided by the standard deviation.

modified as an early screening indicator for muscle mass loss (2). Previous studies also found that physical intervention affected muscle strength, but had little effect on muscle mass (20, 21). According to these data, muscle strength might be more sensitive to reflect the change in muscle function than muscle mass.

The change of muscle composition, the loss of muscle mass and the infiltration of fat into muscle, was a main indicator for muscle quality evaluation and a cause of muscle function decline (22, 23). Here, the age-related change in fat mass showed a difference between the two sexes. In men, the dominant upper limb had little fat mass than the non-dominant side in young age, and the fat mass of both upper limbs increased after 50 years old. Contrary to men, the dominant upper limb had more fat mass than the non-dominant side from young to old in women. This sex difference might have been caused by hormone effect. The decrease of testosterone, which is a potent anabolic factor promoting muscle protein synthesis and muscular regeneration, may induce muscle composition changed (24).

Bone loss is a major risk for fall-related injury in older adults. Interestingly, the dominant upper limb had more bone area and bone mineral content than the non-dominant upper limb. Bone mineral density is a common indicator for bone health assessment, which is calculated by dividing bone mineral content by bone area. Previous studies had proved that high-intensity physical activity is an effective contributor to bone mineral density (25). Inconsistent with this, the bone mineral density of two upper limbs was similar in this study. These results suggested that daily activities might promote large bone area development in adolescent and maintained it into old age, but were not enough to increase bone mineral density.

10.3389/fpubh.2023.1284959

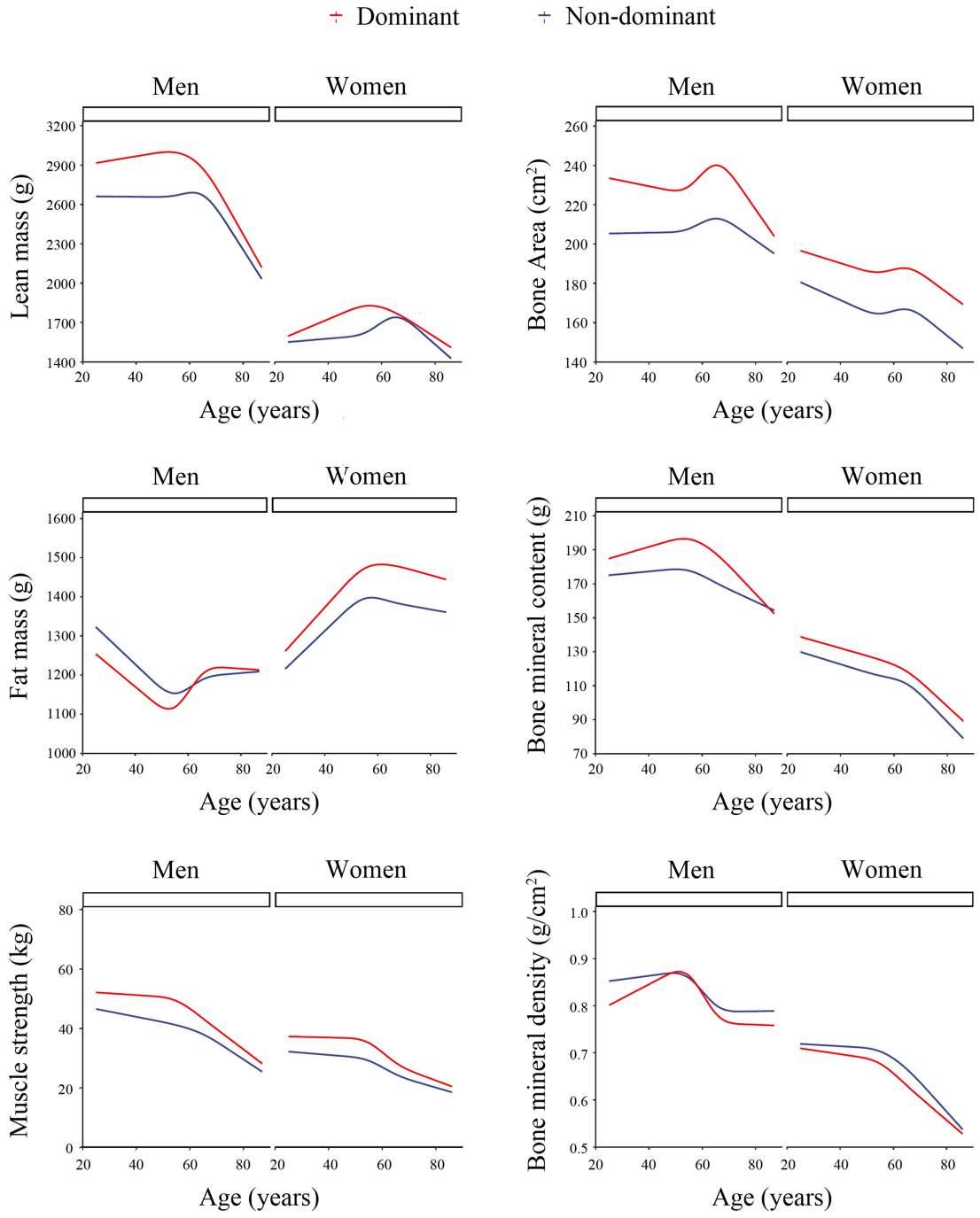


FIGURE 1
Age-related changes in muscle performance indicators between the two upper limbs. The curves obtained by the restricted cubic spline analysis. The red line represented the change of the dominant upper limb; the blue line represented the change of the non-dominant upper limb.

This was the first study to use the difference in daily activities between the two upper limbs to determine the relationship among muscle performance, physical activity, and aging. In daily living, the dominant upper limb always completes more daily activities than the non-dominant side. Does this kind of physical activity slow the age-related decrease in muscle function? Our data showed that daily activities can promote high muscle function reserve, but cannot prevent muscle function decline with aging. In addition, the interaction of person and environment has been a focus of attention. Environmental factors, such as living arrangements, financial status, and electronics, may influence the lifestyle of older adults and have potential confounding impacts on muscle performance (26, 27). In this study, data on the amounts of physical activity and other influence factors were not investigated, thus more detailed analysis was missing. Further study may focus on the quantitative analysis between physical activity and muscle function maintenance during the aging process.

10.3389/fpubh.2023.1284959

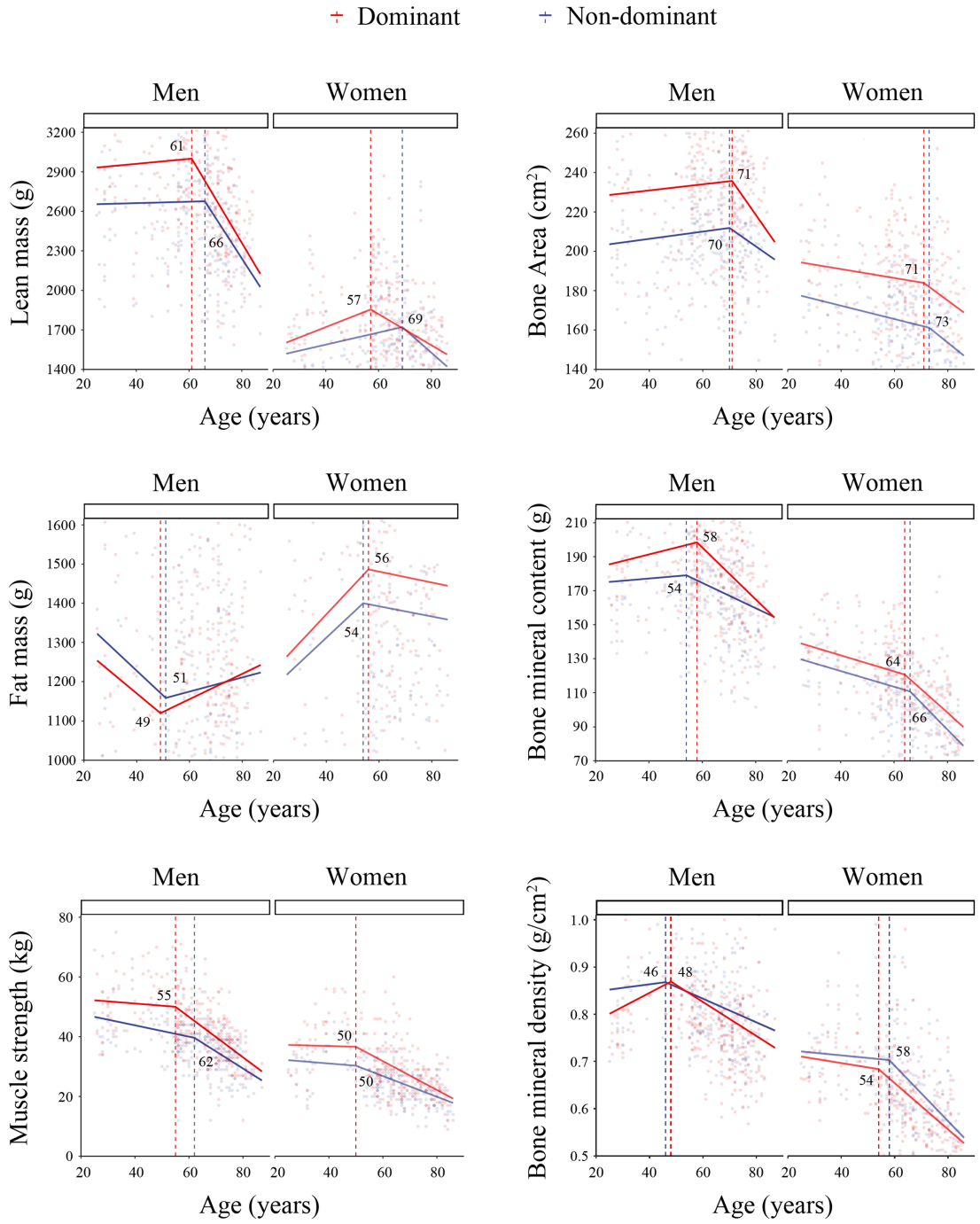


FIGURE 2
The cutoff points of muscle performance indicators changed with age. The age at the cutoff point was marked. The red line represented the change of the dominant upper limb; the blue line represented the change of the non-dominant upper limb.

Conclusion

Muscle strength, lean mass, fat mass, bone area and bone mineral content were obviously different between the two upper limbs, and showed different aging patterns (Figure 3). In older adults, despite more regular use, the dominant hand's muscle and bone quality was not protected against ageing. Additional exercise should be recommended for older adults to delay motor function decline and promote healthy aging. Comparison of the age-related trends of muscle performance indicators, fat mass increased earliest in men, and muscle strength declined first in women. The detection of muscle strength and fat mass may be useful for early recognition and intervention of motor function decline. Overall, as compared with the performance of the non-dominant upper limb, the dominant upper limb showed better muscle performance

10.3389/fpubh.2023.1284959

TABLE 3 The slope of age-related changes in muscle performance indicators.

Indicators	Before cutoff point		After cutoff point	
	Men (n = 284)	Women (n = 242)	Men (n = 284)	Women (n = 242)
Muscle strength				
Non-dominant	−0.1896	−0.0742	−0.5711	−0.3465
Dominant	−0.0725	−0.0249	−0.6764	−0.4822
Bone area				
Non-dominant	0.184	−0.3386	−0.9462	−1.0905
Dominant	0.155	−0.2262	−1.9421	−1.0017
Bone mineral content				
Non-dominant	0.1348	−0.4622	−0.7447	−1.5933
Dominant	0.394	−0.4717	−1.5254	−1.3958
Lean mass				
Non-dominant	0.5416	4.5967	−30.978	−17.69
Dominant	1.8802	7.8551	−33.619	−11.782
Fat mass				
Non-dominant	−6.3086	6.3029	1.8025	−1.3025
Dominant	−5.5937	7.1818	3.2365	−1.3951

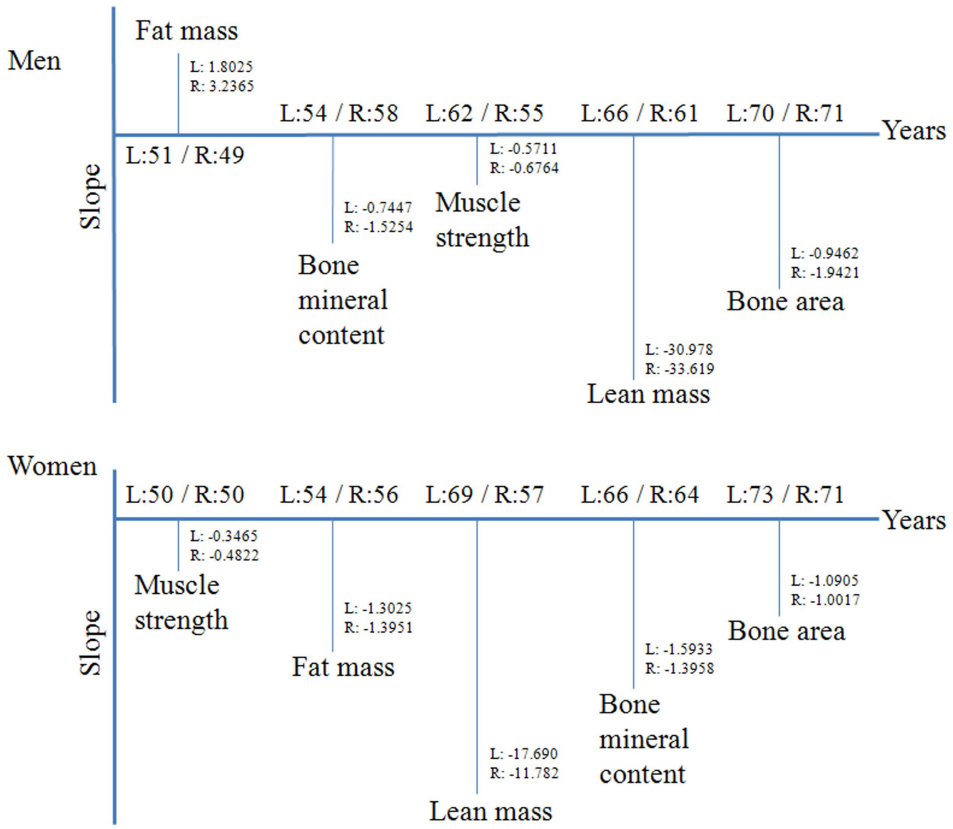


FIGURE 3
The key points of muscle performance indicators changed with age. The horizontal line marked the age of each indicator changed significantly. The vertical line marked the slope of each indicator changed after the cutoff point. L: the non-dominant upper limb; R: the dominant upper limb.

and bone quality from young to old. The long-term beneficial effect of daily activities on muscle and bone health was verified. Engaging in more physical activities at a younger age should be recommended to maintain independent living ability and decrease the occurrence of sarcopenia and falls later in life.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by the Ethics Committee of Beijing Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JP: Funding acquisition, Investigation, Project administration, Writing – original draft, Writing – review & editing. FT: Data curation, Writing – original draft. YH: Investigation, Writing – original draft. EZ: Investigation, Writing – original draft. YZ: Investigation, Writing – original draft. TZ: Funding acquisition, Project administration, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by National Key R&D Program of China (2021YFE0111800), the National Natural Science Foundation of China (No. 81970745), and the Research Special Fund for Public Welfare Industry of Health (No. 201302008). All sources of funding received for the research being submitted.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European working group on sarcopenia in older people. *Age Ageing*. (2010) 39:412–23. doi: 10.1093/ageing/afq034

2. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*. (2019) 48:16–31. doi: 10.1093/ageing/afy169

3. Francis P, Lyons M, Piasecki M, Mc Phee J, Hind K, Jakeman P. Measurement of muscle health in aging. *Biogerontology*. (2017) 18:901–11. doi: 10.1007/s10522-017-9697-5

4. Taekema DG, Gussekloo J, Maier AB, Westendorp RGJ, de Craen AJM. Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old. *Age Ageing*. (2010) 39:331–7. doi: 10.1093/ageing/afq022

5. Nguyen NTT, Nguyen TX, Nguyen AT, Nguyen TTH, Nguyen TN, Nguyen HTT, et al. A description of handgrip strength in the very older adult people living in rural Vietnam and its associatin with daily functions. *Biomed Res Int*. (2021) 2021:1–6. doi: 10.1155/2021/1237547

6. Chen LK, Woo J, Assantachai P, Auyeung T, Chou M, Iijima K, et al. Asian working group for sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. *J Am Med Dir Assoc*. (2020) 21:300–307.e2. doi: 10.1016/j.jamda.2019.12.012

7. Rantanen T, Guralnik JM, Foley D, Masaki K, Leveille S, Gurb JD, et al. Midlife hand grip strength as a predictor of old age disability. *JAMA*. (1999) 281:558–60. doi: 10.1001/jama.281.6.558

8. Giampaoli S, Ferrucci L, Cecchi F, Lo Noce C, Poce A, Dima F, et al. Hand-grip strength predicts incident disability in non-disabled older men. *Age Ageing*. (1999) 28:283–8. doi: 10.1093/ageing/28.3.283

9. Hiraoka A, Tamura R, Oka M, Izumoto H, Ueki H, Tsuruta M, et al. Prediction of risk of falls based on handgrip strength in chronic liver disease patients living independently. *Hepatol Res*. (2019) 49:823–9. doi: 10.1111/hepr.13322

10. Neri S, Lima R, Ribeiro H, Vainshelboim B. Poor handgrip strength determined clinically is associated with falls in older women. *J Frailty Sarcopenia Falls*. (2021) 6:43–9. doi: 10.22540/JFSF-06-043

11. Pham T, McNeil JJ, Barker AL, Orchard SG, Newman AB, Robb C, et al. Longitudinal association between handgrip strength, gait speed and risk of serious falls in a community-dwelling older population. *PLoS One*. (2023) 18:e0285530. doi: 10.1371/journal.pone.0285530

12. Ingram LA, Butler AA, Walsh LD, Brodie MA, Lord SR, Gandevia SC. The upper limb physiological profile assessment: description, reliability, normative values and criterion validity. *PLoS One*. (2019) 14:e0218553. doi: 10.1371/journal.pone.0218553

13. Bohannon RW. Muscle strength: clinical and prognostic value of hand-grip dynamometry. *Curr Opin Clin Nutr Metab Care*. (2015) 18:465–70. doi: 10.1097/MCO.0000000000000202

14. Chen C, McGee CW, Rich TL, Prudente CN, Gillick BT. Reference values of intrinsic muscle strength of the hand of adolescents and young adults. *J Hand Ther*. (2018) 31:348–56. doi: 10.1016/j.jht.2017.05.012

15. Tieland M, Trouwborst I, Clark BC. Skeletal muscle performance and ageing. *J Cachexia Sarcopenia Muscle*. (2018) 9:3–19. doi: 10.1002/jcsm.12238

16. Muggeo VMR. Estimating regression models with unknown break-points. *Stat Med*. (2003) 22:3055–71. doi: 10.1002/sim.1545

17. Zhou J, Deng Y, Shen L, Wen C, Yan Q, Ning D, et al. Temperature mediates continental-scale diversity of microbes in forest soils. *Nat Commun*. (2016) 7:12083. doi: 10.1038/ncomms12083

18. Abe T, Thiebaud RS, Loenneke JP. Age-related change in handgrip strength in men and women: is muscle quality a contributing factor? *Age (Dordr)*. (2016) 38:28. doi: 10.1007/s11357-016-9891-4

19. Lauretani F, Russo CR, Bandinelli S, Bartali B, Cavazzini C, DiIorio A, et al. Age-associated changes in skeletall muscle and their effect on mobility: an operational diagnosis of sarcopenia. *J Appl Physiol*. (2003) 95:1851–60. doi: 10.1152/japplphysiol.00246.2003

20. Haider S, Dorner TE, Luger E, Kapan A, Titze S, Lackinger C, et al. Impact of a home-based physical and nutritional intervention program conducted by lay-volunteers on handgrip strength in prefrail and frail older adults: a randomized control trial. *PLoS One*. (2017) 12:e169613. doi: 10.1371/journal.pone.0169613

21. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance type

exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. *J Am Med Dir Assoc*. (2012) 13:713–9. doi: 10.1016/j.jamda.2012.05.020

22. Reinders I, Murphy RA, Brouwer IA, Visser M, Launer L, Siggeirsdottir K, et al. Muscle quality and myosteatosis: novel associations with mortality risk: the age, gene/environment susceptibility (AGES)-Reykjavik study. *Am J Epidemiol*. (2016) 183:53–60. doi: 10.1093/aje/kwv153

23. Heymsfield SB, Gonzalez MC, Lu J, Jia G, Zheng J. Skeletal muscle mass and quality: evolution of modern measurement concepts in the context of sarcopenia. *Proc Nutr Soc*. (2015) 74:355–66. doi: 10.1017/S0029665115000129

24. Anderson LJ, Liu H, Garcia JM. Sex differences in muscle wasting. *Adv Exp Med Biol*. (2017) 1043:153–97. doi: 10.1007/978-3-319-70178-3_9

25. Troy KL, Mancuso ME, Butler TA, Johnson JE. Exercise early and often: effects of physical activity and exercise on women's bone health. *Int J Environ Res Public Health*. (2018) 15:878. doi: 10.3390/ijerph15050878

26. Lien WC, Guo NW, Chang JH, Lin YC, Kuan TS. Relationship of perceived environmental barriers and disability in community-dwelling elderly in Taiwan—a population-based study. *BMC Geriatr*. (2014) 14:59. doi: 10.1186/1471-2318-14-59

27. Poppe L, Bourdeaudhuij ID, Verloigne M, Shadid S, Cauwenberg JV, Compernolle S, et al. Efficacy of a self-regulation-based electronic and mobile health intervention targeting an active lifestyle in adults having type 2 diabetes and in adults aged 50 years or older: two randomized controlled trials. *J Med Internet Res*. (2019) 21:e13363. doi: 10.2196/13363

frontiers | Frontiers in Endocrinology

TYPE Systematic Review
PUBLISHED 28 November 2023
DOI 10.3389/fendo.2023.1265637

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Woo Jung Kim,
Yonsei University, Republic of Korea
Giuseppe Barisano,
Stanford University, United States
Aleksandra Pavlovic,
University of Belgrade, Serbia

*CORRESPONDENCE
I-Wen Chen
CheniwenA60912@gmail.com

RECEIVED 23 July 2023
ACCEPTED 13 November 2023
PUBLISHED 28 November 2023

CITATION
Hung K-C, Liu C-C, Wu J-Y, Ho C-N, Lin M-C, Hsing C-H and Chen I-W (2023) Association between the neutrophil-to-lymphocyte ratio and cognitive impairment: a meta-analysis of observational studies.
Front. Endocrinol. 14:1265637.
doi: 10.3389/fendo.2023.1265637

COPYRIGHT
© 2023 Hung, Liu, Wu, Ho, Lin, Hsing and Chen. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Association between the neutrophil-to-lymphocyte ratio and cognitive impairment: a meta-analysis of observational studies

Kuo-Chuan Hung[1,2], Chien-Cheng Liu[3,4,5], Jheng-Yan Wu[6], Chun-Ning Ho[2], Ming-Chung Lin[2], Chung-Hsi Hsing[2,7] and I-Wen Chen[8]*

[1]School of Medicine, College of Medicine, National Sun Yat-sen University, Kaohsiung, Taiwan, [2]Department of Anesthesiology, Chi Mei Medical Center, Tainan, Taiwan, [3]Department of Anesthesiology, E-Da Hospital, I-Shou University, Kaohsiung, Taiwan, [4]Department of Nursing, College of Medicine, I-Shou University, Kaohsiung, Taiwan, [5]School of Medicine, I-Shou University, Kaohsiung, Taiwan, [6]Department of Nutrition, Chi Mei Medical Center, Tainan, Taiwan, [7]Department of Medical Research, Chi-Mei Medical Center, Tainan, Taiwan, [8]Department of Anesthesiology, Chi Mei Medical Center, Liouying, Tainan, Taiwan

Background: Systemic inflammation is one of the underlying mechanisms of cognitive impairment. The neutrophil-to-lymphocyte ratio (NLR) has emerged as a systemic inflammation indicator. This meta-analysis aimed to evaluate the association between high NLR and cognitive impairment (CI) risk.

Method: A comprehensive systematic search was conducted to identify eligible studies published until May 30, 2023. The reference group comprised patients with the lowest NLR level, whereas the exposure group comprised those with the highest NLR level. The main outcome was to examine the relationship between NLR and CI risk. The secondary outcome included the association between patient characteristics or comorbidities and CI risk.

Results: This meta-analysis included 11 studies published between 2018 and 2023, involving 10,357 patients. Patients with CI had a higher NLR than those without (mean difference=0.35, 95% confidence interval [CI]: 0.26–0.44, $p <$ 00001, $I^2 =$ 86%). Consistently, pooled results revealed an association between high NLR and CI risk (odds ratio [OR]=2.53, 95% CI:1.67–3.82, p<0.0001, $I^2 =$ 84%). Furthermore, aging (mean difference =4.31 years, 95% CI:2.83–5.8, $p <$ 0.00001, $I^2 =$ 92%), diabetes (OR=1.59, 95% CI:1.35–1.88, $p <$ 0.00001, $I^2 =$ 66%), and hypertension (OR=1.36, 95% CI:1.19–1.57, $p <$ 0.00001, $I^2 =$ 0%) were significant risk factors for CI. However, no significant associations were observed between CI and male gender (OR = 0.84, 95% CI:0.64–1.11, $p =$ 0.22, $I^2 =$ 81%), body mass index (mean = –0.32 kg/m^2, 95% CI: –0.82, 0.18, $p =$ 0.2, $I^2 =$ 82%), alcohol consumption (OR = 1.11, 95% CI:0.95–1.3, $p =$ 1.35, $I^2 =$ 0%), and smoking (OR = 0.99, 95% CI:0.87–1.13, $p =$ 0.86, $I^2 =$ 0%). Meta-regression found that diabetes and hypertension, but not age, significantly moderated the association between NLR and CI.

Conclusion: This meta-analysis showed a significant association between high NLR and increased CI risk. Moreover, meta-regression identified diabetes and

hypertension, but not age, as significant moderating factors in the relationship between NLR and CI. To validate and strengthen these findings, further large-scale studies are required.

Systematic Review Registration: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023430384, identifier CRD42023430384.

KEYWORDS

neutrophil-to-lymphocyte ratio, cognitive impairment, meta-analysis, age, mild cognitive impairment

1 Introduction

Mild cognitive impairment is characterized by a noticeable decline in cognitive abilities, including memory, thinking, and attention, which is greater than expected for a person's age and education level (1). However, individuals with mild cognitive impairment can independently perform daily activities without any significant interference. Conversely, cognitive impairment is a broader term that encompasses various conditions characterized by a decline in cognitive abilities. It includes mild cognitive impairment but also extends to more severe forms of cognitive decline, including dementia. In the general population, the estimated prevalence of mild cognitive impairment is approximately 3–18.6% (2–4), whereas in stroke survivors, the prevalence may be as high as approximately 60% (5, 6). Cognitive impairment, irrespective of its degree of severity, in older adults increases susceptibility to falls, disability, and deterioration in health-related quality of life (7–9). Even mild cognitive impairment demonstrates a conversion rate to dementia ranging from 18.4% to 43% (10–12). Timely detection and treatment using both non-pharmacological and pharmacological interventions for mild cognitive impairment may delay or avert subsequent dementia development (13, 14). Moreover, the presence of preoperative cognitive impairment is associated with a substantial increase in the risk of postoperative delirium, postoperative complications, 30-day readmission, discharge to assisted care, and 1-year mortality (15). Considering the aging population, cognitive impairment has emerged as a significant global public health concern (16). Therefore, there is an urgent clinical need to identify diagnostic biomarkers that can identify older adults who are susceptible to cognitive impairment.

Evidence suggests that chronic inflammation plays a pathogenic role in the development of cognitive impairment/mild cognitive impairment and Alzheimer's disease (AD) in older adults (17–21). For example, a study conducted over a 20-year period involving approximately 2,000 patients has provided evidence indicating a higher cognitive impairment probability in individuals exhibiting recurrent elevations or progressive increases in interleukin (IL)-6 levels (18). A previous meta-analysis showed higher peripheral levels of soluble tumor necrosis factor receptor 2, monocyte chemoattractant protein-1, and IL-6, along with decreased IL-8 levels, in patients diagnosed with mild cognitive impairment when compared with controls (22). These findings suggest an association between inflammation and cognitive decline. The neutrophil-to-lymphocyte ratio (NLR) has emerged as a preferred biomarker for assessing systemic inflammation owing to its novelty, cost-effectiveness, and suitability for extensive screening (23–25). Recently, several studies demonstrated a positive correlation between elevated NLR and cognitive impairment/mild cognitive impairment (26–28). Integrating NLR assessment into routine screening protocols may enhance the early identification of individuals at risk for cognitive decline, thereby leading to improved patient outcomes and the potential for preventive measures to mitigate cognitive impairment progression. To synthesize the clinical evidence available, the current meta-analysis and systematic review were conducted to explore the potential association between elevated NLR and increased risk of cognitive impairment in the population without previous dementia or psychiatric disease (e.g., bipolar disorder).

2 Methods

2.1 Protocol registration

This systematic review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Registration number of systematic reviews in PROSPERO: CRD42023430384).

2.2 Eligibility criteria

Regardless of publication date or language, studies that investigated the correlation between NLR and cognitive impairment in adults were eligible. We considered both observational studies and randomized controlled trials as eligible for inclusion. Studies were excluded if they met any of the following criteria: (1) unavailability of outcomes; (2) involvement of the postoperative setting; (3) presentation as conference abstracts, case reports, duplicated studies, unpublished reports, or review articles; (4) exclusive inclusion of patients with AD (to avoid significant pre-existing cognitive impairment) or bipolar disorder (to avoid mood-related cognitive fluctuations); or (5) studies

focusing on delirium or dementia as outcomes. We chose not to exclude studies centered on patients with stroke or diabetes because these diseases are recognized risk factors for cognitive impairment. Analyzing NLR in such a high-risk demographic can offer valuable perspectives.

2.3 Information sources and search strategies

A comprehensive systematic search was conducted across four electronic databases, including Medline (OVID), EMBASE (OVID), Google Scholar, and the Cochrane Library, to identify eligible studies published until May 30, 2023. Boolean operators (e.g., OR and AND) were employed to combine search terms in these databases. The following were the search terms used: ("NLR" or "Neutrophil*-to-lymphocyte" or "Neutrophile*-to-Lymphocyte Ratio" or "Neutrophil*/lymphocyte" or "Neutrophil* to lymphocyte ratio" or "Neutrophil* lymphocyte ratio") and ("Cognitive impairment" or "Impaired cognition" or "Cognitive decline" or "Cognitive dysfunction" or "Cognitive disability" or "Cognitive disorder" or "Cognitive impairment" or "Cognitive deficit").

To ensure an exhaustive search, controlled vocabulary terms (e.g., MeSH terms) were employed as search terms. Moreover, to identify studies that met the eligibility criteria, reference lists of pertinent articles, including review articles, were scrutinized. The relevant search strategies for one of the databases (e.g., Medline [OVID]) are presented in Supplemental Table 1.

2.4 Selection process and data collection

The study eligibility determination process included the following three steps: (1) duplicated articles were excluded using EndNote software; (2) two authors independently screened titles and abstracts to identify eligible articles for full-text review; and (3) studies meeting the inclusion criteria following full-text reading were included. Any discrepancies encountered during the selection process were resolved by consultation with a third author.

Data obtained from each study encompassed the following information: study population, first author's name, publication year, age, sex, body mass index (BMI), method of diagnosing cognitive impairment, sample size, NLR value, type of odds ratio (OR) (e.g., adjusted or non-adjusted), and country. In cases where discrepancies arose, resolution was sought through consultation with a third author. Furthermore, in instances where certain information was absent from the article, attempts were made to contact the corresponding author on three separate occasions to acquire the missing data.

2.5 Definitions and outcomes

In the present meta-analysis, the term "cognitive impairment" also included mild cognitive impairment. The main objective of this study was to examine the relationship between NLR and cognitive impairment risk. The primary outcome measure used for analysis was OR, which assessed the association between NLR and the likelihood of developing cognitive impairment. In the present meta-analysis, the reference group comprised of patients with the lowest NLR, whereas the exposure group comprised of those with the highest NLR. The NLR cutoff values or diagnosis of cognitive impairment were based on the criteria used in each individual study, rather than applying a single unified criterion. The secondary outcomes included the association between patient characteristics, comorbidities, and cognitive impairment risk.

2.6 Quality assessment

The Newcastle-Ottawa Scale (NOS) was used to evaluate the methodological rigor of the studies included in the analysis. The assessment encompassed three key aspects: subject selection, comparability of groups, and outcome or exposure assessment. Each study was assigned a quality grade based on a scale ranging from low (0–3), moderate (4–6), to high (7–9). Any discrepancies that arose during the evaluation process were resolved through consensus.

2.7 Statistical analyses

The Cochrane Review Manager (RevMan 5.3; Copenhagen: The Nordic Cochrane Center, The Cochrane Collaboration, 2014) and comprehensive Meta-Analysis (CMA) V3 software (Biostat, Englewood, NJ, USA) was used for data synthesis. To account for potential heterogeneities arising from variations in clinical settings, we employed the Mantel–Haenszel random-effects model to analyze dichotomous outcome data, presenting the results as ORs accompanied by 95% confidence intervals (CIs). The mean differences (MDs) and their corresponding 95% CIs were reported for outcomes involving continuous variables. Significant heterogeneity was defined as an I^2 value > 50%. Through visual examination of a funnel plot, publication bias was assessed for the outcomes mentioned in at least ten studies. Furthermore, the potential influence of individual studies on the overall results was assessed using a "leave-one-out" sensitivity analysis. To investigate the possible moderating influences of risk factors on the relationship between NLR and cognitive impairment, we performed meta-regression analyses. A significant coefficient implies that the moderator variable significantly influences the strength of the association between NLR and cognitive impairment. All comparisons were subjected to two-tailed tests, with statistical significance set at a p-value < 0.05.

3 Results

3.1 Search results and study characteristics

The study selection procedure is illustrated in Figure 1. Initially, 677 potentially pertinent articles were retrieved from the electronic databases. Among these, 75 duplicates were eliminated and an

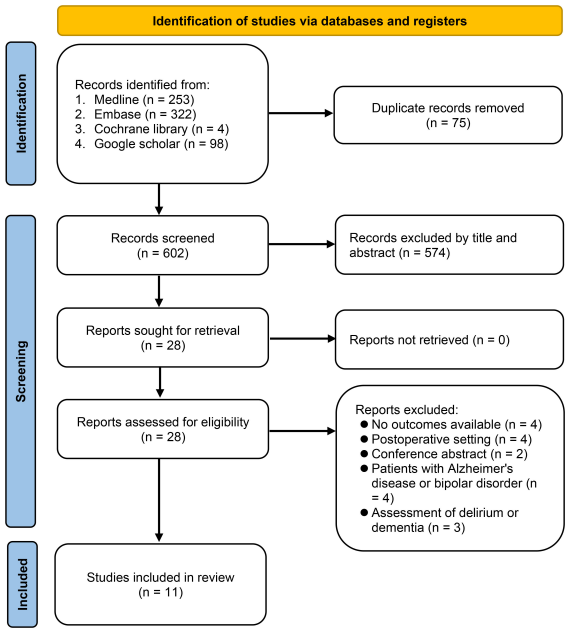


FIGURE 1
Flow chart for study selection.

additional 574 articles were deemed unsuitable based on their titles and abstracts. Subsequently, to assess potential eligibility, the remaining 28 studies were subjected to a comprehensive full-text review. After applying the exclusion criteria, 17 studies were excluded, leaving 11 studies published between 2018 and 2023 (26–36). These studies involved 10,357 patients and were included in the meta-analysis. Of the articles selected for this meta-analysis, all were identified as observational studies.

The characteristics of the 11 included studies are summarized in Table 1. The analysis included four studies involving patients aged ≥ 60 years or older (26, 28, 30, 36), four studies involving patients with stroke (27, 29, 33, 35), two studies focused on patients with type 2 DM (32, 34), and one study involving patients with metabolic syndrome (31). In one study (36), even though the main emphasis was on the relationship between NLR and delirium risk, it also presented valuable data on the association between NLR and cognitive impairment. For our analysis, we extracted and incorporated only the data pertaining to the link between NLR and cognitive impairment, ensuring it met our inclusion criteria. All included studies enrolled participants of both sexes, with the percentage of males ranging from 38.9% to 76.1%. The mean or median age of recruited individuals varied across studies, ranging from 47.9 to 84 years. Regarding the sample size, the number of patients included in the studies varied, ranging from 60 to 4,579. Among them, two studies were large-scale studies, including 2,479 (30) and 4,579 (28) patients, respectively, whereas two studies were small-scale studies, involving only 60 patients (31, 32). Ten studies explicitly stated the diagnostic method used for cognitive impairment (26–35), whereas one study did not provide any description (36). Among the included studies, nine reported ORs, with seven (26–30, 33, 34) and two (32, 36) studies presenting adjusted and unadjusted ORs, respectively. Additionally, two studies exclusively provided NLR values for patients with and without cognitive impairment (31, 35). The studies were conducted across multiple countries, including China (26, 28–30, 33–36), South Korea (27), Thailand (31), and India (32), with China being the predominant country of study.

The quality of the studies is summarized in Table 1. Four of the 11 studies evaluated were considered to have potential biases (e.g., NOS = 6), indicating some limitations or weaknesses in their study design. Conversely, seven studies were considered to have a low risk of bias (e.g., NOS range:7–9), suggesting that they have a more robust and reliable methodology.

3.2 Outcomes

3.2.1 Risk of cognitive impairment in patients with high NLR ratio

The results of pooled data from included studies showed significantly higher NLR in patients with cognitive impairment (MD = 0.35, 95% CI:0.26–0.44, p < 00001, I^2 = 86%, sensitivity analysis: consistent, range of MD: 0.33-0.38, all p value<0.05) (Figure 2) (26, 27, 29–32, 34, 35). Nine studies provided information to estimate the pooled risk of cognitive impairment in patients with a high NLR (primary outcome). Meta-analysis showed an association between a high NLR and cognitive impairment risk (OR = 2.53, 95% CI:1.67–3.82, p < 0.0001, I^2 = 84%) (Figure 3) (26–30, 32–34, 36). Sensitivity analysis showed consistent findings (range of OR: 2.25-2.84, all p value<0.05) when one study was removed individually.

3.2.2 Other risk factors for cognitive impairment

We conducted a meta-analysis to examine the association between cognitive impairment and various factors. Results indicated a significant association between cognitive impairment and old age (MD = 4.31 years, 95% CI:2.83–5.8, p < 0.00001, I^2 = 92%, sensitivity analysis: consistent, range of MD: 3.86-5.02, all p value<0.05) (Figure 4), diabetes (OR = 1.59, 95% CI:1.35–1.88, p < 0.00001, I^2 = 66%, sensitivity analysis: inconsistent, range of OR: 1.18-1.7) (Figure 5), and hypertension (OR = 1.36, 95% CI:1.19–1.57, p < 0.00001, I^2 = 0%, sensitivity analysis: consistent, range of OR: 1.29-1.46, all p value<0.05) (Figure 6). However, no association was observed between cognitive impairment and male sex (OR = 0.84, 95% CI:0.64–1.11, p = 0.22, I^2 = 81%, sensitivity analysis: consistent, range of OR: 0.77-0.95, all p value>0.05) (Supplemental Figure 1), BMI (MD = −0.32 kg/m^2, 95% CI: −0.82, 0.18, p = 0.2, I^2 = 82%, sensitivity analysis: inconsistent, range of MD: -0.16 to -0.52) (Supplemental Figure 2), alcohol consumption (OR = 1.11, 95% CI:0.95–1.3, p = 1.35, I^2 = 0%, sensitivity analysis: consistent, range of OR: 1.03-1.17, all p value>0.05)(Supplemental Figure 3), and smoking (OR = 0.99, 95% CI:0.87–1.13, p = 0.86, I^2 = 0%, sensitivity analysis: consistent, range of OR: 0.92-1.02, all p value>0.05) (Supplemental Figure 4). Owing to the limited number of studies available for each outcome, the funnel plots were not examined.

3.2.3 Meta-regression

To examine the potential moderating effects of age, diabetes, and hypertension on the association between NLR and cognitive impairment, meta-regression analyses were conducted. The mean

TABLE 1 Characteristics of studies (n = 11).

Studies	Population	Age (years) ¶	Male (%) ¶	N	Diagnosis for CI	Adjusted OR (Y/N)	High NLR	Low NLR	Country	NOS
An 2019 (26)	Adults aged 65 or older	73.1 vs. 71.1	42 vs. 47	339	MPC	Y	>2.07	<2.07	China	9
Hou 2022 (27)	Adults with cerebral small vessel disease	61.2 vs. 64.5	43.2 vs. 57.5	147	MoCA score	Y	>1.89	<1.89	China	9
Lee 2021 (28)	Adults with ischemic stroke	66.7 vs. 62	53.5 vs. 67.2	345	K-VCIHS-NP	Y	≥3.8	≤1.57	Korea	9
Li 2023 (29)	Adults aged 60 years or older	73.5 vs. 68.6	46.5 vs. 46.5	2479	CCSZ	Y	>2.88	≤1.53	China	7
Liu 2020 (30)	Adults aged 60 or older	67.6‡	52‡	4579	AMT	Y	>2.64	<1.53	China	9
Pipatpiboon 2022 (31)	Adults with metabolic syndrome	57.47‡	47‡	60	MOCA score	NA	>1.84	<1.61	Thailand	6
Sasirekha 2018 (32)	Adults with type II DM	50.8 vs. 47.9	38.9 vs. 54.8	60	MMSE	N	>2	<2	India	6
Shang 2022 (33)	Adults with mild acute ischemia stroke	62 vs. 61	68.4 vs. 76.1	454	MOCA score	Y	≥4.05	≤1.62	China	8
Yu 2023 (34)	Adults with type 2 DM	60 vs. 55	45.2 vs. 49.4	787	MOCA score	Y	>1.99	<1.48	China	8
Zha 2022 (35)	Adults with ischemia stroke	67.3 vs. 60.1	42.5 vs. 67.1	367	MMSE	NA	>2.73	<2.14	China	6
Zhao 2021 (36)	Hospitalized patients aged ≥ 70 years	84‡	71.20‡	740	NA	N	>3.63	≤3.63	China	6

MPC, modified Petersen's criteria; MoCA, Montreal Cognitive Assessment; K-VCIHS-NP, Korean version of the Vascular Cognitive Impairment Harmonization Standards-Neuropsychological Protocol; AMT, Abbreviated Mental Test; MMSE, Mini-Mental State Examination; CCSZ, Composite cognitive score Z-score; OR, odd ratio; Y, yes; N, no; NA, not available; CI, cognitive impairment; ¶present as patients with cognitive impairment vs. without cognitive impairment; ‡overall population; NOS, Newcastle-Ottawa Scale; NLR, neutrophil-to-lymphocyte ratio

age of participants, proportion of patients with diabetes, and proportion of patients with hypertension were entered as moderators in separate univariate meta-regression models. These findings reveal that both diabetes (coefficient: -0.067, p = 0.0003) (Figure 7) and hypertension (coefficient: -0.03, p = 0.004) (Figure 8) play a significant role as covariates in the relationship between NLR and cognitive impairment. On the other hand, age doesn't possess a comparable covariate linkage in this setting (coefficient: 0.049, p = 0.248) (Figure 9).

4 Discussion

This meta-analysis included 11 studies published between 2018 and 2023, involving 10,357 patients. Pooled results revealed that patients with cognitive impairment had a higher NLR than those without cognitive impairment. From the nine studies that provided relevant data, a meta-analysis was conducted to estimate the pooled risk of cognitive impairment in patients with a high NLR, which showed a significant association (OR = 2.53). Our meta-regression

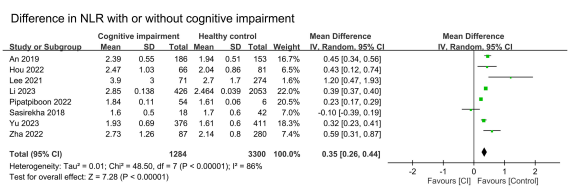


FIGURE 2
Forest plot comparing the neutrophil-to-lymphocyte ratio (NLR) in patients with cognitive impairment (CI) and those without. The point estimates and their 95% confidence intervals are represented by squares and horizontal lines, respectively. A point estimate to the right of the centerline indicates a higher NLR in the CI group relative to the control group, denoted by 'favours [Control]'.

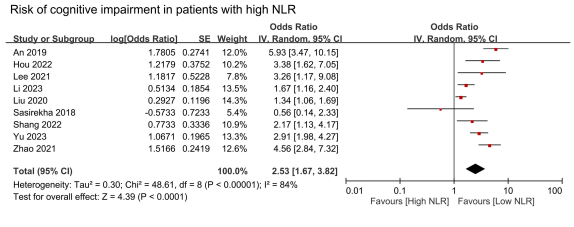


FIGURE 3
Forest plot showing cognitive impairment risk in patients with high neutrophil-to-lymphocyte ratio (NLR). IV, inverse variation; CI, confidence interval; SE, standard error. The point estimates and their 95% confidence intervals are represented by squares and horizontal lines, respectively. A point estimate to the right of the centerline indicates a higher cognitive impairment risk in the high NLR group relative to the low NLR group, denoted by 'favours [low NLR]'.

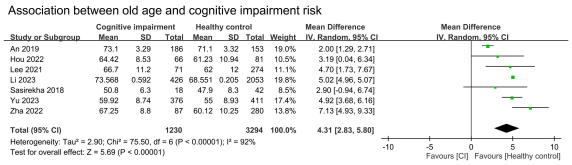


FIGURE 4
Forest plot showing an association between old age and cognitive impairment risk. IV, inverse variation; CI, confidence interval. The point estimates and their 95% confidence intervals are represented by squares and horizontal lines, respectively. A point estimate to the right of the centerline suggests a younger age in the healthy control group relative to the cognitive impairment group, denoted by 'favours [healthy control]'.

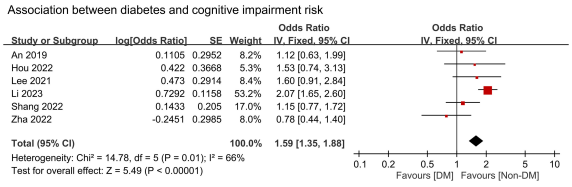


FIGURE 5
Forest plot showing an association between diabetes and cognitive impairment risk. IV, inverse variation; CI, confidence interval. The point estimates and their 95% confidence intervals are represented by squares and horizontal lines, respectively. A point estimate to the right of the centerline suggests a higher cognitive impairment risk in the DM group relative to the Non-DM group, denoted by 'favours [Non-DM]'.

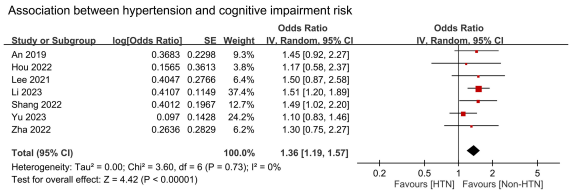


FIGURE 6
Forest plot showing an association between hypertension and cognitive impairment risk. IV, inverse variation; CI, confidence interval. The point estimates and their 95% confidence intervals are represented by squares and horizontal lines, respectively. A point estimate to the right of the centerline suggests a higher cognitive impairment risk in the HTN group relative to the Non-HTN group, denoted by 'favours [Non-HTN]'.

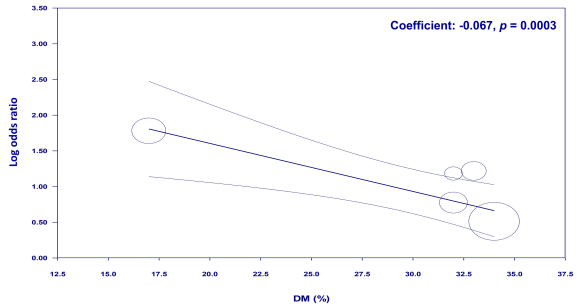


FIGURE 7
Meta-regression showing the potential moderating effect of diabetes on the association between neutrophil-to-lymphocyte ratio (NLR) and cognitive impairment.

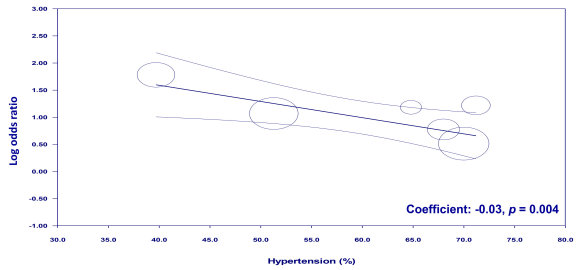


FIGURE 8
Meta-regression showing the potential moderating effect of hypertension on the association between neutrophil-to-lymphocyte ratio (NLR) and cognitive impairment.

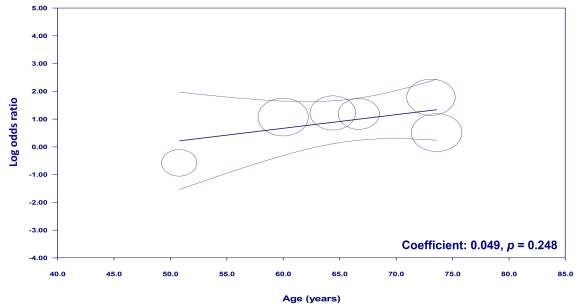


FIGURE 9
Meta-regression showing no moderating effect of age on the association between neutrophil-to-lymphocyte ratio (NLR) and cognitive impairment.

indicates diabetes and hypertension, but not age, as significant moderating factors influencing the association between NLR and risk of cognitive impairment.

Systemic inflammation has emerged as a significant contributor to cognitive impairment (37–39). In an animal study, aging mice were found to be more prone to episodic systemic inflammation, and cognitive impairments in these mice were linked to increased oxidative stress and abnormal cytokine production in the brain, emphasizing the significance of neuroinflammation and oxidative stress in age-related cognitive decline (40). Several studies have also demonstrated an association between elevated levels of proinflammatory markers, including C-reactive protein, IL-6, and tumor necrosis factor-alpha (TNF-α), and cognitive decline as well as an increased risk of neurodegenerative disorders (e.g., AD and vascular dementia) (41–44). For example, a previous study of 300 community-dwelling participants with mild-to-severe AD reported that acute systemic inflammatory events were associated with a two-fold increase in cognitive decline over a 6-month period, whereas

high TNF-α baseline levels were associated with a four-fold increase in cognitive decline (37). The negative impact of systemic inflammation on cognitive function is likely due to several factors, including the ability of chronic inflammation to cause vascular dysfunction, which can result in impaired cerebral blood flow and oxygenation, ultimately compromising neuronal function and cognitive processes (45, 46). Furthermore, inflammatory mediators may directly affect the brain by disrupting the blood–brain barrier, activating microglia, and releasing neurotoxic substances, ultimately leading to neuroinflammation and neuronal damage (41).

Detecting cognitive impairment early and potentially preventing its progression can significantly improve the quality of life of older adults while also reducing the social, psychological, and economic burdens faced by their families and caregivers. In the present meta-analysis, nine studies were analyzed and showed a significant association (OR = 2.53) between high NLR and cognitive impairment risk, which was consistent even after sensitivity analyses. The findings of this meta-analysis provide robust evidence to support the notion that a high NLR is associated with an increased risk of cognitive impairment. Notably, the high heterogeneity observed among the included studies highlights the necessity for additional research to investigate optimal NLR threshold values for cognitive impairment detection. Nevertheless, our research findings provide evidence supporting the clinical applicability of the NLR as a promising biomarker. Integrating NLR assessment into routine screening protocols may enhance the early identification of individuals at risk for cognitive decline, thereby leading to improved patient outcomes and the potential for preventive measures to mitigate cognitive impairment progression.

Our findings indicate a significant association between cognitive impairment and factors including advanced age, diabetes, and hypertension, consistent with the existing literature on the subject. For example, a previous meta-analysis of 19 studies and a total of 44,714 participants reported that individuals with diabetes had a significantly increased risk of mild cognitive impairment (relative risk:1.21) compared to those without diabetes (47). Furthermore, a meta-analysis involving 112,632 community-dwelling Chinese populations aged > 55 years reported an increase in the prevalence of mild cognitive impairment with advancing age (48). A prospective community-based cohort study involving 918 individuals reported an association between hypertension and a higher risk of developing mild cognitive impairment (hazard ratio,1.40) following a mean follow-up period of 4.7 years (49). Meta-regression analysis revealed that diabetes and hypertension, rather than age, played significant roles as moderating factors influencing the relationship between the NLR and the risk of cognitive impairment. As a result, future studies seeking to employ NLR as a screening tool for cognitive impairment should carefully consider the impact of these modulators.

No associations between cognitive impairment and male sex, BMI, alcohol consumption, or smoking were observed in this study. A previous study that analyzed data from three large clinical trials observed that participants classified as obese (BMI ≥ 30 kg/m^2) had a 29% higher prevalence of cognitive impairment than those with normal weight to overweight (50). Moreover, obesity was linked to a 1.29-fold higher prevalence of cognitive impairment even after adjusting for age, sex, diabetes, and hypertension (50). In the current meta-analysis, no significant relationship between cognitive impairment and BMI was noted. This lack of correlation may be attributed to the inclusion of participants who were not obese (e.g., mean BMI < 30 kg/m^2 in all individuals). Conflicting findings have been reported in the current literature regarding cigarette smoking and cognitive impairment. During a 10-year follow-up period of 1,436 participants without cognitive impairment at baseline, both past and current smokers had a reduced likelihood of developing cognitive impairment compared with those who had never smoked, indicating a potential protective effect of smoking on cognitive function (51). In contrast, a study involving 3,012 participants aged 60 years reported that current smoking and alcohol consumption are significantly associated with a higher risk of cognitive impairment risk (52). Further studies are needed to elucidate these associations and better understand their underlying mechanisms.

This study has some limitations. First, the included studies were restricted to specific populations, including patients with ischemic stroke, which may restrict the generalizability of the findings to a broader population. Second, small sample sizes may increase the risk of bias and compromise the statistical power required to accurately detect small associations. Third, discrepancies were observed in the cognitive diagnosis criteria employed across studies, leading to heterogeneity and potentially impacting the comparability of findings. Additionally, the extent of adjustment for confounding factors varied among studies, with some performing adjusted analyses and others omitting this crucial step. This variability may have influenced the interpretation of the results and the ability to adequately control for potential confounders. Finally, most studies were conducted in China. Consequently, caution should be exercised when attempting to generalize these findings to other geographical regions.

5 Conclusion

This meta-analysis showed a higher NLR in patients with cognitive impairment, indicating a potential association between the NLR and cognitive decline. Moreover, high NLR was significantly associated with an increased risk of cognitive impairment, with an OR of 2.53. Meta-regression showed that diabetes and hypertension were identified as significant moderating factors in the relationship between NLR and CI, while age did not show a significant moderating effect. Further large-scale investigations with diverse populations and standardized

diagnostic criteria are warranted to validate and strengthen our findings.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author/s.

Author contributions

KH: Conceptualization, Data curation, Writing – original draft. CL: Investigation, Methodology, Software, Writing – original draft. JW: Formal Analysis, Software, Validation, Writing – original draft. CH: Investigation, Project administration, Resources, Writing – original draft. ML: Project administration, Resources, Validation, Writing – original draft. CH: Investigation, Methodology, Validation, Writing – original draft. IC: Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was funded by the Chi Mei Medical Center, Tainan, Taiwan (grant number: CMOR11203).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fendo.2023.1265637/full#supplementary-material

References

1. Gauthier S, Reisberg B, Zaudig M, Petersen RC, Ritchie K, Broich K, et al. Mild cognitive impairment. *Lancet* (2006) 367:1262–70. doi: 10.1016/S0140-6736(06)68542-5

2. Ganguli M, Dodge HH, Shen C, DeKosky ST. Mild cognitive impairment, amnestic type: an epidemiologic study. *Neurol* (2004) 63:115–21. doi: 10.1212/01.WNL.0000132523.27540.81

3. Hänninen T, Hallikainen M, Tuomainen S, Vanhanen M, Soininen H. Prevalence of mild cognitive impairment: a population-based study in elderly subjects. *Acta neurologica Scandinavica* (2002) 106:148–54. doi: 10.1034/j.1600-0404.2002.01225.x

4. Iype T, Babu V, Sreelakshmi PR, Alapatt PJ, Rajan R, Soman B. The prevalence of mild cognitive impairment (Mci) among older population of Rural Kerala: A cross-sectional study. *Neurol India* (2023) 71:296–300. doi: 10.4103/ni.ni_676_21

5. Kaddumukasa MN, Kaddumukasa M, Katabira E, Sewankambo N, Namujju LD, Goldstein LB. Prevalence and predictors of post-stroke cognitive impairment among stroke survivors in Uganda. *BMC Neurol* (2023) 23:166. doi: 10.1186/s12883-023-03212-8

6. Yu KH, Cho SJ, Oh MS, Jung S, Lee JH, Shin JH, et al. Cognitive impairment evaluated with Vascular Cognitive Impairment Harmonization Standards in a multicenter prospective stroke cohort in Korea. *Stroke* (2013) 44:786–8. doi: 10.1161/STROKEAHA.112.668343

7. Shimada H, Makizako H, Doi T, Tsutsumimoto K, Lee S, Suzuki T. Cognitive impairment and disability in older Japanese adults. *PloS One* (2016) 11:e0158720. doi: 10.1371/journal.pone.0158720

8. Monachan D, Vargese SS, Johny V, Mathew E. Risk of Fall among Older Adults and its Association with Cognitive Impairment in a Semi-Urban Community. *Indian J Community Med* (2020) 45:463–6. doi: 10.4103/ijcm.IJCM_491_19

9. Hussenoeder FS, Conrad I, Roehr S, Fuchs A, Pentzek M, Bickel H, et al. Mild cognitive impairment and quality of life in the oldest old: a closer look. *Qual Life Res an Int J Qual Life aspects treatment Care rehabilitation.* (2020) 29:1675–83. doi: 10.1007/s11136-020-02425-5

10. Alagiakrishnan K, Dhami P, Senthilselvan A. Predictors of conversion to dementia in patients with mild cognitive impairment: the role of low body temperature. *J Clin Med Res* (2023) 15:216–24. doi: 10.14740/jocmr4883

11. Thaipisuttikul P, Jaikla K, Satthong S, Wisajun P. Rate of conversion from mild cognitive impairment to dementia in a Thai hospital-based population: A retrospective cohort. *Alzheimer's dementia (New York N Y)* (2022) 8:e12272. doi: 10.1002/trc2.12272

12. Baird K, Baillon S, Lau LSL, Storey M, Lindesay J, Velayudhan L. Predictive factors for conversion to dementia in individuals with early-onset mild cognitive impairment. *Dementia Geriatr Cogn Disord* (2021) 50:548–53. doi: 10.1159/000520882

13. Chen YX, Liang N, Li XL, Yang SH, Wang YP, Shi NN. Diagnosis and treatment for mild cognitive impairment: A systematic review of clinical practice guidelines and consensus statements. *Front Neurol* (2021) 12:719849. doi: 10.3389/fneur.2021.719849

14. Wallin A, Nordlund A, Jonsson M, Lind K, Edman Å, Göthlin M, et al. The Gothenburg MCI study: Design and distribution of Alzheimer's disease and subcortical vascular disease diagnoses from baseline to 6-year follow-up. *J Cereb Blood Flow Metab* (2016) 36:114–31. doi: 10.1038/jcbfm.2015.147

15. Chen L, Au E, Saripella A, Kapoor P, Yan E, Wong J, et al. Postoperative outcomes in older surgical patients with preoperative cognitive impairment: A systematic review and meta-analysis. *J Clin anesthesia* (2022) 80:110883. doi: 10.1016/j.jclinane.2022.110883

16. Ruangritchankul S, Peel NM, Shafiee Hanjani L, Gray LC. The changes in medication prescribing among the older people with cognitive impairment in the acute care setting. *Clin Interventions aging* (2020) 15:865–76. doi: 10.2147/CIA.S252432

17. Gorelick PB. Role of inflammation in cognitive impairment: results of observational epidemiological studies and clinical trials. *Ann New York Acad Sci* (2010) 1207:155–62. doi: 10.1111/j.1749-6632.2010.05726.x

18. Wichmann MA, Cruickshanks KJ, Carlsson CM, Chappell R, Fischer ME, Klein BE, et al. Long-term systemic inflammation and cognitive impairment in a population-based cohort. *J Am Geriatr Society* (2014) 62:1683–91. doi: 10.1111/jgs.12994

19. Magaki S, Mueller C, Dickson C, Kirsch W. Increased production of inflammatory cytokines in mild cognitive impairment. *Exp Gerontol* (2007) 42:233–40. doi: 10.1016/j.exger.2006.09.015

20. Pistell PJ, Morrison CD, Gupta S, Knight AG, Keller JN, Ingram DK, et al. Cognitive impairment following high fat diet consumption is associated with brain inflammation. *J Neuroimmunol* (2010) 219:25–32. doi: 10.1016/j.jneuroim.2009.11.010

21. Guerreiro RJ, Santana I, Brás JM, Santiago B, Paiva A, Oliveira C. Peripheral inflammatory cytokines as biomarkers in Alzheimer's disease and mild cognitive impairment. *Neurodegenerative Dis* (2007) 4:406–12. doi: 10.1159/000107700

22. Shen X-N, Niu L-D, Wang Y-J, Cao X-P, Liu Q, Tan L, et al. Inflammatory markers in Alzheimer's disease and mild cognitive impairment: a meta-analysis and systematic review of 170 studies. *J Neurol Neurosurg Psychiatry* (2019) 90:590–8. doi: 10.1136/jnnp-2018-319148

23. Bhikram T, Sandor P. Neutrophil-lymphocyte ratios as inflammatory biomarkers in psychiatric patients. *Brain behavior immunity* (2022) 105:237–46. doi: 10.1016/j.bbi.2022.07.006

24. Qian B, Zheng Y, Jia H, Zheng X, Gao R, Li W. Neutrophil-lymphocyte ratio as a predictive marker for postoperative infectious complications: A systematic review and meta-analysis. *Heliyon* (2023) 9:e15586. doi: 10.1016/j.heliyon.2023.e15586

25. Zawiah M, Hayat Khan A, Abu Farha R, Usman A, Bitar AN. Neutrophil-lymphocyte ratio, monocyte-lymphocyte ratio, and platelet-lymphocyte ratio in stroke-associated pneumonia: a systematic review and meta-analysis. *Curr Med Res opinion* (2023) 39:475–82. doi: 10.1080/03007995.2023.2174327

26. An P, Zhou X, Du Y, Zhao J, Song A, Liu H, et al. Association of neutrophil-lymphocyte ratio with mild cognitive impairment in elderly chinese adults: a case-control study. *Curr Alzheimer Res* (2019) 16:1309–15. doi: 10.2174/1567205017666200103110521

27. Lee M, Lim J-S, Kim C-H, Lee S-H, Kim Y, Hun Lee J, et al. High neutrophil–lymphocyte ratio predicts post-stroke cognitive impairment in acute ischemic stroke patients. *Front Neurol* (2021) 12:693318. doi: 10.3389/fneur.2021.693318

28. Liu J-H, Zhang Y-J, Ma Q-H, Sun H-P, Xu Y, Pan C-W. Elevated blood neutrophil to lymphocyte ratio in older adults with cognitive impairment. *Arch Gerontol Geriatr* (2020) 88:104041. doi: 10.1016/j.archger.2020.104041

29. Hou L, Zhang S, Qi D, Jia T, Wang H, Zhang W, et al. Correlation between neutrophil/lymphocyte ratio and cognitive impairment in cerebral small vessel disease patients: a retrospective study. *Front Neurol* (2022) 13. doi: 10.3389/fneur.2022.925218

30. Li W, Li S, Shang Y, Zhuang W, Yan G, Chen Z, et al. Associations between dietary and blood inflammatory indices and their effects on cognitive function in elderly Americans. *Front Neurosci* (2023) 17. doi: 10.3389/fnins.2023.1117056

31. Pipatpiboon N, Sripetchwandee J, Sa-nguanmoo P, Tachaudomdach C, Jomgeow T, Phrommintikul A, et al. Neutrophil-Lymphocyte Ratio (NLR) is positively associated with impaired cognitive performance in patients with metabolic syndrome. *CMU J Nat Sci* (2022) 21:e2022013. doi: 10.12982/CMUJNS.2022.013

32. Sasirekha G, Celine D, Umayal C, Viji D, Indumathi M, Subathra S, et al. Association between neutrophil lymphocyte ratio and cognitive function in Type II Diabetes Mellitus. *Indian J Physiol Pharmacol* (2018) 62:74–9.

33. Shang T, Ma B, Shen Y, Wei C, Wang Z, Zhai W, et al. High neutrophil percentage and neutrophil-lymphocyte ratio in acute phase of ischemic stroke predict cognitive impairment: a single-center retrospective study in China. *Front Neurol* (2022) 13:907486. doi: 10.3389/fneur.2022.907486

34. Yu ZW, Wang Y, Li X, Tong XW, Zhang YT, Gao XY. Association between the neutrophil to lymphocyte ratio and mild cognitive impairment in patients with type 2 diabetes. *Aging Clin Exp Res* (2023) 35(6):1339–45. doi: 10.1007/s40520-023-02420-z

35. Zha F, Zhao J, Chen C, Ji X, Li M, Wu Y, et al. A high neutrophil-to-lymphocyte ratio predicts higher risk of poststroke cognitive impairment: development and validation of a clinical prediction model. *Front Neurol* (2022) 12:2444. doi: 10.3389/fneur.2021.755011

36. Zhao Y, Yue J, Lei P, Lin T, Peng X, Xie D, et al. Neutrophil-lymphocyte ratio as a predictor of delirium in older internal medicine patients: a prospective cohort study. *BMC Geriatr* (2021) 21:334. doi: 10.1186/s12877-021-02284-w

37. Holmes C, Cunningham C, Zotova E, Woolford J, Dean C, Su K, et al. Systemic inflammation and disease progression in Alzheimer disease. *Neurol* (2009) 73:768–74. doi: 10.1212/WNL.0b013e3181b6bb95

38. Schram MT, Euser SM, De Craen AJ, Witteman JC, Frölich M, Hofman A, et al. Systemic markers of inflammation and cognitive decline in old age. *J Am Geriatr Society* (2007) 55:708–16. doi: 10.1111/j.1532-5415.2007.01159.x

39. Wang WY, Tan MS, Yu JT, Tan L. Role of pro-inflammatory cytokines released from microglia in Alzheimer's disease. *Ann Transl Med* (2015) 3(10):136. doi: 10.3978/j.issn.2305-5839.2015.03.49

40. d'Avila JC, Siqueira LD, Mazeraud A, Azevedo EP, Foguel D, Castro-Faria-Neto HC, et al. Age-related cognitive impairment is associated with long-term neuroinflammation and oxidative stress in a mouse model of episodic systemic inflammation. *J Neuroinflamm* (2018) 15(1):28. doi: 10.1186/s12974-018-1059-y

41. Takata F, Nakagawa S, Matsumoto J, Dohgu S. Blood-brain barrier dysfunction amplifies the development of neuroinflammation: understanding of cellular events in brain microvascular endothelial cells for prevention and treatment of BBB dysfunction. *Front Cell Neurosci* (2021) 15:661838. doi: 10.3389/fncel.2021.661838

42. Stenfors CU, Jonsdottir I, Hanson LM, Theorell T. Associations between systemic pro-inflammatory markers, cognitive function and cognitive complaints in a population-based sample of working adults. *J psychosomatic Res* (2017) 96:49–59. doi: 10.1016/j.jpsychores.2017.03.010

43. Lyra e Silva NM, Gonçalves RA, Pascoal TA, Lima-Filho RA, Resende E, Vieira EL, et al. Pro-inflammatory interleukin-6 signaling links cognitive impairments and peripheral metabolic alterations in Alzheimer's disease. *Trans Psychiatry* (2021) 11:251. doi: 10.1038/s41398-021-01349-z

44. Ravaglia G, Forti P, Maioli F, Chiappelli M, Montesi F, Tumini E, et al. Blood inflammatory markers and risk of dementia: The Conselice Study of Brain Aging. *Neurobiol Aging* (2007) 28:1810–20. doi: 10.1016/j.neurobiolaging.2006.08.012

45. Kure CE, Rosenfeldt FL, Scholey AB, Pipingas A, Kaye DM, Bergin PJ, et al. Relationships among cognitive function and cerebral blood flow, oxidative stress, and inflammation in older heart failure patients. *J cardiac failure* (2016) 22:548–59. doi: 10.1016/j.cardfail.2016.03.006

46. Chen HL, Lin HC, Lu CH, Chen PC, Huang CC, Chou KH, et al. Systemic inflammation and alterations to cerebral blood flow in obstructive sleep apnea. *J sleep Res* (2017) 26:789–98. doi: 10.1111/jsr.12553

47. Cheng G, Huang C, Deng H, Wang H. Diabetes as a risk factor for dementia and mild cognitive impairment: a meta-analysis of longitudinal studies. *Internal Med J* (2012) 42:484–91. doi: 10.1111/j.1445-5994.2012.02758.x

48. Lu Y, Liu C, Yu D, Fawkes S, Ma J, Zhang M, et al. Prevalence of mild cognitive impairment in community-dwelling Chinese populations aged over 55 years: a meta-analysis and systematic review. *BMC Geriatr* (2021) 21:10. doi: 10.1186/s12877-020-01948-3

49. Reitz C, Tang M-X, Manly J, Mayeux R, Luchsinger JA. Hypertension and the risk of mild cognitive impairment. *Arch Neurol* (2007) 64:1734–40. doi: 10.1001/archneur.64.12.1734

50. Feinkohl I, Lachmann G, Brockhaus WR, Borchers F, Piper SK, Ottens TH, et al. Association of obesity, diabetes and hypertension with cognitive impairment in older age. *Clin Epidemiol* (2018) 10:853–62. doi: 10.2147/CLEP.S164793

51. Wang C-C, Lu T-H, Liao W-C, Yuan S-C, Kuo P-C, Chuang H-L, et al. Cigarette smoking and cognitive impairment: a 10-year cohort study in Taiwan. *Arch Gerontol Geriatr* (2010) 51:143–8. doi: 10.1016/j.archger.2009.09.041

52. Zhou H, Deng J, Li J, Wang Y, Zhang M, He H. Study of the relationship between cigarette smoking, alcohol drinking and cognitive impairment among elderly people in China. *Age ageing* (2003) 32:205–10. doi: 10.1093/ageing/32.2.205

frontiers | Frontiers in Public Health

TYPE Systematic Review
PUBLISHED 01 December 2023
DOI 10.3389/fpubh.2023.1277995

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Xue Lan,
China Medical University, China
Mervyn Jun Rui Lim,
National University Hospital, Singapore

*CORRESPONDENCE
Juan Li
✉ 694807055@qq.com

RECEIVED 15 August 2023
ACCEPTED 13 November 2023
PUBLISHED 01 December 2023

CITATION
Xue C, Li J, Hao M, Chen L, Chen Z, Tang Z, Tang H and Fang Q (2023) High prevalence of subjective cognitive decline in older Chinese adults: a systematic review and meta-analysis. *Front. Public Health* 11:1277995. doi: 10.3389/fpubh.2023.1277995

COPYRIGHT
© 2023 Xue, Li, Hao, Chen, Chen, Tang, Tang and Fang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

High prevalence of subjective cognitive decline in older Chinese adults: a systematic review and meta-analysis

Chao Xue[1,2], Juan Li[2]*, Mingqing Hao[2], Lihua Chen[2], Zuoxiu Chen[2], Zeli Tang[3], Huan Tang[3] and Qian Fang[2]

[1]School of Nursing, Guizhou University of Traditional Chinese Medicine, Guiyang, Guizhou, China, [2]Department of Nursing, Guizhou Provincial People's Hospital, Guiyang, Guizhou, China, [3]School of Nursing, Zunyi Medical University, Zunyi, Guizhou, China

Background: Subjective cognitive decline (SCD) is considered a preclinical stage of Alzheimer's disease. However, reliable prevalence estimates of SCD in the Chinese population are lacking, underscoring the importance of such metrics for policymakers to formulate appropriate healthcare strategies.

Objective: To systematically evaluate SCD prevalence among older Chinese adults.

Methods: PubMed, Web of Science, The Cochrane Library, Embase, CNKI, Wanfang, VIP, CBM, and Airiti Library databases were searched for studies on SCD in older Chinese individuals published before May 2023. Two investigators independently screened the literature, extracted the information, and assessed the bias risk of the included studies. A meta-analysis was then conducted using Stata 16.0 software via a random-effects model to analyze SCD prevalence in older Chinese adults.

Results: A total of 17 studies were included (n = 31,782). The SCD prevalence in older Chinese adults was 46.4% (95% CI, 40.6–52.2%). Further, subgroup analyzes indicated that SCD prevalence was 50.8% in men and 58.9% among women. Additionally, SCD prevalence in individuals aged 60–69, 70–79, and ≥ 80 years was 38.0, 45.2, and 60.3%, respectively. Furthermore, SCD prevalence in older adults with BMI <18.5, 18.5–24.0, and > 24.0 was 59.3, 54.0, and 52.9%, respectively. Geographically, SCD prevalence among older Chinese individuals was 41.3% in North China and 50.0% in South China. In terms of residence, SCD prevalence was 47.1% in urban residents and 50.0% among rural residents. As for retired individuals, SCD prevalence was 44.2% in non-manual workers and 49.2% among manual workers. In the case of education, individuals with an education level of "elementary school and below" had an SCD prevalence rate of 62.8%; "middle school, "52.4%; "high school, "55.0%; and "college and above, "51.3%. Finally, SCD prevalence was lower among married individuals with surviving spouses than in single adults who were divorced, widowed, or unmarried.

Conclusion: Our systematic review and meta-analysis identified significant and widespread SCD prevalence in the older population in China. Therefore, our review findings highlight the urgent requirement for medical institutions and policymakers across all levels to prioritize and rapidly develop and implement comprehensive preventive and therapeutic strategies for SCD.

Systematic review registration: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023406950, identifier: CRD42023406950.

KEYWORDS

Chinese, subjective cognitive decline, prevalence, meta-analysis, Alzheimer's disease

1 Introduction

Alzheimer's disease (AD) is the leading cause of dementia (1, 2), with the latest data from the 2023 Alzheimer's Disease Facts and Figures report indicating that approximately 10% of the world's population aged over 65 years is living with AD (1). Moreover, the number of individuals with AD is projected to exceed 131 million by 2050 (3). Furthermore, the current status of AD epidemiology in China appears to be much worse than the global average. China, which has the fastest-growing older population in the world, may account for approximately half of the global AD population by 2050 (4, 5). With the increasing aging population in China, dementia (particularly AD) incidence is escalating rapidly (6, 7). AD is now the fifth leading cause of death in China (4, 8), and it is seriously affecting the physical and mental health of patients and family caregivers, utilizing national public health resources, and exacerbating the social and economic burden (1, 4, 5, 9).

Recent studies have indicated that preventive strategies for AD are the key to reducing this disease prevalence (1). Accurate identification and scientific interventions during the early AD stages can result in effective treatments for its comprehensive management (10–12), thereby reducing the financial and caregiving burdens associated with this neurodegenerative disease. In 2014, Jessen et al. (13) formally proposed the concept of subjective cognitive decline (SCD), referring to an individual's subjective perception of a persistent decline in cognitive function or memory compared to their previous normal state, irrespective of the normal results on objective neuropsychological examinations (13–15). Additionally, Jessen et al. (13, 16) suggested that SCD might serve as a preclinical stage of AD, aiding in the prediction of AD development. SCD has garnered considerable worldwide attention from scholars since its initial proposal, becoming a focal point in the fields of geriatric neurology and cognition (14, 17, 18). A meta-analysis of longitudinal studies found that SCD is associated with an increased risk of developing dementia (HR = 1.90, 95% CI 1.52–2.36; OR = 2.48, 95% CI 1.97–3.14), with an average progression to dementia of 10% (19). However, considering that SCD-related research in China was initiated relatively later, its prevalence and severity may be underestimated in the older adult population of this country.

Epidemiological studies have been prioritized in the Beijing area since 2015 to understand SCD prevalence among older Chinese adults and guide policy-making to address this trend (20). Although concerns regarding SCD emerging as a major public health issue in China have increased (21–24), epidemiological data on SCD in China's older population are scarce, with existing surveys being limited to the specific characteristics, study methodologies, identification, and classification of SCD (20, 25, 26). Thus, direct comparisons between individual studies are constrained.

In this systematic review and meta-analysis, our primary objective was to evaluate SCD prevalence in older Chinese adults by analyzing all available published data related to this topic. Additionally, we aimed to compare prevalence estimates among various subgroups, including those based on sex, age, body mass index (BMI), marital status, education level, geographical region, residence, and occupation type before retirement.

2 Methods

This review adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) (27) and the Meta-Analysis of Observational Studies in Epidemiology (28). Furthermore, this review was registered with PROSPERO (registration no. CRD42023406950).

2.1 Search strategy

Here, we systematically searched nine databases, including Embase, PubMed, The Cochrane Library, Web of Science, China National Knowledge Infrastructure Database, Wanfang Database, Chinese Biomedical Literature Database, Chinese Scientific Journal Database (VIP database), and Airiti Library, to locate all relevant publications on SCD epidemiology in China. The search period was from the date of database inception to May 1, 2023, with no language restrictions. Before finalizing the search strategy, we consulted with a librarian knowledgeable about systematic review methodology and the process of refining search terms. We also conducted several preliminary searches to obtain the most comprehensive collection of relevant literature. The search terms entered were as follows: ("subjective cognitive decline" OR "subjective memory decline" OR "subjective memory complain*" OR "subjective cognitive complain*" OR "subjective memory loss") AND ("incidence" OR "prevalence" OR "occurrence" OR "rate*" OR "epidemiology") AND ("Chinese" OR "China" OR "Hong Kong" OR "Macao" OR "Taiwan").

2.2 Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) studies with participants older than 60 years, (2) those including participants residing in China, including mainland China, Hong Kong, Macao, and Taiwan, (3) observational research study types, including cross-sectional and cohort studies, (4) those that applied the SCD diagnostic criteria (13, 16) and reported SCD prevalence, and (5) those published in Chinese or English. The exclusion criteria were as follows: (1) non-research articles such as reviews, case reports, comments, letters, and editorials, (2) duplicate publications, (3) studies without full-text availability, or (4) those of low research quality, i.e., Agency for Healthcare Research and Quality (AHRQ) quality assessment scores <4 (29).

2.3 Study selection and data extraction

All of the retrieved literature was imported into Endnote 20. After deleting duplicate initial search results within and between different databases, the two authors (C XUE and M HAO) independently reviewed the titles and abstracts to identify potentially eligible articles requiring a full assessment. In the case of multiple publications utilizing the same sample or original data, the publication with the largest sample size and the most thorough information on data extraction was given preference. To resolve differing opinions between the two reviewers, a third researcher (L CHEN) was consulted and asked to deliberate and vote on the specific issue. The two reviewers (C XUE and M HAO) then used a standardized form to independently extract and record the following information: first author, publication year, geographical

location, sample size, number and age of participants, assessment tools, and SCD prevalence.

2.4 Quality assessment

Two researchers (C XUE and M HAO) independently evaluated the bias risk in the included studies and cross-checked their assessments. In the case of disagreement, a discussion or a third-party consultation was used to obtain a judgment. To examine the methodological quality of the cross-sectional studies, we used an 11-item checklist recommended by the AHRQ (30). In this checklist, each item contained three options: "Yes, ""No, "or "Not clear." A score of 1 point was given for "Yes," whereas 0 points were scored for "No" and "Not clear." The overall score ranged from 0 to 11, wherein articles with scores of 0–3 were classified as low quality; 4–7, moderate quality; and 8–11, high quality.

2.5 Statistical analysis

The metaprop command in Stata 16.0 (StataCorp, College Station, TX, United States) was used to statistically analyze SCD prevalence in the older Chinese population. Furthermore, the χ^2 (with a test level of $\alpha = 0.1$) and I^2 tests were employed to analyze the heterogeneity of the results. For study results with no statistical heterogeneity ($p \geq 0.1$ and $I^2 \leq 50\%$), a fixed-effects model was utilized for the meta-analysis. Conversely, in those involving statistical heterogeneity ($p < 0.1$ or $I^2 > 50\%$), the results were further analyzed to identify the heterogeneity source (31). After eliminating the obvious clinical heterogeneity, a random-effects model was employed for the meta-analysis. The significance level for the meta-analysis was $\alpha = 0.05$. Additionally, subgroup analysis was performed to evaluate SCD prevalence based on sex, age, BMI, marital status, education level, occupation type before retirement, and geographical region. Additionally, sensitivity analysis was conducted by sequentially excluding each study and then recalculating the pooled estimates of the remaining studies to determine the effect of individual studies on the overall prevalence estimates. Lastly, publication bias was evaluated using funnel plots and Egger's test (32, 33).

3 Results

3.1 Study selection and characteristics

The initial database search yielded 532 relevant literature, which was imported into the EndNote Literature Manager software. After deleting duplicates, 447 studies remained. Next, the two researchers (C XUE and M HAO) independently read the titles and abstracts and deleted studies that did not meet the review's inclusion and exclusion criteria, resulting in 44 remaining studies. Further, the full text of the articles was read, leading to the deletion of 27 articles. Among them, seven had no available data, six were duplicates of previous publications, three did not have accessible full text, eight consisted of noncompliant study designs, and three involved noncompliant study populations. References of the included literature were also checked to identify any potentially missed publications. After this step-by-step filtering procedure, 17 studies were included in the final meta-analysis. The included studies had a total sample size of 31,782 participants, of which 14,390 were from the SCD population. The literature screening process and results are shown in Figure 1.

Table 1 presents the characteristics of the studies included in the meta-analysis. A total of 17 studies were included, comprising 31,782 older adults. Regarding the inclusion criteria, all 17 studies stated that the study subjects were permanent local residents aged 60 years and above. Additionally, they were required to have normal objective cognitive function and daily living ability, as well as the ability to answer the relevant questionnaires independently. In terms of the exclusion criteria, all 17 studies mentioned excluding mild cognitive impairment and dementia. Thirteen studies mentioned excluding diseases that might affect objective cognitive function. Furthermore, 14 studies mentioned excluding severe mental disorders, 10 studies mentioned excluding severe visual or hearing impairment that could hinder normal assessment, and 9 studies mentioned excluding severe organ failure. Moreover, 6 studies mentioned excluding substance abuse, 2 studies mentioned excluding alcohol dependence, and 2 studies mentioned excluding participation in other interventional studies. Lastly, only 1 study mentioned excluding shift-workers. The sample sizes in these studies ranged from 173 to 10,312 individuals. The data examined in these studies were obtained from the years 2016 to 2023. The studies were conducted in 16 administrative divisions, including provinces, autonomous regions, and municipalities directly under the central government in China. Geographically, 10 studies were conducted in South China, whereas seven in North China. In terms of residence, 12 studies (70.6%) were performed in urban settings, three in rural areas (17.6%), and two (11.8%) involved urban and rural locations. Furthermore, the evaluation of literature quality yielded AHRQ scores of 5–9 for the included articles, indicating medium- to high-quality articles and confirming reliability in our review results.

3.2 Pooled prevalence of SCD

As illustrated in Figure 2, SCD prevalence in older Chinese individuals ranged from 18.8 to 76.3%. Further, the estimated pooled prevalence of SCD in the 17 studies was 46.4% (95% CI, 40.6–52.2%).

3.3 Subgroup analyzes

Table 2 presents the subgroup analysis findings of SCD prevalence among older Chinese adults in the included studies. The results indicated that men had a significantly lower SCD prevalence (50.8, 95% CI, 41.4–60.2%) than women (58.9, 95% CI, 50.3–67.3%, $p < 0.001$).

Additionally, SCD prevalence was found to significantly increase with age ($p < 0.001$), with the 60–69 years age group exhibiting an SCD prevalence of 38.0% (95% CI, 21.4–56.2%); 70–79 years, 45.2% (95% CI, 34.9–56.7%); and ≥ 80 years, 60.3% (95% CI, 50.8–69.5%).

Furthermore, SCD prevalence in older adults decreased with increasing BMI. In particular, SCD prevalence in older adults with BMI <18.5, 18.5–24.0, and > 24.0 was 59.3% (95% CI, 45.6–72.4%), 54.0% (95% CI, 43.4–64.5%), and 52.9% (95% CI, 40.1–65.5%),

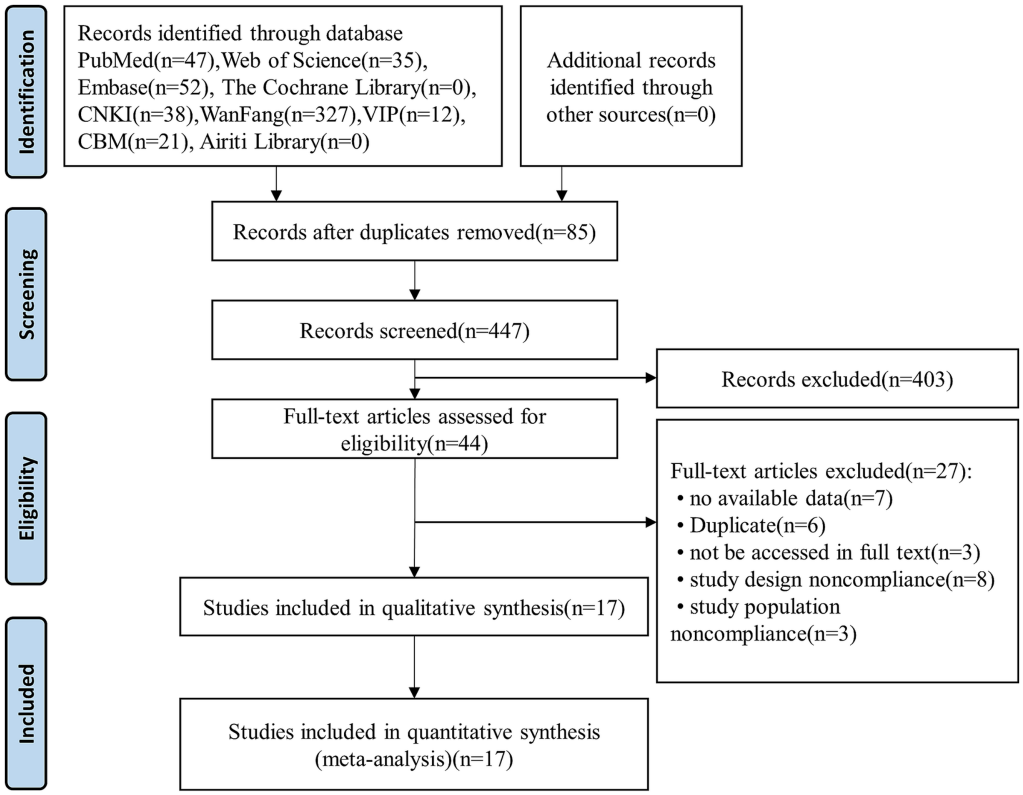


FIGURE 1
PRISMA flowchart for study selection.

respectively. Although this difference was only marginally significant ($p = 0.051$), this observation is still worth noting.

In terms of geographical regions, SCD prevalence significantly varied ($p < 0.001$) between older adults in South China (50.0, 95% CI, 44.1–56.0%) and those from North China (41.3, 95% CI, 30.4–52.6%). Furthermore, individuals residing in rural areas exhibited significantly higher SCD prevalence (50.0, 95% CI, 30.3–69.8%) than those in urban locations (47.1, 95% CI, 38.3–56.0%, $p = 0.003$).

Moreover, occupation type before retirement and education level also demonstrated significant differences in SCD prevalence. SCD prevalence among retired non-manual (44.2, 95% CI, 20.2–69.8%) was significantly lower than that in retired manual workers (49.2, 95% CI, 27.0–71.7%, $p < 0.001$). As for education level, SCD prevalence decreased as education level increased, with a significant difference among the four education levels ($p < 0.001$), including "elementary school and below," "middle school," "high school," and "college and above." Of which, individuals with a higher education level (i.e., college and above) had the lowest prevalence (51.3, 95% CI, 37.7–64.8%), followed by those with secondary education (i.e., middle school [52.4, 95% CI, 43.3–61.5%] and high school [55.0, 95% CI, 39.2–70.2%]). Older adults with education levels of elementary school and below had the highest SCD prevalence of 62.8% (95% CI, 56.8–68.5%).

Lastly, SCD prevalence in married individuals with surviving spouses was lower (51.6%; 95% CI, 38.8–64.2%) than in single adults who were divorced, widowed, or unmarried (58.2, 95% CI, 50.3–65.8%). However, this difference was not statistically significant ($p = 0.38$).

3.4 Sensitivity analysis

We also conducted a sensitivity analysis by excluding one study at a time to assess whether the variation between studies affected the overall estimate. As depicted in Figure 3, none of the studies caused significant changes in the pooled prevalence. This indicates that the results of the Meta analysis are reliable and stable.

3.5 Publication bias

Visual inspection revealed slight signs of asymmetry in the funnel plot (Figure 4). Additionally, Egger's test indicated no significant publication bias, with no statistical significance detected for t ($t = 0.16$) and ($p = 0.878$) values. Based on the visual evaluation and Egger's test results, we concluded that the publication bias risk in this review was low.

4 Discussion

AD has become a public health priority in the context of aging (4, 5, 7). In recent years, SCD, a proposed preclinical stage of AD, has received considerable global interest (14, 16). To the best of our knowledge, this is the first systematic review to investigate SCD prevalence in older adults in China. We found that SCD prevalence was 46.4% among older Chinese adults, suggesting that this condition was particularly common within this population. Moreover, this result

TABLE 1 Characteristics of the included studies.

References	Research sites	Age	Total sample size	Numbers of SCD	Prevalence of SCD (%)	Assessment tools for SCD	AHRQ score
Song et al. (34)	Guangzhou	≥60	612	250	40.85	SCD-Q9	8
Yu et al. (35)	Baotou	≥60	1,120	491	43.84	SCD-Q9	8
Ai et al. (36)	Shanghai	60–85	173	132	76.3	Self-developed SCD-Q	8
Dong et al. (37)	Suzhou, Anhui Province	≥60	264	153	57.95	SCD-Q9	9
Wen et al. (38)	Northern China	≥65	1,165	493	42.32	Self-developed SCD-Q	7
Hu et al. (39)	Guangzhou	≥60	212	86	40.57	SCD-Q9	9
Huang et al. (40)	Hubei Province	≥65	10,312	5,134	48.93	SCD-Q9	8
Zhou et al. (41)	Beijing	≥60	337	111	32.9	SCD-Q9	8
Yang et al. (42)	Wuhan	≥60	211	105	49.8	SCD-Q	9
Wang et al. (43)	Yanggu county in Shandong Province	≥60	5,765	2,654	46.04	SCD-Q9	9
Chen et al. (44)	Guangzhou	≥60	212	42	19.81	Self-developed SCD-Q	7
Han et al. (45)	Xiamen	≥60	1,318	749	56.8	SCD complaints	9
Ruan et al. (46)	Changning, Shanghai	≥60	5,328	2,217	41.61	SCD-Q	9
Lin et al. (25)	Guangzhou	≥60	688	402	58.4	SCD-Q9	9
Hao et al. (20)	Shunyi, Beijing	60–80	2,689	506	18.8	SCD-Q9	9
Su et al. (26)	Daqing	≥60	308	155	49.68	SCD-Q	9
Xiao et al. (47)	Shanghai	≥60	1,068	710	66.5	COWAT	5

SCD-Q9, Subjective Cognitive Decline-Questionnaire 9; SCD-Q, Subjective Cognitive Decline-Questionnaire; COWAT, Controlled Oral Word Association Test; AHRQ, Agency for Healthcare Research and Quality.

was higher than the SCD prevalence of 25.5 and 36.7% reported in the United States of America (48) and Australia (49), respectively, and comparable to that of 36.1–68.6% in Japan (50, 51). However, attention should be given to the fact that SCD prevalence in older adults may vary greatly between studies conducted in different countries due to the differences in sample source, sample size, geographical environment, and cultural background.

The 17 studies included in this review established strict inclusion and exclusion criteria when selecting study subjects to ensure homogeneity. All studies applied SCD diagnostic criteria consistent with those proposed by the Subjective Cognitive Decline Initiative (SCD-I) (13), ensuring the authenticity and accuracy of the reported SCD prevalence.

Additionally, our review found some distinctive findings during the subgroup analyzes. First, SCD prevalence was higher in women than in men. This difference may be because women are more sensitive to perceiving dynamic changes in their cognitive functioning than men; therefore, they are more likely to show concern about SCD (38, 40).

Second, SCD prevalence was positively correlated with increasing age, indicating that advanced age was associated with a higher risk of developing SCD. As individuals grow older, they may experience stressor overload, chronic inflammation (52, 53), and accelerated aging of brain cells (54), resulting in the gradual reduction of the brain's cognitive reserve along with a continuous decline in cognitive function (55).

Third, older adults with an elementary school education or less had a higher SCD prevalence rate (62.8%). This observation suggests that higher education may be a protective factor for healthy cognitive functioning, consistent with previous findings (20, 34, 56, 57). This protective benefit could be attributed to the better knowledge base, stronger compensation function of the brain network, and increased neuronal vitality in older adults with higher education levels compared to those with an elementary school education or less (34, 35). These advantages could in turn lead to a better subjective cognitive status and relatively higher health literacy, making them more receptive to health knowledge and preventive and curative measures for SCD (34, 58). Therefore, medical professionals and policymakers should focus on the older population with lower education levels, develop a comprehensive cognitive screening and assessment process, and increase SCD awareness in the general population to improve health literacy and promote healthy behavior in older adults.

Fourth, this study found a higher prevalence of SCD in individuals with a BMI <18.5, at 59.3%. Although the difference in prevalence between BMI subgroups was only marginally statistically significant, these findings suggest that older adults with a lower BMI are more likely to experience SCD compared to those with a normal BMI. Previous research has also demonstrated a greater risk of concurrent malnutrition in older adults with a lower BMI (59), which can potentially contribute to persistent cognitive impairment (60). Therefore, it is recommended that the older population strive to maintain a normal BMI to preserve their ability to perform daily activities and retain good cognitive function.

Fifth, SCD prevalence in North and South China was >40.0%, implying a higher SCD prevalence in the Chinese population across different regions. Accordingly, physicians should conduct early comprehensive screening of subjective cognitive function in the

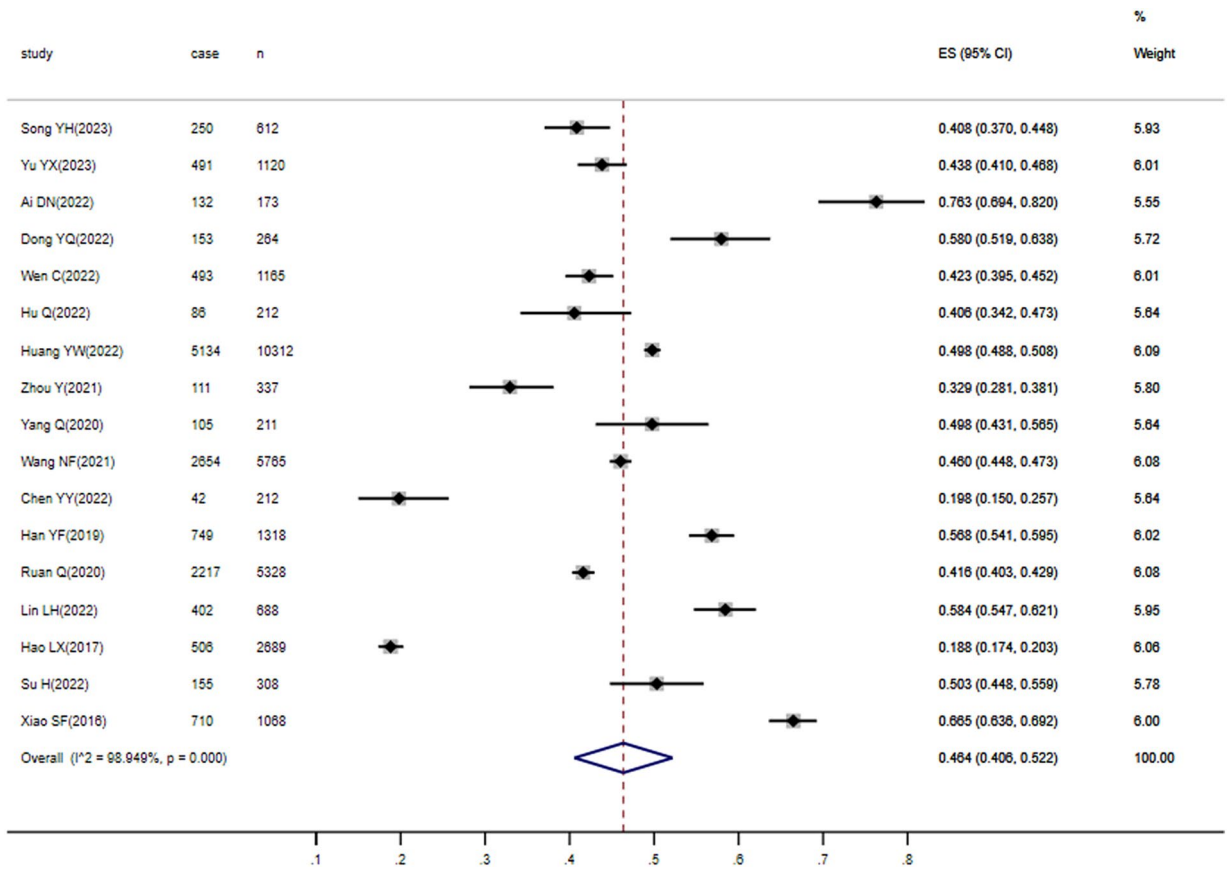


FIGURE 2
Forest plot of overall SCD prevalence in Chinese older adults.

Chinese population. This strategy will enable the timely detection and prevention of further cognitive function deterioration in individuals with SCD. Additionally, SCD prevalence in urban communities was found to be slightly lower than that in rural areas. This difference may be ascribed to the previously reported higher prevalence of cognitive disorders, including SCD, mild cognitive impairment, and dementia, in the rural areas of China (61).

Finally, manual laborers had a higher SCD prevalence than non-manual workers, possibly due to the better cognitive performance associated with higher education levels among the non-manual workers included in this study (34, 40, 41). Conversely, non-manual workers have been suggested to experience comparatively greater work stress, prolonged sedentary behavior, and a lack of appropriate physical activity (25, 62), potentially leading to excessive concern about their emotional state and cognitive functioning. Therefore, encouraging middle-aged and older populations to actively participate in community cultural activities is important (63). Such activities will help them avoid prolonged stress or negative emotions, ultimately enhancing their cognitive reserve as well as physical and mental well-being.

5 Research implications

Our systematic review and meta-analysis revealed that women, individuals of advanced age, those with low education levels, residents in the southern region and rural areas, and those with manual work before retirement may exhibit higher SCD prevalence. Consequently, studies focusing on these specific populations should be prioritized by future researchers. Furthermore, we observed that most original studies relied on the SCD questionnaire (including SCD-Q9, SCD-Q, and COWAT, etc.) alone to assess subjective cognitive function. However, using only one tool to evaluate SCD might not provide adequate diagnostic value (13, 16). Nonetheless, considering the wide and convenient clinical application of SCD-Q9/SCD-Q, subsequent studies should build upon this questionnaire as well as emphasize the development of an in-depth SCD assessment process and tools. Moreover, the aging and health trend will likely become exacerbated in China due to the increasing life expectancy accompanied by worsening health conditions (64). This trend will eventually impose substantial stress on the necessity for population-wide cognitive screening. Therefore, the widespread implementation of AI technology in SCD screening and diagnosis could be a potential research area to help address this issue.

6 Strength and limitations

This study has many strengths that are worth mentioning. To the best of our knowledge, this is the first systematic review and meta-analysis to evaluate SCD prevalence in older Chinese adults. Additionally, our review adopted a thorough search strategy

TABLE 2 Various subgroup analyzes of SCD prevalence in Chinese older adults.

Subtype	Numbers of studies	Heterogeneity assessment		Random/fixed effects model	Meta-analysis results	*p*-value across subgroups
		I^2(%)	*P*		Prevalence of SCD (95%CI)	
Gender						
Male	11	98.6%	<0.001	Random	50.8% (41.4, 60.2%)	<0.001
Female	11	98.6%	<0.001	Random	58.9% (50.3, 67.3%)	
Age, years						
60–69	8	99.4%	<0.001	Random	38.0% (21.4, 56.2%)	<0.001
70–79	9	98.5%	<0.001	Random	45.2% (34.9, 56.7%)	
≥80	8	93.4%	<0.001	Random	60.3% (50.8, 69.5%)	
BMI, Kg/m²						
<18.5	5	77.3%	0.001	Random	59.3% (45.6, 72.4%)	0.051
18.5 ~ 24.0	5	96.2%	<0.001	Random	54.0% (43.4, 64.5%)	
>24.0	5	97.5%	<0.001	Random	52.9% (40.1, 65.5%)	
Education level						
Primary and Illiteracy	9	95.0%	<0.001	Random	62.8% (56.8, 68.5%)	<0.001
middle school	5	97.5%	<0.001	Random	52.4% (43.3, 61.5%)	
high school	4	93.4%	<0.001	Random	55.0% (39.2, 70.2%)	
college and above	6	93.4%	<0.001	Random	51.3% (37.7, 64.8%)	
Region						
Northern China	7	99.2%	<0.001	Random	41.3% (30.4, 52.6%)	<0.001
Southern China	10	98.1%	<0.001	Random	50.0% (44.1, 56.0%)	
Residence						
City	14	99.1%	<0.001	Random	47.1% (38.3, 56.0%)	0.003
Rural	5	99.6%	<0.001	Random	50.0% (30.3, 69.8%)	
Married status						
surviving spouse	7	99.4%	<0.001	Random	51.6% (38.8, 64.2%)	0.38
no spouse	7	92.0%	<0.001	Random	58.2% (50.3, 65.8%)	
Occupation before						
Manual labor	3	98.7%	<0.001	Random	49.2% (27.0, 71.7%)	<0.001
Mental labor	3	93.4%	<0.001	Random	44.2% (20.2, 69.8%)	

encompassing nine databases in the Chinese and English languages. We also utilized a double review process, thereby enhancing the comprehensiveness of our search results on SCD epidemiology in China. Furthermore, the original studies included in our analysis were classified as moderate- to high-quality articles, ensuring the reliability of our findings. Finally, we conducted extensive subgroup analyzes to explore the epidemiological characteristics of SCD in older Chinese adults.

Nonetheless, our study has several limitations that should be addressed in future research. First, a substantial amount of heterogeneity was detected in the subgroup analyzes. However, this heterogeneity is unavoidable in the meta-analysis of epidemiological surveys (65). Second, the SCD assessment tools and diagnostic criteria employed in the included studies were not standardized, potentially introducing measurement bias and reducing our results' reliability. Third, most studies we reviewed were conducted in eastern China, thus underrepresenting the country's western region. Consequently, our sample does not adequately represent all 34 Chinese provinces, including provincial-level municipalities, autonomous regions, and special administrative regions. Lastly, although our findings are promising, they should be interpreted cautiously owing to the high heterogeneity observed among studies, moderate bias risk in certain studies, and the likelihood of mild publication bias.

7 Conclusion

Our review suggests that monitoring SCD prevalence in older adults in China is crucial for the effective planning and organization of related healthcare services. Based on the available literature, our systematic review and meta-analysis indicate that SCD has a prevalence of 46.4% in older Chinese adults. However,

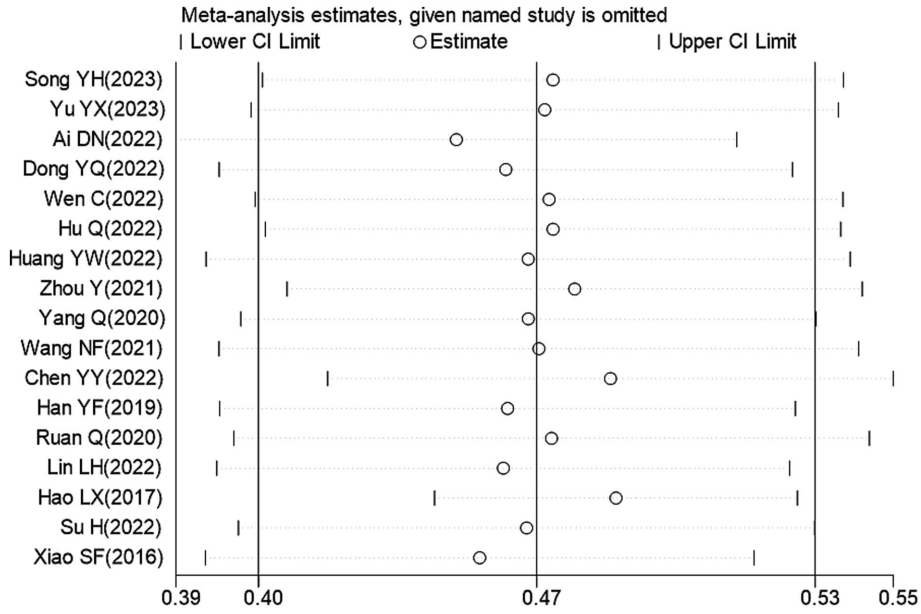


FIGURE 3
Sensitivity analysis of overall SCD prevalence in Chinese older adults.

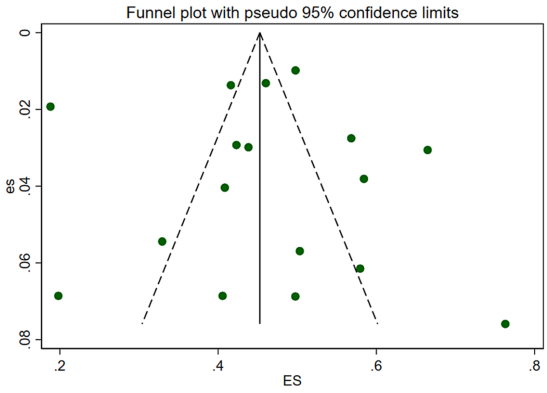


FIGURE 4
Funnel chart of overall SCD prevalence in Chinese older adults.

these values may be an underestimation of the true prevalence because of insufficient high-quality data. Therefore, future research should focus on investigating the incidence, risk factors, and causes of SCD. Furthermore, the relevant authorities in China are critically required to accelerate the development and implementation of a broad range of preventive and therapeutic strategies for SCD. Moreover, initiatives for the early screening, diagnosis, and prevention of SCD will further help alleviate the social care and economic burdens caused by AD in the older population in China.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

CX: Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. MH: Data curation, Investigation, Methodology, Software, Writing – original draft. LC: Investigation, Methodology, Software, Writing – original draft. ZC: Methodology, Software, Validation, Visualization, Writing – original draft. ZT: Methodology, Software, Validation, Visualization, Writing – original draft. HT: Methodology, Software, Validation, Visualization, Writing – original draft. QF: Conceptualization, Formal analysis, Supervision, Writing – review & editing. JL: Conceptualization, Formal analysis, Funding acquisition, Supervision, Visualization, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was supported by funding from the National Natural Science Foundation of China (No. 72364005), and Guizhou Administration of Traditional Chinese Medicine (No. QZYY-2023-115).

Acknowledgments

We thank Bullet Edits Limited for the linguistic editing and proofreading of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. 2023 Alzheimer's disease facts and figures. *Alzheimers Dement*. (2023) 19:1598–695. doi: 10.1002/alz.13016

2. Feigin VL, Nichols E, Alam T, Bannick MS, Beghi E, Blake N, et al. Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the global burden of disease study 2016. *Lancet Neurol*. (2019) 18:459–80. doi: 10.1016/S1474-4422(18)30499-X

3. Arvanitakis Z, Shah RC, Bennett DA. Diagnosis and management of dementia: review. *JAMA*. (2019) 322:1589–99. doi: 10.1001/jama.2019.4782

4. Ren R, Qi J, Lin S, Liu X, Yin P, Wang Z, et al. The China alzheimer report 2022. *Gen Psychiatr*. (2022) 35:e100751. doi: 10.1136/gpsych-2022-100751

5. Jia L, Quan M, Fu Y, Zhao T, Li Y, Wei C, et al. Dementia in China: epidemiology, clinical management, and research advances. *Lancet Neurol*. (2020) 19:81–92. doi: 10.1016/S1474-4422(19)30290-X

6. Qi S, Yin P, Zhang H, Zhang Q, Xiao Y, Deng Y, et al. Prevalence of dementia in China in 2015: a nationwide community-based study. *Front Public Health*. (2021) 9:733314. doi: 10.3389/fpubh.2021.733314

7. Li R, Qi J, Yang Y, Wu Y, Yin P, Zhou M, et al. Disease burden and attributable risk factors of alzheimer's disease and dementia in China from 1990 to 2019. *J Prev Alzheimers Dis*. (2022) 9:306–14. doi: 10.14283/jpad.2021.69

8. Jia J, Wei C, Chen S, Li F, Tang Y, Qin W, et al. The cost of alzheimer's disease in China and re-estimation of costs worldwide. *Alzheimers Dement*. (2018) 14:483–91. doi: 10.1016/j.jalz.2017.12.006

9. Chhetri JK, Chan P, Vellas B, Touchon J, Gauthier S. Report from the first clinical trials on alzheimer's disease (ctad) asia-China 2018: bringing together global leaders. *J Prev Alzheimers Dis*. (2019) 6:144–7. doi: 10.14283/jpad.2019.2

10. Sperling RA, Aisen PS, Beckett LA, Bennett DA, Craft S, Fagan AM, et al. Toward defining the preclinical stages of alzheimer's disease: recommendations from the national institute on aging-alzheimer's association workgroups on diagnostic guidelines for alzheimer's disease. *Alzheimers Dement*. (2011) 7:280–92. doi: 10.1016/j.jalz.2011.03.003

11. Zhang J, Gao Y, Gao Y, Munsell BC, Shen D. Detecting anatomical landmarks for fast alzheimer's disease diagnosis. *IEEE Trans Med Imaging*. (2016) 35:2524–33. doi: 10.1109/TMI.2016.2582386

12. Xu X, Li W, Tao M, Xie Z, Gao X, Yue L, et al. Effective and accurate diagnosis of subjective cognitive decline based on functional connection and graph theory view. *Front Neurosci*. (2020) 14:577887. doi: 10.3389/fnins.2020.577887

13. Jessen F, Amariglio RE, Boxtel M, Breteler M, Ceccaldi M, Chételat G, et al. A conceptual framework for research on subjective cognitive decline in preclinical alzheimer's disease. *Alzheimers Dement*. (2014) 10:844–52. doi: 10.1016/j.jalz.2014.01.001

14. Rabin LA, Smart CM, Amariglio RE. Subjective cognitive decline in preclinical alzheimer's disease. *Annu Rev Clin Psychol*. (2017) 13:369–96. doi: 10.1146/annurev-clinpsy-032816-045136

15. Molinuevo JL, Rabin LA, Amariglio R, Buckley R, Dubois B, Ellis KA, et al. Implementation of subjective cognitive decline criteria in research studies. *Alzheimers Dement*. (2017) 13:296–311. doi: 10.1016/j.jalz.2016.09.012

16. Jessen F, Amariglio RE, Buckley RF, van der Flier WM, Han Y, Molinuevo JL, et al. The characterisation of subjective cognitive decline. *Lancet Neurol*. (2020) 19:271–8. doi: 10.1016/S1474-4422(19)30368-0

17. Wang X, Huang W, Su L, Xing Y, Jessen F, Sun Y, et al. Neuroimaging advances regarding subjective cognitive decline in preclinical alzheimer's disease. *Mol Neurodegener*. (2020) 15:55. doi: 10.1186/s13024-020-00395-3

18. Jessen F, Spottke A, Boecker H, Brosseron F, Buerger K, Catak C, et al. Design and first baseline data of the dzne multicenter observational study on predementia alzheimer's disease (delcode). *Alzheimers Res Ther*. (2018) 10:15. doi: 10.1186/s13195-017-0314-2

19. Pike KE, Cavuoto MG, Li L, Wright BJ, Kinsella GJ. Subjective cognitive decline: level of risk for future dementia and mild cognitive impairment, a meta-analysis of longitudinal studies. *Neuropsychol Rev*. (2022) 32:703–35. doi: 10.1007/s11065-021-09522-3

20. Hao L, Wang X, Zhang L, Xing Y, Guo Q, Hu X, et al. Prevalence, risk factors, and complaints screening tool exploration of subjective cognitive decline in a large cohort of the chinese population. *J Alzheimers Dis*. (2017) 60:371–88. doi: 10.3233/JAD-170347

21. Xu S, Ren Y, Liu R, Li Y, Hou T, Wang Y, et al. Prevalence and progression of subjective cognitive decline among rural chinese older adults: a population-based study. *J Alzheimers Dis*. (2023) 93:1355–68. doi: 10.3233/JAD-221280

22. Hao L, Xing Y, Li X, Mu B, Zhao W, Wang G, et al. Risk factors and neuropsychological assessments of subjective cognitive decline (plus) in chinese memory clinic. *Front Neurosci*. (2019) 13:846. doi: 10.3389/fnins.2019.00846

23. Cheng G, Liu D, Huang L, Han G, Hu F, Wu Z, et al. Prevalence and risk factors for subjective cognitive decline and the correlation with objective cognition among community-dwelling older adults in China: results from the Hubei memory and aging cohort study. *Alzheimers Dement*. (2023) 19:5074–85. doi: 10.1002/alz.13047

24. Jiang X, Hu X, Daamen M, Wang X, Fan C, Meiberth D, et al. Altered limbic functional connectivity in individuals with subjective cognitive decline: converging and diverging findings across chinese and german cohorts. *Alzheimers Dement*. (2023) 19:4922–34. doi: 10.1002/alz.13068

25. Lin LH, Wang SB, Xu WQ, Hu Q, Zhang P, Ke YF, et al. Subjective cognitive decline symptoms and its association with socio-demographic characteristics and common chronic diseases in the southern chinese older adults. *BMC Public Health*. (2022) 22:127. doi: 10.1186/s12889-022-12522-4

26. Su H, Zhou YQ, Sun YJ, Cai YJ. The relationship between depression and subjective cognitive decline in older adults of China: the mediating role of general self-efficacy. *Psychol Health Med*. (2022) 28:1057–67. doi: 10.1080/13548506.2022.2125165

27. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The prisma 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. (2021) 372:n71. doi: 10.1136/bmj.n71

28. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis of observational studies in epidemiology (moose) group. *JAMA*. (2000) 283:2008–12. doi: 10.1001/jama.283.15.2008

29. Hu S, Pan N, Liu C, Wang Y, Zhang T. Age matching is essential for the study of cerebrospinal fluid strem2 levels and alzheimer's disease risk: a meta-analysis. *Front Aging Neurosci*. (2021) 13:775432. doi: 10.3389/fnagi.2021.775432

30. Zeng X, Zhang Y, Kwong JSW, Zhang C, Li S, Sun F, et al. The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. *J Evid Based Med*. (2015) 8:2–10. doi: 10.1111/jebm.12141

31. Ullah I, Bibi S, Ul Haq I, Safia UK, Ge L, et al. The systematic review and meta-analysis on the immunogenicity and safety of the tuberculosis subunit vaccines m72/as01e and mva85a. *Front Immunol*. (2020) 11:1806. doi: 10.3389/fimmu.2020.01806

32. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ (Clinical research ed)*. (1997) 315:629–34. doi: 10.1136/bmj.315.7109.629

33. Sterne JA, Egger M. Funnel plots for detecting bias in meta-analysis: guidelines on choice of axis. *J Clin Epidemiol*. (2001) 54:1046–55. doi: 10.1016/S0895-4356(01)00377-8

34. Song Y, Liu Y, Yang Q, Wang S, Hu Q, Zheng C, et al. Correlation of subjective cognitive decline with multimorbidity among elderly people. *Chinese Gen Pract*. (2023) 26:1241–9. doi: 10.12114/j.issn.1007-9572.2022.0800

35. Yu Y, Bai R, Yu W, Guo X, Wu L. Occurrence status and influencing factors of cognitive dysfunction in population aged 60 and above in Inner Mongolia. *Chinese Gen Pract*. (2023) 26:2581–8. doi: 10.12114/j.issn.1007-9572.2023.0004

36. Ai D, Nie J, Lin X, Gu C, Fei C, Li L, et al. Correlation analysis between subjective cognitive decline and emotional state of the community elderly. *Geriatr Health Care*. (2022) 28:978–82. doi: 10.3969/j.issn.1008-8296.2022.05.008

37. Dong Y, Wang W. Correlation study between subjective cognitive decline and grip strength in elderly community population. *Chinese Gen Pract*. (2022) 20:1363–6. doi: 10.16766/j.cnki.issn.1674-4152.002598

38. Wen C. *Risk factors for subjective cognitive decline and association of subjective cognitive decline with cerebrospinal fluid biomarkers of Alzheimer's disease pathology in cognitively intact older adults: the CABLE study*. Qingdao: Qingdao University (2022).

39. Hu Q, Song Y, Wang S, Zhao W, Liu Y, Zhang P. Subjective cognitive decline among institutionalized older adults and its influencing factor. *J Nurs Sci*. (2022) 37:87–90. doi: 10.3870/j.issn.1001-4152.2022.09.087

40. Huang Y. *Study on the prevalence and risk factors of subjective cognitive decline in the community-dwelling old adults*. Wuhan: Wuhan University of Science and Technology (2022).

41. Zhou Y, Gan S, Li Z. Status quo of subjective cognitive decline and its influencing factors among community-dwelling elder adults. *Nurs J Chin PLA*. (2021) 38:21–4. doi: 10.3969/j.issn.1008-9993.2021.04.006

42. Yang Q. *Subjective cognitive decline and its behavioral and psychological symptoms in community-dwelling elderly*. Huazhong: Huazhong University of Science & Technology (2020).

43. Wang N, Song Z, Liu X, Wang L, Cao J, Du Y. The characteristics and influencing factors of subjective cognitive decline in rural elderly. *Chin J Behav Med Brain Sci*. (2021):30, 402–407. doi: 10.3760/cma.j.cn371468-20210107-00016

44. Chen Y, Zhang Z, Zuo Q, Gao Y. Status quo of reversible cognitive frailty among the elderly in a community of Guangzhou and its influencing factors. *Nurs J Chin PLA*. (2022):39, 13–16. doi: 10.3969/j.issn.1008-9993.2022.06.004

45. Han Y, Yuan M, Fang Y. Impact of common chronic diseases on preexisting mild cognitive dysfunction in older adults. *Chin J Health Stat*. (2019) 36:232–5.

46. Ruan Q, Xiao F, Gong K, Zhang W, Zhang M, Ruan J, et al. Prevalence of cognitive frailty phenotypes and associated factors in a community-dwelling elderly population. *J Nutr Health Aging*. (2020) 24:172–80. doi: 10.1007/s12603-019-1286-7

47. Xiao SF, Lewis M, Mellor D, McCabe M, Byrne L, Wang T, et al. The China longitudinal ageing study: overview of the demographic, psychosocial and cognitive data of the shanghai sample. *J Ment Health*. (2016) 25:131–6. doi: 10.3109/09638237.2015.1124385

48. Liew TM. Depression, subjective cognitive decline, and the risk of neurocognitive disorders. *Alzheimers Res Ther*. (2019) 11:70. doi: 10.1186/s13195-019-0527-7

49. Brodaty H, Aerts L, Crawford JD, Heffernan M, Kochan NA, Reppermund S, et al. Operationalizing the diagnostic criteria for mild cognitive impairment: the salience of objective measures in predicting incident dementia. *Am J Geriatr Psychiatry*. (2017) 25:485–97. doi: 10.1016/j.jagp.2016.12.012

50. Tomata Y, Sugiyama K, Kaiho Y, Sugawara Y, Hozawa A, Tsuji I. Predictive ability of a simple subjective memory complaints scale for incident dementia: evaluation of japan's national checklist, the "kihon checklist". *Geriatr Gerontol Int*. (2017) 17:1300–5. doi: 10.1111/ggi.12864

51. Tsutsumimoto K, Makizako H, Doi T, Hotta R, Nakakubo S, Makino K, et al. Subjective memory complaints are associated with incident dementia in cognitively intact older people, but not in those with cognitive impairment: a 24-month prospective cohort study. *Am J Geriatr Psychiatry*. (2017) 25:607–16. doi: 10.1016/j.jagp.2016.12.008

52. Fulop T, Larbi A, Pawelec G, Khalil A, Cohen AA, Hirokawa K, et al. Immunology of aging: the birth of inflammaging. *Clin Rev Allergy Immunol*. (2023) 64:109–22. doi: 10.1007/s12016-021-08899-6

53. Franceschi C, Garagnani P, Parini P, Giuliani C, Santoro A. Inflammaging: a new immune-metabolic viewpoint for age-related diseases. *Nat Rev Endocrinol*. (2018) 14:576–90. doi: 10.1038/s41574-018-0059-4

54. Boots A, Thomason ME, Espinoza-Heredia C, Pruitt PJ, Damoiseaux JS, Roseboom TJ, et al. Sex-specific effects of prenatal undernutrition on resting-state functional connectivity in the human brain at age 68. *Neurobiol Aging*. (2022) 112:129–38. doi: 10.1016/j.neurobiolaging.2022.01.003

55. Dong Y. *Study on subjective cognitive decline and grip strength and related risk factors in elderly population in community*. Anhui: Anhui Medical University (2022).

56. Wen C, Hu H, Ou YN, Bi YL, Ma YH, Tan L, et al. Risk factors for subjective cognitive decline: the cable study. *Transl Psychiatry*. (2021) 11:576. doi: 10.1038/s41398-021-01711-1

57. Mondini S, Pucci V, Montemurro S, Rumiati RI. Protective factors for subjective cognitive decline individuals: trajectories and changes in a longitudinal study with italian elderly. *Eur J Neurol*. (2022) 29:691–7. doi: 10.1111/ene.15183

58. Meier C, Vilpert S, Borrat-Besson C, Jox RJ, Maurer J. Health literacy among older adults in Switzerland: cross-sectional evidence from a nationally representative population-based observational study. *Swiss Med Wkly*. (2022) 152:w30158. doi: 10.4414/SMW.2022.w30158

59. Sun B, Zhao Y, Lu W, Chen Y. The relationship of malnutrition with cognitive function in the older chinese population: evidence from the chinese longitudinal healthy longevity survey study. *Front Aging Neurosci*. (2021) 13:13. doi: 10.3389/fnagi.2021.766159

60. Caçador C, Teixeira-Lemos E, Martins SO, Ramos F. The role of nutritional status on polypharmacy, cognition, and functional capacity of institutionalized elderly: a systematic review. *Nutrients*. (2021) 13:3477. doi: 10.3390/nu13103477

61. Jia L, Du Y, Chu L, Zhang Z, Li F, Lyu D, et al. Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: a cross-sectional study. *Lancet Public Health*. (2020) 5:e661–71. doi: 10.1016/S2468-2667(20)30185-7

62. Ma C, Li M, Wu C. Cognitive function trajectories and factors among chinese older adults with subjective memory decline: charls longitudinal study results (2011-2018). *Int J Environ Res Public Health*. (2022) 19:19. doi: 10.3390/ijerph192416707

63. Zhang W, Zhang Y, Wang J. Effect and mechanism of reading habits on physical and mental health among the elderly: evidence from China. *Front Public Health*. (2022) 10:1031939. doi: 10.3389/fpubh.2022.1031939

64. Yao Y, Zhang S, Li A. Effects of educational attainment and housing condition on self-rated health in old age: heterogeneity and tendency in China. *Front Public Health*. (2022) 9:774364. doi: 10.3389/fpubh.2021.774364

65. Zeng L, Zong Q, Zhang J, Lu L, An F, Ng CH, et al. Prevalence of sexual harassment of nurses and nursing students in China: a meta-analysis of observational studies. *Int J Biol Sci*. (2019) 15:749–56. doi: 10.7150/ijbs.28144

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 19 December 2023
DOI 10.3389/fpubh.2023.1272428

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Carolyn Fang,
Fox Chase Cancer Center, United States
Bongjeong Kim,
Cheongju University, Republic of Korea

*CORRESPONDENCE
Soomin Ryu
✉ soominr@umich.edu
Sunmin Lee
✉ sunminl7@hs.uci.edu

RECEIVED 04 August 2023
ACCEPTED 04 December 2023
PUBLISHED 19 December 2023

CITATION
Ryu S, Morey BN, Shi Y and Lee S (2023) Acculturation and self-rated health among Chinese and Korean immigrants aged 49 to 75. *Front. Public Health* 11:1272428. doi: 10.3389/fpubh.2023.1272428

COPYRIGHT
© 2023 Ryu, Morey, Shi and Lee. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Acculturation and self-rated health among Chinese and Korean immigrants aged 49 to 75

Soomin Ryu[1]*, Brittany N. Morey[2], Yuxi Shi[3] and Sunmin Lee[3]*

[1]Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI, United States, [2]Program in Public Health, Department of Health, Society, and Behavior, University of California, Irvine, Irvine, CA, United States, [3]Department of Medicine, School of Medicine, University of California, Irvine, Irvine, CA, United States

Background: Given the rapidly growing Asian populations in the U.S. due to immigration, and the aging demographic of Asian immigrants, it is crucial to understand how acculturation shapes health among older adult Asian immigrants. We study the relationship between acculturation and self-rated health (SRH) and moderating roles of age and Asian subgroup.

Methods: Our cross-sectional study consisted of 200 Chinese and 200 Korean immigrants aged 49–75 living in Baltimore–Washington DC metropolitan area, who were recruited from primary care physicians' clinics in Maryland and Northern Virginia. The participants completed the survey either in-person or by phone in their preferred language. Multidimensional proxies were used to measure acculturation: years living in the U.S. (≥23 years, <23 years), English proficiency (fluently/well, so-so, poorly/not at all), and ethnic identity (very Asian, mostly Asian, bicultural/westernized). SRH was measured using the question "How would you rate your general health?" (excellent/very good/good, fair/poor). Poisson regression models with robust error variance examined associations between acculturation and SRH, accounting for socioeconomic and health insurance factors.

Results: Speaking English so-so and fluently/well had 0.73 (95% confidence intervals (CI): 0.55–0.97) and 0.51 (95% CI: 0.30–0.87) times the prevalence of having fair or poor SRH compared to speaking English poorly/not at all, respectively. The magnitudes and statistical significance of these associations were stronger among Chinese participants than Korean participants. Moreover, individuals who self-identified as bicultural/westernized had 0.63 times the prevalence of having fair or poor SRH (95% CI: 0.43–0.92) as those who self-identified as very Asian. The association was more pronounced among older participants (≥58) compared to younger participants (<58).

Conclusion: Further research should identify the possible mechanisms linking acculturation with health to find effective strategies to enhance health among aging Asian immigrant populations.

KEYWORDS

acculturation, English proficiency, ethnic identity, self-rated health, Asian Americans, immigrants, Chinese Americans, Korean Americans

Introduction

Many previous studies on acculturation and health among immigrants have found support for a "healthy immigrant effect"—the paradox that recent immigrants have better health profiles than their native-born counterparts in the host country and that recent immigrants' health erodes with increasing time since migration (1–3). Acculturation is generally defined as "all changes that arise as a consequence of contact between individuals and groups of different cultural backgrounds (4)". Overall, a higher level of acculturation among immigrant groups has been associated with a higher risk of unhealthy behavior such as drinking (5) as well as chronic diseases (6) including obesity (7–9), breast cancer (10), and diabetes (11–13). This may be because immigrants converge to the health profile of the host population due to the adoption of dietary patterns, health-related norms, and other health behaviors during the acculturation process (2, 14). Moreover, acculturation may have negative effects on health of immigrants because combining the ethnic culture with the mainstream culture is a stressful process (15, 16). However, acculturation can be also beneficial in terms of adaptability to multiple cultural environments and abilities, which benefit mental wellness (16). As acculturation is a complex and dynamic process and immigrants are diverse (17, 18), exact changes that occur during acculturation remain unclear (19, 20).

Examining the healthy immigrant effect among Asian Americans is important, as 6 out of 10 Asian Americans were born outside of the United States (U.S.) (21). Asians are the fastest-growing racial/ethnic group in the U.S.: Asians grew 81% between 2000 and 2019, from 10.5 million to 18.9 million, while the number is projected to increase to 35.8 million by 2060, more than triple Asians' population in 2000 (22). Considering the continuous growth of Asian Americans, it is crucial to study how acculturation shapes Asian immigrants' health over time.

The evidence for greater acculturation leading to worse overall health among Asian immigrant populations has used self-rated health (SRH) to compare more and less acculturated groups with regards to their health. SRH is increasingly used to evaluate immigrant health as it is a strong indicator of overall health outcomes linked to morbidity and mortality (23, 24). It has been a quick and useful measure that enables comparisons across datasets and studies, including studies among Asian immigrants (2). Prior research has supported the healthy immigrant effect of the negative association between acculturation and SRH. Longer duration of residence in the U.S. was associated with worse SRH among nationally representative samples of U.S.-born and foreign-born Asian Americans (2) as well as among samples of only foreign-born Asian immigrants in the U.S. (1, 25). Using a sample from the New Immigrant Survey that included Asian, Black, Hispanic, Multiracial, and White immigrants, Lee and colleagues also showed that longer duration in the U.S. was associated with reported worsening of SRH since moving to the U.S. (26).

On the contrary, other evidence has suggested that acculturation is associated with more optimal SRH. One study found that Chinese immigrants who lived in the U.S. longer than 5 years were more likely to report better SRH than those living in the U.S. for <5 years (27). Using a sample of U.S.-born and foreign-born Asian Americans and accounting for potential cohort confounding, Ro and colleagues demonstrated that a longer duration of stay in the U.S. was associated with lower odds of reporting poor-to-fair SRH (28). In the previously cited studies, length of residence was used as a proxy for acculturation. This assumes that the longer that Asian immigrants live in the U.S., the more acculturated they become. Prior studies may have been mixed in their findings because length of residence is an imperfect proxy for acculturation. Immigrants may not necessarily undergo acculturation simply due to living longer in the U.S. This begs the question of what it is about living in the U.S. as an immigrant that affects better or worse overall health.

Acculturation measured by language proficiency has more consistent findings. English proficiency and preference were associated with better SRH among samples of Asian immigrants (29, 30) and combined samples of U.S.-born and foreign-born Asian Americans (14). Another study also suggested that Chinese, Korean, Vietnamese, and Filipino Americans with low English proficiency were more likely to have fair or poor SRH compared to English proficient non-Hispanic White Americans (31). Kimbro and colleagues suggested that bilingual Asian immigrants were more likely to have physically and mentally better SRH compared to those who were Asian language dominant (32). A study used ethnic identity as another proxy for acculturation, reporting that U.S.-born and foreign-born Asian Americans who identified themselves as American were 3.5 times more likely to report good SRH than those who self-identified as Asian (14). To capture variations in acculturation experiences, two prior studies classified Asian immigrants into multiple categories based on several measures of acculturation, suggesting consistent findings that acculturation to the U.S. was associated with better SRH (33, 34).

Examining the role of acculturation on SRH may be especially important among older Asian immigrants, a growing population with health needs. Low English proficiency was found to be consistently associated with poor SRH among older adult Asian immigrants (29, 30) as well as combined samples of U.S.-born and foreign-born Asian Americans (35). For the length of residence in the U.S., Lam and colleagues suggested that the older adult Asian Americans who immigrated later in life had poorer self-rated physical health outcomes, whereas there was no significant association for mental health (36). Ro and colleagues also demonstrated that SRH improved with longer duration in the U.S. particularly among older cohorts of Asian immigrants (28). A recent study reported the moderating role of age in the association between the acculturation and SRH with different patterns by gender: the probability of having poor to fair SRH increased with age among less acculturated or bicultural Asian immigrant women, whereas the probability increased steeply with age among the highly acculturated Asian immigrant men (34). Older Asian immigrants are more likely to suffer from isolation and limited utilization of health services than their younger counterparts (30, 37, 38) which may result in poor SRH.

In addition to age, the country of origin may influence the relationship between acculturation and health. Westernization and its effects vary by country of origin because each country and ethnic group has different economic, political, and cultural backgrounds (32, 39, 40). These different histories influence exposure to Western culture, even prior to migration, making it likely that specific ethnic

groups experience acculturation differently (41). Nevertheless, much less attention has been given to the heterogenous differences between Asian ethnic subgroups (32). A few studies highlighted differential associations of acculturation with health across Asian subgroups. For example, Park and colleagues showed that a longer duration of stay in the U.S. was significantly associated with increased alcohol use among people who immigrated from the Philippines, but not among people who immigrated from China or Vietnam, indicating the importance of Asian subgroup analysis (40). For SRH, Kimbro and colleagues found a stronger association between high language proficiency and better SRH among people who immigrated from the Philippines than people who immigrated from China or Vietnam (32).

Given the rapidly growing Asian populations in the U.S. particularly due to immigration, and the aging demographic of Asian immigrants, it is crucial to understand how acculturation shapes perceived health among older adult Asian immigrants (34). Relying on a single measure of acculturation (e.g., duration in the U.S.) may paint an incomplete picture. As acculturation is a dynamic, multifaceted, and complex construct (42), using several measurements should more effectively capture the level of acculturation (43, 44). The current study examined the association between acculturation and SRH among foreign-born older Chinese and Korean immigrants aged 49–75 and tested moderating roles of age and Asian subgroup using multidimensional proxies of acculturation: years living in the U.S., English proficiency, and ethnic identity. Considering that the positive relationship between acculturation and health has been relatively consistent among older adult Asian immigrants (28, 30, 35, 36), we hypothesized that more acculturated older adult Chinese and Korean immigrants who lived in the U.S. for longer, had high English proficiency and westernized ethnic identity would be less likely to report worse SRH. We also hypothesized that the magnitude and statistical significance of the associations between acculturation and SRH would be stronger among older Chinese and Korean immigrants than younger immigrants and there would be different associations by Asian subgroup.

Materials and methods

Sample

We used the baseline survey data from a randomized controlled trial to increase colorectal cancer (CRC) screening among 400 Chinese and Korean American immigrants (200 Chinese and 200 Korean immigrants). Study participants were recruited from primary care physicians' clinics in Maryland and Northern Virginia, and they were between the ages of 49 and 75, living in the Baltimore-Washington DC Metropolitan Area. All participants completed the survey between August 2018 and June 2020 either in-person or by phone in their preferred language (Mandarin, Korean, or English). Eighty-nine percent of the participants completed a self-administered questionnaire in-person, and 11 percent of the participants completed a research assistant-led phone survey due to the COVID-19 outbreak in March 2020. In-person survey participants signed informed consent forms during the meeting, while phone survey participants submitted consent forms prior to the survey via mail. Participants were able to get help from research assistants if they had any questions about survey items. This study was approved by the Institutional Review Boards of the University of Maryland, College Park and the University of California, Irvine.

Self-rated health

Our dependent variable, SRH, was assessed using a question, "Would you say that in general your health is excellent, very good, good, fair or poor?" SRH is a widely used predictor of various health outcomes including morbidity (23) and mortality (24) and health behaviors such as smoking and alcohol consumption (45), and it has been applied in diverse populations including Chinese and Korean American immigrants (46). Responses were dichotomized into "excellent/very good/good" and "fair/poor" based on the previous studies (46, 47).

Acculturation

We measured acculturation using three variables: years living in the U.S., English proficiency, and ethnic identity. Years living in the U.S. was calculated using the year difference between the date of baseline survey and the date of arriving in the U.S. We classified years living in the U.S. into two categories using 23 years (median) as a cutoff (13). As a sensitivity analysis, we repeated the same analysis using years in the US as a continuous variable and 3-categorical variable ($\leq$10 years [11.8%], 11–20 years [28.5%], $\geq$21 years [59.8%]), with similar results (results not shown, but available upon request). English proficiency was evaluated using a question, "How well do you speak English?" Responses were recoded into three categories: "fluently like a native speaker/well," "so-so," and "poorly/not at all." Ethnic identity was assessed using the question, "How would you rate yourself?" Available response options were "very Asian," "mostly Asian," "bicultural," "mostly westernized," or "very westernized" (48, 49). Few people rated themselves as mostly westernized (1.25% of the sample) or very westernized (0.25% of the sample), so we combined them with people identifying as bicultural. The ethnic identity variable used in analysis included three categories: very Asian, mostly Asian, or bicultural/westernized.

Covariates

Age, gender, Asian subgroup, marital status, education, household income, employment status, and health insurance were included in the analysis. Age was used as a four categorical variable ($<$55, 55–59, 60–64, $\geq$65), gender was classified as male and female, and Asian subgroup was categorized as Chinese and Korean. Marital status was used as a binary variable: married/cohabiting and not currently married. Education was recoded into five categories: less than high school, high school graduate or GED, business/vocational school/some college, college graduate, and attended graduate/professional school. Household income was treated as six categories: $<$\$20,000, \$20,000–39,999,

$40,000–59,999, $60,000–79,999, $80,000–99,999, and ≥$100,000. Employment status was categorized as full time, part time, and not employed. Health insurance status was recoded as private health insurance, Medicare/Medicaid, and no health insurance.

Statistical analysis

First, descriptive analysis was conducted for the sample overall and stratified by SRH. Means and standard errors were reported for continuous variables and frequencies and percentages were reported for categorical variables. Two sample t-tests for continuous variables and chi-square tests for categorical variables were conducted to compare the differences by SRH. Second, Poisson regression models with robust error variance were used to estimate associations between acculturation variables and SRH. Poisson regression models were used in lieu of logistic models because logistic models may overestimate the associations using odds ratios when the outcome variable is prevalent at >10% (50, 51). We conducted a regression model for each acculturation variable, which included age, gender, Asian subgroup, and marital status, education, household income, employment status, and health insurance status. In the final model, we included all three acculturation variables together, adjusting for all covariates. Third, we tested age (using median age: 58) and Asian subgroup as potential effect modifiers for the associations between three acculturation variables and SRH. For interaction terms with $p<0.1$, we presented stratified analyses (non-significant findings with $p \geq 0.1$ are not shown, but available upon request). All statistical analyses were computed using SAS version 9.4.

Results

Table 1 presents the characteristics of the study participants. Of the 400 participants, 223 (55.8%) were classified as excellent/very good/good SRH, while 177 (44.2%) were classified as fair/poor SRH. There was a significant difference in English proficiency between two SRH groups: 32.7% of participants who had better SRH spoke English fluently like a native speaker/well, while only 10.2% participants who had worse SRH did. Also, participants with better SRH reported a significantly lower proportion of self-identifying as very Asian (51.6%) compared to those with worse SRH (71.8%). In addition, those that reported excellent/very good/good SRH had higher proportions of male (53.4%), attended graduate/professional school (34.5%), ≥$100,000 household income (36.8%), working full time (64.1%), and had private health insurance (66.4%) compared to those with fair/poor SRH (male: 39.6%, attended graduate/professional school: 11.3%, ≥$100,000 household income: 14.7%, working full time: 49.7%, private health insurance: 53.7%).

Table 2 shows the results of Poisson regression models to estimate the associations between three acculturation variables and SRH. The adjusted prevalence ratios (aPR) and 95% confidence intervals (CI) are reported. In Model 1, duration of living in the U.S. was not associated with reporting fair or poor SRH (aPR: 0.94 95% CI: 0.74–1.18). In Model 2, individuals who spoke English so-so and fluently like a native speaker or well had 0.73 (95% CI: 0.56–0.95) and 0.48 (95% CI: 0.28–0.81) times the prevalence of having fair or poor SRH compared to those who spoke English poorly or not at all. In Model 3, individuals who self-identified as bicultural/westernized were less likely to have fair or poor SRH compared to those who identified as very Asian (aPR: 0.58, 95% CI: 0.39–0.85). When three measures of acculturation were included together in Model 4, English proficiency and ethnic identity were associated with SRH. Participants speaking English so-so and those speaking English fluently like a native speaker or well had 0.73 (95% CI: 0.55–0.97) and 0.51 (95% CI: 0.30–0.87) times the prevalence of having fair/poor SRH compared to those speaking English poorly or not at all. Additionally, those who identified as bicultural/westernized had 0.63 times the prevalence of having fair or poor SRH (95% CI: 0.43–0.92) as those who identified as very Asian. However, years living in the U.S. was not associated with prevalence of fair or poor SRH.

We tested age and Asian subgroup as potential effect modifiers for the associations between three measures of acculturation and SRH using models adjusted for all sociodemographic variables. The stratified results are presented in Table 3 only if the effect modification results were significant at $p<0.1$. Age modified the association between ethnic identity and SRH. Therefore, we present stratified analysis by whether participants were <58 years-old or equal to or >58 years-old (the median age). Among the participants aged 58 or older, people who identified as bicultural/westernized were much less likely to have fair or poor SRH compared to those who were very Asian (aPR: 0.29, 95% CI: 0.12–0.67), while the association between ethnic identity and SRH among the participants aged younger than 58 was lesser in magnitude. We additionally conducted effect-modification analysis using a binary age group based on retirement age (65 years) and more narrow age groups (<55, 55–59, 60–64, ≥65). Although these age groups were not statistically significant effect-modifiers, the stratified analysis confirmed that the magnitude of negative associations between being bicultural/westernized and fair/poor SRH were pronounced among participants who were older compared to those who were younger (Appendix 1). Asian subgroup modified the association between English proficiency and SRH. Among the Chinese participants, those who spoke English fluently like a native speaker/well or so-so were less likely to have fair or poor SRH (fluently like a native speaker/well: aPR: 0.33, 95% CI: 0.14–0.78; so-so: aPR: 0.46, 95% CI: 0.29–0.73) compared with those who speak English poorly/not at all. These associations were not statistically significant among the Korean participants, but still in the same direction.

Discussion

With the rapid growth and eventual aging of Asian immigrants, it is essential to study the health and overall wellbeing of older Asian immigrants as they adapt to the U.S. (52). This paper provides findings about the association between multidimensional acculturation and SRH among older Chinese and Korean American immigrants and differential associations by age and Asian subgroup.

Our findings suggest that higher acculturation measured by English proficiency and ethnic identity was associated with better

10.3389/fpubh.2023.1272428

TABLE 1 Characteristics of the study participants (n = 400).

	Total	Self-rated health		*P*-value
		Excellent/very good/good	Fair/poor	
	n = 400 (100%)	*n* = 223 (55.75%)	*n* = 177 (44.25%)	
Years living in the US, *n* (%)				
<23 years	200 (50.0)	103 (46.2)	97 (54.8)	0.0870
≥23 years	200 (50.0)	120 (53.8)	80 (45.2)	
English proficiency, *n* (%)				
Fluently/well	91 (22.8)	73 (32.7)	18 (10.2)	<0.0001
So-so	148 (37.0)	89 (39.9)	59 (33.3)	
Poorly/not at all	161 (40.3)	61 (27.4)	100 (56.5)	
Self-identity, *n* (%)				
Very Asian	242 (60.5)	115 (51.6)	127 (71.8)	<0.0001
Mostly Asian	62 (15.5)	36 (16.1)	26 (14.7)	
Bicultural/mostly Westernized/very Westernized	96 (24.0)	72 (32.3)	24 (13.6)	
Age, *n* (%)				
<55	141 (35.3)	87 (39.0)	54 (30.5)	0.2370
55-59	86 (21.5)	47 (21.1)	39 (22.0)	
60-64	103 (25.8)	50 (22.4)	53 (29.9)	
≥65	70 (17.5)	39 (17.5)	31 (17.5)	
Gender, *n* (%)				
Female	211 (52.8)	104 (46.6)	107 (60.5)	0.0060
Male	189 (47.3)	119 (53.4)	70 (39.6)	
Asian subgroup, *n* (%)				
Chinese	200 (50.0)	119 (53.4)	81 (45.8)	0.1310
Korean	200 (50.0)	104 (46.6)	96 (54.2)	
Marital status, *n* (%)				
Not currently married	59 (14.8)	29 (13.0)	30 (17.0)	0.2691
Married/cohabit	341 (85.3)	194 (87.0)	147 (83.1)	
Education, *n* (%)				
Less than high school	43 (10.8)	20 (9.0)	23 (13.0)	<0.0001
High school graduate or GED	91 (22.8)	37 (16.6)	54 (30.5)	
Business/vocational school/some college	68 (17.0)	34 (15.3)	34 (19.2)	
College graduate	101 (25.3)	55 (24.7)	46 (26.0)	
Attended graduate/professional school	97 (24.3)	77 (34.5)	20 (11.3)	
Household income, *n* (%)				
<$20,000	62 (15.5)	22 (9.9)	40 (22.6)	<0.0001
$20,000–39,999	64 (16.0)	26 (11.7)	38 (21.5)	
$40,000–59,999	85 (21.3)	43 (19.3)	42 (23.7)	
$60,000–79,999	49 (12.3)	29 (13.0)	20 (11.3)	
$80,000–99,999	32 (8.0)	21 (9.4)	11 (6.2)	
≥$100,000	108 (27.0)	82 (36.8)	26 (14.7)	
Employment, *n* (%)				
Working full time	231 (57.8)	143 (64.1)	88 (49.7)	0.0146

(Continued)

TABLE 1 (Continued)

	Total	Self-rated health		*P*-value
		Excellent/very good/good	Fair/poor	
	n = 400 (100%)	*n* = 223 (55.75%)	*n* = 177 (44.25%)	
Working part time	84 (21.0)	39 (17.5)	45 (25.4)	
Not currently working	85 (21.3)	41 (18.4)	44 (24.9)	
Health insurance, *n* (%)				
Private health insurance	243 (60.8)	148 (66.4)	95 (53.7)	0.0309
Medicare/Medicaid	74 (18.5)	37 (16.6)	37 (20.9)	
No health insurance	83 (20.8)	38 (17.0)	45 (25.4)	

SE, standard error.

SRH among older adult Asian immigrants. Individuals with higher English proficiency and who identified as bicultural or westernized were less likely to report poor to fair SRH compared to their less acculturated counterparts. These results are consistent with growing evidence that greater acculturation is associated with better SRH among Asian immigrants. Previous studies suggested that English proficiency was consistently associated with better SRH among samples of Asian immigrants (29, 30, 32) and in combined samples of U.S.-born and foreign-born Asian Americans (14, 31). For ethnic identity, a prior study also found that U.S.- and foreign-born Asians who self-identified as American were 3.5 times more likely to have good SRH than those who self-identified as Asian (14). By contrast, our result suggested that the association between the length of residence in the U.S. and odds of poor SRH was not statistically significant after adjusting for socioeconomic status covariates or including other acculturation proxies. Our finding is consistent with a previous study that reported insignificant association between duration of time in the U.S. and SRH among Asian immigrants (32). However, the finding is contrary to some studies that showed a positive association of duration of residence with poor SRH among Asian Americans (1, 2), which included both U.S.-born and foreign-born Asian Americans. Together, our findings suggest that acculturation is a complex construct that should be assessed using multidimensional measures.

Our results are consistent with previous studies on acculturation and SRH, while they contrast with the traditional knowledge about the erosion of immigrant health since migration, which suggests that acculturation is associated with unhealthy behaviors and chronic diseases (1–3, 5–8, 13) as immigrants adopt dietary patterns, health-related norms and behaviors in the U.S. (2, 14). The result for SRH is different probably because SRH is a holistic and subjective indicator of perceived physical, mental, emotional health, which depends on external factors and internal responses (32, 53). For example, acculturative stress is prominent for less acculturated Asian Americans, which contributes to poor mental health and ultimately worse SRH despite their lower prevalence of major diseases compared to more acculturated populations (14). Additionally, more acculturated Asian Americans are more likely to receive health screening and healthcare services than less acculturated Asian Americans (14, 32, 34, 54). In particular, higher English proficiency and more bicultural or western identity—the acculturation factors most associated with better SRH—are likely associated with higher health literacy and better access to health care, as structural barriers to access will be easier for those individuals to overcome (55–57).

Additionally, we also found that age and Asian subgroup were effect modifiers for the associations between acculturation and SRH using models adjusted for all covariates. The negative association between English proficiency and poor to fair SRH was more pronounced among Chinese immigrants than Korean immigrants. To our knowledge, this is the first study to demonstrate differences between Chinese and Korean Americans in this association. It may be that English proficiency confers better health for Chinese immigrants more so than for Korean immigrants due to a greater ability to access health promoting resources in English in the study area for Chinese compared to Korean populations. This finding is consistent with previous studies that found the heterogeneity of Asian immigrants in the associations between acculturation and health behaviors or outcomes (32, 39, 40). The process and effects of acculturation are diverse across the country of origin due to different reasons and contexts for migration, economic and political circumstances of host countries, ethnic differences in their social networks, as well as cultural differences in the conception of health status (32, 39, 40).

Age modified the association between ethnic identity and SRH, such that there was a stronger health protective effect of identifying as bicultural/westernized vs. very Asian for people at older ages than those at younger ones. This finding is consistent with several previous studies that reported a positive association between acculturation and SRH among older adult Asian immigrants (28, 36). It is noteworthy that the sample was generally older to begin with, with ages ranging from 49 to 75, but we still found the difference by age group. It is likely that as age increases, older Asian immigrants are more likely to suffer from cultural and social isolation and limited access to culturally appropriate health services (30, 37, 38). Therefore, for much older Asian immigrants, identifying as bicultural or westernized may have a more pronounced protective effect on health, since their social networks are broader or it is easier for them to access the health and social services they need (46, 58).

This study has some limitations to highlight. First, we were not able to examine causal mechanisms between acculturation and SRH as the data was cross-sectional. Second, our study was

10.3389/fpubh.2023.1272428

TABLE 2 Poisson regression analyses: years living in the US, English proficiency, self-identity, and self-rated health ($n = 400$).

	Fair/poor self-rated health			
	PR (95% CI)			
	Model 1	Model 2	Model 3	Model 4
Years living in the US				
<23 years	1.00			1.00
≥23 years	0.94 (0.74–1.18)			1.13 (0.89–1.44)
English proficiency				
Fluently/well		0.48 (0.28–0.81)**		0.51 (0.30–0.87)*
So–so		0.73 (0.56–0.95)*		0.73 (0.55–0.97)*
Poorly/not at all		1.00		1.00
Self–identity				
Very Asian			1.00	1.00
Mostly Asian			0.85 (0.61–1.18)	0.87 (0.62–1.21)
Bicultural/mostly Westernized/very Westernized			0.58 (0.39–0.85)**	0.63 (0.43–0.92)*
Age				
<55	1.00	1.00	1.00	1.00
55–59	1.12 (0.83–1.52)	1.09 (0.82–1.46)	1.14 (0.84–1.54)	1.10 (0.82–1.47)
60–64	1.05 (0.78–1.40)	0.96 (0.72–1.28)	1.07 (0.80–1.42)	0.98 (0.73–1.31)
≥65	0.89 (0.61–1.30)	0.83 (0.57–1.21)	0.88 (0.59–1.30)	0.81 (0.55–1.20)
Gender				
Male	1.00	1.00	1.00	1.00
Female	1.27 (1.01–1.60)*	1.25 (1.00–1.57)*	1.28 (1.02–1.60)*	1.26 (1.01–1.58)*
Asian subgroup				
Korean	1.00	1.00	1.00	1.00
Chinese	0.93 (0.73–1.20)	0.91 (0.71–1.16)	1.10 (0.85–1.42)	1.06 (0.82–1.38)
Marital status				
Married/cohabit	1.00	1.00	1.00	1.00
Not currently married	1.06 (0.81–1.40)	1.04 (0.79–1.37)	1.14 (0.87–1.50)	1.10 (0.83–1.45)
Education				
Less than high school	1.82 (1.06–3.12)*	1.27 (0.72–2.24)	1.63 (0.95–2.82)†	1.18 (0.65–2.13)
High school graduate or GED	1.98 (1.22–3.23)**	1.42 (0.85–2.38)	1.83 (1.12–2.98)*	1.36 (0.80–2.30)
Business/vocational school/some college	1.87 (1.13–3.11)*	1.54 (0.92–2.57)	1.81 (1.10–3.00)*	1.51 (0.90–2.54)
College graduate	1.79 (1.10–2.92)*	1.45 (0.87–2.40)	1.70 (1.04–2.77)*	1.42 (0.85–2.37)
Attended graduate/professional school	1.00	1.00	1.00	1.00
Income				
<$20,000	1.86 (1.15–3.00)*	1.57 (0.97–2.55)†	1.70 (1.06–2.73)*	1.52 (0.94–2.45)†
$20,000–39,999	1.62 (1.01–2.59)*	1.36 (0.85–2.17)	1.56 (0.98–2.49)†	1.37 (0.86–2.19)
$40,000–59,999	1.37 (0.88–2.14)	1.17 (0.75–1.85)	1.38 (0.89–2.13)	1.21 (0.77–1.89)
$60,000–79,999	1.15 (0.68–1.93)	1.01 (0.60–1.72)	1.13 (0.67–1.90)	1.03 (0.61–1.73)
$80,000–99,999	0.97 (0.54–1.72)	0.86 (0.47–1.58)	0.96 (0.54–1.72)	0.89 (0.48–1.63)
≥$100,000	1.00	1.00	1.00	1.00
Employment status				
Working full time	1.00	1.00	1.00	1.00

(Continued)

TABLE 2 (Continued)

	Fair/poor self-rated health PR (95% CI)			
	Model 1	Model 2	Model 3	Model 4
Working part time	1.06 (0.82–1.38)	1.06 (0.82–1.37)	1.04 (0.80–1.35)	1.05 (0.81–1.35)
Not currently working	1.02 (0.76–1.37)	0.94 (0.70–1.27)	1.00 (0.74–1.34)	0.94 (0.70–1.27)
Health insurance				
Private health insurance	1.00	1.00	1.00	1.00
Medicare/Medicaid	1.00 (0.72–1.38)	1.04 (0.76–1.44)	1.05 (0.76–1.47)	1.08 (0.77–1.51)
No health insurance	1.15 (0.89–1.49)	1.14 (0.88–1.47)	1.15 (0.89–1.49)	1.14 (0.89–1.47)

$^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$.
R, prevalence ratio; CI, confidence interval.

TABLE 3 Stratified analysis: English proficiency, self-identity, and self-rated health ($n = 400$).

	Fair/poor self-rated health PR (95% CI)	
	Korean[a]	Chinese[a]
	$n = 200$	$n = 200$
English proficiency		
Fluent like a native speaker/well	0.63 (0.33-1.21)	0.33 (0.14-0.78)*
So-so	0.90 (0.63-1.27)	0.46 (0.29-0.73)***
Poorly/not at all	1.00	1.00
	Age < 58[b]	**Age ≥ 58[b]**
	***n* = 197**	***n* = 203**
Self-identity		
Very Asian	1.00	1.00
Mostly Asian	0.85 (0.50–1.45)	0.92 (0.60–1.43)
Bicultural/mostly Westernized/very Westernized	0.78 (0.49–1.24)	0.29 (0.12–0.67)**

[a]English proficiency + age, gender, marital status, education, household income, employment status, health insurance.
[b]Self-identity + gender, Asian subgroup, marital status, education, household income, employment status, health insurance.
PR, prevalence ratio; CI, confidence interval.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

limited to the Chinese and Korean immigrants aged 49–75 living in the Baltimore-Washington D.C. Area, who were not randomly selected. In particular, as we used survey data of CRC screening study, the exclusion and inclusion criteria related to CRC might have affected our study's results. For example, Chinese and Korean immigrants who had CRC diagnosis were excluded from our study. It is possible that we might have excluded participants who might have had lower SRH, which could have underestimated the true association. Therefore, the sample is not representative of the population of Chinese and Korean immigrants. Third, we did not have information about participants' health-promoting behaviors, such as receiving health screening or utilizing healthcare services, which would allow us to test their mediating role in the association between acculturation and SRH (14, 32, 34).

Nonetheless, the current study has public health implications for Asian American communities, policy makers, and medical professionals. By using multidimensional proxies of acculturation, the findings suggest that being less acculturated was associated with worse SRH overall among older adult Asian immigrants. Our study also highlights that the association was more pronounced among Chinese immigrants and older participants compared to Korean immigrants and younger participants. There is a critical need to develop intervention programs to improve health among less acculturated Asian immigrants, particularly older and Korean immigrants. For example, local governments and community centers may support in-language and culturally appropriate education programs, free or low-cost health services, and vital social supports. Classes to learn basic English might also be useful for interested Chinese and Korean immigrants. We also learned that duration of stay in the U.S. alone will not provide sufficient information for degree of acculturation. This is important given that many national-level surveys use duration of stay in the U.S. as a marker for acculturation.

Using a prospective study design, future research on this topic should investigate the causal relationship between acculturation and SRH and focus on finding potential mediators between the association between acculturation and SRH. It will provide levers for future intervention. Moreover, future studies need to examine differential associations across various Asian subgroups and a wide range of age groups as these findings will help to target future interventions. Furthermore, studies should carefully assess acculturation with various measurements (e.g., social interactions, attitudes, values). By doing so, we will find effective strategies to enhance health among aging Asian immigrant populations in the U.S.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Institutional Review Boards of the University of Maryland, College Park and the University of California, Irvine. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SR: Data curation, Formal analysis, Writing – original draft. BM: Formal analysis, Writing – review & editing. YS: Data curation, Formal analysis, Writing – review & editing. SL: Funding acquisition, Project administration, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. Research reported in this publication was supported by the National Institute On Minority Health and Health Disparities of the National Institutes of Health under Award Number R01MD012778.

Acknowledgments

We would like to thank the respondents who have generously shared their time and experiences with our study personnel.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author disclaimer

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Frisbie WP, Cho Y, Hummer RA. Immigration and the health of Asian and Pacific Islander adults in the United States. *Am J Epidemiol.* (2001) 153:372–80. doi: 10.1093/aje/153.4.372

2. Acevedo-Garcia D, Bates LM, Osypuk TL, McArdle N. The effect of immigrant generation and duration on self-rated health among US adults 2003-2007. *Soc Sci Med.* (2010) 71:1161–72. doi: 10.1016/j.socscimed.2010.05.034

3. Gomez SL, Kelsey JL, Glaser SL, Lee MM, Sidney S. Immigration and acculturation in relation to health and health-related risk factors among specific Asian subgroups in a health maintenance organization. *Am J Public Health.* (2004) 94:1977–84. doi: 10.2105/AJPH.94.11.1977

4. Berry JW, Sam DL. *Theoretical Perspectives*. New York: Cambridge University Press. (2016) p. 11–29.

5. Hahm HC, Lahiff M, Guterman NB. Asian American adolescents' acculturation, binge drinking, and alcohol- and tobacco-using peers. *J Community Psychol.* (2004) 32:295–308. doi: 10.1002/jcop.20002

6. Huh J, Prause JA, Dooley CD. The impact of nativity on chronic diseases, self-rated health and comorbidity status of Asian and Hispanic immigrants. *J Immigr Minor Health.* (2008) 10:103–18. doi: 10.1007/s10903-007-9065-7

7. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord.* (2000) 24:1188–94. doi: 10.1038/sj.ijo.0801365

8. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA.* (2004) 292:2860–7. doi: 10.1001/jama.292.23.2860

9. Chen L, Juon HS, Lee S. Acculturation and BMI among Chinese, Korean and Vietnamese adults. *J Community Health.* (2012) 37:539–46. doi: 10.1007/s10900-011-9476-1

10. John EM, Phipps AI, Davis A, Koo J. Migration history, acculturation, and breast cancer risk in Hispanic women. *Cancer Epidemiol. Biomark Prevent.* (2005) 14:2905–13. doi: 10.1158/1055-9965.EPI-05-0483

11. Fujimoto WY, Bergstrom RW, Boyko EJ, Chen K, Kahn SE, Leonetti DL, et al. Type 2 diabetes and the metabolic syndrome in Japanese Americans. *Diabetes Res Clin Pract.* (2000) 50 Suppl 2:S73–6. doi: 10.1016/S0168-8227(00)00182-0

12. Huang B, Rodriguez BL, Burchfiel CM, Chyou PH, Curb JD, Yano K. Acculturation and prevalence of diabetes among Japanese-American men in Hawaii. *Am J Epidemiol.* (1996) 144:674–81. doi: 10.1093/oxfordjournals.aje.a008980

13. Morey BN, Ryu S, Shi Y, Park HW, Lee S. Acculturation and cardiometabolic abnormalities among Chinese and Korean Americans. *J Racial Ethn Health Disparities.* (2022) 10:1605–15. doi: 10.1007/s40615-022-01347-x

14. Lee S, Chen L, He X, Miller MJ, Juon H-S, A. cluster analytic examination of acculturation and health status among Asian Americans in the Washington DC metropolitan area, United States. *Soc Sci Med.* (2013) 96:17–23. doi: 10.1016/j.socscimed.2013.07.007

15. Gassman-Pines A, Skinner AT. Psychological acculturation and parenting behaviors in mexican immigrant families. *J Fam Issues.* (2018) 39:1139–64. doi: 10.1177/0192513X16687001

16. Balidemaj A, Small M. The effects of ethnic identity and acculturation in mental health of immigrants: a literature review. *Int J Soc Psychiatry.* (2019) 65:643–55. doi: 10.1177/0020764019867994

17. Lommel LL, Thompson L, Chen J-L, Waters C, Carrico A. Acculturation, inflammation, and self-rated health in mexican american immigrants. *J Immig Minority Health.* (2019) 21:1052–60. doi: 10.1007/s10903-018-0805-7

18. van der Zee K, van Oudenhoven JP. Towards a dynamic approach to acculturation. *Int J Intercult. Relat.* (2022) 88:119–24. doi: 10.1016/j.ijintrel.2022.04.004

19. Consedine NS, Chentsova-Dutton YE, Krivoshekova YS. Emotional acculturation predicts better somatic health: experiential and expressive acculturation

among immigrant women from four ethnic groups. *J Soc Clin Psychol.* (2014) 33:867–89. doi: 10.1521/jscp.2014.33.10.867

20. Rudmin F. Editorial: steps towards the renovation of acculturation research paradigms: what scientists' personal experiences of migration might tell science. *Cult Psychol.* (2010) 16:299–312. doi: 10.1177/1354067X10371140

21. Budiman A, Ruiz NG. *Key facts about Asian origin groups in the U.S. Pew Research Center.* (2021).

22. Budiman A, Ruiz NG. *Asian Americans are the Fastest-Growing Racial or Ethnic Group in the U.S.: Pew Research Center.* (2021). Available online at: https://www.pewresearch.org/fact-tank/2021/04/09/asian-americans-are-the-fastest-growing-racial-or-ethnic-group-in-the-u-s/ (accessed May 21, 2023).

23. Jonnalagadda SS. Diwan S. Health behaviors, chronic disease prevalence and self-rated health of older Asian Indian immigrants in the US. *J Immigr Health.* (2005) 7:75–83. doi: 10.1007/s10903-005-2640-x

24. Idler E, Leventhal H, McLaughlin J, Leventhal E. In sickness but not in health: self-ratings, identity, and mortality. *J Health Soc Behav.* (2004) 45:336–56. doi: 10.1177/002214650404500307

25. Gong F. Beyond conventional socioeconomic status: examining subjective and objective social status with self-reported health among Asian immigrants. *J Behav Med.* (2011) 35:407–19. doi: 10.1007/s10865-011-9367-z

26. Lee S, O'Neill AH, Ihara ES, Chae DH. Change in self-reported health status among immigrants in the United States: associations with measures of acculturation. *PLoS ONE.* (2013) 8:e76494. doi: 10.1371/journal.pone.0076494

27. Chou C-F, Johnson PJ, Blewett LA. Immigration and selected indicators of health status and healthcare utilization among the Chinese. *J Immig Minor Health.* (2010) 12:470–9. doi: 10.1007/s10903-009-9240-0

28. Ro A, Geronimus A, Bound J, Griffith D, Gee G. Cohort and duration patterns among Asian immigrants: comparing trends in obesity and self-rated health. *Biodemography Soc Biol.* (2015) 61:65–80. doi: 10.1080/19485565.2014.950721

29. Tsoh JY, Sentell T, Gildengorin G, Le GM, Chan E, Fung LC, et al. Healthcare communication barriers and self-rated health in older Chinese American immigrants. *J Community Health.* (2016) 41:741–52. doi: 10.1007/s10900-015-0148-4

30. Kim G, Worley CB, Allen RS, Vinson L, Crowther MR, Parmelee P, et al. Vulnerability of older Latino and Asian immigrants with limited English proficiency. *J Am Geriatr Soc.* (2011) 59:1246–52. doi: 10.1111/j.1532-5415.2011.03483.x

31. Kandula NR, Lauderdale DS, Baker DW. Differences in self-reported health among Asians, Latinos, and Non-Hispanic Whites: the role of language and nativity. *Ann Epidemiol.* (2007) 17:191–8. doi: 10.1016/j.annepidem.2006.10.005

32. Kimbro RT, Gorman BK, Schachter A. Acculturation and self-rated health among latino and asian immigrants to the United States. *Soc Probl.* (2012) 59:341–63. doi: 10.1525/sp.2012.59.3.341

33. Bulut E, Gayman MD. Acculturation and self-rated mental health among Latino and Asian immigrants in the United States: a latent class analysis. *J Immig Minor Health.* (2016) 18:836–49. doi: 10.1007/s10903-015-0258-1

34. Kim MJ, Gorman BK. Acculturation and self-rated health among Asian immigrants: the role of gender and age. *Popul Res Policy Rev.* (2022) 41:89–114. doi: 10.1007/s11113-021-09642-x

35. Min JW, Rhee S, Lee SE, Rhee J, Tran T. Comparative analysis on determinants of self-rated health among non-Hispanic White, Hispanic, and Asian American older adults. *J Immigr Minor Health.* (2014) 16:365–72. doi: 10.1007/s10903-013-9852-2

36. Lam J, Yip T, Gee G. The physical and mental health effects of age of immigration, age, and perceived difference in social status among first generation Asian Americans. *Asian Am J Psychol.* (2012) 3:29–43. doi: 10.1037/a0027428

37. Wong ST, Yoo GJ, Stewart AL. An empirical evaluation of social support and psychological well-being in older Chinese and Korean immigrants. *Ethn Health.* (2007) 12:43–67. doi: 10.1080/13557850600824104

38. Wong ST, Yoo GJ, Stewart AL. Examining the types of social support and the actual sources of support in older Chinese and Korean immigrants. *Int J Aging Hum Dev.* (2005) 61:105–21. doi: 10.2190/AJ62-QQKT-YJ47-B1T8

39. Salant T, Lauderdale DS. Measuring culture: a critical review of acculturation and health in Asian immigrant populations. *Soc Sci Med.* (2003) 57:71–90. doi: 10.1016/S0277-9536(02)00300-3

40. Park SY, Anastas J, Shibusawa T, Nguyen D. The impact of acculturation and acculturative stress on alcohol use across Asian immigrant subgroups. *Subst Use Misuse.* (2014) 49:922–31. doi: 10.3109/10826084.2013.855232

41. Lee S-K, Sobal J, Frongillo EA. Acculturation and health in Korean Americans. *Soc Sci Med.* (2000) 51:159–73. doi: 10.1016/S0277-9536(99)00446-3

42. Fox M, Thayer ZM, Wadhwa PD. Acculturation and health: the moderating role of sociocultural context. *Am Anthropol.* (2017) 119:405–21. doi: 10.1111/aman.12867

43. Berry JW. Conceptual approaches to acculturation. In: Acculturation: Advances in theory, measurement, and applied research. Washington, DC, US: American Psychological Association. (2003) p. 17–37.

44. Abraído-Lanza AF, Armbrister AN, Flórez KR, Aguirre AN. Toward a theory-driven model of acculturation in public health research. *Am J Public Health.* (2006) 96:1342–6. doi: 10.2105/AJPH.2005.064980

45. Tran TV, Nguyen D, Chan K, Nguyen T-N. The association of self-rated health and lifestyle behaviors among foreign-born Chinese, Korean, and Vietnamese Americans. *Qual Life Res.* (2013) 22:243–52. doi: 10.1007/s11136-012-0155-1

46. Morey BN, Valencia C, Park HW, Lee S. The central role of social support in the health of Chinese and Korean American immigrants. *Soc Sci Med.* (2021) 284:114229. doi: 10.1016/j.socscimed.2021.114229

47. Wu S, Wang R, Zhao Y, Ma X, Wu M, Yan X, et al. The relationship between self-rated health and objective health status: a population-based study. *BMC Public Health.* (2013) 13:320. doi: 10.1186/1471-2458-13-320

48. Suinn RM, Ahuna C, Khoo G. The Suinn-Lew Asian self-identity acculturation scale: Concurrent and factorial validation. *Educ Psychol Meas.* (1992) 52:1041–6. doi: 10.1177/0013164492052004028

49. Suinn RM, Khoo G, Ahuna C. The Suinn-Lew Asian self-identity acculturation scale: cross-cultural information. *J Multicult Couns Devel.* (1995) 23:139–48. doi: 10.1002/j.2161-1912.1995.tb00269.x

50. Richardson DB, Kinlaw AC, MacLehose RF, Cole SR. Standardized binomial models for risk or prevalence ratios and differences. *Int J Epidemiol.* (2015) 44:1660–72. doi: 10.1093/ije/dyv137

51. Tamhane AR, Westfall AO, Burkholder GA, Cutter GR. Prevalence odds ratio versus prevalence ratio: choice comes with consequences. *Stat Med.* (2016) 35:5730–5. doi: 10.1002/sim.7059

52. Yellow Horse AJ, Patterson SE. Greater inclusion of Asian Americans in Aging research on family caregiving for better understanding of racial health inequities. *Gerontologist.* (2022) 62:704–10. doi: 10.1093/geront/gnab156

53. Ro A. Bostean G. Duration of US stay and body mass index among Latino and Asian immigrants: A test of theoretical pathways. *Soc Sci Med.* (2015) 144:39–47. doi: 10.1016/j.socscimed.2015.09.001

54. Lee S, Chen L, Jung MY, Baezconde-Garbanati L, Juon H-S. Acculturation and cancer screening among Asian Americans: role of health insurance and having a regular physician. *J Community Health.* (2014) 39:201–12. doi: 10.1007/s10900-013-9763-0

55. Gee GC, Sangalang CC, Morey BN, Hing AK. *The Global and Historical Nature of Racism and Health Among Asian Americans Racism: Science & Tools for the Public Health Professional: American Public Health Association.* Washington, DC: American Journal of Public Health (2019).

56. Lee HY, Rhee TG, Kim NK, Ahluwalia JS. Health literacy as a social determinant of health in asian american immigrants: findings from a population-based survey in California. *J Gen Intern Med.* (2015) 30:1118–24. doi: 10.1007/s11606-015-3217-6

57. Ohtani A, Suzuki T, Takeuchi H, Uchida H. Language barriers and access to psychiatric care: a systematic review. *Psychiat Serv.* (2015) 66:798–805. doi: 10.1176/appi.ps.201400351

58. Dong X, Chang ES, Wong E, Simon M. Perception and negative effect of loneliness in a Chicago Chinese population of older adults. *Arch Gerontol Geriatr.* (2012) 54:151–9. doi: 10.1016/j.archger.2011.04.022

10.3389/fpubh.2023.1272428

Appendix

Stratified analysis: self-identity and self-rated health by different age group ($n = 400$).

	Fair/poor self-rated health PR (95% CI)			
	Age < 65	**Age ≥ 65**		
	***n* = 330**	***n* = 70**		
Self-identity				
Very Asian	1.00	1.00		
Mostly Asian	0.83 (0.57–1.21)	0.62 (0.26–1.45)		
Bicultural/mostly Westernized/very Westernized	0.66 (0.44–0.98)*	0.16 (0.03–0.87)*		
	Age < 55	**55 ≤ Age < 60**	**60 ≤ Age < 65**	**Age ≥ 65**
	***n* = 141**	***n* = 86**	***n* = 103**	***n* = 70**
Self-identity				
Very Asian	1.00	1.00	1.00	1.00
Mostly Asian	0.69 (0.34–1.39)	1.05 (0.44–2.50)	1.09 (0.62–1.92)	0.62 (0.26–1.45)
Bicultural/mostly Westernized/very Westernized	0.72 (0.40–1.30)	0.73 (0.35–1.54)	0.51 (0.20–1.34)	0.16 (0.03–0.87)*

Model: Self-identity + gender, Asian subgroup, marital status, education, household income, employment status, health insurance.
R, prevalence ratio; CI, confidence interval.
*$p < 0.05$.

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 05 January 2024
DOI 10.3389/fpubh.2023.1298657

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Isha Karmacharya,
Miami University, United States
Mariela Deliverska,
Medical University Sofia, Bulgaria

*CORRESPONDENCE
Yuan Zhang
✉ fangao0804@163.com

RECEIVED 22 September 2023
ACCEPTED 05 December 2023
PUBLISHED 05 January 2024

CITATION
Zhang J and Zhang Y (2024) Decomposing differences in the chronic disease condition between rural and urban older adults in China: a cross-sectional analysis.
Front. Public Health 11:1298657.
doi: 10.3389/fpubh.2023.1298657

COPYRIGHT
© 2024 Zhang and Zhang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Decomposing differences in the chronic disease condition between rural and urban older adults in China: a cross-sectional analysis

Jian Zhang[1] and Yuan Zhang[2]*

[1]School of Public Administration, Xi'an University of Architecture and Technology, Xi'an, China, [2]School of Law and Public Administration, China Three Gorges University, Yichang, China

Background: With the increasing in aging in China, there has been an increase in older adults suffering from chronic diseases. However, little is known about the differences in chronic disease conditions between rural and urban older adults. The objective of this study is to identify chronic disease conditions and investigate the factors that cause differences in chronic disease conditions between urban and rural older adults.

Methods: The data are from the fourth wave of the China Health and Retirement Longitudinal Study. The coarsened exact matching (CEM) method was used to reduce the biases for a comparative study. After the CEM method, this study included 5,927 participants aged 60 and above. Chronic disease condition was used as the indicator to measure the health of older adults. Specifically, Fairlie's decomposition analysis was carried out to discover the differences in chronic disease conditions between urban and rural older adults.

Results: The study showed that the proportion of those suffering from chronic diseases was significantly higher among urban older adults (51.26%) than rural older adults (46.56%). In those suffering from chronic diseases, there were significant differences in gender, education level, minorities, religiosities, duration of sleep, drinking alcohol, social activity, insurance, and socioeconomic status between rural and urban older adults, while in those not suffering from chronic diseases, there were significant differences in age, education level, marital status, drinking alcohol, social activity, insurance, region, and socioeconomic status between rural and urban older adults. For rural older adults, those who were widowers [Odds ratios (OR): 1.267], who drink alcohol (OR: 1.421), and having government medical insurance (OR: 4.869) had higher odds of having chronic diseases. However, those who were in high school and above (OR: 0.802), reporting a duration of sleep of 4–8 h (OR: 0.745) or above 8 h (OR: 0.649), having social activity (OR: 0.778), and having the most affluent socioeconomic status (OR: 0.778) had lower odds of having chronic diseases. As for urban older adults, those who were aged 65–74 years (OR: 1.246) and had government medical insurance (OR: 2.362) had higher odds of having chronic diseases. Fairlie's decomposition analysis indicated that 23.57% of the differences in chronic diseases conditions could be traced to duration of sleep, drinking alcohol, social activity, and region.

Conclusion: This study illustrated that the proportion of chronic diseases was higher among urban older adults than rural older adults. Considering duration of

sleep, drinking alcohol, region, social activity, and region, the study demonstrated health differences between urban and rural older adults and provided evidence for policy-making to narrow the health gap between urban and rural areas.

KEYWORDS

chronic diseases, differences, rural and urban older adults, Fairlie's decomposition, CHARLS

1 Introduction

The global aging population is rapidly increasing. The percentage of the world's population of people aged 60 years and above will almost double from 2015 to 2050 (1). In China, the number of adults aged 60 years and above had grown to 264 million by the end of 2020, representing 18.7% of the total population (2). By the year 2050, China's population of people aged 60 years and above is predicted to reach 498 million (3). As aging progresses, suffering from chronic diseases has become a worldwide public health issue and is a major health concern in low- and middle-income countries (4–6).

According to the World Health Organization (WHO), chronic diseases are afflictions that persist for an extensive duration and frequently advance progressively, which include cardiovascular disease, cancer, chronic respiratory disease, and diabetes (7). High incidence, prevalence, disability, mortality, and medical costs are characteristics of suffering from chronic diseases, which significantly affect the quality of life of residents (8). According to the WHO, in *Focusing on non-communicable diseases*, chronic diseases have become one of the main causes of death worldwide and have been one of the most significant health issues worldwide (9). Chronic diseases led to 88.5% of all deaths in China in 2019. Even worse, due to population aging, advanced urbanization, industrialization, and behavioral risks, chronic diseases will persistently escalate in China (10). Risk factors for chronic diseases include smoking, insufficient physical activity, poor diet, hazardous alcohol consumption, and so on. The management of chronic diseases is not only limited to clinical intervention but also influenced by lifestyle and societal structures. It is a complex system that needs coordination, so the United Nations has identified chronic diseases as one of the major global challenges (11).

The differences in health status between urban and rural older adults are important aspects of older adults' health studies. For example, Saha et al. (12) found that urban older adults had better health status than rural older adults in India. Moss et al. (13) found that the burden of chronic diseases was higher among rural older adults than among urban older adults in the mid-Atlantic United States. In South Africa, Peltzer et al. (14) found that urban older adults had a higher prevalence of diabetes, edentulism, and cognitive functioning than rural older adults. Moreover, Norris et al. (15) found that urban–rural health disparities existed in 21 African countries. These studies presented empirical evidence to improve the health disparity between urban and rural older adults.

Chronic diseases are prevalent diseases associated with biological, psychological, and social factors (16). Studies have shown that personal and behavioral characteristics could lead to chronic diseases, and individuals' health is also affected by complex social environments (17). For example, different marital status and place of residence often lead to differences in personal health (18). Grossman (19) put forward the concept of health capital in 1972, showing that factors influencing residents' health included personal attributes, social backing, financial standing, and lifestyle. Wilkinson and Pickett (20) found that the economic status of individuals in developed countries was more likely to be a determining factor in their health. Furthermore, Bassuk et al. (21) found that regional socioeconomic situations influenced the correlation between personal wealth and health.

Demographic factors, lifestyle, and environmental elements predominantly influence chronic disease incidence among older adults (22–24). For example, Gaballa et al. (25) found that premature mortality from chronic diseases, including hypertension, diabetes, and coronary heart disease, escalated with age. Ahmed et al.'s (26) study showed that older adults with higher levels of education had a higher risk of developing hyperlipidemia. Irigaray et al. (27) found that lifestyle was the key risk factor of suffering from chronic diseases, including smoking, alcoholism, bad eating habits, lack of physical activity, and so on. The WHO pointed out that smoking heavily increased global chronic disease prevalence. To date, almost all of the substances in tobacco are harmful to the human body, and more than 40 carcinogens have been identified (28). Makimoto and Higuchi (29) found that heavy alcohol consumption was a major determinant of liver cancer and death due to liver cancer in Japan. The WHO promoted physical activity that could reduce the prevalence of chronic diseases (30). Numerous studies have demonstrated a correlation between socioeconomic status and chronic disease prevalence (31, 32). A study involving individuals aged 60 years and above indicated that economic status significantly influenced the chronic disease prevalence in the older demographic group (31). Concerning research methodology, most studies examined the differences in chronic disease conditions between rural and urban older adults using multiple regression. However, these studies could not explain the rural-urban health differences. To solve the issues contributing to health differences between urban and rural older adults with chronic conditions, decomposition analysis is necessary. Therefore, this study aimed to decompose the differences in chronic disease conditions among rural and urban older adults in China, identifying contributing factors. This study may enrich the understanding of health among older adults in China, and the findings can also provide a reference for narrowing the health gap.

2 Methods

2.1 Data

The fourth wave survey data from the China Health and Retirement Longitudinal Study (CHARLS, wave 4), which was released in 2020, was used. CHARLS contains micro-data reflecting Chinese households and individuals aged 45 years and above, providing a chance to explore China's population aging conundrum and invigorating multidisciplinary aging studies. The CHARLS baseline survey ensured nationwide representation by covering 150 countries/districts and 450 villages/urban communities, involving 17,708 individuals in 10,257 households representing older adults in China. A multi-tiered probability proportional to size sampling (PPS) and random selection method was utilized, stratified by urban district and rural county per capita GDP (33). The samples can be trackable every 2 or 3 years, and post-survey data could be made available to the academic community annually.

2.2 Chronic disease condition measurement

Chronic disease condition among older adults was measured through 14 questions related to chronic diseases. The questions are in the attached materials. For these 14 questions, respondents answered "yes" or "no." Answering "no" was defined as "not suffering from chronic diseases" and answering at least one "yes" was defined as "suffering from chronic diseases."

2.3 Description of variables

Numerous variables were considered in CHARLS based on prior empirical pieces of research (34–38). Variables related to chronic disease conditions between rural and urban older adults are shown in Table 1.

2.4 Statistical analysis

In 1956, the UN categorized people in the ages of 65 years and above in developed nations and 60 years and above in developing nations as older adults (39). Aligning with developing-country norms, older adults were defined as individuals aged 60 years and above in China. This study initially enrolled 10,577 participants aged 60 years and above. After data refinement, excluding non-respondents of chronic disease status ($n = 40$) and unknown respondents ($n = 53$), a total of 10,484 participants remained. First, since there are no equal numbers of participants between rural and urban older adults, it could lead to biases. In this study, the coarsened exact matching (CEM) method was used to match two sets of data on older adults in rural and urban areas to reduce the biases. After matching, rural older adults and urban older adults could become (or very close to) identical in relation to individual characteristics. A total of 5,927 respondents were matched after the CEM method. Rural older adults accounted for 68.64% of the respondents and urban older adults accounted for 31.36%. Second, a description of urban–rural older adults' demographics was conveyed using frequencies and percentages. The chi-square was employed to contrast chronic disease status with categorical variables between urban and rural older adults. Third, odds ratios (OR) of the covariates in logistic regression models were computed to reflect pertinent influences on chronic disease status among rural–urban older adults. Fourth, Fairlie's decomposition was used to analyze the contribution of the differences in suffering from chronic diseases between rural and urban older adults. Fairlie's decomposition aims to decompose health differences into explained and unexplained components. The former is attributed to group variations in visible variables and is typically classified as "endowment." The second segment elucidates undetected cohort diversity (40–45). Following Fairlie, the non-linear equation can be expressed as follows:

$$Y_r = F(X_r\beta_r) \tag{1}$$

$$Y_u = F(X_u\beta_u) \tag{2}$$

Fairlie's decomposition can be expressed as follows:

$$\overline{Y_u} - \overline{Y_r} = \left[\sum_{i=1}^{N^u} \frac{F(X_i^u\beta^u)}{N^u} - \sum_{i=1}^{N^r} \frac{F(X_i^r\beta^u)}{N^r}\right] + \left[\sum_{i=1}^{N^r} \frac{F(X_i^r\beta^u)}{N^u} - \sum_{i=1}^{N^r} \frac{F(X_i^r\beta^r)}{N^r}\right] \tag{3}$$

The average chronic disease condition in urban and rural older adults was independently assessed by $\overline{Y_r}$ and $\overline{Y_u}$. r and u represented rural and urban older adults, encompassing factors such as gender, age, education level, and so on. β represented coefficient. N^r and N^u signified sample sizes for urban and rural older adults, respectively. Statistical analyses were executed with Stata 15.0.

3 Results

3.1 Characteristics of the participants

Table 2 illustrates the descriptive statistics of rural and urban older adults. After matching, the prevalence of those suffering from chronic diseases was reported to be 1,894 and 953 among rural and urban older adults among 5,927 respondents. From the results, it can be inferred that 48.03% of the older adults had suffered from chronic diseases, while 51.97% had not suffered from chronic diseases. The proportion of men (45.30%) in rural areas was slightly lower than that of women (54.70%), and the proportion of men (48.31%) in urban areas was slightly lower than that of women (51.69%). The proportion of older adults aged 60–64 years in rural areas was 32.84%, the proportion of older adults aged 65–74 years was 51.82%, and the proportion of older adults aged over 75 years was 15.34%, while in urban areas, the proportion was 32.22%, 49.22%, and 18.56%, respectively. In terms of education

TABLE 1 Description of variables.

Variable category	Variable name	Variable measurement
Dependent variable	Chronic disease condition	Non-chronic disease = 0; Chronic disease = 1
Grouped variable	Residential address location	In the rural area = 0; In the urban area = 1
Demographic and sociological characteristics	Gender	Women = 0; Men = 1
	Age	60–64 = 1; 65–74 = 2; ≥75 = 3
	Educational attainment	Elementary school and below = 1; Junior school = 2; High School and above = 3
	Marital status	Married with spouses living together = 1; Married with spouses but not living together = 2; Divorced = 3; Widowed = 4; Unmarried = 5
	Minorities	Han = 0; Non-Han = 1
	Religiosities	No = 0; Yes = 1
	Duration of sleep	≤4 h = 1; 4–8 h = 2; >8 h = 3 (h = hour)
	Smoking	No = 0; Yes = 1
	Drinking alcohol	No = 0; Yes = 1
	Social activity	No = 0; Yes = 1
	Physical activity	No = 0; Yes = 1
Social system and economic status	Insurance	No = 1; Resident medical insurance# = 2; Urban employee medical insurance = 3; Government medical insurance = 4
	Region	East = 1; Central = 2; West = 3
	Socioeconomic status	Lowest = 1; Less affluent = 2; Average = 3; More affluent = 4; Most affluent = 5

Resident medical insurance# comprises both urban resident medical insurance and new rural cooperative medical insurance.

level, the proportion of rural older adults with elementary school and below education level was 59.98%, the proportion of those with junior school education level was 22.07%, and the proportion of those with high school and above education level was 17.94%, while for urban older adults, the proportion is 29.48%, 21.84%, and 48.68%, respectively. In terms of marital status, the proportion of rural older adults married with spouses living together was 84.44%, the proportion of rural older adults married with spouses but not living together was 0.69%, the proportion of divorced rural older adults was 0.05%, and the proportion of widowed rural older adults was 14.82%, while for urban older adults, the proportion was 82.89%, 1.24%, 0.11%, and 15.76%, respectively. The proportion of older adults in rural areas who were ethnic Han was 98.43%, and the proportion of non-Han was 1.57%, while the proportion of older adults in urban areas was 97.74% and 2.26%, respectively. The proportion of rural older adults with no religious belief was 96.04% and the proportion of those with religious belief was 3.96%, respectively, while the proportion of urban older adults with no religious belief was 94.46% and those with religious belief was 5.54%, respectively. Other characteristics of the participants are all shown in Table 2.

3.2 Comparative analysis of variable distributions in different chronic disease conditions

Table 3 demonstrates the comparative analysis of variable distribution in chronic disease conditions among rural and urban older adults. It was reported that there were significant differences in gender ($p < 0.05$), education level ($p < 0.001$), minorities ($p < 0.01$), religiosities ($p < 0.01$), duration of sleep ($p < 0.01$), smoking ($p < 0.001$), social activities ($p < 0.001$), insurance ($p < 0.001$), and socioeconomic status ($p < 0.001$) between rural and urban older adults suffering from chronic diseases. However, there were significant differences in age ($p < 0.05$), education level ($p < 0.001$), marital status ($p < 0.05$), drinking alcohol ($p < 0.05$), social activity ($p < 0.001$), insurance ($p < 0.001$), region ($p < 0.001$), and socioeconomic status ($p < 0.001$) between rural and urban older adults who had not suffered from chronic diseases.

3.3 Associations between chronic disease conditions and their determinants

Table 4 shows the matched logistic results of rural and urban older adults suffering from chronic diseases. For rural older adults, those who were widowers (OR: 1.267, CI: 1.047–1.533), who drink alcohol (OR: 1.421, CI: 1.210–1.668), and having government medical insurance (OR: 4.869, CI: 1.144–1.861) had higher odds of suffering from chronic diseases. However, those who had an education level of high school and above (OR: 0.802, CI: 0.664–0.968), were minorities (OR: 0.608, CI: 0.387–0.955), who reported a duration of sleep of 4–8 h (OR: 0.745, CI: 0.619–0.896) or above 8 h (OR: 0.649, CI: 0.446–0.943), and who had the most affluent socioeconomic status (OR: 0.778, CI: 0.627–0.964) had lower odds of suffering from chronic diseases. As for urban older adults, those who were aged 65–74 years (OR: 1.246, CI: 1.051–1.552) and having

TABLE 2 Descriptive statistics of independent variables.

Variable	Before matching *N* (%)		*p*-Value	After matching *N* (%)		*p*-Value
	Rural	Urban		Rural	Urban	
Demographic and sociological characteristics						
Chronic disease condition						
No+	4,222 (53.30)	1,223 (47.70)	<0.001	2,174 (53.44)	906 (48.74)	<0.001
Yes	3,699 (46.70)	1,341 (52.30)		1,894 (46.56)	953 (51.26)	
Gender						
Female+	4,022 (50.78)	1,335 (52.07)	0.256	2,225 (54.70)	961 (51.69)	0.053
Male	3,899 (49.22)	1,229 (47.93)		1,843 (45.30)	898 (48.31)	
Age						
60–64+	2,490 (31.44)	828 (32.29)	0.266	1,336 (32.84)	599 (32.22)	0.302
65–74	3,737 (47.18)	1,163 (45.36)		2,108 (51.82)	915 (49.22)	
≥75	1,694 (21.38)	573 (22.35)		624 (15.34)	345 (18.56)	
Education level						
Elementary school and below+	4,937 (62.33)	749 (29.21)	<0.001	2,440 (59.98)	548 (29.48)	<0.05
Junior school	1,675 (21.15)	558 (21.76)		898 (22.07)	406 (21.84)	
High School and above	1,309 (16.52)	1,257 (49.03)		730 (17.94)	905 (48.68)	
Marital status						
Married with spouses living together+	5,879 (74.22)	1,942 (75.74)	<0.001	3,435 (84.44)	1,541 (82.89)	0.101
Married with spouses but not living together	278 (3.51)	82 (3.20)		28 (0.69)	23 (1.24)	
Divorced	75 (0.95)	51 (1.99)		2 (0.05)	2 (0.11)	
Widowed	1,625 (20.52)	481 (18.77)		603 (14.82)	293 (15.76)	
Unmarried	64 (0.80)	8 (0.30)		–	–	
Minorities						
Han+	7,362 (92.94)	2,385 (93.02)	0.896	4,004 (98.43)	1,817 (97.74)	0.064
Non-Han	559 (7.06)	179 (6.98)		64 (1.57)	42 (2.26)	
Religiosities						
No+	7,051 (89.02)	2,300 (89.70)	0.330	3,907 (96.04)	1,756 (94.46)	0.420
Yes	870 (10.98)	264 (10.30)		161 (3.96)	103 (5.54)	
Life-style and health behavior						
Duration of sleep						
≤4 h+	1,863 (23.53)	416 (16.23)	<0.001	728 (17.90)	264 (14.20)	0.085
4–8 h	5,040 (63.66)	1,990 (77.64)		3,221 (79.18)	1,528 (82.20)	
>8 h	1,014 (12.81)	157 (6.13)		119 (2.92)	67 (3.60)	
Smoking						
No+	4,342 (54.84)	1,502 (58.63)	<0.01	2,414 (59.34)	1,086 (58.42)	0.503
Yes	3,575 (45.16)	1,060 (41.37)		1,654 (40.66)	773 (41.58)	
Drinking alcohol						
No+	5,538 (69.95)	1,708 (66.67)	<0.01	3,001 (73.77)	1,270 (68.32)	0.079
Yes	2,379 (30.05)	854 (33.33)		1,067 (26.23)	589 (31.68)	
Social activity						
No+	4,516 (57.04)	1,017 (39.68)	<0.001	2,209 (54.30)	748 (40.24)	0.101
Yes	3,401 (42.96)	1,546 (60.32)		1,859 (45.70)	1,111 (59.76)	

(Continued)

TABLE 2 (Continued)

Variable	Before matching *N* (%)		*p*-Value	After matching *N* (%)		*p*-Value
	Rural	Urban		Rural	Urban	
Physical activity						
No+	4,610 (58.23)	1,414 (55.17)	<0.01	2,307 (56.71)	1,008 (54.22)	0.073
Yes	3,307 (42.77)	1,149 (44.83)		1,761 (43.29)	851 (45.78)	
Social system and economic status						
Insurance						
No+	273 (3.48)	39 (1.54)	<0.001	111 (2.75)	27 (1.47)	0.095
Resident medical insurance	7,173 (91.43)	1,154 (45.61)		3,694 (91.39)	852 (46.38)	
Urban employee medical insurance	328 (4.18)	433 (48.74)		199 (4.92)	883 (48.07)	
Government medical insurance	71 (0.91)	104 (4.11)		38 (0.94)	75 (4.08)	
Region						
East+	2,714 (34.59)	675 (27.51)	<0.001	1,376 (33.94)	536 (29.04)	0.062
Middle	2,619 (33.38)	1,056 (43.03)		1,524 (37.59)	802 (43.45)	
West	2,513 (32.03)	723 (29.46)		1,154 (28.47)	508 (27.52)	
Socioeconomic status						
Lowest+	2,103 (26.59)	372 (14.54)	<0.001	974 (23.94)	276 (14.85)	0.058
Less affluent	2,086 (26.37)	351 (13.72)		882 (21.68)	259 (13.93)	
Average	1,567 (19.81)	470 (18.37)		859 (21.12)	359 (19.31)	
More affluent	1,359 (17.18)	553 (21.61)		840 (20.65)	423 (22.75)	
Most affluent	795 (10.05)	813 (31.76)		513 (12.61)	542 (29.16)	

+ Reference levels in the regressions; virtual variables for Chi-square test; N (%) were reported.

government medical insurance (OR: 2.362, CI: 1.203–5.912) had higher odds of suffering from chronic diseases.

3.4 Decomposition analysis

This study aimed to explore the differences in suffering from chronic diseases between rural and urban older adults. The health differences between the two groups are shown in Table 5. Moreover, 23.57% of the differences in chronic disease conditions were influenced by considered factors, while 76.43% could be attributed to urban and rural areas. This study showed that duration of sleep (−6.60%), drinking alcohol (−10.80%), social activity (14.77%), and region (6.95%) significantly influenced chronic disease conditions.

4 Discussion

4.1 Summary of the main findings

This study conducted a comparative analysis in China examining the differences in suffering from chronic diseases between rural and urban older adults (aged 60 years and above) and the nation with the largest older adult population. This study provided empirical data evaluating health differences among rural and urban older adults.

This study indicated that 48.03% of older adults were grappling with chronic diseases, with a notably increased proportion in urban areas (51.26%) compared to rural areas (46.56%). The finding was similar to *An Analysis Report of the Sixth National Health Services Survey in China* (46), which reported that 59.10% of older adults were suffering from chronic diseases, and the proportion of urban older adults (60.60%) suffering from chronic diseases was higher than that of rural older adults (57.50%), which might be because the urban older adults had a high level of education, a strong awareness of prevention and healthcare, and go to hospitals with a high level of medical care after being ill. On the contrary, the rural older adults had a weak awareness of self-care due to factors such as economic status and medical conditions, and some older adults had not had a physical examination for several years or even decades and had never gone to a doctor without serious clinical symptoms, which led to a high prevalence of older adults suffering from chronic diseases and a low rate of them seeing a doctor in rural areas (47). In 2017, the Chinese government launched the *China medium and long-term plan for the prevention and treatment of chronic diseases (2017–2025)*, which called for targeted prevention and control measures based on the epidemic characteristics of chronic diseases in different areas and different population groups (48).

TABLE 3 Comparative analysis of variable distribution in chronic disease condition.

Variable	Suffering from chronic diseases			Not suffering from chronic diseases		
	Rural	Urban	*p*-Value	Rural	Urban	*p*-Value
Demographic and sociological characteristics						
Gender						
Female+	1,008 (57.02)	500 (52.47)	<0.05	1,145 (52.67)	461 (50.88)	0.366
Male	814 (42.98)	453 (47.53)		1,029 (47.33)	445 (49.12)	
Age						
60–64+	572 (30.20)	393 (29.31)	0.301	764 (35.14)	318 (35.10)	<0.05
65–74	1,014 (53.54)	632 (47.13)		1,094 (50.32)	420 (46.36)	
≥75	308 (16.26)	316 (23.56)		316 (14.54)	168 (18.54)	
Education level						
Elementary school and below+	1,180 (62.30)	297 (31.16)	<0.001	1,260 (57.96)	251 (27.70)	<0.001
Junior school	407 (21.49)	208 (21.83)		491 (22.59)	198 (21.85)	
High School and above	307 (16.21)	448 (47.01)		423 (19.46)	457 (50.44)	
Marital status						
Married with spouses living together+	1,559 (82.31)	788 (82.69)	0.465	1,876 (86.29)	753 (83.11)	<0.05
Married with spouses but not living together	12 (0.63)	8 (0.84)		16 (0.74)	15 (1.66)	
Divorced	–	1 (0.10)		2 (0.09)	1 (0.11)	
Widowed	323 (17.05)	156 (16.37)		280 (12.88)	137 (15.12)	
Minorities						
Han+	1,869 (98.68)	927 (97.27)	<0.01	2,135 (98.21)	890 (98.23)	0.957
Non-Han	25 (1.32)	26 (2.73)		39 (1.79)	16 (1.77)	
Religiosities						
No+	1,815 (95.83)	891 (93.49)	<0.01	2,092 (96.23)	865 (95.47)	0.330
Yes	79 (4.17)	62 (6.51)		82 (3.77)	41 (4.53)	
Life-style and health behavior						
Duration of sleep						
≤4 h+	394 (20.80)	151 (15.84)	<0.01	334 (15.36)	113 (12.47)	0.079
4–8 h	1,449 (76.50)	770 (80.80)		1,772 (81.51)	758 (83.66)	
>8 h	51 (2.69)	32 (3.36)		68 (3.13)	35 (3.86)	
Smoking						
No+	1,165 (61.51)	570 (59.81)	0.381	1,249 (57.45)	516 (56.95)	0.799
Yes	729 (38.49)	383 (40.19)		925 (42.55)	390 (43.05)	
Drinking alcohol						
No+	1,470 (77.61)	665 (69.78)	<0.001	1,531 (70.42)	605 (66.78)	<0.05
Yes	424 (22.39)	288 (30.22)		643 (29.58)	301 (33.22)	
Social activity						
No+	1,003 (52.96)	382 (40.08)	<0.001	1,206 (55.47)	366 (40.40)	<0.001
Yes	891 (47.04)	571 (59.92)		968 (44.53)	540 (59.60)	
Physical activity						
No+	1,086 (57.34)	526 (55.19)	0.276	1,221 (56.16)	482 (53.20)	0.132
Yes	808 (42.66)	427 (44.81)		953 (43.84)	424 (46.80)	

(Continued)

TABLE 3 (Continued)

Variable	Suffering from chronic diseases			Not suffering from chronic diseases		
	Rural	Urban	*p*-Value	Rural	Urban	*p*-Value
Social system and economic status						
Insurance						
No+	48 (2.55)	12 (1.28)	<0.001	63 (2.929)	15 (1.67)	<0.001
Resident medical insurance	1,717 (91.14)	430 (45.74)		1,977 (91.61)	422 (47.05)	
Urban employee medical insurance	95 (5.04)	452 (48.09)		104 (4.82)	431 (48.05)	
Government medical insurance	24 (1.27)	46 (4.89)		14 (0.65)	29 (3.23)	
Region						
East+	584 (30.97)	275 (29.16)	0.485	792 (36.53)	261 (28.90)	<0.001
Middle	756 (40.08)	377 (39.98)		768 (35.42)	425 (47.07)	
West	546 (28.95)	291 (30.86)		608 (28.04)	217 (24.03)	
Socioeconomic status						
Lowest+	478 (25.24)	151 (15.84)	<0.001	496 (22.82)	125 (13.80)	<0.001
Less affluent	434 (22.91)	140 (14.69)		448 (20.61)	119 (13.13)	
Average	392 (20.70)	178 (18.68)		467 (21.48)	181 (19.98)	
More affluent	377 (19.90)	219 (22.98)		463 (21.30)	204 (22.52)	
Most affluent	213 (11.25)	265 (27.81)		300 (13.80)	277 (30.57)	

+ Reference levels in the regressions; virtual variables for Chi-square test; N (%) were reported.

Therefore, the construction of rural healthcare should strengthen the prevention and treatment of older adults suffering from chronic diseases.

Many studies have shown that chronic disease prevalence increased significantly with age (23, 25), and the logistic regression results showed that participants aged 65–74 years in urban areas projected a heightened prevalence of chronic diseases. This was largely attributed to the escalating risk of hypertension, diabetes, coronary heart disease, and other chronic diseases with age (25). For example, studies by Brustio et al. (49) and Béghin et al. (50) indicated that the physical function of older adults would decline with age. Therefore, age is an important consideration in the prevention and treatment of chronic diseases. Compared to the education level of elementary school and below, the rural older adults with an education level of high school and above had a lower prevalence of chronic diseases, which might be because older adults with a higher education level would have a better chance of learning about health and possessing better health literacy. Furthermore, relevant studies showed that chronic patients with higher education had better self-efficacy (51). This study showed a higher prevalence of chronic diseases among widowed rural older adults. The reason might be that the physical health of older adults in rural areas deteriorates when they are helpless because of a lack of companionship and care of their spouses. This finding was similar to the finding in England by Nartey et al. (52), which showed that chronic diseases were more prevalent among widowed or divorced individuals. This study showed that older adults who drink alcohol had a higher prevalence of chronic diseases in rural areas, which was similar to some studies that indicated that drinking alcohol could lead to a variety of diseases. A number of studies have shown that drinking alcohol is associated with many chronic diseases (53, 54). For example, drinking alcohol can cause damage to the heart and heart muscle cells, which can lead to heart failure. Even worse, long-term drinking of alcohol can cause osteoporosis, bone pain, and fracture. The harm of drinking alcohol to the human body is various (55). Acetaldehyde, a non-oxidative metabolite of alcohol, has been identified as a kind of carcinogen by the cancer research organization of the World Health Organization, including oral cancer, laryngeal cancer, esophageal cancer, liver cancer, colorectal cancer, and so on (56). In a word, drinking alcohol can increase the risk of suffering from chronic diseases among older adults as their physical functions deteriorate. This study showed a lower prevalence of chronic diseases among rural older adults who participated in social activities. The reason might be that participating in social activities could bring emotional value and promote health. This finding was similar to the study by Jeon and Park (57), which reported participating in social activities could improve the health of older adults in Korea. This study showed that older adults with government medical insurance had a higher prevalence of chronic diseases both in rural and urban areas. The result was similar to the study by Zhou et al. (58), which reported that the prevalence of chronic diseases was higher among older adults with government medical insurance and was obviously higher than the older adults with urban employee medical insurance and resident medical insurance. In addition, older adults with urban employee medical insurance had a higher prevalence of chronic diseases in urban areas, which was mainly due to the difference in the guaranteed ability of different health insurance. In China, the security ability of government medical insurance, urban employee medical insurance, resident medical

TABLE 4 Matched logistic results of rural and urban older adults suffering from chronic diseases.

Variable	Rural			Urban		
	OR	95% CI		OR	95% CI	
Demographic and sociological characteristics						
Gender	1.141	1.144	1.816	1.212	0.872	1.685
Age						
65–74 years	1.107	0.954	1.284	1.246*	1.051	1.552
≥75 years	1.051	0.855	1.292	1.028	0.756	1.397
Education level						
Junior school	0.904	0.765	1.068	0.897	0.682	1.179
High School and above	0.802*	0.664	0.968	0.846	0.654	1.094
Marital status						
Married, not cohabiting	0.889	0.487	1.624	0.517	0.204	1.313
Divorced	–	–	–	0.997	0.061	16.42
Widowed	1.267*	1.047	1.533	0.990	0.745	1.314
Minorities	0.608	0.387	0.955	1.358	0.708	2.606
Religiosities	1.067	0.807	1.412	1.466	0.960	2.237
Lifestyle and health behavior						
Duration of sleep						
4–8	0.745**	0.619	0.896	0.788	0.598	1.039
>8	0.649*	0.446	0.943	0.700	0.402	1.217
Smoking	1.200	0.973	1.481	1.145	0.839	1.564
Drinking alcohol	1.421***	1.210	1.668	1.119	0.884	1.416
Social activity	0.778***	1.122	1.473	0.902	0.893	1.344
Physical activity	1.011	0.887	1.153	0.928	0.763	1.128
Social system and economic status						
Insurance						
Resident medical insurance	1.318	0.873	1.989	1.268	0.576	2.793
Urban employee medical insurance	1.914	1.187	3.085	1.426	0.643	3.162
Government medical insurance	4.869***	2.407	9.851	2.352*	1.203	5.912
Region						
Central	1.062	0.910	1.239	0.835	0.665	1.049
West	1.031	0.866	1.227	1.266	0.978	1.639
Socioeconomic status						
Less affluent	0.989	0.782	1.251	1.013	0.713	1.440
Average	0.888	0.712	1.107	0.918	0.661	1.274
More affluent	0.872	0.703	1.080	0.969	0.703	1.336
Most affluent	0.778*	0.627	0.964	0.880	0.638	1.215
Constant	0.437**	0.254	0.752	0.748	0.283	1.982
Prob > chi^2	<0.001			<0.01		
Number of observation	4,026			1,824		

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.
All predictors entered the logistic regression simultaneously.

TABLE 5 Fairlie's decomposition of differences in suffering from chronic diseases between rural and urban older adults.

Decomposition terms	Chronic disease condition		
Difference	−0.0441		
Explained (%)	−0.0104 (23.57%)		
Explained			
Contribution to difference	**Contribution (%)**	**95% CIs**	
Gender	2.83%	−0.0036	0.0011
Age	−0.16%	−0.0015	0.0016
Education level	−27.17%	−0.0024	0.0264
Marital status	0.96%	−0.0015	0.0007
Minorities	−0.91%	−0.0003	0.0011
Religiosities	−0.19%	−0.0012	0.0013
Duration of sleep	−6.60%**	0.0013	0.0046
Smoking	−0.41%	−0.0009	0.0013
Drinking alcohol	−10.80%**	0.0023	0.0072
Social activity	14.77%**	−0.0109	−0.0022
Physical activity	−0.09%	−0.0008	0.0009
Insurance	57.95%	−0.0582	0.0070
Region	6.95%**	−0.0052	−0.0010
Socioeconomic status	−13.77%	−0.0031	0.0152

*$p < 0.05$.
*$p < 0.01$.
***$p < 0.001$.
95% CI, 95% coefficient interval.

insurance, and no insurance ranked from high to low (59). Kaliski (60) discovered that health insurance could increase the consumption of healthcare resources. For example, Niu et al. (54) found that the out-patient and in-patient services of the residents with urban employee medical insurance were 2.7 times and 1.80 times of the residents with resident medical insurance, respectively. Therefore, in the process of exploring the integration of urban and rural residents' health insurance, the government should pay attention to reducing the difference in medical service utilization among different health insurance (61). This study showed that rural older adults with a duration of sleep of 4–8 h and above had a lower prevalence of chronic diseases in rural and urban areas. The reason might be the crucial role of appropriate rest in optimizing bodily functions and fostering physiological wellbeing among older adults, typically frailer than before (38). A study by Laposky et al. (62) revealed diminished sleep health conditions, encompassing inadequate sleep duration, diverse sleep timings, low sleep quality, and sleep circadian disruptions, which were prevalent in contemporary societies and linked with multiple disease risks and consequences, including those related to health disparities (e.g., cardiovascular disease, obesity and diabetes, mental disorders, and cancer). Therefore, keeping adequate sleep time is very important for the health of older adults. This study showed that the rural older adults with the most affluent socioeconomic status had a lower prevalence of chronic diseases. The explanation might be that wealthy older adults had better nutrition and access to health services. This finding was similar to the study in Canada by Shah (63), which showed that chronic diseases were more prevalent among individuals from lower socioeconomic status backgrounds.

In addition, Fairlie's decomposition results showed that duration of sleep, drinking alcohol, social activity, and region were the factors of urban–rural differences in chronic disease conditions among older adults in China. The reason might be that there was a dualistic urban–rural structure. In other words, the level of urban and rural economic development, living environment, and medical services are not balanced in China (64). Therefore, this study indicated compellingly that the government should pursue strategies to narrow the urban–rural gap.

4.2 Implications

Based on the urban–rural differences in chronic disease conditions, this study has some implications. First, as for duration of sleep, older adults should pay attention to the quality of sleep, and sleep disorders should be treated in time (65). Second, as for drinking alcohol, the government should strengthen the promotion of health literacy among older adults, especially to reduce alcohol consumption. Third, this study showed that social activity had a positive effect on the health of older adults. At present, community home-based older adult care is the most dominant model in China (66). Therefore, the role of social activity in home-based older adult care should

be paid attention to. Fourth, as for region, the government should further strengthen health support, such as free medical check-ups and free vaccinations for older adults, to reduce the health differences among older adults in different areas in China.

4.3 Limitations

Notably, there are several limitations in this research. First, given the cross-sectional nature of CHARLS (wave 4), tracking shifts at distinct intervals might pose challenges. Second, chronic diseases were classified as suffering from chronic diseases and not suffering from chronic diseases, overlooking the intensity of suffering from chronic diseases. Third, despite numerous factors linked to chronic diseases of older adults, further analysis was restricted. Despite these constraints, this study might illuminate the differences in chronic disease conditions between rural and urban older adults in China. In future research, more complete data and other influencing factors will be considered to validate the findings of this study.

5 Conclusion

This study focused on the differences in chronic disease conditions between rural and urban older adults in China. The proportion of urban older adults was higher than that of rural older adults suffering from chronic diseases. Factors including drinking alcohol, social activity, and assets should be addressed to reduce the urban–rural older adults differences in chronic disease conditions in China. This study may help provide evidence for health policies in reducing urban–rural older adults' differences and breaking down the dual barriers in urban and rural areas in an aging society in China. At the same time, this study provided evidence for future research on the health of older adults.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: http://charls.pku.edu.cn/en.

Author contributions

JZ: Conceptualization, Data curation, Formal analysis, Funding acquisition, Writing – original draft. YZ: Funding acquisition, Project administration, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was funded by the Research Project of Major Theoretical and Practical Issues of Shaanxi Province (grant number: 2023ZD1082) and the National Natural Science Foundation of China (grant number: 72374125).

Acknowledgments

The authors acknowledge the China Health and Retirement Longitudinal Study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1298657/full#supplementary-material

References

1. World Health Organization. *Aging and Health*. Available online at: https://www.who.int/zh/news-room/fact-sheets/detail/ageing-and-health (accessed August 1, 2023).

2. The National Bureau of Statistics. *Interpretation of the Communique of the Seventh National Census*. Available online at: https://www.stats.gov.cn/sj/sjjd/202302/t20230202_1896484.html (accessed August 2, 2023).

3. Chen YM, Liu ZF, Li XD, Huang YX. The aging trend of Chinese population and the prediction of aging population in 2015–2050. *Chin J Soc Med.* (2018) 35:480–3.

4. Yeni K. Anticipated stigma and related factors in patients with chronic diseases. *Arch Health Sci Res*. (2023) 10:71–6. doi: 10.5152/ArcHealthSciRes.2023.22132

5. The CPC Central Committee and the State Council. *Outline of Health China 2030 Plan*. Available online at: https://www.gov.cn/ (accessed August 20, 2023).

6. Shi MF, Li YH, Liu YY, Li L, Nie XQ, Zhang G, et al. The correlation analysis between the level of chronic disease prevention and treatment literacy of the elderly in our country and the prevalence of chronic diseases. *Chin Health Educ.* (2020) 36:387–417.

7. World Health Organization. *Preventing Chronic Diseases: A Vital Investment*, Vol. 126. Geneva: WHO (2008), p. 95.

8. Zhan XY. *Epidemiology*, 8th ed. Beijing: People's Medical Publishing House (2023), p. 154–6.

9. World Health Organization. *2023 Call for Innovative Health Technologies for Low-Resource Settings. Focusing on Non-Communicable Diseases*. Available online at: https://www.who.int/news-room/articles (accessed November 24, 2023).

10. General Office of the State Council. *A Press Conference was Held on the Situation of Nutrition and Chronic Diseases in Chinese Residents*. (2020). Available online at: http://www.gov.cn/ (accessed November 13, 2023).

11. Jia WP. The new trend for prevention and management of chronic diseases. *Chin J Intern Med*. (2021) 60:1–4. doi: 10.3760/cma.j.cn112138-20201105-00921

12. Saha A, Rahaman M, Mandal B, Sourav B, Dipti G. Rural urban differences in self-rated health among older adults: examining the role of marital status and living arrangements. *BMC Public Health*. (2022) 22:2175. doi: 10.1186/s12889-022-14569-9

13. Moss JL, Hearn M, Cuffee YL, Wardecker BM, Kitt-Lewis E, Pinto CN. The role of social cohesion in explaining rural/urban differences in healthcare access and health status among older adults in the mid-Atlantic United States. *Prev Med*. (2023) 173:107588. doi: 10.1016/j.ypmed.2023.107588

14. Peltzer K, Phaswana-Mafuya N, Pengpid S. Rural-urban health disparities among older adults in South Africa. *Afr J Prim Health Care Fam Med*. (2019) 11:e1–6. doi: 10.4102/phcfm.v11i1.1890

15. Norris M, Klabbers G, Pembe AB, Hanson C, Baker U, Aung K, et al. A growing disadvantage of being born in an urban area? Analysing urban-rural disparities in neonatal mortality in 21 African countries with a focus on Tanzania. *BMJ Glob Health*. (2022) 7:e007544. doi: 10.1136/bmjgh-2021-007544

16. Qi YT, Liu Y, Du J, Liu YW, Ma GF. Study on the influencing factors of chronic disease comorbidity of the elderly in our country based on Health Ecology Model. *Chin Gen Pract*. (2023) 26:8. doi: 10.12114/J.ISSN.1007-9572.2022.0458

17. Mao Y, Zhu B, Liu JL, Wang X. Research on the risk factors of chronic diseases in the elderly under the perspective of health ecology. *J Xi'an Jiaotong Univ Soc Sci*. (2015) 35:15–24. doi: 10.15896/j.xjtuskxb.201505003

18. Brown SL, Manning WD, Wu H. Relationship quality in midlife: a comparison of dating, living apart together, cohabitation, and marriage. *J Marriage Fam*. (2022) 84:860–78. doi: 10.1111/jomf.12813

19. Grossman M. The demand for health, 30 years later: a very personal retrospective and prospective reflection. *J Health Econ*. (2004) 23:629–36. doi: 10.1016/j.jhealeco.2004.04.001

20. Wilkinson RG, Pickett KE. Income inequality and population health: a review and explanation of the evidence. *Soc Sci Med*. (2006) 62:1768–84. doi: 10.1016/j.socscimed.2005.08.036

21. Bassuk SS, Berkman LF, Amick BC. Socioeconomic status and mortality among the elderly: findings from four US communities. *Am J Epidemiol*. (2002) 155:520–33. doi: 10.1093/aje/155.6.520

22. Varela LM. Dietary influence on nutritional epidemiology, public health and our lifestyle. *Nutrients*. (2023) 15:174. doi: 10.3390/books978-3-0365-7713-5

23. Fenga C. Gut microbiota modulation: a tailored approach for the prevention of chronic diseases. *Biomed Rep*. (2022) 16:23. doi: 10.3892/br.2022.1506

24. Furnham A, Cheng H. The Big-Five personality factors, cognitive ability, health, and social-demographic indicators as independent predictors of self-efficacy: a longitudinal study. *Scand J Psychol*. (2023) 6:520–33. doi: 10.1111/sjop.12953

25. Gaballa A, Hajj AA, El DJ, Popovic Z, Wang TKM, Reed GW, et al. Predictors of long-term outcomes of patients with concomitant moderate aortic and mitral valves diseases: a single tertiary care center experience 2010-2018. *Eur Heart J*. (2023) 44:(Supplement_2). doi: 10.1093/eurheartj/ehad655.1635

26. Ahmed F, Waslien C, Al-Sumaie M, Prakash P. Trends and risk factors of hypercholesterolemia among Kuwaiti adults: National Nutrition Surveillance Data from 1998 to 2009. *Nutrition*. (2012) 28:917–23. doi: 10.1016/j.nut.2011.12.012

27. Irigaray P, Newby JA, Clapp R, Hardell L, Howard V, Montagnier L, et al. Lifestyle-related factors and environmental agents causing cancer: an overview. *Biomed Pharmacother*. (2007) 61:640–58. doi: 10.1016/j.biopha.2007.10.006

28. Kajale NA, Khadilkar AV, Chiplonkar SA, Khadilkar VV. Prevalence of obesity and overweight among school children of Pune city, Maharashtra, India: a cross sectional study. *Int J Res Med Sci*. (2015) 3:3599–603. doi: 10.18203/2320-6012.ijrms20151406

29. Makimoto K, Higuchi S. Alcohol consumption as a major risk factor for the rise in liver cancer mortality rates in Japanese men. *Int J Epidemiol*. (1999) 28:30–4. doi: 10.1093/ije/28.1.30

30. Tukuitonga C, Keller I. Implementing the World Health Organization Global Strategy on Diet, Physical Activity and Health. *Nutrition Newsletter*. (2005) 49:122–6. doi: 10.1080/11026480500277026

31. Leng Y, Luo D, Liu L, Ma YJ, Deng J. Research on the economic risk of diseases in middle-aged and elderly patients with diabetes-evidence from China. *J Public Health*. (2020) 29:1001–11. doi: 10.1007/s10389-020-01208-z

32. Nagib SN, Abdelwahab S, Amin GEE-D, Allam MF. What is the prevalence of chronic kidney disease among hypertensive non-diabetic Egyptian patients attending primary healthcare? *Clin Exp Hypertens*. (2023) 45:2203411. doi: 10.1080/10641963.2023.2203411

33. Zhao YH, Strauss J, Chen X, Wang Y, Gong J, Meng Q, et al. (2020). *China Health and Retirement Longitudinal Study Wave 4 User's Guide*. Beijing: National School of Development, Peking University.

34. Allegrante JP, Wells MT, Peterson JC. Interventions to support behavioral self-management of chronic diseases. *Annu Rev Public Health*. (2019) 40:127–46. doi: 10.1146/annurev-publhealth-040218-044008

35. Choi B, Susanna J, Changmin L, Chang OK, Yun ML, Hey JJ. Factors affecting the intention to use exoskeleton for exercise and the moderating effect of frailty. *Innov Aging*. (2021) 5:656–7. doi: 10.1093/geroni/igab046.2482

36. Achoki T, Sartorius B, Watkins D, Glenn SD, Kengne AP, Oni T, et al. Health trends, inequalities and opportunities in South Africa's provinces, 1990-2019: findings from the Global Burden of Diseases 2019 Study. *J Epidemiol Community Health*. (2022) 76:471–81. doi: 10.1136/jech-2021-217480

37. Amos A, Khiatah B. Mechanisms of action of nutritionally rich *Hibiscus sabdariffa*'s therapeutic uses in major common chronic diseases: a literature review. *J Am Coll Nutr*. (2021) 41:116–24. doi: 10.1080/07315724.2020.1848662

38. Ciolac E. Aquatic exercise in adults with chronic diseases: evidence of benefit for individuals with hypertension. *Scand J Med Sci Sports*. (2023) 33:1576–8. doi: 10.1111/sms.14422

39. Jun M. *Population ageing and Policy Responses in China*. Nanjing: Nanjing University Press (2023).

40. Li D, Zhou Z, Shen C, Zhang J, Yang W, Nawaz R. Health disparity between the older rural-to-urban migrant workers and their rural counterparts in China. *Int J Environ Res Public Health*. (2020) 17:955. doi: 10.3390/ijerph17030955

41. Mehta HB, Rajan SS, Aparasu RR, Johnson ML. Application of the nonlinear Blinder-Oaxaca decomposition to study racial/ethnic disparities in antiobesity medication use in the United States. *Res Soci Adm Pharm*. (2013) 9:13–26. doi: 10.1016/j.sapharm.2012.02.006

42. Bustamante AV, Fang H, Garza J, Carter-Pokras O, Wallace SP, Rizzo JA, et al. Variations in healthcare access and utilization among Mexican immigrants: the role of documentation status. *J Immigr Minor Health*. (2010) 14:146–55. doi: 10.1007/s10903-010-9406-9

43. Fairlie RW. The absence of the African-American owned business: an analysis of the dynamics of self-employment. *J Lab. Eco*. (1999) 17:80–108. doi: 10.1086/209914

44. Fairlie WD, Moore AG, Bauskin AR, Russell PK, Zhang HP, Breit SN. MIC-1 is a novel TGF-βsuperfamily cytokine associated with macrophage activation. *J Leukoc Biol*. (1999) 65:2–5. doi: 10.1002/jlb.65.1.2

45. Yang W, Li D, Gao J, Zhou X, Li F. Decomposing differences in depressive symptoms between older rural-to-urban migrant workers and their counterparts in mainland China. *BMC Public Health*. (2020) 20:1442. doi: 10.1186/s12889-020-09374-1

46. Center for Statistics and Information, NHC. *An Analysis Report of National Health Service Survey in China, 2018*. Beijing: People's Medical Publishing House (2021), p. 3.

47. Liu SX, Li B, Liu Y, Shan ZJ, Zhang JY. Investigation and comparison of health conditions of old people in Changchun urban and rural community of Jilin Province. *J Jilin Univ*. (2012) 16:1718–21. doi: 10.13481/j.1671-587x.2012.04.004

48. General Office of the State Council. *Circular on Issuing China's Medium and Long-Term plan for the Prevention and Treatment of Chronic Diseases (2017-2025)*. Available online at: http://www.gov.cn/zhengce/content/.htm (accessed November 22, 2023).

49. Brustio PR, Rainoldi A, Petrigna L, Rabaglietti E, Pizzigalli L. Postural stability during dual- and triple-task conditions: the effect of different levels of physical fitness in older adults. *Sci Sports*. (2021) 36:143–51. doi: 10.1016/j.scispo.2020.02.012

50. Béghin L, Ternynck C, Labreuche J, Ovigneur H, Deschamps T, Vanhelst J. Differential decline of physical fitness with age according to Body Mass Index levels. *J Sports Med Phys Fitness*. (2023) 63:697–706. doi: 10.23736/S0022-4707.23.14441-0

51. Shakya D. Self-efficacy among patients with chronic diseases and its associated factors. *J Kathmandu Med Coll*. (2018) 7:82–8. doi: 10.3126/jkmc.v7i3.22675

52. Nartey Y, Chalitsios CV, Khan N, Simpson G, Dambha-Miller H, Farmer A. Factors associated with multimorbidity in England: an analysis of the English Longitudinal Study of Ageing. *Lancet*. (2023) 402(Suppl 1):S73. doi: 10.1016/S0140-6736(23)02126-8

53. Kelly S, Olanrewaju O, Cowan A, Brayne C, Lafortune L. Alcohol in older people: systematic reviews of interventions and context. *Lancet*. (2016) 388:S64. doi: 10.1016/S0140-6736(16)32300-5

54. Niu HY, Ni R, Wang Y, Zhou XC, Chen YT, Liu XG, et al. Prevalence and influencing factors of chronic diseases among the elderly in Zhejiang Province. *Chin Rural Health Serv Adm*. (2014) 4:377–81.

55. Zhang L, Cheng G, Song S, Yuan B, Zhu W, He L, et al. Primary health care in China: a decade of development after the 2009 health care reform. *Health Care Sci*. (2022) 1:146–59. doi: 10.1002/hcs2.14

56. GBD 2016 Alcohol Collaborators. Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* (2018) 392:1015–35. doi: 10.1016/S0140-6736(18)31310-2

57. Jeon BJ, Park KH. The impact of social network characteristics on health among community-dwelling older adults in Korea: application of social network analysis. *Int J Environ Res Public Health.* (2022) 19:4013. doi: 10.3390/ijerph19074013

58. Zhou Z, Zhao Y, Shen C, Lai S, Nawaz R, Gao J. Evaluating the effect of hierarchical medical system on health seeking behavior: a difference-in-differences analysis in China. *Soc Sci Med.* (2020) 268:113372. doi: 10.1016/j.socscimed.2020.113372

59. Qian J. Health reform in China: developments and future prospects. *Health Care Sci.* (2022) 1:166–72. doi: 10.1002/hcs2.19

60. Kaliski D. Identifying the impact of health insurance on subgroups with changing rates of diagnosis. *Health Econ.* (2023) 32:2098–112. doi: 10.1002/hec.4718

61. Zhou Z, Si Y, Zhou Z, Wang X. Who benefits the most from basic health insurances? Income-related equity analysis for patients with chronic diseases in China. *Lancet.* (2017) 390:S74. doi: 10.1016/S0140-6736(17)33212-9

62. Laposky AD, Cauter EV, Diez-Roux AV. Reducing health disparities: the role of sleep deficiency and sleep disorders. *Sleep Med.* (2016) 18:3–6. doi: 10.1016/j.sleep.2015.01.007

63. Shah NUH. *Do We Need a New Perspective on Chronic Diseases? The Combined Effects of Workplace Stress and Socioeconomic Status as Non-Traditional Disease Risk Factors in Canada*. UWSpace (2019). Available online at: http://hdl.handle.net/10012/15526 (accessed November 26, 2023).

64. Chen H, Liu Y, Zhu Z, Li Z. Does where you live matter to your health? Investigating factors that influence the self-rated health of urban and rural Chinese residents: evidence drawn from Chinese General Social Survey data. *Health Qual Life Outcomes.* (2017) 15:78. doi: 10.1186/s12955-017-0658-0

65. Calabrò RS. Sleep in disorders of consciousness: a brief overview on a still under investigated issue. *Brain Sci.* (2023) 13:275. doi: 10.3390/brainsci13020275

66. Wang YL, Duan Y, Zhang Y. A summary of researches on the quality of home-based care services in China. *Public Adm Res.* (2021) 10:41. doi: 10.5539/par.v10n1p41

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 08 January 2024
DOI 10.3389/fpubh.2023.1304982

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
José Eduardo Teixeira,
Polytechnic Institute of Bragança (IPB), Portugal
Wenchao Xu,
Huazhong University of Science and Technology, China
Dongdong Qin,
Yunnan University of Chinese Medicine, China

*CORRESPONDENCE
Rocío Llamas-Ramos
✉ rociollamas@usal.es

RECEIVED 30 September 2023
ACCEPTED 21 December 2023
PUBLISHED 08 January 2024

CITATION
Llamas-Ramos I, Llamas-Ramos R, Lugones-Sánchez C, González-García S, Tamayo-Morales O, Alvarado-Omenat JJ, Pablos-Hernández C, Gómez-Marcos MA, García-Ortiz L and Rodríguez-Sánchez E (2024) Effect of a lifestyle-integrated functional exercise (LiFE) group intervention (sLiFE) to falls prevention in non-institutionalized older adults. Protocol of a randomised clinical trial.
Front. Public Health 11:1304982.
doi: 10.3389/fpubh.2023.1304982

COPYRIGHT
© 2024 Llamas-Ramos, Llamas-Ramos, Lugones-Sánchez, González-García, Tamayo-Morales, Alvarado-Omenat, Pablos-Hernández, Gómez-Marcos, García-Ortiz and Rodríguez-Sánchez. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Effect of a lifestyle-integrated functional exercise (LiFE) group intervention (sLiFE) to falls prevention in non-institutionalized older adults. Protocol of a randomised clinical trial

Inés Llamas-Ramos[1,2,3,4], Rocío Llamas-Ramos[1,2]*, Cristina Lugones-Sánchez[1], Susana González-García[1], Olaya Tamayo-Morales[1], Jorge Juan Alvarado-Omenat[5], Carmen Pablos-Hernández[1,4], Manuel A. Gómez-Marcos[1,3,6], Luis García-Ortiz[1,3,7] and Emiliano Rodríguez-Sánchez[1,3,6]

[1]Institute of Biomedical Research of Salamanca (IBSAL), Primary Care Research Unit of Salamanca (APISAL), Salamanca, Spain, [2]Department of Nursing and Physiotherapy, Universidad de Salamanca, Salamanca, Spain, [3]Health Service of Castilla and Leon (SACyL), Salamanca, Spain, [4]University Hospital of Salamanca, Salamanca, Spain, [5]FisioSport Salamanca, Salamanca, Spain, [6]Department of Medicine, Universidad de Salamanca, Salamanca, Spain, [7]Department of Biomedical and Diagnostic Sciences, Universidad de Salamanca, Salamanca, Spain

Introduction: Personalized programs of integrated strength and balance activities have been shown their effectiveness in falls reduction in the older adults.

Objective: To measure whether a group intervention with the strength and balance principles of the sLiFE program is more effective than standard health advice in reducing the incidence of falls.

Methods: The study will comprise 650 participants with more than 65 years who live at home, observing established inclusion and exclusion criteria. Participants will be randomly assigned in two groups: group intervention ($n = 325$) and standard health advice ($n = 325$). The intervention group will follow the balance and strength activities described in the LiFE program manual. The group intervention will be carried out in groups of 12–14 and will consist of seven one-hour sessions over 12 weeks in health centres. Incidence of falls and quality of life will be assessed as primary outcome variables. Fear of falling and exercise adherence will be analysed as secondary outcome variables.

Discussion: Physical activity has been put forward as an effective treatment technique for these patients; however, long-term adherence to these programs remains a challenge. Group interventions could reduce dropout rates.

Conclusion: Falls represent a major health problem globally due to the disability they cause in older people. Prevention would help reduce not only their incidence but also the health costs derived from their treatment. Group intervention helps clinicians to save resources and time, being able to attend more people with the same quality of care.

Clinical trial registration: https://clinicaltrials.gov/study/NCT05912088?distance=50&term=NCT05912088&rank=1, identifier NCT05912088.

KEYWORDS

physical activity, prevention, falls, older adults, balance

1 Introduction

Practitioners and researchers are focused on ageing and frailty, as demonstrated by different initiatives (1, 2). It has been shown that in the population older than 70 years, frailty represent a 5.5 times higher adjusted risk of mortality, a 2.5 times higher risk of new disability, and a 2.7 times higher risk of loss of mobility (3). To reduce frailty, action must be taken on its main risk factor, sedentary lifestyle (4), and the prevention of falls is thus of particular importance; falls are among the five main health problems related with disability in people older than 60 years (5).

Approximately 30% of people aged over 65% and 50% of those over 80 who live in the community have one fall once a year as a minimum (3, 5, 6). Similarly, about 30% of those who fall suffer a new fall in the same year and 10% suffer several falls (7). Falling is, therefore, a risk factor for further falls. Furthermore, Noureldin et al. found that 15% of hospitalised older adults people had a fall within 30 days of discharge (8).

Falls represent a major cause of disability in older adults and over 50% present sequelae (5, 6); half of those suffering a fracture from a fall do not fully recover their previous functional level. Older adults are admitted to hospital for injuries related to falls more frequently and they also present discharges and consecutive readmissions over the following three years (8, 9). Besides, between 32% and 80% of patients who survive hospitalisation after a hip fracture are left with a permanent disability (10), being a 95% of hip fracture cases a result of falls (11). In this regard, it has been observed that physical exercise approaches can reverse the functional disability caused by hospitalisation in older patients (12).

Several studies have demonstrated improvements at cardiovascular and mental levels (dementia), and in psychological stress and quality of life (13, 14). Exercise programs, multifactorial strategies for fall prevention and home interventions diminish falls (6, 15). Other systematic reviews and meta-analyses which have found multifactorial interventions, including exercise, postulated as the most effective, with a single intervention with exercise also showing significant effects are in this line. The literature suggests that exercise is the best approach for preventing falls at this population, but this could be influence by the exercise component selected (16, 17). Other structured training programs aim to improve muscle strength and balance, for example, the Otago Exercise Program (18). Nevertheless, they often do not generate long-term change, participation and adherence (19, 20); however, physical activity has shown numerous benefits (21). A review concluded that multicomponent group exercise and exercise at home, as well as safety interventions at home, diminish the rate and the risk of falls (22).

The LiFE study (Lifestyle-integrated Functional Exercise) intervention stood out as achieving the best results in preventing falls with a reduction of 13% (23). It is a personalized program which has demonstrated its effectiveness improving balance, strength, and physical activity, while falls in older adults were reduced by incorporating exercise activities into their daily activities. This program shown a clinically significant reduction of 31% in fall rate in comparison to the control program. A 30% in falls reduction is like most interventions currently recommended for preventing falls in clinical guidelines. It has recently been suggested in a pilot study that LiFE could be effective administered in a group setting in comparison to an individual intervention (24).

This project aims to compare the standard health advice to the original LiFE program implemented in a group (sLiFE), with the aim of facilitating large-scale implementation with lower use of resources and verifying effectiveness in terms of fall rates, physical activity, and profitability.

The objectives will be to assess if a group intervention implementing the sLiFE program principles reduces fall rates compared to standard advice; to assess whether fall prevention is more efficient in the group intervention than standard individual recommendations; to measure the incidence rate of falls according to participants' level of physical activity; to assess medium- and long-term adherence to the exercise program and to find out the participants' fear of falling.

2 Hypothesis

The sLiFE group intervention is more effective than usual health advice for the prevention of falls in older adults people living at home.

3 Methods

3.1 Design

Multicentre randomised clinical trial with two parallel arms, designed according to the CONSORT statement. This protocol has followed the SPIRIT guidelines for randomised trials. It was registered with ClinicalTrial.gov in June 2023 under the identifier NCT05912088.

3.2 Sample/participants

The study population will comprise subjects aged over 65 years who be in agreement to take part in the study and are being treated in the primary care setting of the Health Area of "X." This study was reviewed and approved by the Salamanca Drug Research Ethics Committee in July 2022 under registration number PI 2022 071126. Before the study onset, all participants will be informed of the study objectives and will sign an informed consent form. Throughout the study the standards established in the Declaration of Helsinki will be followed. All those meeting the inclusion criteria in the health centres will be invited to participate.

3.2.1 Inclusion criteria

older adults older 65 years, living at home and speaking and reading Spanish.

3.2.2 Exclusion criteria

Heart failure (NYHA class III-IV); previous stroke (<6 months); Parkinson's disease diagnosis; in active cancer treatment (last 6 months); chronic obstructive pulmonary disease (GOLD class III-IV); lower extremity fragile fracture; lower extremity amputation, treatment for depression less than six months ago, resting systolic pressure blood pressure > 160 or diastolic pressure > 100 uncontrolled; unavailable for the intervention, having more than two months travel or transfers planned in the first six months of the study; cognitive impairment moderate–severe (Mini Mental Cognitive Assessment <23); simultaneously participation in another clinical intervention trial.

3.3 Sample size

The main variable of the study was used to estimate the sample size, the annual incidence rate of falls in this population. An alpha risk of 0.05 and a beta risk of 0.2 (Power for Chi square 80% and t-test 94%), effect size estimated 0.30 (Cohen D) and 0.01 (V de Cramer) in a two-sided contrast has been accepted, 325 participants in the intervention group and 325 in the control are needed to find differences of ten percentage points as statistically significant between the control group, expected to be 30% [the estimate of falls in people older than 65 years of age (3, 5, 6)] and the intervention group, expected to be 20%. A give up rate of 10% during follow-up has been estimated.

This data has been calculated following the formula for qualitative variables published by Argimon Pallàs et al. (25).

$$N=\frac{Za.\ddot{O}\,2.p.(1-p)+Z\dot{b}\ddot{O}\,p1.(1-p1)+p2.(1-p2)2}{(p1-p2)2}$$

3.4 Participant assessment

An external researcher will receive the participants and carry out the initial evaluation. The interview will be completed with information from the participants' primary care medical history and the records of the University Hospital of "X." The visit will take around 50–60 min and includes the collection of sociodemographic data, lifestyle, physical activity, cognitive status, adherence to exercise, quality of life and fear of falling. Participants will be fitted with a digital pedometer to record their physical activity for eight days. After the initial assessment, participants will be randomized to the intervention or control group.

3.5 Randomisation

Once the inclusion criteria have been assessed, participants will sign informed consent and will then be randomised into the intervention/control group (Figure 1). An independent investigator, blinded until groups have been assigned will be in charge of generate the allocation sequence generated in a 1:1 ratio using the Epidat 4.2 software package. Considering the nature of the study, participants cannot be blinded to the intervention.

3.6 Procedure for the sLiFE program intervention

The intervention will take place in four different stages.

3.6.1 Stage one

Physiotherapists (who led the sessions) will establish the guidelines to be followed and the intervention dynamics (sessions will be carried out in the same way and with the same contents in all health centres). The manuals for professionals, in Spanish, will be used to guarantee the reproducibility (26).

3.6.2 Stage two

The intervention group (12–14 participants) will be given a brief guide in Spanish from the participant's manual to advise them in carrying out the activities. The intervention group ($n = 325$) will do the balance activities (tandem stance, tandem walk, one-legged stand, leaning from side to side, leaning forward and backward, stepping over obstacles forwards and backwards, stepping over obstacles sideways) and strength activities (knee bends, sitting down and getting up from normal and low chairs, toe stand, toe walk, heel stand, heel walk, walking sideways, climbing stairs, and tightening muscles), the principles and implementation strategies (26). A total of five one-hour in-person sessions and two follow-up telephone sessions will be held.

3.6.3 Stage three

Implementation of the sLiFE program (26). The total intervention comprises twelve weeks according to the following schedule (Table 1).

3.6.4 Stage four

Follow-up evaluation at six months.

Spirit figure has been added as Supplementary material.

3.7 Variables

3.7.1 Sociodemographic variables

Participants' age, education level, marital status, and profession will be noted. The prescribed pharmacological treatment, lifestyle habits, smoking history and smoking pattern and alcohol consumption will be collected.

3.7.2 Anthropometric variables

Height will be measured with the portable Seca 222 system, with the subject standing. The average of two measurements, rounded to the nearest centimetre, will be recorded. Weight will be measured using a SOEHNLE 7830 digital column scale.

Waist and hip circumference will be measured twice, the recommendations of the Spanish Society for the Study of Obesity will be followed.

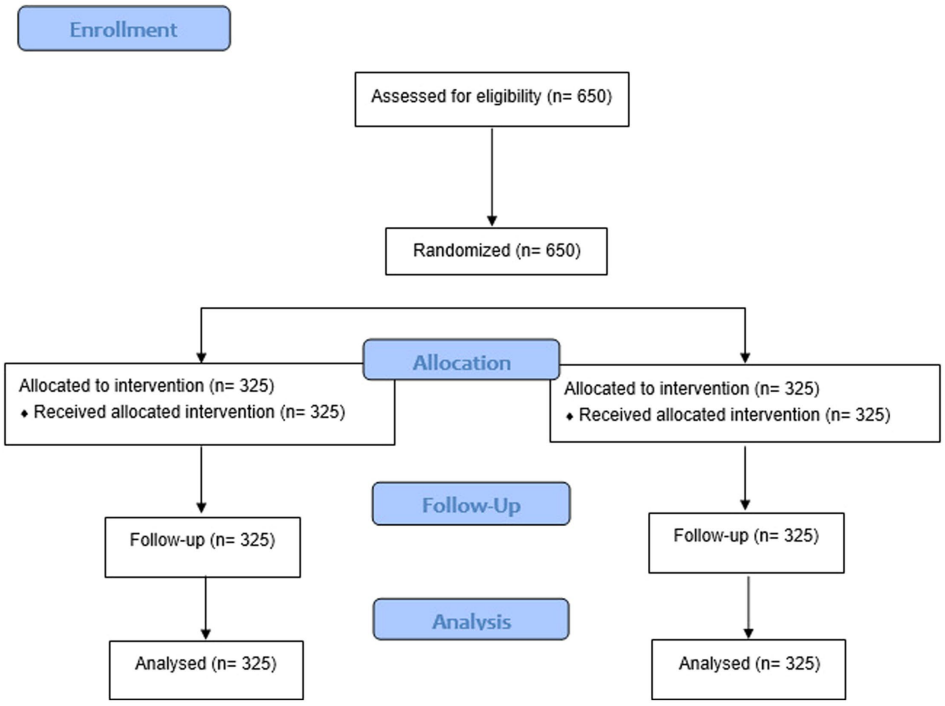


FIGURE 1
Sample size flow chart.

TABLE 1 Session schedule.

Session/week	Balance	Strength
1 (on-site)/Week 1	*Tandem stance *Tandem walk	*Knee bends *Sitting down and getting up (normal chair/low chair)
2 (on-site)/Week 2	*Standing on one leg	*Toe stand *Toe walk *Heel stand *Heel walk
3 (on-site)/Week 3	*Leaning side-to-side *Leaning forwards and backwards	*Walking sideways *Climbing stairs
4 (on-site)/Week 4	*Stepping over obstacles forwards and backwards *Stepping over obstacles sideways	*Flexing muscles
5 (on-site)/Week 6	Rest	Rest
6 (telephone)/Week 8	Follow-up	Follow-up
7 (telephone)/Week 12	Follow-up	Follow-up

Systolic and diastolic blood pressure will be measured with a validated OMRON M10-IT blood pressure monitor (Omron Health Care, Kyoto, Japan), the recommendations of the European Society of Hypertension will be followed.

3.7.3 Charlson Comorbidity Index

The Charlson Comorbidity Index (CCI) was developed in 1987 by Mary E. Charlson. It has been considered the gold-standard tool in clinical research as a prognostic index to predict mortality. This index is a standardized score calculated as a simple weighted sum of comorbidity item scores (27, 28). The original version of the CCI was composed on 19 items which correspond to different clinical comorbidities (27).

3.7.4 Frailty

Frailty will be measured following the five criteria of Fried's phenotype (29): (1) Low muscle strength; (2) Poor nutrition; (3) Poor endurance; (4) Slow walking; and (5) Low physical activity. Participants who meet these criteria will nevertheless be classified as active if they reported a high amount of daily usual physical activity (climbing stairs or lifting weights). The outcome will be meeting one frailty criterion at least.

3.7.5 Physical activity

Physical activity will be assessed with a digital pedometer (Omron HJ-321 Tri-Axial) (30), to be placed front and middle on one thigh for a period of 8 consecutive days (30). In addition, the Global Physical Activity Questionnaire (GPAQ) will be used (31). This questionnaire is made up of 16 questions about PA carried out in a typical week, differentiating between the different types of activity in work, travel and free time. Data is collected on intensity (low/moderate/high), frequency (days / usual week) and duration (hours–minutes/typical day) of physical activities carried out in three domains: (1) work (paid employment or unpaid, study, housework or job search), (2) commuting (walking/cycling to get from one place to another), and (3) free time (leisure). A question is also included about sedentary behaviour (time usually spent sitting or lying down, excluding time spent sleeping at night).

3.7.6 Mobility

The Short Physical Performance Battery (SPPB) assesses three aspects of mobility: balance, gait speed and strength of limbs or lower limbs to get up from a chair (32).

3.7.7 Cognitive performance

The Montreal Cognitive Assessment (MOCA) (33) determines the existence of mild cognitive dysfunctions. It comprises 30 questions and takes 10–12 min to complete.

3.7.8 Primary outcome measures

- The incidence rate of falls will be estimated based on the intervention and control group. Falls will be recorded using a daily log sent to the study centre monthly. On suffering a fall, participants must provide information about the time, date, injuries and prescribed treatment in relation to the fall, the fall location, and the movement which cause the fall. The person will be interviewed by telephone to correct any lack of data to determine the injuries details and to confirm their health status at this time (7).
- Quality of life will be measured through the EuroQol 5D questionnaire, validated in Spanish (34). This questionnaire comprises five items (mobility, personal care, daily activities, pain/discomfort, and anxiety/depression) and a self-assessed thermometer of health status.

3.7.9 Secondary outcome measures

- Fear of falling: Short Falls International Scale of Efficacy (Short FES-I) assess "concerns about falling" (35). The scale is the falls efficacy scale-international short version, comprising seven items (items 2,4,6,7,9,15 and 16). Item responses are coded on a 4-point Likert scale: (1) not at all concerned, (2) somewhat concerned, (3) fairly concerned, and (4) very concerned.
- Exercise adherence will be measured using the Exercise Adherence Rating Scale (EARS) as part of the schedule sent in monthly. This scale is composed of 16 items, scored using a 5-point Likert scale (0 = completely agree to 4 = completely disagree) with a total summed score range from 0 to 64 (36).
- Cost-effectiveness of the intervention: Incremental cost-effectiveness ratio (ICER) related with the ratio of the difference in costs to the health effects difference in both interventions (37). These costs include outpatient treatment, formal/informal care, medication, transportation, room rental, intervention costs involving labour costs, staff and participants transportation, and materials.

3.8 Procedures

Six months after the initial control group assessment and six months after the intervention group sessions have finished, subjects of both groups will be assessed with the same tests that were carried out in the initial assessment. After random assignment, follow-up assessments will be performed by the blind group assignment assessors. The database used in this study will only display information unrelated to the intervention when they are logged in to ensure the blinding of assessors. Should a participant wish to withdraw from the study, they will continue to be eligible to complete the follow-up measurements with their consent. Researchers will record the reasons and date of withdrawal, but data recorded before withdrawal will be used unless the participant decide to use their right to have all data deleted.

Study data will be collected and managed using REDCap electronic data capture tools, hosted at the University of "X." REDCap is a secure, web-based software platform designed to support data capture for research studies.

3.9 Statistical analysis

The study population baseline characteristics will be expressed as means ± standard deviation (SD) for quantitative variables and in frequency distributions for categorical variables. Student's t-test, chi-square, and Fisher's exact tests will be applied to find differences in baseline characteristics between intervention and control groups. All analyses of the variables obtained from the questionnaires will be analyzed using the reliability and validity criteria proposed by their authors.

The main analyses will be performed on the intention-to-treat principle, so all randomised subjects will be included in the data analysis set for which the initial assessment was performed. Participants who withdraw or drop out will be asked to be included in follow-up measurements; those lost to follow up will be considered in the full set of analyses as missing data. Detailed modelling of variations between participants and groups will be done in terms of factors such as dose, acceptability, and contextual factors. Using the Chi-square test, we will compare the proportions of subjects who have had a fall in both groups. The comparison of all outcomes between baseline, six and twelve months will be carried out using the two-way repeated measures ANOVA. Logistic regression analysis will be conducted to determine the influence of the different risk factors on falls. Statistics analysed will be performed with SPSS V.25.0 statistical package (SPSS Inc., Chicago, Illinois, United States). p values for cut-off values for significance were established at <0.05 (two-tailed). Results were interpreted according *[Cohen]*, who considers small size if Cohen D are between $0.2 \leq$ and < 0.5; average effect size if differences are between $0.5 \leq$ and < 0.8 and very high effect size if differences are ≥ 0.8 (38).

3.10 Trial status

Nowadays people have been contacted to invite them to participate. First groups will be collected until the end of the year.

4 Discussion

Falls prevention is seen as one of the most needed interventions in the population aged over 65. Both the NICE guide on fall prevention (39) and the British and American Geriatrics Societies (6) recommend annual screening of subjects older than 65 years for a falls history and the presence of disorders in gait and balance.

While some publications have found evidence of the efficacy of a multifactorial intervention in reducing falls in older adults and/or their consequences (40), some interventions developed in primary care in Spain have not been able to reduce the frequency of falls (7, 40). However, the 2018 Cochrane review showed that most of these multifactorial and multicomponent studies were of low quality, and high risk of bias, and that there may be little or no effect on other fall-related outcomes. Furthermore, structured programs have failed to induce long-term behaviour change towards more regular exercise, demonstrating poor adherence (41). New concepts and formats with large-scale implementation and long-term adherence to balance and strength in exercise are required urgently.

The intervention of the LiFE study has achieved the best results in preventing falls (23) and is considered to be of high quality. Moreover, the LiFE program in terms of function and participation, was superior providing support for this program in measuring both frailty and fall risk. However, less than 10% of older people regularly do strength training and probably even less do balance activities. In the LiFE program, adherence was significantly better (23) and exceeded the 42% adherence reported in the New Zealand Otago trial; this trial tested a successful structured and home-based exercise program (18). However, despite its effectiveness, the implementation of the home-based program LiFE requires considerable economic costs and human resources. Nevertheless, no study has yet been implemented comparing the LiFE intervention group format to standard health advice in a larger population.

A group intervention could facilitate adherence to these activities and clinicians could save resources and time to be more effective and to guarantee the care quality.

For these reasons, the sLiFE program aims to promote the performance of physical activity centered on modifying the behaviour of participants and has demonstrated its effectiveness in a large randomised controlled trial to risk of falls reduction. It seems necessary to assess whether the sLiFE program intervention implemented in a group format can be recommended over individual participation.

4.1 Limitations

The 24 months prior to data collection could be a long period to remember such events for such individuals. In this study the interview will be complemented with the information available in the participants' primary care medical history and in the records of the University Hospital "X" to ensure that all falls which had consequences are considered.

5 Conclusion

This project can help to increase physical activity are effective in falls reduction and in avoiding the consequences derived from them. The key characteristic is the analysis of whether a more economical (group) intervention can be recommended if similar results are obtained in comparison to the individual intervention carried out: LiFE program which has been shown a fall reduction in older adults. It could be applied to larger groups, and it would be possible to recommend it to most older people as the best fall prevention strategy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Salamanca Drug Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IL-R: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. RL-R: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. CL-S: Methodology, Writing – review & editing. SG-G: Methodology, Writing – review & editing. OT-M: Methodology, Writing – review & editing. JA-O: Methodology, Writing – review & editing. CP-H: Methodology, Writing – review & editing. MG-M: Methodology, Writing – review & editing. LG-O: Formal Analysis, Methodology, Writing – review & editing. ER-S: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study has been funded by the Spanish Ministry of Science and Innovation, Instituto de Salud Carlos III (ISCIII). RD21/0016/0010 (Network for Research on Chronicity, Primary Care, and Health Promotion (RICAPPS) is funded by the

European Union-Next Generation EU, Facility for Recovery and Resilience (MRR). Government of Castilla y León also collaborated with the funding of this study through the research projects (GRS 2502/B/22). They played no role in the study design, data analysis, reporting results, nor the decision to submit the manuscript for publication.

Acknowledgments

Members of the sLiFE research group: ER-S, MG-M, LG-O, IL-R, RL-R, CL-S, SG-S, OT-M, JA-O, Elena Rodríguez-Rodríguez, María Elena Villarrubia-Montero de Espinosa, María Teresa Hernández-Moreno, María Dolores Luengo-Plaza, Bonifacia Carpio-Torres, José Ramón Saiz-Llamosas, María Nieves Hernández-Alonso, Ana María Roncero-Bejarano, Rodrigo Salvador-Sánchez, Manuel Eduardo Díaz Delgado, María Cristina Garzón-Melón, Cristina Sastre-Benito, José A. Maderuelo-Fernández, María Carmen Pablos-Hernández, Alfonso González-Ramírez, Víctor Manuel González-Rodríguez, Pilar Martín-González, Carmen Castaño-Sánchez, Ana Belén Castro-Rivero, Paz Muriel-Díaz, Janire Zorita-Pérez, Silvia Domínguez-Domínguez.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1304982/full#supplementary-material

References

1. Spiteri K, Broom D, Bekhet AH, de Caro JX, Laventure B, Grafton K. Barriers and motivators of physical activity participation in middle-aged and older-adults–a systematic review. *J Aging Phys Act*. (2019) 27:929–44. doi: 10.1123/japa.2018-0343

2. Aguiñaga S, Ehlers DK, Salerno EA, Fanning J, Motl RW, McAuley E. Home-based physical activity program improves depression and anxiety in older adults. *J Phys Act Health*. (2018) 15:692–6. doi: 10.1123/jpah.2017-0390

3. Abizanda P, Romero L, Sánchez PM, Martínez M, Gomez L, Alfonso S. Frailty and mortality, disability and mobility loss in a Spanish cohort of older adults: the FRADEA study. *Maturitas*. (2013) 74:54–60. doi: 10.1016/j.maturitas.2012.09.018

4. Arocha Rodulfo JI. Sedentary lifestyle a disease from xxi century. *Clin Investig Arterioscler*. (2019) 31:233–40. doi: 10.1016/j.arteri.2019.04.004

5. WHO O. *World report on ageing and health*. Geneva: World Health Organization (2015).

6. Society AG, Society BG. *AGS/BGS clinical practice guideline: Prevention of falls in older persons*. New York (NY): American Geriatrics Society (2010). 36 p.

7. Rodríguez-Molinero A, Narvaiza L, Gálvez-Barrón C, de la Cruz JJ, Ruíz J, Gonzalo N, et al. Falls in the Spanish elderly population: incidence, consequences and risk factors. *Rev Esp Geriatr Gerontol*. (2015) 50:274–80. doi: 10.1016/j.regg.2015.05.005

8. Noureldin M, Hass Z, Abrahamson K, Arling G. Fall risk, supports and services, and falls following a nursing home discharge. *Gerontologist*. (2018) 58:1075–84. doi: 10.1093/geront/gnx133

9. McGibbon CA, Slayter JT, Yetman L, McCollum A, Mccloskey R, Gionet SG, et al. An analysis of falls and those who fall in a chronic care facility. *J Am Med Dir Assoc*. (2019) 20:171–6. doi: 10.1016/j.jamda.2018.06.022

10. Veronese N, Maggi S. Epidemiology and social costs of hip fracture. *Injury*. (2018) 49:1458–60. doi: 10.1016/j.injury.2018.04.015

11. Mitchell R, Harvey L, Brodaty H, Draper B, Close J. Hip fracture and the influence of dementia on health outcomes and access to hospital-based rehabilitation for older individuals. *Disabil Rehabil*. (2016) 38:2286–95. doi: 10.3109/09638288.2015.1123306

12. Martínez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, Sáez de Asteasu ML, Lucia A, Galbete A, et al. Effect of exercise intervention on functional decline in very elderly patients during acute hospitalization: a randomized clinical trial. JAMA. *Intern Med*. (2019) 179:28–36. doi: 10.1001/jamainternmed.2018.4869

13. Jakovljevic DG. Physical activity and cardiovascular aging: physiological and molecular insights. *Exp Gerontol*. (2018) 109:67–74. doi: 10.1016/j.exger.2017.05.016

14. Soni M, Orrell M, Bandelow S, Steptoe A, Rafnsson S, d'Orsi E, et al. Physical activity pre- and post-dementia: English longitudinal study of ageing. *Aging Ment Health*. (2019) 23:15–21. doi: 10.1080/13607863.2017.1390731

15. Franse CB, Rietjens JA, Burdorf A, van Grieken A, Korfage IJ, van der Heide A, et al. A prospective study on the variation in falling and fall risk among community-dwelling older citizens in 12 European countries. *BMJ Open*. (2017) 7:e015827. doi: 10.1136/bmjopen-2017-015827

16. Elliott S, Leland NE. Occupational therapy fall prevention interventions for community-dwelling older adults: a systematic review. *Am J Occup Ther*. (2018) 72:7204190040p1–7204190040p11. doi: 10.5014/ajot.2018.030494

17. Sherrington C, Tiedemann A, Fairhall N, Close JC, Lord SR. Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. *N S W Public Health Bull*. (2011) 22:78–83. doi: 10.1071/NB10056

18. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ*. (1997) 315:1065–9. doi: 10.1136/bmj.315.7115.1065

19. Hill KD, Hunter SW, Batchelor FA, Cavalheri V, Burton E. Individualized home-based exercise programs for older people to reduce falls and improve physical performance: a systematic review and meta-analysis. *Maturitas*. (2015) 82:72–84. doi: 10.1016/j.maturitas.2015.04.005

20. Bauman A, Merom D, Bull FC, Buchner DM, Fiatarone Singh MA. Updating the evidence for physical activity: summative reviews of the epidemiological evidence, prevalence, and interventions to promote "active aging". *Gerontologist*. (2016) 56:S268–80. doi: 10.1093/geront/gnw031

21. Reiner M, Niermann C, Jekauc D, Woll A. Long-term health benefits of physical activity – a systematic review of longitudinal studies. *BMC Public Health*. (2013) 13:813. doi: 10.1186/1471-2458-13-813

22. Gillespie LD, Robertson MC, Gillespie WJ, Sherrington C, Gates S, Clemson LM, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. (2012) 2021:CD007146. doi: 10.1002/14651858.CD007146.pub3

23. Clemson L, Fiatarone Singh MA, Bundy A, Cumming RG, Manollaras K, O'Loughlin P, et al. Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. *BMJ*. (2012) 345:e4547. doi: 10.1136/bmj.e4547

24. Li K, Comer K, Huang T, Schmidt K, Tong M. Effectiveness of a modified lifestyle-integrated functional exercise program in residential retirement communities-a pilot study. *SAGE Open Nurs*. (2018) 4:237796081879303. doi: 10.1177/2377960818793033

25. Argimon Pallàs JM, Jiménez VJ. *Métodos de investigación clínica y epidemiológica. 4ª Edición. Travessera de Gràcia, 17–21–08021 Barcelona*. Elsevier España, S.L.: España (2013).

26. Llamas-Ramos I, Llamas-Ramos R, González-Sánchez S, Rodríguez-Sánchez E. *Programa de Ejercicio Funcional Integrado en el Estilo de Vida (LiFE) para prevenir caídas*. Manual del participante:. Sidney: Sidney University Press (2021).

27. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. (1987) 40:373–83. doi: 10.1016/0021-9681(87)90171-8

28. Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson comorbidity index: a critical review of Clinimetric properties. *Psychother Psychosom*. (2022) 91:8–35. doi: 10.1159/000521288

29. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Cardiovascular health study collaborative research group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. (2001) 56:M146–57. doi: 10.1093/gerona/56.3.M146

30. Steeves JA, Tyo BM, Connolly CP, Gregory DA, Stark NA, Bassett DR. Validity and reliability of the Omron HJ-303 tri-axial accelerometer-based pedometer. *J Phys Act Health*. (2011) 8:1014–20. doi: 10.1123/jpah.8.7.1014

31. Armstrong T, Bull F. Development of the World Health Organization global physical activity question-naire (GPAQ). *J Public Health*. (2006) 14:66–70. doi: 10.1007/s10389-006-0024-x

32. Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci*. (2000) 55:M221–31. doi: 10.1093/gerona/55.4.M221

33. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal cognitive assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. (2005) 53:695–9. doi: 10.1111/j.1532-5415.2005.53221.x

34. Badia X, Schiaffino A, Alonso J, Herdman M. Using the EuroQoI 5-D in the Catalan general population: feasibility and construct validity. *Qual Life Res*. (1998) 7:311–22. doi: 10.1023/A:1008894502042

35. Kempen GI, Yardley L, van Haastregt JC, Zijlstra GA, Beyer N, Hauer K, et al. The short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling. *Age Ageing*. (2008) 37:45–50. doi: 10.1093/ageing/afm157

36. Newman-Beinart NA, Norton S, Dowling D, Gavriloff D, Vari C, Weinman JA, et al. The development and initial psychometric evaluation of a measure assessing adherence to prescribed exercise: the exercise adherence rating scale (EARS). *Physiotherapy*. (2017) 103:180–5. doi: 10.1016/j.physio.2016.11.001

37. McCabe C, Claxton K, Culyer AJ. The NICE cost-effectiveness threshold: what it is and what that means. *PharmacoEconomics*. (2008) 26:733–44. doi: 10.2165/00019053-200826090-00004

38. Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd ed (1988).

39. National Institute for health and care excellence. *Falls: assessment and prevention of falls in older people*. London (UK): National Institute for Health and Care Excellence (NICE) (2013). 33 p (Clinical guideline; no. 161).

40. Ferrer A, Formiga F, Plana-Ripoll O, Tobella MA, Gil A, Pujol R, et al. Risk of falls in 85-year-olds is associated with functional and cognitive status: the Octabaix study. *Arch Gerontol Geriatr*. (2012) 54:352–6. doi: 10.1016/j.archger.2011.06.004

41. Hopewell S, Adedire O, Copsey BJ, Boniface GJ, Sherrington C, Clemson LM, et al. Multifactorial and multiple component interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. (2018) 2018:CD012221. doi: 10.1002/14651858.CD012221.pub2

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 15 January 2024
DOI 10.3389/fpubh.2023.1303467

Check for updates

OPEN ACCESS

EDITED BY
Miriam Rodriguez-Monforte,
Ramon Llull University, Spain

REVIEWED BY
Jean-Marie Robine,
Institut National de la Santé et de la Recherche Médicale (INSERM), France
Xinlei Miao,
The Second Hospital of Dalian Medical University, China

*CORRESPONDENCE
Li Zhang
✉ 390026566@qq.com

†These authors have contributed equally to this work and share first authorship

RECEIVED 28 September 2023
ACCEPTED 13 December 2023
PUBLISHED 15 January 2024

CITATION
Liu M, Zhang M, Zhou J, Song N and Zhang L (2024) Research on the healthy life expectancy of older adult individuals in China based on intrinsic capacity health standards and social stratification analysis.
Front. Public Health 11:1303467.
doi: 10.3389/fpubh.2023.1303467

COPYRIGHT
© 2024 Liu, Zhang, Zhou, Song and Zhang. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Research on the healthy life expectancy of older adult individuals in China based on intrinsic capacity health standards and social stratification analysis

Mengya Liu†, Meng Zhang†, Jinglei Zhou†, Nannan Song† and Li Zhang*

Bengbu Medical University, Bengbu, Anhui, China

Background: Based on the health standard of intrinsic capacity, this paper conducts an empirical study on the healthy life expectancy of older adult individuals aged 60 and older in China and analyzes the health inequities associated with different social characteristics to provide a reference for improving care for the older adult in China.

Methods: Data from the China Health and Retirement Longitudinal Study from 2011 to 2015 were used to evaluate the intrinsic capacity level of older adult individuals, and the multistate life table method was used to measure the healthy life expectancy of older adult individuals in China with the help of IMaCH software. Based on the theory of social stratification, the health inequality between older adult individuals in different social classes was analyzed in three dimensions: residence, income and education level.

Results: The calculation results show that the average life expectancy of the older adult in China at age 60 is 21.07 years, the healthy life expectancy is 16.89 years, and the healthy life expectancy accounts for 80.2% of the average life expectancy. The healthy life expectancy of older adult individuals with different social characteristics in China shows significant differences, and the healthy life expectancy of older adult individuals who are male, live in urban environments, have high levels of education and have middle- to high-income levels is significantly better than that of older adult individuals who are female, live in rural areas, have low levels of education and income.

Conclusion: Healthy life expectancy measured by intrinsic capacity as the health standard has a certain reference value, which reflects the overall health level of older adult individuals in China and expands the transformation and multidimensional understanding of the healthy thinking of older adult individuals in China. The analysis by social stratification reflects the large health inequities that exist in the older adult population in China.

KEYWORDS

healthy life expectancy, intrinsic capacity, older age, social stratification, health aging

Introduction

The aging of the world's population is a serious situation. According to the World Population Prospects report released by the United Nations in 2022, the proportion of the global population aged 60 and older will increase from 13.5% in 2020 to 21.4% by 2050 (1). China is also facing the challenge of a rapidly aging population. In 2020, China's seventh population census reported ∼260 million older adult aged 60 and older, accounting for 18.7% of the total population, indicating that China has an aging society (2). The greatest challenge posed by an aging population is the serious and complex health problems of older adult individuals. By the end of 2020, Chinese life expectancy was 77.3 years, while healthy life expectancy was only 69 years, indicating that older adult individuals in China have 8.3 years in which they will experience health problems such as disease, impairment and disability (3). Lifespan only reflects the length of life, and health truly reflects the quality of life. With the development of China's economy and the improvement of living conditions, we are paying more attention to improving the quality of life of older adult individuals, and the primary pursuit is not to "live longer" but to "live healthier and happier." How to help older adult individuals live longer and healthier lives is the top priority of the Chinese government's work on aging in the new era. The Central Committee of the Communist Party of China and the State Council have issued the "Healthy China 2030" planning outline, which proposes to further promote the strategic theme of "co-construction and sharing, and health for all" (4) with people's health as the center and "healthy life expectancy" as an important monitoring indicator to comprehensively reflect the level of health. Combining the length of life with the quality of life, healthy life expectancy is a comprehensive evaluation index to evaluate the health level of the world population.

One of the focuses of healthy life expectancy research is the selection of health assessment criteria. At present, scholars from all over the world have developed and formulated a variety of health status evaluation indicators based on disease surveillance and health survey data, such as disease burden, disability, ability to perform activities of daily living (ADLs), and health self-assessment, and these indicators are applicable to people of all ages to assess their health. Population aging is a common trend in world population development, the health of the older adult is attracting increasing international attention, and traditional universal health indicators lack characteristics and pertinence for evaluating the health of older adult individuals. Therefore, we need an evaluation index dedicated to evaluating the health of older adult. In 2015, the WHO released the Global Report on Aging and Health, which breaks the traditional concept of focusing on diseases and defines "healthy aging" as the process of developing and maintaining the functional exertion required for healthy life among the older adult from the perspective of functional maintenance (5). Intrinsic capacity (IC) is the basis for functional performance, which refers to the combination of all physical functions and mental power that an individual can use at any time. As a framework for monitoring the health of older adult individuals, intrinsic capacity reflects the overall state of older adult individuals, paying more attention to the various functions that older adult can do as they wish, which they deem important. To translate theoretical models into practice, the constituent elements of intrinsic capacity need to be defined to make assessment, measurement and monitoring operational. After multiregional and multidisciplinary expert consultation, literature review and empirical pilot research, WHO proposed five dimensions of intrinsic capacity, including cognition, motor, vitality, sensory and psychology, which are considered to fully reflect the physical function and brain changes in the framework of healthy aging, representing measurable aging indicators, and can scientifically, comprehensively and standardize the health level of the older adult from different perspectives. To fully reflect the change in global cognition of the health of the older adult, this study will use intrinsic capacity as a health standard to measure the healthy life expectancy of the older adult in China, explore a new measurement index for measuring the healthy life expectancy of older adult, and scientifically, objectively and operably evaluate the health level of the older adult in China.

In the context of the deepening of aging, how to promote "healthy aging" and improve the health level of older adult individuals has become an important issue for government and society (6). In 2019, the Chinese government released the "Opinions of the General Office of the State Council on Promoting the Development of Elderly Care Services," which pointed out that the current construction of the older adult care service system has achieved remarkable results, but there are still many problems, such as uneven development (6). The health level of the older adult is the basic factor for forming the demand for elder care services and building a social elder care service system, and the health inequality caused by social stratification is an important perspective to consider when exploring the imbalance of elder care service development (7). Social stratification refers to the stratification or difference phenomenon caused by the different social resources of members of society and social groups; Weber identified three basic dimensions of social stratification, namely, wealth, power and prestige (8). Previous studies have shown significant differences in healthy life expectancy among different social classes; groups with higher social classes tend to live longer and healthier lives, and the difference in healthy life expectancy is significantly greater than the difference in life expectancy (9–11).

This study uses the data of the China Health and Retirement Longitudinal Study, takes intrinsic capacity as the health measurement standard, and uses the multistate life table method to measure the healthy life expectancy of the older adult in China to construct health indicators for the older adult that meet international standards and suit China's national conditions and enrich the health connotation of older adult individuals. The aim is to provide a basis for scientific, objective, standardized and operable evaluation of the health level of the older adult in China and to verify and supplement the empirical results of Chinese scholars in the field of healthy life expectancy in older adult individuals. Based on the theory of social stratification, the impact of different social stratification indicators on the health status of older adult individuals is comprehensively analyzed from a dynamic perspective, and the problems of health imbalance in the elder care service system are examined to provide accurate guidance for the government to formulate relevant policies and improve the social system and a reference for the construction of the retirement service system.

Methods

Study population

Participants in this study were from the China Health and Retirement Longitudinal Study (CHARLS). The CHARLS collected high-quality longitudinal study data (e.g., demographic, economic, health, retirement) of a nationally representative population of individuals aged 45 and older and their spouses, covering 150 counties and 450 communities (villages) in 28 provinces (autonomous regions and municipalities directly under the central government) (12). The baseline study was conducted in 2011, and follow-up assessments were conducted every 2 years using face-to-face computer-assisted individual interviews. This study uses CHARLS data because it includes details such as basic information, health status and functioning, household information, and financial income. These comprehensive and longitudinal data enable assessment of the intrinsic capacity level of older adult individuals, accurate estimates of healthy life expectancy and analysis of social stratification. In this study, the CHARLS project team applied for authorization to use the data, and it was approved by the Biomedical Ethics Committee of Peking University (approval number: IRB00001052-11015). All participants signed informed consent forms (12).

This study used sociological and health CHARLS data from 2011, 2013 and 2015 (health examination data for the older adult in 2018 is lacking). The CHARLS project is a multistage sample survey, and CHARLS has made weighted structural adjustments to the 2011 baseline respondent information data. The 2013 and 2015 longitudinal tracking survey data weights are based on the baseline weights (or rather, weights with nonresponse adjustments), inverse probability weighting factors are constructed from whether respondents participated in the second wave of logit regression conditional on participation in the baseline, and the longitudinal weights account for the data of deceased respondents. In 2011, there were 17,705 weighted samples, 15,179 weighted samples participated in the 2013 longitudinal follow-up survey, and 14,574 weighted samples participated in the 2015 longitudinal follow-up survey, including 6,053 cases in the population aged 60 and older. The sample (233 people) with missing key variables (gender, education level, place of residence, economic income, etc.) and abnormal intrinsic ability assessment results and the sample (28 people) who did not participate in the intrinsic ability assessment in the 3 surveys were obtained, and the baseline number was 5,792 cases. In the end, the number of people remaining in the 2015 follow-up survey was 4,468.

Intrinsic capacity assessment

The WHO proposes five dimensions of intrinsic capacity, including motor, cognition, vitality, sensory and psychology, the determination of which is of great significance for objectively measuring the intrinsic capacity of the older adult and comprehensively reflects the health status of the older adult from a holistic perspective. Beard et al. (13) clearly described the components of each domain and examined the structure and predictive validity of the concept of intrinsic capacity. At the same time, the WHO has also developed corresponding assessment tools based on each dimension of intrinsic capacity, providing recommendations and guidelines for its measurement from the perspective of screening and in-depth assessment and elaborating in the publication (ICOPE). In this study, we used the data of the 2011–2015 China Health and Retirement Longitudinal Study. Based on the information available in the database and the tools recommended by WHO ICOPE, this study selected the following methods for the assessment of intrinsic capacity: cognition (temporal orientation, memory and manipulation), motor (gait speed, sit-up test, and balance test), vitality (BMI), sensory (hearing and vision), and psychological (depression).

Cognition

The cognitive dimension mainly includes the ability to orient time (year, month, day, week, season); memory (listening to ten words, repeating them and recalling them when questioned); and calculation power (100 minus 7). The total score was 30, with $\leq$9 being moderate to severe cognitive impairment, 10–26 being mild to moderate cognitive impairment, and 27–30 being normal (14).

Motor

The motor dimension mainly includes gait speed, sit-up test and balance test. Each section scored a total of 4 out of 12, with $\leq$2 being classified as moderate to severe impairment of motor function, 3–9 as mild to moderate impairment, and 10–12 as normal (14).

Vitality

Indicators of vitality function are not clear, and there is no uniform definition. The vitality dimension of this study mainly measured body mass index (BMI). BMI is one of the most commonly used nutritional evaluation indicators in clinical practice, and many foreign studies have used BMI as a single index to investigate the incidence of malnutrition in patients and affirm its clinical value. In this study, BMI was divided into three categories according to Chinese standards, namely thin type (BMI $<$ 18.5 kg/m2), normal type (18.5 kg/m2 $\leq$ BMI $<$ 24 kg/m2), and obesity or overweight (BMI $\geq$ 24 kg/m2).

Sensory

The sensory dimensions mainly included hearing and visual function, and self-report methods were used to assess hearing and visual function. Vision is mainly measured by asking older adult individuals: "How do you see things in the distance? For example, can you recognize a friend across the street (with or without glasses)?" Hearing is mainly measured by asking older adults, "How is your hearing?" (If you wear hearing aids, how do you hear

when you wear hearing aids?) Visual acuity and hearing results are assessed using a 5-point Likert scale, with "1" meaning poor vision and hearing and "5" meaning excellent vision and hearing.

Psychological

The psychological dimension is a depression assessment that uses a 10-item Chinese version of the depression self-rating scale (CESD). Huang et al. (15) studied the reliability and validity of the scale in the middle-aged and older adult of China, and the results showed that the total Cronbach's α coefficient of the scale was 0.815. The options for each item are composed of 4 levels and assigned as follows: "little or not at all = 0," "some or little = 1," "occasional or moderate = 2," and "most or all = 3." The total score ranges from 0 to 30 points. Questions 5 and 8 are positive factors, and reverse scoring is needed. A CESD score <10 points is considered to indicate no depressive symptoms, 11–17 points represents possible depressive symptoms, and >18 points indicates depressive symptoms (14, 16).

Given the clinical practical utility of summary scores from routine geriatric assessments, López-Ortiz et al. (14) proposed an intrinsic capacity score accounts for the characteristics that each person possesses as a whole. López-Ortiz et al. (14) argue that composite scores ranging from 0 (worst) to 10 (highest) can be used, which equally weights all five dimensions by establishing a 0–2 range to stratify the state of each of them (i.e., 0 = severely impaired; 1 = partially damaged; 2 = slightly damaged or normal). This study draws on the scoring method of intrinsic capacity in López-Ortiz's study (14), that is, total intrinsic capacity score = motor score + vitality score + cognitive score + psychological score + sensory score, where 1 represented mild impairment and 2 represented no impairment. The total scores of each dimension were added to form a complete intrinsic capacity score, in which 0–4 indicated severe disability or care dependence, 5–8 indicated functional decline, and 9–10 indicated high and stable intrinsic ability (14).

Multistate life table method

In this study, healthy life expectancy was calculated with the help of IMaCH software. Because IMaCH software is able to fit subjects with missing health status data at only partial time points, it can still fit the probability of healthy transfer measured in the overall sample (17). Therefore, the IMaCH software function was applied in this study, and some samples with missing data at the point in time were not deleted to preserve the integrity of the samples to the greatest extent and ensure that the measurement results were representative (17).

In this study, the multistate life table method was used to measure healthy life expectancy. The multistate life table method is one of the important methods of demography. Healthy life expectancy, which is based on the multistate life table, refers to the average number of years that an individual will live in a healthy state under the current mortality and morbidity estimates. The probability of health transfer is calculated by tracking the transition between different health states, and the average life expectancy is estimated by estimating the length of time in different healthy states (13, 18, 19). This method accounts for the transition between the health status of the study subjects and can more accurately and realistically calculate healthy life expectancy than Sullivan's method (18).

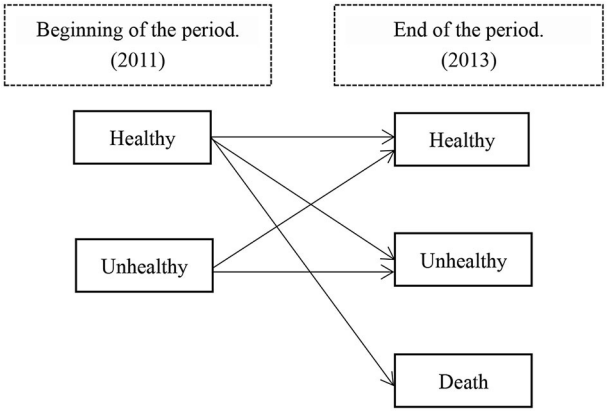


FIGURE 1
Health status transition diagram.

This study defines health status based on the total intrinsic capacity score. That is, a total score of intrinsic ability ≥9 points is defined as a state of health; a score of 9 < is defined as an unhealthy state. During follow-up, if the participant died, it was defined as a state of death. The death confirmation of the respondent usually requires the representative who has been living with the respondent for a long time to present the respondent's death registration and certificate, which is issued by the hospital or the neighborhood committee where the respondent is registered, which records the respondent's death registration number, time, place, cause of death, and the respondent's previous information. The healthy and unhealthy states are transfer states, and the death state is the absorption state. Figure 1 shows the health transition diagram.

Based on longitudinal data, the operation of the multistate life table method first estimates the probability of health transition according to the change in health status between different time points, and the probability of health state transfer refers to the probability that the individual who is in state i at moment x is in state j at time $x+n$ later, that is, ${}^{i}P^{j}_{x,x+n}$. First, assume that following the Markov chain, the probability that the individual's state at age x is j, and the age state of $x+h$ is k: ${}_{h}P^{jk}_{x}=P[X(x+h)=k|X(x)=j]$. Second, let $L^{(i)}_{t1-t2}$ represent the probability ${}_{d1}P^{jk}_{x1}$ of the transition of an individual from state j to state k between $t1$ and $t2$, and if there are two transformations (from j to k and then to l), then the probability of state transition of individual i is $L^{(i)} = ({}_{d1}P^{jk}_{x1})\times({}_{d2}P^{kl}_{x2})$. The initial state of health status is i, and the proportion of outcome states 1 (healthy) and 2 (unhealthy), healthy probability and unhealthy probability: ${}_{t}W^{i1}(x) = {}_{t}P^{i1}_{x-t}/{}_{t}P^{i1}_{x-t} + {}_{t}P^{i2}_{x-t}$; ${}_{t}W^{i2}(x) = {}_{t}P^{i2}_{x-t}/{}_{t}P^{i2}_{x-t} + {}_{t}P^{i2}_{x-t}$. The incidence of individual outcome status j was then calculated: ${}_{y}P^{j}_{x}(\theta) = {}_{y}P^{1j}_{x}(\theta) + W^{2}(x,\theta)[{}_{y}P^{2j}_{x}(\theta) - {}_{y}P^{1j}_{x}(\theta)]$.

After obtaining the probability of transition of different states of health, the three states of health, unhealth and death are encoded as h, u and d, respectively, and a first-order matrix of the probability of transition between different states of health and the matrix of the number of surviving people are constructed (20).

$$P_{x,x+t} = ({}^{i}P^{j}_{x,x+n}) = \begin{bmatrix} {}^{h}P^{h}_{x,x+n} & {}^{h}P^{u}_{x,x+n} & {}^{h}P^{d}_{x,x+n} \\ {}^{u}P^{h}_{x,x+n} & {}^{u}P^{u}_{x,x+n} & {}^{u}P^{d}_{x,x+n} \\ 0 & 0 & 1 \end{bmatrix}$$

$$l_{x,x+t} = \begin{bmatrix} {}^{h}l^{h}_{x,x+n} & 0 & 0 \\ 0 & {}^{h}l^{h}_{x,x+n} & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Based on the transfer probability matrix and the surviving number matrix, the multistate life table calculation formula is used to calculate the healthy life expectancy. X is age, h is healthy, u is unhealthy, d is death, and n is follow-up. This study was conducted over a 4-year period.

l_x is the total number of people aged X, l^h_x is the healthy number of years X, l^u_x is the unhealthy number of years X, the number of years x-n is l_{x-n}, the healthy number of years x-n is l^h_{x-n}, and the unhealthy number of years x-n is l^u_{x-n}. lx is the number of years of survival, L^h_x is the number of years of healthy survival, and L^u_x is the number of years of unhealthy survival. Tx is the cumulative number of years of survival, T^h_x is the cumulative number of years of healthy survival, and T^u_x is the cumulative number of years of unhealthy survival. ${}^{h}P^{h}_{x-n}$ represents the probability that a person who is healthy at age x-n will remain in a healthy state at age x; ${}^{h}P^{u}_{x-n}$ represents the probability that a person whose state is healthy at age x-n will change to an unhealthy state at age x; ${}^{h}P^{d}_{x-n}$ represents the probability that a person whose state is healthy at age x-n will change to death at age x; ${}^{u}P^{h}_{x-n}$ represents the probability that a person whose state is unhealthy at age x-n will change to a healthy state at age x; ${}^{u}P^{u}_{x-n}$ represents the probability that a person whose state is unhealthy at age x-n will change to an unhealthy state at age x; ${}^{u}P^{d}_{x-n}$ represents the probability that a person whose state is unhealthy at age x-n will change to death by the age of x.

$$l_x = l^h_x + l^u_x$$

$$l^h_x = l^h_{x-n} - (l^h_{x-n} \times {}^{h}P^{u}_{x-n}) - (l^h_{x-n} \times {}^{h}P^{d}_{x-n}) + (l^u_{x-n} \times {}^{u}P^{h}_{x-n})$$

$$l^u_x = l^u_{x-n} - (l^u_{x-n} \times {}^{u}P^{h}_{x-n}) - (l^u_{x-n} \times {}^{u}P^{d}_{x-n}) + (l^h_{x-n} \times {}^{h}P^{u}_{x-n})$$

$$L_x = (l_x + l_{x-n})$$

$$L^h_x = (l^h_x + l^h_{x-n})$$

$$L^u_x = (l^u_x + l^u_{x-n})$$

$$T_x = \sum_{x=60}^{Max} L_x(x = 60, 64, 68, 72 \ldots, 100 + \text{for the highest age group})$$

$$T^h_x = \sum_{x=60}^{Max} L^h_x(x = 60, 64, 68, 72 \ldots, 100 + \text{for the highest age group})$$

$$T^u_x = \sum_{x=60}^{Max} L^u_x(x = 60, 64, 68, 72 \ldots, 100 + \text{for the highest age group})$$

Life expectancy: $e_{x = Tx/lx}$

Healthy life expectancy: $HE_x = T^h_x / l^h_x$

Social stratification analysis

Based on Weber's theory of social stratification and the experience of previous researchers, this study explores the differences in healthy life expectancy among older adult individuals with five different social characteristics: age, gender, place of residence, income, and education level, and it makes a comprehensive judgment on the social status factors of health inequality. Study subjects were asked, "Where do you mainly live?," "What is your average annual income?," and "What is your level of education?" In this study, considering the visibility of the analysis results and the research patterns in the literature, the responses to some questions were integrated. During follow-up analyses, missing values were considered lost. Table 1 describes the variable settings.

Statistical methods

SPSS 25.0 software was used for analysis, the measurement data were expressed as the mean ± standard deviation ($x \pm s$), and the chi-square test and rank sum test were used for the between-group comparison of baseline data. The t test was used for normally distributed data, and the nonparametric test was used for nonnormally distributed data. $P < 0.05$ was considered statistically significant. The preparation of life tables and the calculation of healthy life expectancy under different social stratifications was recorded in Excel and facilitated the comprehensive comparison of the healthy life expectancy of older adult individuals with different social statuses. Finally, an explanatory conclusion was drawn.

Results

Basic information

A total of 5,792 older adult aged 60 years and older who participated in intrinsic capacity assessment were included as baseline survey participants, and a total of 4,468 people participated in tracking and surviving in 2015. Among them, 92.01% of older adult were under 80 years old in 2011 and 94.11% in 2015. With the occurrence of deaths, the proportion of older adult in this cohort gradually decreased. In the two tracking datasets, the proportion of males was higher than that of females, which was consistent with the law of the sex ratio of the older adult (7). The research subjects were mainly older adult rural residents, the education level of older adult was concentrated at the level of primary school and less, and most of the interviewed older adult had low incomes. In terms of health status, the proportion of healthy older adult decreased during the follow-up period. Basic information and health transfer status are shown in Table 2.

TABLE 1 Variable settings.

Items	Variables	Variables explained in the questionnaire
Demography variable	Gender	"male" = 1, "female" = 2
	Age (year old)	"60–63" = 1, "64–67" = 2, "68–71" = 3, "72–75" = 4, "76–79" = 5, "≥80" = 6
Social stratification	Income	"Low income" = 1, "middle-high income" = 2
	Place of residence	"Town (town, urban and rural or combined towns and townships)" = 1, "rural" = 2
	Education level	"Primary school level and less" = 1, "Middle school level and more" = 2

TABLE 2 Basic information and health transfer status of the study subjects.

Items	2011 baseline survey frequency (%)	2013 follow-up survey frequency (%)	2015 follow-up survey frequency (%)
Age group (year)			
60~	1,403 (24.22)	1,318 (25.83)	1,226 (27.44)
64~	1,260 (21.75)	1,152 (22.57)	1,029 (23.03)
68~	1,073 (18.53)	957 (18.75)	831 (18.60)
72~	827 (14.28)	713 (13.98)	615 (13.76)
76~	766 (13.23)	638 (12.50)	504 (11.28)
80~	463 (7.99)	325 (6.37)	263 (5.89)
Gender			
Male	3,334 (57.56)	2,981 (58.42)	2,663 (59.60)
Female	2,458 (42.44)	2,122 (41.58)	1,805 (40.40)
Place of residence			
City and town	2,637 (45.53)	2,408 (47.19)	2,117 (47.38)
Rural	3,155 (54.47)	2,695 (52.81)	2,351 (52.62)
Level of education			
Primary school and less	3,016 (52.07)	2,743 (53.75)	2,254 (50.45)
Middle school and more	2,776 (47.93)	2,360 (46.25)	2,214 (49.55)
Income			
Low income	3,519 (60.76)	3,048 (59.73)	2,659 (59.51)
Middle-high income	2,273 (39.24)	2,055 (40.27)	1,809 (40.49)
Health status			
Healthy	1,914 (33.05)	1,656 (33.45)	1,437 (32.16)
Unhealthy	3,878 (66.95)	3,447 (67.55)	3,031 (67.84)
Died	0	407 (7.03)	413 (7.13)
Lost to follow-up	0	282 (4.87)	222 (3.83)

Healthy life expectancy of older persons in different social stratifications

In this study, the differences in healthy life expectancy among older adult individuals in different social strata were explored from five aspects: age, gender, place of residence, economic income, and education level. The results are mainly presented as life expectancy (LE), healthy life expectancy (HLE), and the proportion of healthy life expectancy to average life expectancy.

Table 3 shows the average life expectancy and healthy life expectancy of the older adult by age and sex in China. The calculation results show that the average life expectancy of older adult in China at age 60 is 21.07 more years, the healthy life expectancy is 16.89 more years, and the healthy life expectancy accounts for 80.2%. With increasing age, the health status of the older adult in China is gradually declining in the process of aging. In terms of gender, the average life expectancy of men at age 60 is 20.36 more years, the healthy life

expectancy is 17.16 more years, and the proportion of healthy life expectancy is 84.3%. The average life expectancy of women at age 60 is 20.70 more years, the healthy life expectancy is 16.64 more years, and the proportion of healthy life expectancy is 80.4%. The data show that women's average life expectancy is higher than that of men, but their healthy life expectancy is significantly lower than that of men, indicating that older women, although living longer, do not have as many healthy years as men.

As shown in Table 4, gender, income and education level were used as control variables to measure the average life expectancy, healthy life expectancy and proportion of older adult individuals with different education levels. At age 60, the average life expectancy of older adult rural residents in China is 19.53 more years, the healthy life expectancy is 15.30 more years, and the proportion of healthy life expectancy is 78.3%, while the average life expectancy of older adult urban residents in China at age 60 is 20.84 more years, the healthy life expectancy is 16.17 more years, and the healthy life expectancy accounts for 77.6%. As shown in Table 4, these data show the rural–urban difference in healthy life expectancy among older adult individuals. The average life expectancy and healthy life expectancy of urban older adult are higher than those of rural older adult individuals, but the proportion of healthy life expectancy is lower than that of rural older adult.

As shown in Table 5, gender, urban and rural areas, and education level were used as control variables to measure average life expectancy, healthy life expectancy and proportion of older adult at different education levels. At age 60, the average life expectancy of low-income older adult in China is 20.22 more years, the healthy life expectancy is 15.19 more years, and the healthy life expectancy accounts for 75.1%, while the average life expectancy of middle- and high-income older adult in China is 20.76 more years, the healthy life expectancy is 16.26 more years, and the healthy life expectancy accounts for 78.3%. These data show the impact of income on the healthy life expectancy of older adult. The proportions of average life expectancy, healthy life expectancy and healthy life expectancy of middle- and high-income older adult are higher than those of low-income older adult, indicating that the health status and quality of life of high-income older adult are better than those of low-income older adult.

As shown in Table 6, gender, urban and rural residence, and income were used as control variables to calculate the average life expectancy, healthy life expectancy and proportion of the older adult at different levels of education. At age 60, the average life expectancy of the older adult with a primary school education level and below in China is 21.74 more years, the healthy life expectancy is 16.42 more years, and the proportion of healthy life expectancy is 75.5%, while the average life expectancy of the older adult with a middle school education level over age 60 is 22.84 more years, the healthy life expectancy is 17.15 more years, and the healthy life expectancy accounts for 75.1%. These data show that the average and healthy life expectancy of older people with lower levels of education is longer than that of older people with higher levels of education, but the proportion of healthy life expectancy is relatively high.

Discussion

With the development of the social economy, people's demand for health is increasing, and the understanding of health is more in depth. The selection of healthy life expectancy indicators not only includes objective measurement indicators such as disability and ADLs but also includes subjective measurement indicators based on self-assessment of health, which can reflect the development level of healthy life expectancy of the general population in China. However, with the acceleration of the aging process, the health of the older adult has received increasing attention, and the Global Report on Aging and Health released by the WHO in 2015 (5) promoted healthy aging as a strategic measure to cope with population aging worldwide. Intrinsic capacity is the core of healthy aging, enriching the connotation of the health of older adult.

This study is the first to use intrinsic capacity as a health standard to measure the average life expectancy and healthy life expectancy of the older adult in China. According to data released by the Department of Aging Health of the National Health Commission (21), the life expectancy of 60-year-old people in China is 21.04 years, while the healthy life expectancy is 16.42 years. The life expectancy of 60-year-old people in China measured by this study is 21.07 years, and the healthy life expectancy is 16.89 years, which is close to the data released by the National Health Commission, indicating that the intrinsic capacity as a health evaluation index to measure the healthy life expectancy of the older adult has certain reference value. As a multidimensional and relatively strict evaluation index, the intrinsic capacity fully reflects the reserve function of the older adult and is committed to improving the quality of life and extending the healthy life expectancy of older adult.

In the past, China usually adopted a disease-centered nursing model for older adult, believing that the older adult are healthy without disease, thus proposing the concept of disease-free healthy life expectancy. Liu et al. (22) used the 2011 CHARLS data to measure the disease-free healthy life expectancy of older adult in China, and the results showed that the disease-free healthy life expectancy of the 60-year-old group was only 3.2 more years. Disease-free healthy life expectancy is expressed as life expectancy in a healthy state without certain disease, and as the older adult age, the proportion who suffer from chronic diseases increases; the 2022 14th 5-Year Plan for Healthy Aging shows that more than 78% of the older adult in China have at least one chronic disease (23). At present, most chronic diseases can be prevented and controlled by lifestyle changes. Kong et al. (24) found that lifestyle care management can effectively improve medical compliance behavior, reduce the occurrence of chronic disease complications, and thus improve the quality of life of patients. Therefore, using disease as a determinant of health will increase the number of unhealthy people, resulting in a longer unhealthy life expectancy and a shorter healthy life expectancy. Thus, discussing health in terms of disease no longer meets the health needs of older adult.

In 2001, the WHO published the International Classification of Functioning, Disability and Health, and scholars from various countries began to use disability or function as a health indicator

TABLE 3 Average life expectancy and healthy life expectancy of the older adult by age and sex in China (years).

Age group (year)	Overall			Male			Female		
	LE	HLE	HLE/LE (%)	LE	HLE	HLE/LE (%)	LE	HLE	HLE/LE (%)
60~	21.07	16.89	80.2	20.36	17.16	84.3	20.70	16.64	80.4
64~	18.73	13.14	70.2	16.76	13.55	80.8	16.89	12.88	76.3
68~	14.98	10.02	66.9	12.60	9.58	76.0	13.65	8.98	65.8
72~	9.32	6.11	65.6	9.98	6.50	67.1	11.73	5.67	48.3
76~	6.29	3.88	61.7	5.56	3.44	61.9	6.88	3.00	43.6
80~	2.23	1.11	49.8	3.08	1.54	50.0	3.72	1.30	34.9

TABLE 4 Average life expectancy and healthy life expectancy of the older adult in China by urban and rural areas.

Age group (year)	Rural			Urban		
	LE	HLE	HLE/LE (%)	LE	HLE	HLE/LE (%)
60~	19.53	15.30	78.3	20.84	16.17	77.6
64~	16.78	12.46	74.3	17.24	12.68	73.5
68~	11.64	8.24	70.8	13.42	8.90	66.3
72~	9.49	6.03	63.5	9.79	6.16	62.9
76~	6.98	4.08	58.5	7.48	4.23	56.6
80~	3.93	1.50	38.2	4.67	1.67	35.8

TABLE 5 Average life expectancy and healthy life expectancy of older adult individuals by income level in China (years).

Age group (year)	Low-income			Middle-high income		
	LE	HLE	HLE/LE (%)	LE	HLE	HLE/LE (%)
60~	20.22	15.19	75.1	20.76	16.26	78.3
64~	17.35	12.73	73.4	18.64	13.83	74.2
68~	12.66	8.32	65.7	14.52	9.89	68.1
72~	8.36	4.65	55.6	10.88	6.20	57.0
76~	6.92	3.43	49.6	7.01	3.67	52.3
80~	3.07	1.25	40.7	5.34	2.50	46.8

TABLE 6 Average life expectancy and healthy life expectancy of the older adult by education level in China (years).

Age group (years)	Primary school and less			Middle school and more		
	LE	HLE	HLE/LE (%)	LE	HLE	HLE/LE (%)
60~	21.74	16.42	75.5	22.84	17.15	75.1
64~	18.87	13.83	73.3	20.53	14.54	70.8
68~	14.60	10.12	69.3	16.21	11.20	69.1
72~	11.89	8.13	68.4	12.41	8.40	67.7
76~	8.97	4.29	47.8	9.84	4.43	45.0
80~	5.95	2.00	33.6	7.21	2.30	31.9

to measure the healthy life expectancy of older adult. Wang et al. (25) estimated the healthy life expectancy of older adult aged 60 and older in Jiangxi Province, China, in 2018, and the results showed that the disability-free healthy life expectancy of older adult aged 60 was 18.12 more years, which was significantly higher than the results of this study. Disability-free healthy life expectancy evaluates the health status of a population by combining the disability status of a population with life expectancy. In

2006, China conducted a large-scale national sample survey of persons with disabilities, which not only classified disabilities into visual, hearing, speech, physical, intellectual, mental, and multiple disabilities but also graded each type of disability according to the degree of impairment or abnormality (26, 27). Because the determination of disability and disability level is an objective survey based on medical testing standards and even the use of professional equipment by doctors (27), China's disability statistics are relatively low; according to the survey, the total disability prevalence rate of the population ages 60 and older is 24% (28). Although older adult have defective body parts, if these defects do not affect physical functioning, it is not comprehensive to judge their health based on whether they have physical disabilities.

At present, the most commonly used health indicator in China is the ability to perform ADLs. This indicator was originally proposed by Katz, who paid more attention to the physical ability of older adult, and then Lowton et al. (29) extended the concept of ADLs by introducing the ability to perform instrumental activities of daily living (IADLs); both of these indicators are now used to evaluate the ability of older adult to live independently. Wen et al. (30), based on the 2013–2018 CHARLS data, used ADL as health standards to measure the healthy life expectancy of older adult, and the results indicated that under the ADL standard, the healthy life expectancy of the 60-year-old group in China was 19.8 years. The data show that the healthy life expectancy measured by ADL standards is higher than the results of this study, and the reasons for the differences between different research results are analyzed. First, because ADL mainly measures the physical function of older adult individuals, compared with the assessment of intrinsic capacity, its standard of assessing health is relatively simple, so the number of healthy people with ADL as the standard is significantly more than the healthy number of healthy people with intrinsic capacity as the standard. At the same time, ADL limitations are usually observed when functional decline is obvious, and the decline in intrinsic capacity, a sensitive dynamic indicator of healthy aging, tends to occur before or even earlier than the onset of age-related diseases or symptoms.

Although the reliability and validity of objective measurement indicators such as disease, disability, ADL, etc., are high, it is difficult to measure large-scale populations, so people expect to find a subjective measurement and a method that can be close to objective health measurement, and some studies believe that health self-assessment is a comprehensive evaluation index that can evaluate all health states (31). Based on the CHARLS data from 2011 to 2015, Huang et al. (17) calculated the healthy life expectancy of older adult in China with self-rated health as the standard, and the results showed that the healthy life expectancy of the 60-year-old group of older adult in China was 16.2 years. This is lower than the findings of this study, possibly because people self-evaluate their health status by considering lifestyle, disease burden, mental state, social, physical, and emotional factors, and specific cultural factors. Because Chinese people are deeply influenced by the golden mean, they tend to be more neutral in self-rated health options and are more subtle in expressing their opinions than people in Western countries. Second, self-assessment of health largely depends on the subjective empirical perception of the disease in older adult, and many older adult may subjectively rate their health lower than physical activity status (31).

The results of this study found that the life expectancy of older men is lower than that of women, but the healthy life expectancy of older men is significantly higher than that of women, consistent with most findings. Oyen et al. (32) proposed the male and female sexual health-survival paradox, that is, women have worse health than men, but women are less likely to die than men of the same age, thus showing that women have a longer life expectancy than men, but their healthy life expectancy is lower than that of men. Song et al. (33), based on the analysis of healthy life expectancy and its proportion of total life expectancy, concluded that the value for older adult men is always higher than that of women, and being female and older adult poses a significant health disadvantage. Gender differences in life expectancy include physiological factors and behavioral patterns. Physiologically, it is believed that women have positive immune function, the protective effect of estrogen, and the compensatory effect of the second X chromosome, which can reduce the activity of growth hormone and the insulin-like growth factor 1 signaling cascade, as well as the effect of oxidative stress on aging and disease (34). Second, in terms of behavior, women have lower rates of smoking and drinking and more social activities. Although the incidence of physical illness is higher than that of men, women are more likely to seek medical attention on their own initiative and use health services more frequently. Many of these factors contribute to the lower risk of death in women than in men. However, the study found that women's healthy life expectancy is less than that of men because women are more likely than men to suffer from nonfatal chronic diseases, which, while contributing less to the risk of death, contribute to women's poor health and longer survival from the disease. At the same time, due to the different social division of labor, most women still have to bear heavy housework and family care after retirement, and their health is far worse than that of older men.

The results of this study found that the life expectancy and healthy life expectancy of older adult living in urban areas are significantly higher than those of older adult living in rural areas, but the proportion of healthy life expectancy is lower than that of older adult living in rural areas, which is inconsistent with some of the research results. Liu et al. (35) discussed the trend of self-measured healthy life expectancy and analyzed the differences between urban and rural areas and found that the life expectancy and self-measured healthy life expectancy of urban residents of all ages and their proportions were higher than those of rural residents. Huang et al. (17) measured the healthy life expectancy of the older adult in China by self-rated health as an index and found that the health status of the urban older adult was significantly better than that of the rural older adult; not only was the average life expectancy longer than that of the rural older adult, but the healthy life expectancy was also longer, and the proportion of healthy life expectancy was also higher. China has long had a dual urban–rural structure, the quality of rural health services is lower than that of cities, and the medical environment facilities are relatively underdeveloped, making it difficult to provide relatively sound

health and medical services for older adult in rural areas. Second, the education level of the rural older adult is lower than that of the urban older adult; the level of health education is low, and the health awareness is weak, which causes the life expectancy and healthy life expectancy of the urban older adult to be higher than that of the rural older adult. However, the results of this study also found that the proportion of healthy life expectancy of urban older adult is lower than that of rural older adult, and the reason for this phenomenon may be that the economic income of rural older adult mainly comes from the primary industry, high work intensity, and mainly physical exertion, which potentially leads to the duration of the health state of rural older adult individuals being longer than that of urban older adult. The healthy life expectancy of rural older adult under the original health conditions is longer than that of urban older adult, and rural older adult live shorter lives than urban older adult in an unhealthy state. Conversely, in urban areas, good medical conditions and living conditions protect unhealthy older people, resulting in a relatively high risk of death and extending their overall life expectancy when they are unhealthy.

The results of this study found that the life expectancy, healthy life expectancy and proportion of middle- and upper-income older adult are significantly higher than those of lower-income older people, which is consistent with most research results. Kaneda et al. (36) showed that the income of the male group had a significant impact on their healthy life expectancy, and the healthy life expectancy of the high-income group was 1.57 times that of the low-income group, but there was no significant difference in healthy life expectancy between the high-income group and the low-income group of women. Qiao et al. (37) compared and analyzed the population health indicators among 31 provinces in China and found that the health level of older adult individuals with good socioeconomic conditions was significantly higher than that of older adult with poor economic conditions. Older adult with low incomes cannot flexibly access a variety of health resources through multiple strategies and channels, are limited by economic conditions and are prone to the phenomenon of "minor diseases not treated," and the pursuit of healthy quality of life is low.

The results of this study found that the life expectancy and healthy life expectancy of older adult with higher education were significantly higher than those of older adult with low education, but the proportion of healthy life expectancy was relatively low, which is consistent with some research results. Jiao et al. (38) found that older people with lower levels of education have lower life expectancy and healthy life expectancy than older people with higher levels of education. However, in terms of healthy life expectancy as a proportion of total life expectancy, older people with lower levels of education are higher than those with higher levels of education. Wu et al. (7) used ADL as an indicator to measure the healthy life expectancy of the older adult in China and found that the average life expectancy and healthy life expectancy of the older adult with higher education levels were longer, but the proportion of healthy life expectancy was relatively low. The findings are the same as the difference in healthy life expectancy between urban and rural older people. Older adult with low education levels are mostly physical laborers, and their physical function is relatively good, so in the initial healthy state, their health is expected to be maintained for a relatively long time, but due to the limitations of economic level, older adult individuals with low education levels have a lower functional recovery rate and a higher risk of death, resulting in relatively short unhealthy survival. Conversely, older adults with higher levels of education have higher rates of functional recovery and lower risk of death, and this group is expected to transition to unhealthy for a longer period of time than less educated older people under initially healthy conditions and remain unhealthy under unhealthy conditions for a higher expected period of time than less educated older people, ultimately resulting in a relatively longer overall unhealthy life expectancy for older people with higher levels of education.

The root cause of the health inequality of China's older adult is unequal access to health resources for different social classes. Factors such as living conditions and health services determined by social class are variables related to health level, and these variables should be observed not only in old age but also in the entire life course of the individual (39). In the current social equity-oriented social context and in the global context of promoting healthy aging, we must take active and effective measures to reduce health inequalities caused by social class differences.

Although the current policy benefits for the older adult in society are gender neutral, they ignore the different social roles, responsibilities and abilities of men and women and subtly exacerbate gender health inequalities. Therefore, the government should account for gender differences when formulating public policies and allocating public resources. The focus on promoting women's rights and equality throughout the life cycle requires improving women's disadvantage in nutrition, education, and health services early on and reducing disparities in employment, income, and family care in adulthood to enhance women's health and socioeconomic accumulation throughout their lives (40, 41).

The basic health rights and interests of older adult from low social strata should be guaranteed, including rural older adult with low education levels and poor economic conditions at the bottom of China's basic social security system. At this stage, there are still inequalities in the level of medical services, pension policies and educational resources in China, and the government should actively carry out the reform of the medical and health system to form a fair and healthy medical mechanism for the whole society (42). The government should actively narrow the gap between urban and rural areas, promote the construction of the older adult health service system and older adult health services as an important component of the construction of local health service systems and health development plans, and promote the balanced development of urban and rural and regional older adult health services. At the same time, it is also necessary to actively improve the aging level of the medical and health service system, improve the older adult health service system, promote the older adult health prevention threshold forward, continue to expand the coverage of high-quality community older adult health services in terms of content, region, infrastructure and other aspects, and provide precision health services to the older adult with different intrinsic capacities (43).

The awareness of health services for the older adult should be enhanced, publicity and education on health knowledge

for the older adult should be strengthened, and a variety of methods and media should be used to widely disseminate popular science knowledge such as nutritious diet, sports and fitness, mental health, disease prevention, rational drug use, rehabilitation nursing, life education and health care to the older adult and their caregivers. Health literacy promotion projects for the older adult should be organized and implemented to strengthen health education in a targeted manner and improve the health literacy of older adult. Regular health check-ups should be conducted and the health status of the older adult in the lower social class considered in the provision of high-quality medical protection.

The advantage of this study is that it adopts prospective cohort studies and, for the first time, uses intrinsic capacity as an indicator to measure the health of the older adult by measuring healthy life expectancy, using intrinsic capacity as a framework for assessing and monitoring the health of older adult. Different from the previous concept of discussing health by the presence of diseases, this perspective pays more attention to the function of older adult and measures the healthy life expectancy of the older adult with intrinsic capacity. This forms a new health standard by which to measure healthy life expectancy and expands the theoretical framework of health evaluation connotation. Furthermore, we used the multistate life table method to measure and analyze the difference in the healthy life expectancy of the older adult at different social levels, which not only reflects the changes in the health status of the older adult but also provides a reference for the formulation of national policies. The study was also flawed. First, Because the physical examination data were not published in the CHARLS database in 2018, this study could not use the latest updated follow-up data in 2018 to study the healthy life expectancy of older adult individuals, resulting in the untimeliness of this study. The team will continue to pay attention to the latest news on CHARLS data in 2023 and will continue to conduct further research on the healthy life expectancy of older adult individuals by expanding the sample size and extending the follow-up time; furthermore, the latest data will be used to discuss and analyze the current status of the intrinsic capacity of older adult and the empirical results of the healthy life expectancy of older adult in communities in China based on the intrinsic capacity health standard. Second, intrinsic capacity reflects the overall function of the body and mind, and a reasonable scoring method can better reflect the functional level of older adult and enhance the comparability of different research results. The scoring method of intrinsic capacity is still in the exploratory stage. In this study, only the integrity of intrinsic capacity was used as a health criterion for the older adult, and the decline in intrinsic capacity was considered an unhealthy criterion. Therefore, how to translate each individual function into the scoring method for overall intrinsic capability needs further exploration. Third, older persons are a special group, and existing social stratification standards have certain limitations for them. For example, most people aged 60 and older have withdrawn from the labor market or have become inactive. Therefore, whether the economic income level of the older adult can become the criterion for social stratification needs further confirmation.

Conclusion

Healthy life expectancy combines life length and quality of life and is a comprehensive index used to evaluate the health level of the world population. The health level of the older adult is the basic factor in the construction of a social old-age service system, and the health inequality caused by social stratification is an important perspective when discussing healthy life expectancy. To this end, in today's sharing of the fruits of social and economic development, the government and all levels of society should focus on the health status of older adult in the lower social class, provide them with more health knowledge and medical services through different channels, and protect their health rights and interests. As a framework for monitoring the health of older adult, intrinsic capacity scientifically, objectively and comprehensively evaluates the health level of the older adult in various dimensions and enriches the connotation of health among these individuals in China. Future research can synthesize advanced research concepts at home and abroad and combine China's national conditions to propose a more scientific intrinsic capacity evaluation system and objectively assign weights in various fields to more accurately measure the healthy life expectancy of older adult.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

Ethics statement

The studies involving humans were approved by the public database of the China Health and Retirement Longitudinal Study and received ethics approval from the Biomedical Ethics Committee of Peking University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ML: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing. MZ: Writing – review & editing. LZ: Funding acquisition, Resources, Supervision, Writing – original draft, Writing – review & editing. JZ: Writing – review & editing. NS: Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was supported by the 2021 Anhui University Humanities and Social

Science Research Key Project "Research on Theoretical Model Construction and Intervention Research of Community Elderly Exercise Behavior Health Promotion" (No. SK2021A0443, 2018), the Anhui University Humanities and Social Sciences Research Key Project "Research on Evaluation Index System of Long-term Care Grading Standards for the Elderly" (No. SK2018A0178, 2023), and the Bengbu Medical College Graduate Research and Innovation Program Funding Project "Research on Healthy Life Expectancy and Social Stratification Analysis of Elderly People in China Based on Intrinsic Ability Health Standards" (Project No.: Byycx23016).

Acknowledgments

We would like to express our gratitude to both the study participants and the CHARLS researchers.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. *Population Division, United Nations Department of Economic and Social Affairs*. World Population Prospects 2022 [EB/OL] [2022-7-11].

2. Tong YF. The latest dynamics and trends of Chinese ports—an analysis based on the data of the seventh national census. *J China Institute Labor Relat.* (2021) 35:15–25. doi: 10.1007/978-981-16-3085-9_3

3. World Health Organization. *The Global Health Observatory*. Available online at: http://www.who.int/date/gho/date/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy (accessed February 02, 2022).

4. Reporter. The CPC Central Committee and the State Council issued the "Healthy China 2030" Planning Outline, the health industry has great prospects, and healthy China is imperative. *China Brand Anti-counterfeits.* (2023) 1:4–6.

5. World Health Organization. *Ageing*. Geneva: World Health Organization (2021). Available online at: https://www.who.int/health-topics/ageing#tab=tab-1

6. *The General Office of the State Council issued the Opinions on Promoting the Development of Elderly Care Services.* Civil Affairs of China (2019), p. 5.

7. Wu BY, Dong HL, Yu Q, Wu JL, Qiao XC. Social stratification analysis of healthy life expectancy of elderly population in China. *Popul Dev*. (2021) 27:2–11.

8. Li F. *Comparison of Marx and Weber's Social Stratification Theory*. Shandong University (2022). doi: 10.27272/d.cnki.gshdu.2022.004178

9. Max Weber. *Economy and Society. Lin Rongyuan, trans*. Beijing: Commercial Press (1997).

10. Lièvre A, Alley D, Crimmins EM. Educational different:als in life expectancy with cognitive impairment among the elderly in the United States. *J Aging Health.* (2008) 20:456–77. doi: 10.1177/0898264308315857

11. Solé-Auró A, Beltrán-Sánchez H, Crimmins EM. Are differences in disability-free life expectancy by gender, race, and education widening at older ages. *Popul Res Policy Rev.* (2014) 34:1–18. doi: 10.1007/s11113-014-9337-6

12. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol.* (2014) 43:61–8. doi: 10.1093/ije/dys203

13. Beard JR, Jotheeswaran AT, Cesari M, de Carvalho IA. The structure and predictive value of intrinsic capacity in a longitudinal study of ageing. *BMJ Open.* (2019) 9:e026119. doi: 10.1136/bmjopen-2018-026119

14. López-Ortiz S, Lista S, Peñín-Grandes S, Pinto-Fraga J, Valenzuela PL, Nisticò R, et al. Defining and assessing intrinsic capacity in older people: a systematic review and a proposed scoring system. *Ageing Res Rev.* (2022) 79:101640. doi: 10.1016/j.arr.2022.101640

15. Huang QB, Wang X H, Chen G. Reliability and validity of 10-item CES-D among middle aged and older adults in China. *China J Health Psychol.* (2015) 23:1036–41.doi: 10.13342/j.cnki.cjhp.2015.07.023

16. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D. *Am J Prev Med.* (1994) 10:77–84. doi: 10.1016/S0749-3797(18)30622-6

17. Huang GG, Chen TH, Chen Gong, Guo F. Research on healthy life expectancy of the elderly in China-Based on the measurement of subjective health dimension. *Popul Dev*. (2021) 27:74–84.

18. Weeks JD, Dahlhamer JM, Madans JH, Maitland A. Measuring disability: an examination of differences between the washington group short set on functioning and the American community survey disability questions. *Natl Health Stat Report.* (2021) 161:1–9. doi: 10.15620/cdc:107202

19. Tarazona B, González-Enríquez J, Almazán-Isla J, Alcalde-Cabero E, de Pedro-Cuesta J, Galán I. Validity of the Global Activity Limitation Indicator (GALI) to evaluate severity of disability. *Eur J Public Health.* (2021) 31:539–40. doi: 10.1093/eurpub/ckaa214

20. Huang GG, Chen G, Guo F. Healthy life expectancy of the elderly in China: based on the measurement of depression dimension. *Northwest Popul.* (2020) 41:1–12.

21. National Health Commission of the People's Republic of China. Available online at: http://www.nhc.gov.cn

22. Liu Y. *Calculation and application of healthy life expectancy of the elderly in China* (MA thesis). Minzu University of China (2016).

23. Hua F. *The 15th department issued the "14th Five-Year Plan" for healthy aging. Friends of old comrades: Second half of the month* (2022), p. 15.

24. Kong LY. Effects of lifestyle care management on blood glucose, blood pressure control and complications in patients with diabetes complicated with hypertensive cerebral hemorrhage. *Heilongjiang Med J.* (2023) 47:739–41.

25. Wang S, Hu S, Wang P, Wu Y, Liu Z, Zheng H. Disability-free life expectancy among people over 60 years old by sex, urban and rural areas in Jiangxi Province, China. *Int J Environ Res Public Health*. (2021) 18:4636. doi: 10.3390/ijerph18094636

26. Huang J, Cao HH, Tang J, Wang S. An analysis of the spatial transfer and employment of the disabled labor force. *Northwest Popul.* (2008) 29:111–9.

27. Qiao XC. Comprehensive population health measurement and health measurement. *Popul Soc.* (2022) 38:1–16.

28. Xiong NA, Ye Q, Shi JL. Analysis of disability status of elderly people in China in 2006. *Disabil Res.* (2011) 3:76–9.

29. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist*. (1969) 9:179–86.

30. Wen Y, Lin ZC. Study on healthy life expectancy of elderly people in China based on IADL health standards. *Popul Soc.* (2022) 38:35–46.

31. Du BF, Mu YX, Sheng J. Predictors, contribution degree and group differences of self-rated health of the elderly. *China Health Policy Res.* (2022) 15:8–16.

32. Oyen H, Nusselder W, Jagger C, Kolip P, Cambois E, Robine J-M. Gender differences in healthy life years within the EU: an exploration of the "healthsurvival" paradox. *Int J Public Health*. (2013) 58:143–55. doi: 10.1007/s00038-012-0361-1

33. Song LJ, Yang L. The evolution trajectory and influencing factors of healthy life expectancy of the elderly population: an empirical study based on CLHLS. *Popul Econ*. (2020) 3:57–74.

34. Mascitelli L, Pezzetta F, Sullivan JL. Why women live longer than men: sex differences in longevity. *Gend Med*. (2006) 3:341–2. doi: 10.1016/s15508579(06)802214

35. Liu Z, Zheng H, Wu Y, Wang S, Liu Y, Shu S. Self-rated healthy life expectancy changes in Jiangxi province of China by gender and urban-rural differences, 2013-2018. *Front Public Health*. (2021) 8:596249. doi: 10.3389/fpubh.2020.596249

36. Kaneda T, Zimmer Z, Tang Z. Socioeconomic status differentials in life and active life expectancy among older adults in Beijing. *Disabil Rehabil*. (2005) 27:241–51. doi: 10.1080/09638280400006481

37. Qiao XC, Hu Y. Healthy life expectancy and interprovincial differences among the elderly in China. *Popul Dev*. (2017) 23:2–18.

38. Jiao KS. Inequality of healthy life expectancy for the Chinese elderly and its trend. *J Chinese Sociol*. (2019) 6. doi: 10.1186/s40711-019-0111-3

39. Henriques A, Ruano L, Fraga S, Soares S, Barros H, Talih M. Life-course socio-economic status and its impact on functional health of Portuguese older adults. *J Biosoc Sci*. (2023) 56:36–49. doi: 10.1017/S0021932023000093

40. Lu M, Wang XH, Peng C. Analysis on the trends of disability free life expectancy of older adults in China in the context of gender neutrality of social policy: an empirical study based on the sample survey of 1% population in 2005 and 2015. *Popul Dev*. (2019) 25:100–10.

41. Lu M, Wang X, Shen K, Ji C, Li W. Change trend and gender differences in disability-free life expectancy among older adults in China, 2010-2020. *Front Public Health*. (2023) 11:1167490. doi: 10.3389/fpubh.2023.1167490

42. Dou LL. *Measurement of Health Status and Influencing Factors of Middle Aged and Elderly Population in Henan*. Henan University of Economics and Law (2020).

43. Wang H, Liu HM. Rural old-age security policy in institutional change: integration logic and path selection. *Theor Reform*. (2023) 4:131–46+164.

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 13 February 2024
DOI 10.3389/fpubh.2024.1226239

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Eric Lichtenstein,
University of Basel, Switzerland
José Eduardo Teixeira,
Polytechnic Institute of Bragança (IPB), Portugal

*CORRESPONDENCE
Tian-Shyug Lee
✉ 036665@mail.fju.edu.tw

RECEIVED 21 May 2023
ACCEPTED 12 January 2024
PUBLISHED 13 February 2024

CITATION
Yeh P-C, Syu D-K, Ho C-C and Lee T-S (2024) Associations of lower-limb muscle strength performance with static and dynamic balance control among older adults in Taiwan. *Front. Public Health* 12:1226239. doi: 10.3389/fpubh.2024.1226239

COPYRIGHT
© 2024 Yeh, Syu, Ho and Lee. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Associations of lower-limb muscle strength performance with static and dynamic balance control among older adults in Taiwan

Ping-Chun Yeh[1,2], De-Kai Syu[1,2], Chien-Chang Ho[2,3,4] and Tian-Shyug Lee[1,5]*

[1]Graduate Institute of Business Administration, Fu Jen Catholic University, New Taipei City, Taiwan, [2]Sports Medicine Center, Fu Jen Catholic Hospital, New Taipei City, Taiwan, [3]Department of Physical Education, Fu Jen Catholic University, New Taipei City, Taiwan, [4]Research and Development Center for Physical Education, Health and Information Technology, College of Education, Fu Jen Catholic University, New Taipei City, Taiwan, [5]Artificial Intelligence Development Center, Fu Jen Catholic University, New Taipei City, Taiwan

Background: Aging is an inevitable process of life development. These physical changes can cause a decline in the functional adaptability and health status of older adult individuals.

Aims: The purpose of this study was to investigate the association of lower-limb muscle strength performance with static and dynamic balance control among older adults in Taiwan.

Methods: We conducted a cross-sectional study and reviewed data derived from the National Physical Fitness Survey in Taiwan 2015–2016. A total of 20,846 Taiwanese older adult individuals aged 65 years old or older were recruited as study participants. Demographic characteristics, anthropometric assessments, lifestyle habits, and health-related physical fitness measurements from this dataset were analyzed using the chi-square test, one-way analysis of variance, and linear regression analysis. Lower-limb muscle strength performance was classified into 4 groups based on quartile (Quartile 1 [Q1], Quartile 2 [Q2], Quartile 3 [Q3], and Quartile 4 [Q4]) values.

Results: Increased lower-limb muscle strength levels were significantly associated with static balance in men (Q2: $\beta = 2.539$, $p < 0.0001$; Q3: $\beta = 4.590$, $p < 0.0001$; Q4: $\beta = 7.700$, $p < 0.0001$) and women (Q2: $\beta = 2.022$, $p < 0.0001$; Q3: $\beta = 4.179$, $p < 0.0001$; Q4: $\beta = 6.920$, $p < 0.0001$) after adjusting for potential confounders. In addition, we observed that increased lower-limb muscle strength levels were significantly associated with dynamic balance in men (Q2: $\beta = -1.661$, $p < 0.0001$; Q3: $\beta = -2.434$, $p < 0.0001$; Q4: $\beta = -3.091$, $p < 0.0001$) and women (Q2: $\beta = -1.660$, $p < 0.0001$; Q3: $\beta = -2.548$, $p < 0.0001$; Q4: $\beta = -3.196$, $p < 0.0001$) after adjusting for potential confounders.

Conclusion: Lower-limb muscle strength was the most important factor, as it was an improved method for static and dynamic balance control in both genders.

KEYWORDS

lower-limb muscle strength, balance, older adult, cross-sectional study, Taiwan

Introduction

In 2022, there were 4.1 million or 17.5% adults older than 65 years old living in Taiwan (1). Furthermore, it is estimated that the proportion of Taiwanese older adults could be higher than 20% by 2025, which refers to a "superaged society." Aging is strongly associated with a decrease in muscle strength and muscle mass, resulting in physical dysfunction (e.g., gait speed agility and balance), falling and deterioration in quality of life (2, 3). Therefore, successful aging is an important issue for the older adult population in Taiwan to promote health and maintain active engagement with life (4, 5).

Falls are the leading cause of fractures and even deaths among older adult adults (6). The most common fall-induced fractures occur at the hip, spine, upper arm and forearm (7). Of these fractures, hip fractures have serious consequences, such as reduced mobility and independence and high mortality in the first three months (3, 8). Numerous studies indicated that older adult fallers are characterized by lower muscle strength of the lower extremities and slower walking speeds (6, 9–12). A similar study reported that the main determinants for recurrent falls included fall history, muscle strength, abnormal postural sway (e.g., balance and gait disturbances), and depression (8, 13–15).

It has been shown that the one-leg stance with eye open test is a readily applicable screening tool in clinical and geriatric environments, used to assess postural steadiness during static positions (16); failing to pass a 5-s threshold could indicate functional impairment, thereby heightening the risk of falls (17). Khanal et al. suggested that older adult individuals with a one-leg standing test below the 55-s threshold (the sum of both legs) have low muscle mass and a high risk of developing sarcopenia (18). A study indicated that independent older adult adults have higher walking speeds than dependent older adults, such as those living in nursing or rest homes (19). In addition, the 8-foot up-and-go test has been successfully associated with dynamic balance, agility and walking speed performance, as well as fall risk, in the older adult population (2). Thus, older adult adults with good static and dynamic balance and quick walking speeds might have better independence and a lower risk of sarcopenia and falling. This was supported by past research, which found that the risk of falls in the older adult was associated with low muscle strength and physical fitness, but not with low muscle mass (20).

Taiwan is not only a highly technologically developed country but also an aged society. To our knowledge, no study has yet reported the relationship between lower extremity muscle strength and static and dynamic balance among Taiwanese older populations. Therefore, in the present study, we aimed to investigate the association between lower-limb muscle strength performance and static and dynamic balance control among older adults in Taiwan.

Materials and methods

Study design and sample

This study used a cross-sectional study design with data from the National Physical Fitness Survey in Taiwan (NPFSIT) 2015–2016. The NPFSIT was conducted by the Sports Administration, Ministry of Education in Taiwan and assessed the health-related physical fitness status of a sample population of community-dwelling older Taiwanese adults (≥ 65 years old) selected according to a convenience sampling. Convenience sampling is a specific type of non-probabilistic sampling method that relies on data collection from populations who are conveniently available to participate in the study, and it is most frequently used in quantitative studies (21).

A total of 21,386 participants in the NPFSIT 2015–2016 were recruited from 35 testing stations in 20 cities or counties in Taiwan from October 2015 to April 2016; the detailed procedure of the present study has been published elsewhere (22–24). The NPFSIT combines face-to-face interviews (demographic and socioeconomic characteristics, health-related lifestyles, and disease history) and health-related physical fitness surveys with resting heart rate and blood pressure measurements for safe preliminary screening before conducting physical fitness tests. Table 1 presents the demographic background characteristics of the 20,846 older adults classified into four quartiles of lower limb muscle strength performance. The participants' demographic characteristics included age, gender, body composition (height, body weight, body mass index [BMI], waist circumference [WC], hip circumference [HC], waist-to-hip ratio [WHR]), education level, income level, marital status, relationship status, and regular exercise.

Detailed information about NPFSIT is available at https://isports.sa.gov.tw/index.aspx. Ethical procedures for the study were approved by the Institutional Review Board of Fu Jen Catholic University (FJU-IRB C110113), and written informed consent was obtained from each participant.

Eligibility criteria for study participants

The target population for the NPFSIT was the 2,866,067 older adults whose residence were registered in Taiwan in the middle of 2015 (25). Subsequently, the representative sample size with stratification by gender and age needed, to achieve the study objectives and sufficient statistical power, was calculated with a sample size calculator (26). The sample size calculator arrived at 1,848 participants for each gender- and age-stratification, using a margin of error of ±3%, and a confidence level of 99%. The required total sample size was 18,480 participates in the NPFSIT 2015–2016. The exclusion criteria were (1) systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg; and (2) currently/previously have heart disease, hypertension, chest pain, vertigo or musculoskeletal disorders. Finally, our analysis included a final total of 20,846 Taiwanese older adult participants.

Lower extremity muscle strength performance

Lower extremity muscle strength performance was determined using the 30-s chair stand test (reps). For the 30-s chair stand test, each participant had to sit on a chair with the hands on the opposite shoulder crossed at the wrists, feet flat on the ground, and back straight. At the "Start" sign, individuals had to rise to a full standing position and sit back down again as fast as they could for 30 s. Participants performed the test once, and the total number of repetitions within 30 s was recorded for analysis. Jones et al. (27) reported that the correlation between the 30-s chair stand test and

TABLE 1 Characteristics of the study participants according to lower-limb muscle strength levels among older adults in Taiwan.

Variables	Lower-limb muscle strength levels				F/x^2 (p)	Tukey's *post hoc* test
	Quartile 1 (n = 4,394)	Quartile 2 (n = 5,142)	Quartile 3 (n = 5,702)	Quartile 4 (n = 5,608)		
Age (%)	76.54 ± 6.74	74.22 ± 6.33	72.71 ± 6.00	71.50 ± 5.49	627.74 (< 0.0001*)	Q1 > Q2 > Q3 > Q4
65–74 years old	40.10	55.06	64.91	74.14	1444.49 (< 0.0001*)	
75–84 years old	47.09	37.94	31.09	23.20		
≧85 years	12.81	7.00	4.00	2.66		
Gender (%)					(< 0.0001*)	
Male	39.96	35.80	27.85	39.21		
Female	60.04	64.20	72.15	60.79		
Height (cm)	156.03 ± 8.20	156.36 ± 7.85	155.57 ± 7.53	156.78 ± 7.92	23.77 (< 0.0001*)	Q3 < Q1, Q2 < Q4
Body weight (kg)	61.48 ± 10.79	61.44 ± 10.55	59.92 ± 9.96	59.76 ± 9.87	42.93 (< 0.0001*)	Q1, Q2 > Q3, Q4
BMI (kg/m^2)	25.21 ± 3.75	25.09 ± 3.66	24.72 ± 3.52	24.27 ± 3.31	73.28 (< 0.0001*)	Q1, Q2 > Q3 > Q4
WC (cm)	89.03 ± 10.09	87.19 ± 9.70	84.98 ± 9.64	83.44 ± 9.17	324.63 (< 0.0001*)	Q1 > Q2 > Q3 > Q4
HC (cm)	97.12 ± 7.57	96.63 ± 7.52	95.74 ± 7.08	94.16 ± 6.48	121.99 (< 0.0001*)	Q1 > Q2 > Q3 > Q4
WHR	0.92 ± 0.07	0.90 ± 0.07	0.89 ± 0.07	0.88 ± 0.07	252.14 (< 0.0001*)	Q1 > Q2 > Q3 > Q4
Education level (%)					1220.16 (< 0.0001*)	
Elementary school or lower	77.49	69.55	61.25	45.62		
Junior or senior school	17.23	22.01	27.06	35.27		
College or higher	5.29	8.44	11.70	19.12		
Monthly income level (%)					295.31 (< 0.0001*)	
≦ 20,000 NTD	93.13	90.81	88.48	82.56		
20,001–40,000 NTD	5.07	5.76	6.90	9.72		
≧ 40,001 NTD	1.80	3.43	4.61	7.72		
Marital status (%)					99.41 (< 0.0001*)	
Never married	4.33	3.19	2.95	3.89		
Married	74.99	79.82	80.45	82.53		
Divorced/separation/ widowed	20.69	16.98	16.60	13.58		
Relationship status (%)					46.36 (< 0.0001*)	
Living with someone	78.70	81.27	81.49	84.07		
Not living with someone	21.30	18.73	18.51	15.93		
Weekly regular exercise level (%)					40.57 (< 0.0001*)	
≧150 min/week	21.03	24.17	25.41	26.23		
< 150 min/week	78.97	75.83	74.59	73.77		
30-s chair stand (reps)	8.38 ± 2.53	12.39 ± 0.92	15.52 ± 1.05	21.49 ± 3.67	28189.40 (< 0.0001*)	Q1 < Q2 < Q3 < Q4

BMI, body mass index; HC, hip circumference; NTD, new Taiwan dollar; Quartile 1, Q1; Quartile 2, Q2; Quartile 3, Q3; Quartile 4, Q4; SD, standard deviation; WC, waist circumference; WHR, waist-to-hip ratio. Values are expressed as the means ± SDs. *$p < 0.05$.

one-repetition maximum muscle strength is relatively high ($r = 0.77$). In addition, the high reliability of 30-s chair stand test is 0.89 and considered suitable for demonstrating a reliable and valid measurement of lower extremity muscle strength (27, 28).

The analysis of continuous variables for lower extremity muscle strength performance were conducted. Furthermore, lower extremity muscle strength levels were then categorized into quartiles of 30-s chair stand test performance within gender category strata, with Quartile 1 (Q1) having the worst and Quartile 4 (Q4) the best performance. The quartiles of 30-s chair stand test in males were < 12 reps (Q1), 12–14 reps (Quartile 2 [Q2]), 15–18 reps (Quartile 3 [Q3]), and > 18 reps (Q4). The quartiles of 30-s chair stand test in females were < 11 reps (Q1), 11–13 reps (Q2), 14–18 reps (Q3), and > 18 reps (Q4).

Balance control

Two types of balance control were considered in this study. Static balance was determined using a one-leg stance with an open eye test (seconds). One-leg stance with eye open was measured on the preferred leg indicated by each participant. Individuals had to place their hands on their hips, lift the nonpreferred leg off the ground and maintain their balance while standing with the preferred leg. The participant was timed starting from when the nonpreferred leg was raised until the nonpreferred leg was set back down on the floor, the crossed hands were separated from their hips, or the preferred leg moved from the standing position. Performance was quantified in seconds, a time that took the participant to complete the test. In addition, the high reliability of one-leg stance with an open eye test is 0.90–0.91 and considered suitable for demonstrating a reliable and valid measurement of static balance (29).

Dynamic balance was determined using the 8-foot up-and-go test (seconds). The test began with the participant fully seated on a chair placed at the starting point. On the "Start" signal, the individual rose from the chair, walked around a cone that was placed 8 feet (2.44 m) from the chair, and returned to a seated position on the chair as fast as possible. Performance was quantified in seconds, i.e., a time that the participant took to complete the test. In addition, the high reliability of 8-foot up-and-go test is −0.81 and considered suitable for demonstrating a reliable and valid measurement of dynamic balance (30).

All participants performed the static and dynamic balance tests twice, and better performance was recorded for analysis.

Covariate assessment

Considering the impact of other covariates on static and dynamic balance control performance, we controlled for potential confounders to perform covariate-adjusted analyses. The selection of potential confounders that might affect static and dynamic balance control was performed according to previous studies and accessibility data from the NPFSIT database. Respondents were surveyed on sociodemographic variables, including age, gender (male, female), education level (elementary school or lower, junior or senior school, and college or higher), monthly income level (≦20,000 NTD, 20,001–40,000 NTD, and ≧40,001 NTD), marital status (never married, married, and divorced/separation/widowed), relationship status (living with someone, not living with someone), and weekly regular exercise level (≧150 min/week, < 150 min/week). Anthropometric variables included height, body weight, BMI, WC, HC, and WHR. Height, body weight, WC and HC were measured and recorded by trained study assistants according to NPFSIT anthropometric standard procedures (31). BMI was calculated as the participant's body weight in kilograms divided by the square of height in meters. WHR was calculated as the participant's WC in centimeters divided by the HC in centimeters. Obesity was classified into two categories: general and abdominal obesity. According to the Taiwan's Health Promotion Administration of Ministry of Health and Welfare guidelines (32), the normative values for general obesity was defined as underweight (BMI < 18.5 kg/m^2), normal (18.5 kg/m^2 ≦ BMI < 24.0 kg/m^2), overweight (24.0 kg/m^2 ≦ BMI < 27.0 kg/m^2) and obese (BMI ≧ 27.0 kg/m^2). The normative values for abdominal obesity were defined either way: (1) WC ≥ 90 cm for males or WC ≥ 80 cm for females; (2) WHR ≥ 0.90 for males or WHR ≥ 0.85 for females according to the Taiwan's Health Promotion Administration of Ministry of Health and Welfare guidelines (32).

Statistical analysis

The software used to perform the statistical analysis for this study was SAS, version 9.4 (SAS Institute, Cary, NC, United States). For descriptive statistics, characteristics of the study participants were compared among lower-limb muscle strength quartiles with the chi-square test for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. When a significant F value was found ($p < 0.05$), Tukey's *post hoc* test was performed to determine the differences between the pairs of means. To examine the dose–response relationship of lower-limb muscle strength performance with static and dynamic balance control measurements, we established four different categories (quartiles) for the 30-s chair stand measurement. The lowest quartile (the reference group) comprised participants who performed the worst in the 30-s chair stand measurement. Multiple linear regression models were used to determine the associations of the continuous or categorical (quartiles) variables in lower-limb muscle strength performance with static and dynamic balance control measurements, and the results are presented as β coefficients. All values are expressed as the mean ± standard deviation (SD) or the percentage. For all the analyses, a p value of <0.05 was considered statistically significant.

Results

Table 2 shows the association of continuous or categorical (quartiles) variables in lower extremity muscle strength performance with static and dynamic balance control measures. For both genders, continuous variables in lower extremity muscle strength performance were significantly associated with static and dynamic balance control measures. Moreover, whether the participant was male or female, after adjusting for BMI, education, monthly income, and marital and relationship status, there was still significant, positive regression coefficient values in static balance measures (Men: $\beta = 0.553$, $p \leq 0.0001$; Women: $\beta = 0.503$, $p \leq 0.0001$) and negative regression coefficient values in dynamic measures (Men: $\beta = -0.206$, $p \leq 0.0001$; Women: $\beta = -0.222$, $p \leq 0.0001$).

For both genders, categorical (quartiles) variables in lower extremity muscle strength performance were significantly associated with static and dynamic balance control measures. Increased lower-limb muscle strength levels were significantly associated with static balance in men (Q2: $\beta = 2.539$, $p \leq 0.0001$; Q3: $\beta = 4.590$, $p \leq 0.0001$; Q4: $\beta = 7.700$, $p \leq 0.0001$) and women (Q2: $\beta = 2.022$, $p \leq 0.0001$; Q3: $\beta = 4.179$, $p \leq 0.0001$; Q4: $\beta = 6.920$, $p \leq 0.0001$) after adjusting for potential confounders. In addition, we observed that increased lower-limb muscle strength levels were significantly associated with dynamic balance in men (Q2: $\beta = -1.661$, $p \leq 0.0001$; Q3: $\beta = -2.434$, $p \leq 0.0001$; Q4: $\beta = -3.091$, $p \leq 0.0001$) and women (Q2: $\beta = -1.660$, $p \leq 0.0001$; Q3: $\beta = -2.548$, $p \leq 0.0001$; Q4: $\beta = -3.196$, $p \leq 0.0001$) after adjusting for potential confounders.

TABLE 2 Multiple regressions for the associations of the continuous or categorical (quartiles) variables in lower-limb muscle strength performance with static and dynamic balance control measurements after adjustment for potential confounders.

Variables	Lower-limb muscle strength performance	Model 1[a]				Model 2[b]			
		β	SE	*p*	Partial eta squared	*β*	SE	*p*	Partial eta squared
Men									
Static balance	Continuous variable	0.667	0.023	< 0.0001*	0.111	0.553	0.026	< 0.0001*	0.079
One-leg stance with eye open test (s)	Categorical variable								
	Q4	9.295	0.356	< 0.0001*	0.085	7.700	0.394	< 0.0001*	0.059
	Q3	5.325	0.377	< 0.0001*	0.026	4.590	0.405	< 0.0001*	0.021
	Q2	2.723	0.360	< 0.0001*	0.008	2.539	0.385	< 0.0001*	0.007
	Q1	Ref.	—	—		Ref.	—	—	
Test for trend		*p* < 0.0001*				*p* < 0.0001*			
Dynamic balance	Continuous variable	−0.225	0.004	< 0.0001*	0.327	−0.206	0.005	< 0.0001*	0.295
8-foot up-and-go test (s)	Categorical variable								
	Q4	−3.370	0.067	< 0.0001*	0.255	−3.091	0.073	< 0.0001*	0.224
	Q3	−2.601	0.071	< 0.0001*	0.154	−2.434	0.075	< 0.0001*	0.145
	Q2	−1.755	0.068	< 0.0001*	0.083	−1.661	0.072	< 0.0001*	0.080
	Q1	Ref.	—	—		Ref.	—	—	
Test for trend		*p* < 0.0001*				*p* < 0.0001*			
Women									
Static balance	Continuous variable	0.645	0.018	< 0.0001*	0.094	0.503	0.020	< 0.0001*	0.063
One-leg stance with eye open test (s)	Categorical variable								
	Q4	8.745	0.273	< 0.0001*	0.071	6.920	0.305	< 0.0001*	0.047
	Q3	5.291	0.259	< 0.0001*	0.030	4.179	0.284	< 0.0001*	0.021
	Q2	2.388	0.268	< 0.0001*	0.006	2.022	0.291	< 0.0001*	0.005
	Q1	Ref.	—	—		Ref.	—	—	
Test for trend		*p* < 0.0001*				*p* < 0.0001*			
Dynamic balance	Continuous variable	−0.243	0.003	< 0.0001*	0.324	−0.222	0.004	< 0.0001*	0.287
8-foot up-and-go test (s)	Categorical variable								
	Q4	−3.517	0.052	< 0.0001*	0.252	−3.196	0.060	< 0.0001*	0.218
	Q3	−2.729	0.050	< 0.0001*	0.183	−2.548	0.055	< 0.0001*	0.170
	Q2	−1.773	0.052	< 0.0001*	0.081	−1.660	0.057	< 0.0001*	0.076
	Q1	Ref.	—	—		Ref.	—	—	
Test for trend		*p* < 0.0001*				*p* < 0.0001*			

β, regression coefficient; BMI, body mass index; Quartile 1, Q1; Quartile 2, Q2; Quartile 3, Q3; Quartile 4, Q4; SE, standard error. *$p < 0.05$.
[a]Adjusted for age.
[b]Adjusted for age, BMI, educational levels, monthly income levels, and marital and relationship status.

Discussion

In this study, we analyzed the relationship between lower-limb muscle strength performance and static and dynamic balance control using data from 20,846 Taiwanese older adult adults. The main findings of this study were as follows: First, lower-limb muscle strength was positively associated with static and dynamic balance performance, and we also observed dose–response relationships in the aforementioned variables; and second, higher levels of lower-limb muscle strength were associated with higher regular exercise and a lower risk of abdominal obesity. These findings suggest that older adult adults with good static and dynamic balance and quick walking

speeds are more independent and have a reduced risk of sarcopenia and falling.

It has been reported that adults who perform ≥150 min/week of moderate-intensity physical activity (e.g., cleaning, gardening, walking and yoga), which is associated with lower rates of cardiovascular diseases and premature mortality, are considered regular exercisers (33–35). In addition, Chen et al. found that higher levels of relative grip strength were associated with a lower risk of abdominal obesity and cardiorespiratory fitness (36). In this study, we observed that approximately 75% of older adults were classified as nonregular exercisers in Taiwan, and higher levels of nonregular exercise were associated with lower 30-s chair stand performance and higher body mass index and waist-to-hip ratio. Our findings suggested that older adult adults who exercise regularly may have better lower extremity muscle strength performance and are less at risk for abdominal obesity compared to those who do not exercise regularly. Consistent with previous findings, the results of this study suggest that individuals with weaker leg strength have a higher rate of risk for disease (e.g., metabolic syndrome) (37, 38).

A previous study indicated that older fallers are characterized by lower muscular strength and aerobic endurance performance (chair stand test and 6-min walk test, respectively) than nonfalling older adult men, whereas agility and dynamic balance (8-foot up-and-go test) tended to differ ($p = 0.075$) between the two groups (8). These disparate results could be the result of the sizes of and differences in sample sizes (fallers, $n = 16$ vs. nonfallers, $n = 50$). In the present study, we found that lower-limb muscle strength was positively associated with one-leg stance with the eye open test and 8-foot up-and-go test performance in both genders. A similar study indicated that a one-leg stance with the eye open test was associated with hip fracture risk; for example, the risk of hip fracture was 5% lower with a 1-s longer one-leg stance with the eye open test (39). We suggest that older adult adults with good lower-extremity muscle strength (30-s chair stand test, ≥ 12 repetitions) could increase static and dynamic balance, as well as prevent falling, thereby reducing the risk of fracture and improving quality of life.

Notably, this study is the first to examine the dose–response relationships between lower-limb muscle strength with the one-leg stance with the eye open test and the 8-foot up-and-go test after adjusting for confounding factors (e.g., age, BMI, educational levels, monthly income levels) among Taiwanese older adults. We observed that higher levels of lower-limb muscle strength were associated with higher agility and better static and dynamic balance performance in both genders. In addition, this study took as its starting point the global goal of healthy aging, which makes the study of the health of older adults in Taiwan a critical issue given that Taiwan will become a super-aged society by 2025 and the proportion of older adults in the population will increase more rapidly than in other countries.

The present study has some limitations. First, our questionnaire did not include fall history, physical activity, cardiovascular disease, hypertension or sarcopenia, which could interfere with muscle strength, balance and mobility performance. Second, this study was a cross-sectional study, and no cause and effect relationships can be guaranteed. Future studies should be conducted with a longitudinal study design to understand the cause and effect relationship between thigh muscle strength and static and dynamic balance performance in Taiwanese older adult individuals.

Conclusion

This study demonstrated that lower-limb muscle strength was the most important factor, as it was an improved method for static and dynamic balance control in both genders. As Taiwan has one of the highest aging rates in the world, there is a high demand for comprehensive aging-related policies. Therefore, by providing useful information on personal balance and fall risk to guide the development of appropriate prevention and rehabilitation programs, this study allows older adults to self-assess their balance by conducting tests and taking appropriate actions to reduce fall risk, such as engaging in appropriate exercise and balance training.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

Ethics statement

The studies involving humans were approved by Institutional Review Board of Fu Jen Catholic University (FJU-IRB C110113). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

P-CY and T-SL participated in the design, conducted the statistical analyses, and interpreted the data, drafted and revised the manuscript. D-KS supervised the study, assisted in data interpretation, and critically reviewed the manuscript. C-CH helped to manage and analyze the data. All authors contributed to the article and approved the submitted version.

Acknowledgments

This study is based in part on data from the National Physical Activity Survey provided by the Sports Cloud: Information and Application Research Center of Sports for all, Sport Administration, Ministry of Education in Taiwan. The interpretation and conclusions contained herein do not represent those of Sport Administration, Ministry of Education in Taiwan.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Health Promotion Administration Ministry of Health and Welfare. Survey of elderly population in Taiwan. Available at: https://pop-proj.ndc.gov.tw/chart.aspx?c=10&uid=66&pid=60 (Accessed 5 May 2023)

2. Kang DY, Kim YM, Lee KS. Comparisons of lower extremity strength, cognition, and ankle mobility according to the 8.5 seconds cut-off point for the 8-foot up-and-go test in elderly women. *J Aging Phys Act*. (2015) 10:87–93. doi: 10.13066/kspm.2015.10.3.87

3. Manini TM, Clark BC. Dynapenia and aging: an update. *J Gerontol A Biol Sci Med Sci*. (2011) 67:28–40. doi: 10.1093/gerona/glr010

4. Rowe JW, Kahn RL. Successful aging. *Gerontologist*. (1997) 37:433–40. doi: 10.1093/geront/37.4.433

5. Young Y, Fan MY, Parrish JM, Frick KD. Validation of a novel successful aging construct. *J Am Med Dir Assoc*. (2009) 10:314–22. doi: 10.1016/j.jamda.2009.01.003

6. Maciaszek J. Muscle strength and aerobic endurance as factors differentiating falling and non-falling men over 70 years. *J Hum Kinet*. (2010) 25:35–40. doi: 10.2478/v10078-010-0029-y

7. Stevens JA, Olson S. Reducing falls and resulting hip fractures among older women. *Home Care Provid*. (2000) 5:134–41. doi: 10.1067/mhc.2000.109232

8. Stalenhoef PA, Diederiks JPM, Knottnerus JA, Kester ADM, Crebolder HFJM. A risk model for the prediction of recurrent falls in community-dwelling elderly: A prospective cohort study. *J Clin Epidemiol*. (2002) 55:1088–94. doi: 10.1016/s0895-4356(02)00502-4

9. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. *Maturitas*. (2013) 75:51–61. doi: 10.1016/j.maturitas.2013.02.009

10. Stevens JA, Sogolow ED. Gender differences for non-fatal unintentional fall related injuries among older adults. *INJ Prev*. (2005) 11:115–9. doi: 10.1136/ip.2004.005835

11. Neri GR, Oliveira J, Dario A, Lima R, Tiedemann A. Does obesity increase the risk and severity of falls in people aged 60 years and older? A systematic review and meta-analysis of observational studies. *J Gerontol A Biol Sci Med Sci*. (2020) 75:952–60. doi: 10.1093/gerona/glz272

12. Gadelha AB, Neri SGR, Bottaro M, Lima RM. The relationship between muscle quality and incidence of falls in older community-dwelling women: an 18-month follow-up study. *Exp Gerontol*. (2018) 110:241–6. doi: 10.1016/j.exger.2018.06.018

13. Melzer I, Benjuya N, Kaplanski J. Postural stability in the elderly: a comparison between fallers and non-fallers. *Age Ageing*. (2004) 33:602–7. doi: 10.1093/ageing/afh218

14. Baixinho CL, Dixe MDA. Monitoring episodes of falling in an institution for the elderly. *DOAJ*. (2014) 16:28–34. doi: 10.5216/ree.v16i1.20650

15. Sousa LMM, Marques-Vieira CMA, Caldevilla MNGND, Henriques CMAD, Severino SSP, Caldeira SMA. Risk for falls among community-dwelling older people: systematic literature review. *Rev Gaucha Enferm*. (2017) 37:e55030. doi: 10.1590/1983-1447.2016.04.55030

16. Jonsson E, Seiger Å, Hirschfeld H. One-leg stance in healthy young and elderly adults: a measure of postural steadiness? *Clin Biomech (Bristol, Avon)*. (2004) 19:688–94. doi: 10.1016/j.clinbiomech.2004.04.002

17. Vellas BJ, Wayne SJ, Romero L, Baumgartner RN, Rubenstein LZ, Garry PJ. One-leg balance is an important predictor of injurious falls in older persons. *J Am Geriatr Soc*. (1997) 45:735–8. doi: 10.1111/j.1532-5415.1997.tb01479.x

18. Khanal P, He L, Stebbings GK, Onambele-Pearson GL, Degens H, Williams AG, et al. Static one-leg standing balance test as a screening tool for low muscle mass in healthy elderly women. *Aging Clin Exp Res*. (2021) 33:1831–9. doi: 10.1007/s40520-021-01818-x

19. Cunningham DA, Paterson DH, Himann JE, Rechnitzer PA. Determinants of independence in the elderly. *Can J Appl Physiol*. (1993) 18:243–54. doi: 10.1139/h93-021

20. Tanimoto Y, Watanabe M, Sun W, Sugiura Y, Hayashida I, Kusabiraki T, et al. Sarcopenia and falls in community-dwelling elderly subjects in Japan: defining sarcopenia according to criteria of the European working group on sarcopenia in older people. *Arch Gerontol Geriatr*. (2014) 59:295–9. doi: 10.1016/j.archger.2014.04.016

21. Henry JP, Cassel JC. Psychosocial factors in essential hypertension. Recent epidemiologic and animal experimental evidence. *Am J Epidemiol*. (1969) 90:171–200. doi: 10.1093/oxfordjournals.aje.a121062

22. Lee PF, Ho CC, Yeh DP, Hung CT, Chang YC, Liu CC, et al. Cross-sectional associations of physical fitness performance level and sleep duration among older adults: results from the National Physical Fitness Survey in Taiwan. *Int J Environ Res Public Health*. (2020) 17:388. doi: 10.3390/ijerph17020388

23. Chen HH, Chen HL, Lin YT, Lin CW, Ho CC, Lin HY, et al. The associations between functional fitness test performance and abdominal obesity in healthy ederly people: results from the National Physical Fitness Examination Survey in Taiwan. *Int J Environ Res Public Health*. (2020) 18:264. doi: 10.3390/ijerph18010264

24. Ho CC, Lee PF, Chen HL, Tseng CY, Hsieh XY, Chiu CH. Poor health-related physical fitness performance increases the overweight and obesity risk in older adults from Taiwan. *BMC Geriatr*. (2021) 21:170. oi: 10.1186/s12877-021-02112-1. doi: 10.1186/s12877-021-02112-1

25. Department of Household Registration Affairs. *Ministry of the Interior*. Taiwan: Population policy data collection. Taipei (2016).

26. Raosoft. Sample size calculator 2020. Available at: http://www.raosoft.com/samplesize.html (Accessed 10 March, 2020).

27. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport*. (1999) 70:113–9. doi: 10.1080/02701367.1999.10608028

28. Sawada S, Ozaki H, Natsume T, Deng P, Yoshihara T, Nakagata T, et al. The 30-s chair stand test can be a useful tool for screening sarcopenia in elderly Japanese participants. *BMC Musculoskelet Disord*. (2021) 22:639–6. doi: 10.1186/s12891-021-04524-x

29. Franchignoni F, Tesio L, Martino MT, Ricupero C. Reliability of four simple, quantitative tests of balance and mobility in healthy elderly females. *Aging (Milano)*. (1998) 10:26–31. doi: 10.1007/BF03339630

30. Podsiadlo D, Richardson S. The timed "up & go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*. (1991) 39:142–8. doi: 10.1111/j.1532-5415.1991.tb01616.x

31. Sports Administration, Ministry of Education. *Taiwan national physical fitness test manual*. Taipei, Taiwan: Sports Administration, Ministry of Education (2014).

32. Ministry of Health and Welfare. Health and welfare statistics. Available at: https://dep.mohw.gov.tw/DOS/np-1776-113.html. (Accessed 20 May 2023).

33. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc*. (2011) 43:1334–59. doi: 10.1249/MSS.0b013e318213fefb

34. Chen YT, Lee PF, Lin CF, Chang A, Chung YC, Yeh CP, et al. Association of regular leisure-time physical activity with self-reported body mass index and obesity risk among middle-aged and older adults in Taiwan. *Healthcare*. (2021) 9:1719. doi: 10.3390/healthcare9121719

35. Wedig IJ, Duelge TA, Elmer SJ. Infographic. Stay physically active during COVID-19 with exercise as medicine. *Br J Sports Med*. (2021) 55:346–7. doi: 10.1136/bjsports-2020-103282

36. Chen YT, Lee PF, Lin CF, Su YJ, Chen HL, Chen PC, et al. Associations of health-related physical fitness with waist circumference and abdominal obesity risk in Taiwanese adults. *Healthcare*. (2022) 10:1164. doi: 10.3390/healthcare10071164

37. Zhang W, Zhao Z, Sun X, Tian X. Prevalence of metabolic syndrome according to absolute and relative values of muscle strength in middle-aged and elderly women. *Int J Environ Res Public Health*. (2021) 18:9073. doi: 10.3390/ijerph18179073

38. Sénéchal M, McGavock JM, Church TS, Lee DC, Earnest CP, Sui X, et al. Cut-points of muscle strength associated with metabolic syndrome in men. *Med Sci Sports Exerc*. (2014) 46:1475–81. doi: 10.1249/MSS.0000000000000266

39. Lundin H, Sääf M, Strender LE, Nyren S, Johansson SE, Salminen H. One-leg standing time and hip-fracture prediction. *Osteoporos Int*. (2014) 25:1305–11. doi: 10.1007/s00198-013-2593-1

frontiers | Frontiers in Public Health

TYPE Mini Review
PUBLISHED 29 February 2024
DOI 10.3389/fpubh.2024.1355384

Check for updates

OPEN ACCESS

EDITED BY
Calogero Caruso,
University of Palermo, Italy

REVIEWED BY
Annapina Palmieri,
National Institute of Health (ISS), Italy

*CORRESPONDENCE
Margherita Ghiselli
ghisellmar@paho.org

RECEIVED 13 December 2023
ACCEPTED 19 February 2024
PUBLISHED 29 February 2024

CITATION
Balsells E, Ghiselli M, Hommes C, Nascimento Lins de Oliveira B, Rosado-Valenzuela AL and Vega E (2024) Rethinking immunization programs through the life course approach.
Front. Public Health 12:1355384.
doi: 10.3389/fpubh.2024.1355384

COPYRIGHT
© Pan American Health Organization 2024. Licensee Frontiers Media SA. This is an open access article distributed under the terms of the Creative Commons Attribution IGO License (http://creativecommons.org/licenses/by/3.0/igo/legalcode), which permits unrestricted use, adaptation (including derivative works), distribution, and reproduction in any medium, provided the original work is properly cited. In any reproduction or adaptation of this article there should not be any suggestion that PAHO or this article endorse any specific organization or products. The use of the PAHO logo is not permitted. This notice should be preserved along with the article's original URL.

Rethinking immunization programs through the life course approach

Evelyn Balsells, Margherita Ghiselli*, Carolina Hommes, Beatriz Nascimento Lins de Oliveira, Ana Lucía Rosado-Valenzuela and Enrique Vega

Pan American Health Organization, Washington, DC, United States

The world continues to undergo a profound demographic shift toward increasing longevity –but quality of life is not improving correspondingly. At the same time, countries are taking stock of the negative impacts of the COVID-19 pandemic on national immunization programs. The pandemic exacerbated the declines in vaccination coverage for multiple vaccine-preventable diseases (VPD). To ensure that all persons receive all the vaccines for which they are eligible, it is time to consider how applying a life course approach (LCA) to immunization programs can help reinvigorate and redesign actions for greater vaccine uptake. In this mini review, we present the key concepts and principles of the LCA as applied to national immunization programs. Also, we offer recommendations on how health systems can achieve regional and national goals to ensure all people receive the recommended vaccine doses at every stage of life, thus ensuring the greatest benefits for individuals and societies.

KEYWORDS

life-course, vaccination, immunization, immunosenescence, IA2030

Introduction

As longevity continues to increase, it presents opportunities and challenges for immunization efforts. In the Americas, life expectancy (LE) has increased by approximately 15 years in the past half century (1). Yet, the average number of years a person lives in "full health" (healthy life expectancy – HALE) (2) is 66, compared to an average lifespan of 77 years (3). Immunization strategies such as vaccination, breastfeeding and immunotherapies can contribute to the attainment of a full health status at each stage of life.

Established in 1974, the Expanded Program on Immunization (EPI) has contributed to the prevention of millions of deaths, especially among children younger than five years (4). Yet over the last decade, the Americas have seen a noticeable decline in vaccination coverage rates for all antigens (5). The advent of the COVID-19 pandemic further exacerbated this trend, leaving 1.3 million children younger than one year without a single dose of vaccine in 2022. Nonetheless, the pandemic also presented an opportunity for the Americas to strengthen and expand vaccination platforms beyond childhood – reaching large portions of adolescents, adults, older adults and pregnant women with the COVID-19 vaccines (6). This expansion of national immunization programs is in line with the recommendations of the Immunization Agenda 2030 (IA2030), which recognizes that the LCA framework is necessary to maximize the impact of immunization across an individual's life stages and generations (7). Yet, while some countries have made enormous progress in extending both COVID-19 and routine

vaccination services beyond the pediatric population (5), many still engage with adolescents and adults only in the context of COVID-19 vaccination. These missed opportunities should be documented and addressed to allow all segments of the population to fully benefit from the immediate and long-term protection of vaccines (8).

Study design

In November 2022, the Pan American Health Organization/World Health Organization (PAHO/WHO) held a webinar titled "Building a Better Immunity: A Pathway to Healthy Longevity" (9), to discuss the implications for the present and future of the life course approach in the fields of medicine and public health, as well as to better understand the existing applications of this approach to immunization programs in the region of the Americas and in the world. The webinar included presentations from academic researchers and WHO officers to describe the principles of the LCA to the Ministries of Health of the countries and territories of the Americas, as well as propose first steps to integrate these concepts into the strategic plans of national immunization programs.

The proceedings from the webinar were formatted and expanded to develop a PAHO technical document of the same title (10). For each LCA principle, we searched the PAHO and WHO literature for instances of vaccines that are already included in national immunization schedules and exemplify the application of LCA concepts in national vaccination policies or strategies. Also, we searched the scientific literature to include the biological mechanisms that explain the reasons for favoring the application of specific vaccines at specific ages or under specific conditions. Finally, we provided examples of how the LCA can be used to promote vaccination services as a component of an integrated primary healthcare system – where members of each age group may be offered a complete package of complementary services to boost their overall health and wellbeing depending on their specific needs.

This publication summarizes the key points of the PAHO technical document and adapts them for further dissemination to Ministries of Health outside the Americas, as well as to the broader scientific community.

LCA principles applied to health

The LCA can apply eight principles to a health framework (11) to maximize the potential of improving health outcomes and extend healthy lives. First, health develops over dynamic trajectories that are impacted by transitions –moments in life when there is loss or gain of health functions– and the cumulative impact of positive and negative exposures throughout life. Also, each trajectory can be adjusted during critical periods –moments where health interventions can be applied to generate the strongest and most permanent health responses. LCA concepts also contemplate external forces that impact health. The historical and societal context where individuals and communities live –temporality– and the human agency to make individual decisions are key drivers of a person's health status throughout life. Finally, the interconnectivity between generations ensures the transfer of traits and resources, including health status. Also, the health status of other people who live in the same environment –linked lives– can affect the health of individuals and families.

Why a life course approach to immunization

The LCA considers health as an evolving capacity that develops dynamically over a person's life, across generations and within a community (12, 13). As individuals age, their immune system changes its capacity to respond to pathogens, and eventually declines through a process called immunosenescence (14). Also, individuals experience inflammaging, an increase in pro-inflammatory markers (15) that can disrupt health capacities when the body is unable to mount a response to specific pathogens. To respond to these dynamic trajectories, the LCA promotes person-centered interventions to generate health benefits beyond survival. An example are the national immunization programs that improve individuals' capacity to fight the consequences of infections and therefore generate lasting health for persons and their community. By taking note of the moments when the immune system is weakest or in transition, vaccination schedules can be adjusted to deliver vaccine doses that enhance a person's protection against those vaccine preventable diseases (VPD) to which it is most vulnerable at each stage of life (9). When administered to a sufficient number of vulnerable persons, vaccination programs can reduce the morbidity and mortality burden of an entire community and future generations.

Life course approach principles applied to vaccination

The LCA principles can be applied to national immunization programs (15), so they are optimally designed to take advantage of critical periods, improve health trajectories and minimize the effects of immunosenescence. On a broader scale, the LCA can inform the development of vaccination platforms that take note of the critical periods in a person's life to: (a) design interactions with vaccination services; (b) generate vaccine demand by coupling this service with other age-appropriate health practices; and (c) develop information systems that track a person's medical history (including vaccinations) and identify the most appropriate moments for intervention. Depending on the level of intervention selected by the country, LCA principles can be applied to the national immunization program to benefit individuals, generations, and communities (15).

Individual life trajectories and immunization

Vaccines were developed for different age groups to help maintain the plasticity of innate and adaptive immune systems to respond to external stimuli (infection or vaccination). Therefore, primary schedule vaccine doses are designed to be administered at critical periods of a life trajectory and at moments of transition between life stages to help optimize the body's response to the pathogens that most affect a specific age group. It is recommended these periods are extended through catch-up vaccination (8). Catch-up vaccine doses ensure that the whole length of the critical period is used to provoke a response or prevent illness that can last into other life stages. As we age, immunosenescence has a cumulative impact on a person's inability to respond to infections and affects all individual life trajectories. To compensate, public health officials need to adjust

national vaccination schedules to include booster doses at the time when antibody titers against a specific antigen are known to have declined.

These considerations are especially important for high-risk individuals who experience the cumulative impact of risk factors through repeated exposures to the pathogen (e.g., health workers) or chronic health conditions (e.g., immunocompromised persons). Also, persons living in situation of vulnerability (e.g., migrants, indigenous groups, refugees, internally displaced populations, people in closed institutions) are at higher risk of developing disease due to the unfavorable social determinants that affect their daily lives. For them, the immunity generated through vaccination reduces the risk of disease infection, as well as the interaction of disease sequelae with other comorbidities later in life.

In the Americas, some examples of how vaccines can impact a person's life trajectory and produce long-lasting health benefits are:

- Administration of Bacille Calmette-Guérin (BCG) and hepatitis B vaccines within the first 24 h of life to protect newborns from tuberculosis (TB), in line with PAHO recommendations (16). This is a critical period in the life of a newborn because the immune system is still developing and is especially vulnerable to this disease. If high coverage rates of BCG vaccination within the first 24 h cannot be achieved consistently, a country may consider introducing a catch-up policy to allow this dose to be administered during the first year of life – in line with WHO recommendations (17) – to boost population immunity.
- Administration of the vaccine against the Human Papilloma Virus (HPV) to adolescent girls. One dose administered prior to sexual intercourse minimizes the risk of developing precancerous and cancerous lesions later in life (18).
- Administration of 6 doses (3 primary plus 3 boosters) of tetanus toxoid-containing vaccines (TTCV) throughout childhood and adolescence. Since immunity against tetanus wanes over time, it is recommended that adults receive a booster dose every 10 years to ensure protection throughout life (19).

Intergenerational impact

The LCA pays attention to the intergenerational benefits of vaccination programs, which includes the transmission of maternal antibodies to the fetus via vaccines and to the newborn via breastmilk. Both these instances are clear example of linked lives and the transfer of traits and resources. Also, these are cost-effective strategies that optimize health outcomes across two generations (16, 20). National immunization programs should ensure that: (a) vaccines are available to pregnant women; and (b) they receive all doses for which they are eligible.

Another application of the principle of transfer of traits and resources is the sharing of habits and behaviors within a social unit (e.g., the family nucleus). These behaviors may be favorable or unfavorable to good health. For example, research from countries in the Americas has shown that parents of unvaccinated children are more likely to not trust COVID-19 vaccines than parents of vaccinated children (20). Therefore, national immunization programs could offer outreach services and demand generation activities that target multiple members of a social unit at once, so that vaccine uptake by one member may trigger greater acceptance within the unit. PAHO's own Vaccination Week in the Americas (21) is an example of an outreach event that targets all age groups.

Human agency and temporality, and their impact on community health

The LCA principles can be applied to improve health at the community level. Through human agency, persons who are at high-risk of contracting a VPD or of being hospitalized or dying from it can choose to receive a vaccine dose. By lowering the morbidity and mortality rate in population groups, the burden of disease of the entire community is lowered as well –since high-risk groups are the greatest contributors to that same burden of disease. Also, the LCA highlights temporality trends that shape community patterns in health-seeking behaviors. Specifically, social, cultural, and historical factors at a given point in time can impact vaccine acceptance and uptake. Therefore, human agency can be shaped by temporal trends, and this agency can vary between age groups and risk groups. The combination of these factors can affect the vaccination status in a particular life stage.

Public health officers can influence human agency among high-risk persons though targeted outreach efforts and communications campaigns – thus improving the health of the community. These operations must take into account the temporal issues so that vaccination communication campaigns consider potential habits and behaviors of the target population, the social determinants that affect one's abilities to make decisions about his/her health, and the context in which people live. Thus supported, individuals can better shape their actions to support healthy life trajectories – to the benefit of the community as a whole.

A recent example of a LCA application to national vaccination strategies is the prioritization of COVID-19 vaccines to high-risk groups during the pandemic (22, 23). This decision maximized the impact of the vaccines on the disease burden of the populations by preventing severe disease, hospitalization, and death among the most vulnerable members of society, and relieved health systems of additional burden of care (24, 25).

Toward implementation of the life course approach to immunization

While there is growing evidence in the scientific literature on the benefits of applying LCA principles to vaccination programs, the implementation of these principles to national immunization programs lags behind. Yet there is a need to rethink immunization programs to minimize missed opportunities and extract the full benefit of vaccines for persons of all ages. To develop strong vaccination platforms and immunization strategies, systemic changes are necessary (26). We propose that these changes focus on six elements of a national health system.

(1) *Advocacy*: Strong advocacy to implement the principles of the LCA to national immunization programs must rest with high-level officials and policymakers. This advocacy should translate into expanded vaccination services that reach all persons and offer vaccine doses to all eligible persons according to their age.

(2) *Financing*: To sustain expanded vaccination platforms that promote vaccine doses beyond the pediatric population, adequate and consistent financial resources are required. Funds should translate to the engagement of additional human resources to manage the increased workload, as well as training sessions to ensure that all vaccine doses are adequately administered and recorded in the vaccination registers. Such resources should be seen as a long-term investment given the economic and social benefit of immunizations (i.e., reduced healthcare costs from having prevented infectious diseases and chronic conditions; longer and healthier lifespans for a larger portion of the population).

(3) *Integration of person-centered services*: The consistent expansion of vaccination services to all age groups – including the administration of booster and catch-up doses – requires synergy with other essential health services that are person-centered, age-appropriate and designed around the needs and environments of eligible persons.

(4) *Human Resources*: The positive impact of the LCA on national immunization programs must be communicated broadly to public health officials, health administrators, health providers and vaccinators. Additional training resources must be provided to ensure that vaccines are promoted to individuals of each age group whenever they come in contact with essential services.

(5) *Information and evidence generation*: The benefits of the LCA for national immunization programs must continue to be researched, tracked, and documented to assess how these changes to vaccination services are impacting broader population health outcomes, healthcare, and public health priorities. Health systems should invest in longitudinal research and information systems (e.g., electronic immunization registries) to monitor improvements in limiting missed opportunities and measuring benefits beyond the prevention of a single VPD.

(6) *Equity*: To maximize the benefits of vaccines, they should be available to everyone, everywhere. Countries should establish targeted strategies to reach vulnerable populations. Outreach operations and cultural dialogs are well-documented activities that help reduce inequalities in vaccination coverage rates across the life course.

Conclusion

Rethinking immunization programs from the perspective of a LCA presents an opportunity for adjusting vaccination services to obtain greater health benefits at the individual and community level. An LCA-centered immunization program addresses the health needs of individuals over time by considering their life trajectories and critical periods. Also, it can broaden its scope by designing its interventions to improve the health of communities for generations to come. At least six essential elements of the health system should be targeted when integrating the LCA principles to national immunization programs.

Author contributions

EB: Writing – original draft, Writing – review & editing. MG: Conceptualization, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. CH: Conceptualization, Writing – original draft, Writing – review & editing. BN: Writing – review & editing. AR-V: Conceptualization, Writing – original draft, Writing – review & editing. EV: Conceptualization, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This publication was supported by the Grant of Cooperative Agreement Number, NU66GH002171, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author Disclaimer

The authors are staff members of the Pan American Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the views, decisions or policies of the Pan American Health Organization.

References

1. United Nations. (2022). Revision of world population prospects. 2022. Available at: https://population.un.org/wpp/ (Accessed May 8, 2023)

2. WHO. (2023). The Global Health Observatory – healthy life expectancy (HALE) at birth. Available at: https://www.who.int/data/gho/indicator-metadata-registry/imr-details/66 (Accessed May 8, 2023)

3. WHO. (2023). Life expectancy and healthy life expectancy – data by WHO region. Available at: https://apps.who.int/gho/data/view.main.SDG2016LEXREGv?lang=en (Accessed May 8, 2023)

4. Etienne CF. Expanded program on immunization in the Americas: 40 years. *Rev Panam Salud Pública*. (2017) 41:1–2. doi: 10.26633/RPSP.2017.139

5. WHO/UNICEF. (2022). WHO/UNICEF estimates of National Immunization Coverage (WUENIC). Available at: https://www.who.int/teams/immunization-vaccines-and-biologicals/immunization-analysis-and-insights/global-monitoring/immunization-coverage/who-unicef-estimates-of-national-immunization-coverage (Accessed January 2, 2024)

6. PAHO. (2021). COVID-19 vaccination in the Americas. Available at: https://ais.paho.org/imm/IM_DosisAdmin-Vacunacion.asp (Accessed January 2, 2024)

7. WHO. (2020). Immunization agenda 2030- SP4: Life course and integration. Available at: https://www.immunizationagenda2030.org/strategic-priorities/life-course-integration (Accessed May 8, 2023)

8. Tampi M, Carrasco-Labra A, O'Brien KK, Velandia-González M, Brignardello-Petersen R. Systematic review on reducing missed opportunities for vaccinations in Latin America. *Rev Panam Salud Pública*. (2022) 46:1. doi: 10.26633/RPSP.2022.65

9. PAHO. (2022). Building a better immunity: A pathway to healthy longevity. Available at: https://www.paho.org/en/events/building-better-immunity-pathway-healthy-longevity (Accessed May 8, 2023)

10. PAHO. (2021). Building health throughout the life course. Concepts, implications, and application in public health. Available at: https://iris.paho.org/handle/10665.2/53409 (Accessed May 8, 2023)

11. Hommes C, Ambrose A, Vega E, Martinez R. Four reasons for adopting a life course approach to health in the COVID-19 era and beyond. *Rev Panam Salud Pública*. (2022) 46:1. doi: 10.26633/RPSP.2022.182

12. PAHO. (2023). Healthy life course. Available at: https://www.paho.org/en/topics/healthy-life-course (Accessed May 8, 2023)

13. Goronzy JJ, Weyand CM. Understanding immunosenescence to improve responses to vaccines. *Nat Immunol*. (2013) 14:428–36. doi: 10.1038/ni.2588

14. Santoro A, Bientinesi E, Monti D. Immunosenescence and inflammaging in the aging process: age-related diseases or longevity? *Ageing Res Rev*. (2021) 71:101422. doi: 10.1016/j.arr.2021.101422

15. Philip RK, Attwell K, Breuer T, Di Pasquale A, Lopalco PL. Life-course immunization as a gateway to health. *Expert Rev Vaccines*. (2018) 17:851–64. doi: 10.1080/14760584.2018.1527690

16. PAHO. (2018). Maternal and neonatal immunization field guide for Latin America and the Caribbean. PAHO. Available at: https://iris.paho.org/handle/10665.2/34150 (Accessed May 8, 2023)

17. WHO. (2018). BCG vaccines: WHO position paper – February 2018. Available at: https://www.who.int/publications/i/item/who-wer9308-73-96 (Accessed January 2, 2024)

18. Lei J, Ploner A, Elfström KM, Wang J, Roth A, Fang F, et al. HPV vaccination and the risk of invasive cervical Cancer. *N Engl J Med*. (2020) 383:1340–8. doi: 10.1056/NEJMoa1917338

19. PAHO. (2018). Third ad hoc meeting of the technical advisory group (TAG) on vaccine-preventable diseases – final report. https://www.paho.org/en/documents/03-ad-hoc-tag-final-report-2018 (Accessed January 2, 2024)

20. Nguyen KH, Nguyen K, Mansfield K, Allen JD, Corlin L. Child and adolescent COVID-19 vaccination status and reasons for non-vaccination by parental vaccination status. *Public Health*. (2022) 209:82–9. doi: 10.1016/j.puhe.2022.06.002

21. PAHO. (2023). Vaccination week in the Americas 2023. https://www.paho.org/en/campaigns/vaccination-week-americas-2023 (Accessed May 8, 2023)

22. WHO. (2020). WHO SAGE values framework for the allocation and prioritization of COVID-19 vaccination. Available at: https://apps.who.int/iris/bitstream/handle/10665/334299/WHO-2019-nCoV-SAGE_Framework-Allocation_and_prioritization-2020.1-eng.pdf

23. WHO. (2020). WHO SAGE roadmap for prioritizing uses of COVID-19 vaccines. Available at: https://www.who.int/publications/i/item/WHO-2019-nCoV-Vaccines-SAGE-Prioritization-2022.1 (Accessed May 8, 2023)

24. McNamara LA, Wiegand RE, Burke RM, Sharma AJ, Sheppard M, Adjemian J, et al. Estimating the early impact of the US COVID-19 vaccination programme on COVID-19 cases, emergency department visits, hospital admissions, and deaths among adults aged 65 years and older: an ecological analysis of national surveillance data. *Lancet*. (2022) 399:152–60. doi: 10.1016/S0140-6736(21)02226-1

25. Rojas-Botero ML, Fernández-Niño JA, Arregocés-Castillo L, Ruiz-Gómez F. Estimated number of deaths directly avoided because of COVID-19 vaccination among older adults in Colombia in 2021: an ecological, longitudinal observational study. *F1000Research*. (2022) 11:198. doi: 10.12688/f1000research.109331.2

26. Aguado T, Goodwin J, Holt D. (2018). A life-course approach to vaccination: Adapting European policies. Available at: https://www.healthpolicypartnership.com/app/uploads/A-life-course-approach-to-vaccination-adapting-European-policies.pdf (Accessed May 8, 2023)

frontiers | Frontiers in Public Health

TYPE Study Protocol
PUBLISHED 12 March 2024
DOI 10.3389/fpubh.2024.1256734

Check for updates

OPEN ACCESS

EDITED BY
Constantinos S. Pattichis,
University of Cyprus, Cyprus

REVIEWED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain
Bayram Akdemir,
Konya Technical University, Türkiye

*CORRESPONDENCE
Elvira Maranesi
e.maranesi@inrca.it

RECEIVED 11 July 2023
ACCEPTED 16 February 2024
PUBLISHED 12 March 2024

CITATION
Bevilacqua R, Stara V, Amabili G, Margaritini A, Benadduci M, Barbarossa F, Maranesi E, Rigaud A-S, Dacunha S, Palmier C, Moller J, Browne R, Ogawa T and Wieching R (2024) e-VITA study protocol: EU-Japan virtual coach for smart aging.
Front. Public Health 12:1256734.
doi: 10.3389/fpubh.2024.1256734

COPYRIGHT
© 2024 Bevilacqua, Stara, Amabili, Margaritini, Benadduci, Barbarossa, Maranesi, Rigaud, Dacunha, Palmier, Moller, Browne, Ogawa and Wieching. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

e-VITA study protocol: EU-Japan virtual coach for smart aging

Roberta Bevilacqua[1], Vera Stara[1], Giulio Amabili[1], Arianna Margaritini[1], Marco Benadduci[1], Federico Barbarossa[1], Elvira Maranesi[1]*, Anne-Sophie Rigaud[2,3], Sébastien Dacunha[2,3], Cecilia Palmier[2,3], Johanna Moller[4], Ryan Browne[5], Toshimi Ogawa[5] and Rainer Wieching[6]

[1]Scientific Direction, IRCCS INRCA, Ancona, Italy, [2]Université de Paris, Maladie d'Alzheimer, Paris, France, [3]Services de Gériatrie 1 & 2, AP-HP, Hôpital Broca, Paris, France, [4]Diocesan Caritas Assosiation of the Archdiocese of Cologne e.V., Cologne, Italy, [5]Smart-Aging Research Center, Tohoku University, Sendai, Japan, [6]Institute for New Media & Information Systems, University Siegen, Siegen, Germany

Aim: The aim of this study is to report a trial protocol for assessing the improvement of older adults' well-being, promoting active and healthy aging, and reducing the risks of social exclusion, using a virtual coach.

Background: Increased longevity brings with it reduced autonomy and independence, and it is therefore necessary to act with preventive measures that can promote active and healthy aging. With the development of technology, new tools have appeared, including virtual coaches, which can enable people to lead a healthy lifestyle by identifying individual needs and goals and providing personalized recommendations and advice. However, it is important that these coaches take into consideration the inter-individual and cross-cultural differences of each person.

Design: A randomized controlled trial is proposed.

Methods: This study will recruit 240 healthy subjects aged 65 years and older. Participants will be assigned to an experimental group that will receive the e-VITA system or to the control group that will receive an information booklet only. The primary outcome measure is the person's quality of life (QoL). Data will be collected at baseline, 3 months after the trial, and at the end of the trial, after 6 months.

Discussion: This study will evaluate the effectiveness of the e-VITA system, consisting of a virtual coach, several sensors for monitoring, a smartphone for use at home, and a booklet, in improving the older person's quality of life. The increased perceived well-being will also be linked to improvements in other areas of the person's life, psychological and cognitive status, the area of sociality, nutrition, and eHealth literacy.

KEYWORDS

older adults, virtual coach, protocol, intrinsic capacity, well-being, physical activity, frailty

Introduction

Aging brings with it some chronic conditions, along with the reduction of some functions, (1–3) which can lead to a loss of autonomy and frailty. The care of older adults with a loss of autonomy is therefore becoming a major social, medical, and economic issue due to the insufficient number of family or professional carers, enabling older adults to live at home as long as possible and delay entry to institutionalization (4). However, aging is not the same for all individuals. It is dependent on many factors such as genetic factors that cannot be modified and environmental factors including lifestyle (5). It is on the latter that preventive actions can be carried out throughout life (1). In addition to preventive action, the development of new care solutions is important (6), to reduce or minimize the consequences of these age-related diseases, support the health system, and promote active and healthy aging.

Background

Europeans are living longer and longer. According to INED (7) the life expectancy of a European woman is 83.7 years and 78.3 years for a man in 2018. Japan is the country with the highest life expectancy. Women live on average 88.1 years and men live on average 81.9 years (7). However, the increase in life expectancy is not necessarily accompanied by an increase in healthy life expectancy. In Europe, a woman can expect to live in good health for an average of 64.5 years and a man can expect to live in good health for an average of 63.4 years (8).

As people age, some of their cognitive functions deteriorate (9), and they experience psychological and physical (10–12) difficulties. These changes generate an increase in the workload required by both family and health professionals (13, 14). For these reasons, it is necessary to act with a view to prevention, starting with the concept of active aging. Active and healthy aging refers to the maintenance and development of functional abilities that enable older adults to live well (World Health Organization, n.d) in terms of physical, mental, and social health while actively participating in society.

With the emergence of the concept of healthy and active aging and the identification of factors that contribute to the development of age-related diseases and loss of autonomy, health organizations have tried to improve their strategies to prevent these risk factors and diseases (15). Different structures, organizations, or professionals offer prevention services such as physical, cognitive, emotional, or social activities. However, access to private professionals for prevention targeted to individual needs and preferences is expensive, whereas the offer of public organizations is only slightly customizable and may not be accessible to all seniors. This inequality of access is reinforced by the current health context linked to the COVID-19 crisis, which has led to the cessation or postponement of workshops or face-to-face activities in sports and intergenerational or cultural clubs. A number of videoconference activities have been developed over the past years. However, this remote format does not facilitate the personalization of interventions. With the development of technology, new tools have appeared, including virtual coaches, which seem to be of interest in supporting the behavior of individuals. A virtual coach is defined by Siewiorek et al. (16) as a personalized system that continuously monitors the activities and environment of its users. Virtual coaches detect situations where an intervention would be desirable and proposed to the user. To this end, coaches take the form of activity sensors combined with a coaching application located on the Internet, a smartphone, a sensor (17), or a social assistance robot (SAR) (18). Technology plays an important role in the aging process, impacting both individuals and society as a whole. On a personal level, wearable gadgets and health applications keep track of one's well-being, and telemedicine offerings enhance the availability of healthcare services. At the societal level, health efficiency, data-driven policies, and the development of social platforms connecting users have a positive influence. However, challenges such as equitable digitization and accessibility require attention to ensure a beneficial and inclusive impact, especially considering the skill level of the users of older than 65 years with technology, not only from a user skills perspective but also from a tool acceptance perspective (19, 20). In this regard, several studies have been conducted that quantitatively and qualitatively assess access to the Internet of Things (IoT) among the older adult population (21, 22).

Through a personalized approach, the virtual coaching system can enable people to live a healthy lifestyle, identifying personal needs and goals and providing appropriate risk predictions and individualized recommendations (23, 24). These devices cover a variety of domains and audiences (25). There are a multitude of virtual coaches and apps for the promotion of nutrition (26), physical activity (27), mood, sleep (28), and even more clinical applications, such as rehabilitation (29) or monitoring of cardiovascular pathologies (30).

There are virtual coaches for adults, children with autistic disorders, and older adults. These tools have attracted interest from healthcare organizations and consumers for promoting health, wellness, physical activity, and lifestyle improvement (31). The use of these virtual coaches and apps has great potential to help older adults improve their quality of life by addressing age-related issues and the physical and social implications of aging (32). Moreover, embracing these proactive measures with the assistance of a virtual coach empowers older adults to maintain independence and comfortable living in their homes for an extended period (33). This reduces the need for constant monitoring by health professionals, limits the costs that would otherwise be incurred (32), and helps mitigate the wider impact of demographic aging on healthcare (4).

However, the technologies developed for healthy and active aging have some limitations. Indeed, they are mainly used for short period of time and are poorly integrated into the daily lives of older adults, thus limiting their benefits (6). Moreover, interactions with these technologies are not ideal since they do not lead to realistic and satisfying social interactions due to technologies that are not yet advanced enough (34). It is therefore necessary to design and evaluate new products that consider the needs and preferences of seniors and their relatives for a sustainable and optimal use of these devices (35). The aim is to enable seniors to live independently in their own homes for as long as possible, preventing social isolation and encouraging active participation in social and group activities.

In this context, the creation of an intercultural and customizable virtual coach may represent an effective solution. Through cooperation between European (Italy, France, and Germany) and Japanese partners, the e-VITA project proposes different technological tools that are adapted to older adults and their daily lives, investigating the effect of cultural aspects in accepting technology and how this affects the outcome. In tackling the task of crafting these technological tools,

the e-VITA project takes on a comprehensive approach. This involves seeking input from all stakeholders at both the personal and societal levels. By engaging older adults, their informal and professional health caregivers, community members, and policymakers, the project aims to foster collaboration. The insights gained from these consultations are then mapped and utilized to comprehend the contextual use and identify potential users of the system (36, 37). The inclusion of different types of beneficiaries in all the countries could support local governments to adopt and adapt cross-national policies for AHA that fulfill the real needs of older adults, respecting different cultural perspectives. Therefore, the functionalities and services available and proposed are in response to the needs of older adults and concern social relations, physical activities, skills, autonomy, stimulation, communication, and safety.

The study

Study setting

The study will be conducted at the Center for Cognitive Disorders and Dementia (CDCD) of the Neurology Unit of the Istituto Nazionale Ricovero e Cura per Anziani IRCCS INRCA, Ancona, Italy. In Germany, the study will be carried out by the Diözesan-Caritasverband für das Erzbistum Köln e.V. (Diocesan Caritas Association for the Archdiocese of Cologne e.V.). In France, the study will be conducted by Hôpital Broca, Paris. In Japan, three institutes will carry out the study, namely, Tohoku University –Smart Ageing Research Center, J.F. Oberlin University, and Misawa Homes Institute of Research and Development Co. Ltd.

Aim

The research is structured as a randomized controlled trial with the objective of enhancing well-being in older adults, promoting active and healthy aging, contributing to independent living, and mitigating the risks of social exclusion through the utilization of a virtual coach. Participants will be divided into two groups: the experimental group (EG), receiving a virtual coach, a smartphone, and a booklet, and the control group (CG), receiving only a booklet.

Assessments will be conducted at the baseline (T0), midway through the intervention (after 3 months—T1), and at the conclusion of the intervention (after 6 months—T2). The primary aim of the study is to gauge the enhancement of participants' quality of life (QoL) using EQ 5D 5 L. Additionally, the research will assess the usability, user experience, acceptability, and fulfillment of needs after using the e-VITA system. It will also explore potential changes in various health-related aspects, such as nutrition, loneliness, and health literacy.

Objectives

The general objective is to improve the well-being of older adults, promote active and healthy aging, contribute to independent living, and reduce risks of social exclusion of 240 healthy older adults recruited from Europe (France, Germany, and Italy) and Japan by making use of a digital tool for personalized virtual coaching support.

Design/methodology

Recruitment

Patients are selected by the Neurology Operating Unit and Rehabilitation Medicine Operating Unit of IRCCS INRCA in the Ancona branch. After a reflection period of 2 weeks followed by reading the information letter and the consent form received by email, the participants who confirmed their wish to participate in the research by writing or orally will be invited by the investigator to consult a doctor during 3 months, preceding the start of the research. The doctor, volunteering to carry out the inclusion visits, will be the first to give the participants an information letter and two consent forms. Once the consent forms have undergone thorough proofreading and received signatures from both the participant and the doctor, the doctor will assess the participant's eligibility for the research using an anamnesis Clinical Frailty Scale (CFS) (38), Montreal Cognitive Assessment (MOCA) (39), Geriatric Depression Scale (GDS) (40), and Short Physical Performance Battery (SPPB) (41). This comprehensive medical examination, conducted before the commencement of the experiment, will determine whether participants meet the inclusion criteria. Those who have signed the consent form but do not meet the inclusion criteria as confirmed by the doctor will be excluded from the research. The trial is scheduled to commence in May 2023 and is anticipated to conclude in December 2023.

Participants

Each European country will enroll 40 subjects.

The inclusion criteria are:

- Age $\geq$ 65 years;
- Ability to provide informed consent;
- Able to stand and walk unaided;
- No acute or untreated medical problems;
- MoCA $\geq$22;
- GDS $<$ 9;
- SPPB $\geq$7;
- Clinical Frailty Scale score between 2 and 4;

For patients with MoCA scores between 22 and 25, an informal caregiver is required to be present during the explanation of the project and the administration of the assessment scales.

The exclusion criteria are:

- Failure to meet the inclusion criteria;
- Use of active implant or non-implant medical devices;
- Allergy to nickel;
- Simultaneous participation in other studies;
- Absence of written informed consent;
- Occurrence of a myocardial infarction or stroke within the past 6 months;
- Presence of painful arthritis, spinal stenosis, amputation, painful foot lesions, or neuropathy that significantly limits balance and mobility;
- Uncontrolled hypertension;
- Presence of a pacemaker or implantable cardioverter-defibrillator;
- Advanced Parkinson's disease or other neuromuscular disorders;

- Diagnosis of metastatic cancer or undergoing immunosuppressive therapy;
- Significant visual or hearing impairment.

Sample size determination

In the study by Summers et al. (42), the EuroQol 5 dimensions (EQ 5D) was evaluated in two groups of older adults with physical pre-frailty conditions. EQ 5D, a test widely used to measure health status-related quality of life, was used to calculate the sample size. Assuming an overall sample size of 220 subjects (110 cases and 110 controls), 2 repeated assessments (baseline and follow-up), a significance level of 0.05, power of 90%, a correlation among repeated measures of 0.5, and a non-sphericity correction ε of 1 in an ANOVA model within-between interactions, the achieved effect size for this study is 11% (corresponding to a small effect size in a coherent way with the literature). Even factoring in a dropout rate of 10%, the total number needed would be 240 subjects, evenly divided into 120 cases and 120 controls. The hypothesis is that this sample size is more than adequate to detect variations in secondary outcomes. For these secondary outcomes, a treatment effect size is assumed to be similar to or even greater than the one identified for the primary outcome.

Intervention

The interventions are oriented toward the model of intrinsic capacity (43), and an improvement of the general well-being is to be achieved through the promotion of the different areas. For this study, 240 healthy older adults will be enrolled. Figure 1 illustrates the flowchart, detailing the process of patient selection.

In total, 120 subjects will be enrolled in the experimental group and will receive the e-VITA platform composed of a virtual coach, several sensors for monitoring, and a smartphone to use at home.

The control group will receive only the booklet with nutritional, cognitive, and physical suggestions.

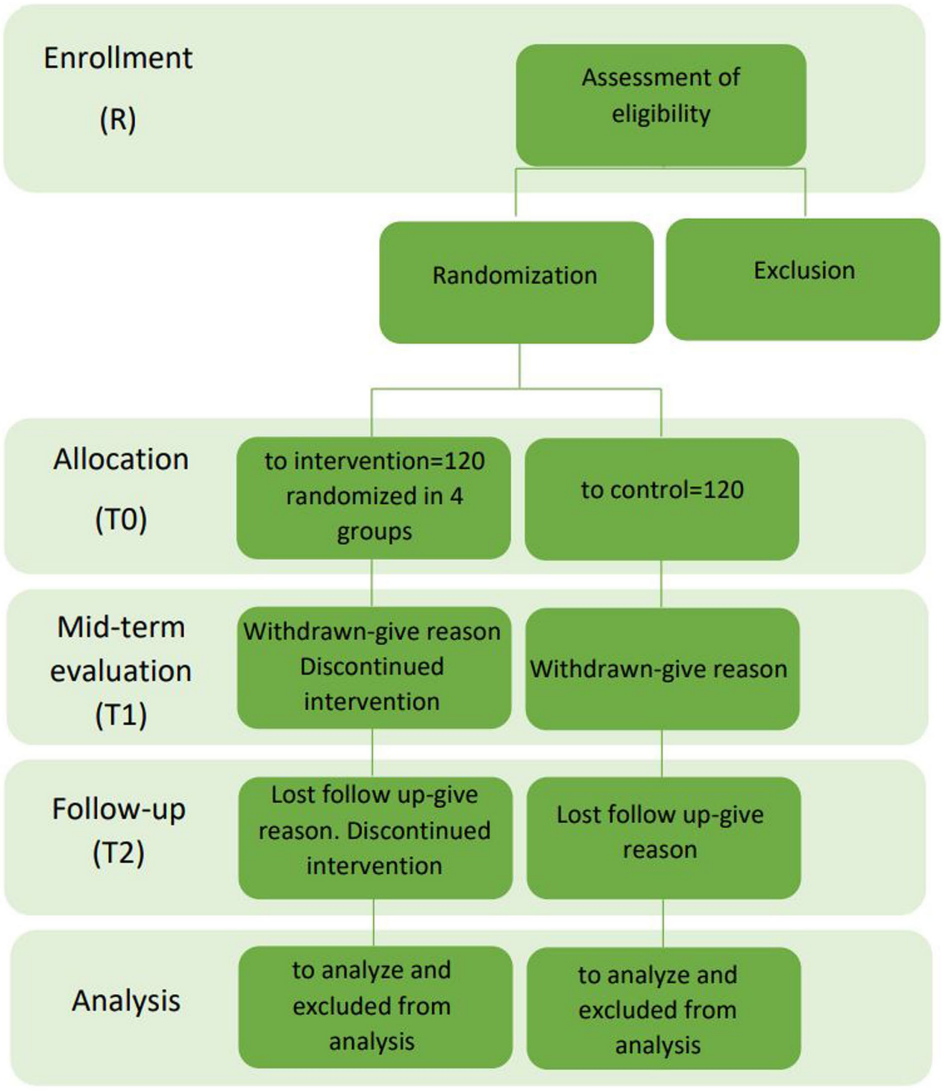


FIGURE 1
Flowchart of the patient selection.

Equipment

An innovative Information and Communication Technology (ICT)-based virtual coaching system has been created to identify subtle changes in the physical, cognitive, psychological, and social domains of older adults. The e-VITA virtual coach is designed to offer personalized recommendations and interventions, fostering sustainable well-being within a smart living environment at home. All the devices will be supplied by the researchers.

The different components of the system are:

- Coaches, consisting of social robots, that will interact with the users and are guided by apps;
- Sensors (both wearable and domestic) to detect physiological parameters, physical activities, and behavior of the users; these sensors are the Huawei smart band (wearable), the NeU device (wearable), and the DeltaDore system (domestic).
- Smartphones (the chatbot to provide insights, suggestion, and stimulation about healthy nutrition and physical exercise; the social platform to encourage users to share their interests).

These components (coaches, sensors, chatbot, and social platform) together with the main software named Digital Enabler (DE) constitute the Virtual Coach. The DE takes into account different types of data (both from the literature and different devices described above together with the user's personal data), to make choices in order to customize the user experience. Choices are made both on the basis of the data received and the use case considered. The DE operates directly on the sensors, robots, and chatbots.

Categorizing sensing technologies and coaching devices based on their inputs is integral to establishing a cohesive and integrated sensor network. This network possesses the ability to recognize user behaviors, physiological states, and emotions, ultimately pinpointing a coaching device that resonates with the user's preferences and acceptance.

Three categories of sensors could be distinguished: (1) those which are worn by the user and aim to sense physiological and actimetric parameters (user-related devices); (2) those which measure physical quantities useful for assessing the level of comfort and quality of the indoor environment and localization of the user (environmental devices); (3) those installed in the home to monitor user behavior and activities (home-based devices). For the e-VITA system, all these types of sensors are combined to make inferences about simple situations of the users (posture, activity level) in their environment and for localization in the home and the users' physiological states. Contextual information is exploited by the interactive voice-based coaching system, the virtual coach. Each domain requires the integration of specific sensors to acquire heterogeneous data, and a coaching device is selected based on the user's information, preferences, and technical characteristics and functionalities performed. This task is performed by the Use Cases Configurator, a tool that aims at identifying the optimal configuration of the sensor network and coaching devices to be used based on the user's needs and requirements. The coaching devices can take four forms, namely, Gatebox, Nao, Google Nest Hub, and Celeste (or DarumaTO for Japan). The specific mobile applications for the usage scenarios are available on the Android smartphone, which is provided to the user as a support device.

Technological description of coaches

The coaching devices used in the study are Nao Robot, Gatebox, and Celeste, substituted by DarumaTO for the Japanese centers (Table 1).

- Nao is a humanoid Robot exhibiting a friendly appearance with eyes and movements reminiscent of a human being. Nao is equipped with an array of sensors, cameras, and microphones, enabling it to perceive and interact with its surrounding environment and human beings. It is powered by advanced artificial intelligence software, enabling capabilities, such as facial recognition, natural language understanding, and learning from user interactions (44–50).
- Gatebox is an intelligent home assistance device developed that appears as a holographic projector embedded in a cylindrical container, housing a virtual editable characteristic. This characteristic is a virtual assistant equipped with artificial intelligence, designed to interact with users akin to a personal assistant. From a technical standpoint, Gatebox utilizes holographic projection technologies to display coach characteristics within a three-dimensional environment. It is equipped with microphones and speakers to recognize and reproduce sound, allowing users to communicate with the virtual assistant through voice recognition and audio responses. Gatebox can perform a variety of tasks, such as providing information related to physical activity recommendations and giving dietary advice. Moreover, it is designed to provide a more intimate and personal interactive experience compared with other virtual assistants, incorporating elements of relationship and affection in its behavior (51–55).
- CelesTE (56–58) and DarumaTO (59–61) are social robots that have religion as a principal theme. CelesTE resembles an angelic statue atop a column inspired by sacred Christianity art and neoclassical architecture. This social robot incorporates the golden ratio to transcend its robotic nature and evoke a sense of holiness. Primarily designed as a "guardian angel" for older adults, CelesTE serves as a prayer companion and repository of religious teaching, including the Bible. AI enables short conversations on sensitive topics and can print selected content. DarumaTO is inspired by the traditional Buddhist and Shinto doll called Daruma. It can communicate through visual tracking and voice and facial expression. Its functionalities are similar to those of CelesTE, but in the case of design, it results in a device that has a familiar appearance to a Buddhist or Shinto older adults.

Such devices are in charge of interacting with the user, exploiting the dialog features provided by the platform.

The randomization technique, performed by the statistician, relies on a singular sequence of random assignments. A computer-generated list of random numbers is employed, and each subject is assigned a number based on their inclusion order in the study. Following this method, subjects are randomly allocated to the utilization of various coaching devices, maintaining an allocation ratio of five subjects for each branch.

TABLE 1 Coaches.

Name	Type	Description	Main functionalities
NAO robot	Coaching device/Robot	Softbank NAO 5 and NAO 6 humanoid interactive mobile robot.	Robot platform that allows multimodal natural language interaction and robot autonomous movement.
Google Nest Hub (2e Generation)	Coaching device/Virtual assistant	Connected speaker enriched with a 7-chip touch screen	Screen whose brightness adapts to the room's atmosphere. It has a loudspeaker and 3 microphones, making interaction possible.
Gatebox	Coaching device/Hologram	Hologram like device that projects characters with which the user can interact.	Internal sensors such as a camera and a microphone allow the user to converse with the projected character. It connects to the Internet via a wireless LAN. With infrared rays and Bluetooth, it can also be connected to household appliances and other devices.
CelesTE	Coaching device/Robot	Prayer companion designed for Christian Catholic users.	The intended main function of CelesTE is to be a "guardian angel," especially thought for older people. It can be a prayer companion, and contains a vast number of teachings, including the whole Bible. Its AI is capable of keeping a short conversation, in which the user may ask and receive an answer about a sensitive topic (such as happiness, death, faith, etc.). It can also printout a selection of contents.

Technological description of sensors

The sensors are wearable and environmental, and they are needed to monitor physiological and environmental parameters. Table 2 presents the sensors available for the study.

On the environmental sensors, Delta Dore motion detectors can detect the presence of a moving person in a room, which provides information on the occupancy of rooms and the movement of occupants from one room to another. This information can be of interest as a complement to the wearable sensors, especially when they are forgotten or under load. In this case, it is possible to use environmental sensors, especially motion sensors, to infer user activity. The sensor network, especially the infrared-based presence detection sensors (PIR sensors), should be strategically installed to effectively monitor the user, particularly in the designated areas of interest within the smart home environment. A predetermined selection ensures coverage of specific rooms. The primary objective of this system is to initially recognize the resident's movements and potentially infer activities within a particular room of the apartment. The Use Case Configurator aggregates all the information detected by the environmental sensors, serving as input to feed the algorithms. Those sensors are:

- The Wireless motion detector-Delta Dore DMB TYXAL. It is a motion sensor and not a presence detector. It has a range of 12 m with a 90^0 opening angle. It generally covers one room, and detection is limited to opaque walls. Its autonomy is of the order of 10 years. The detector is based on passive infrared technology. The motion detection function consists of a pyroelectric sensor, the associated electronics, which process the signal and control the sensor power supply in an optimized way, and finally a lens.
- The Opening magnetic sensor–Delta Dore DO TYXAL+. DO TYXAL+ is an opening sensor developed to detect intrusion in dwelling when doors or windows are opened. It consists of two parts, one of which is attached to the door or window jamb, and this is the active element. The other part is a mechanical part that contains a magnet and is attached to the moving part of the door or window. These parts are attached to the doors with a double-sided tape. The sensor consists of a reed switch on the active element which is closed when the magnetic part is closed and opens when the magnet moves away from it, i.e., when the door is open. The technology is simple, robust, and energy-efficient.
- The Tydom Home. Sensors are battery-powered and communicate detection and maintenance information to a central unit. The Tydom Home IP gateway will be used to collect data from the various products and transfer them to the e-VITA configurator.

TABLE 2 Sensors.

Name / Type	Description	Main functionalities	
DELTA DORE Tydom platform	IoT Device/Sensor	Set of sensors and measuring devices and IOT platform. The sensors can be used with a gateway connected to any dedicated platform.	Set of smart living sensors (motion sensors, door sensors, metering devices) and IOT platform.
Samsung Galaxy S20+ Smartphone	IoT Device	Android smartphone	To access all the apps and services
Smart band Huawei	IoT Device/Sensor	Wearable smart band that tracks physiological parameters.	Parameters monitored: activity level, step, calories, sleep duration, sleep quality, etc.
NEU XB-01	IoT Device/Sensor	Ultra-compact device with a butterfly-style design that bends in the middle to conform easily to any individual's forehead. Data is transferred via Bluetooth in real-time to any smartphone, making it possible to measure brain activity.	Brain activity is measured using NIRS technology and the brain's rate of blood flow change is measured using weak near-infrared light.

Description of the end-users' platform

The end-user's platform is composed of a privacy dashboard, smartphone app, Chatbot, social platform, and use case configurator. Through those applications, the end-users will be capable of managing his/her data and receiving information on health activities and social events. However, the virtual coaches represent the main interface of the system through vocal communication with the end-users.

- *Privacy Dashboard*: CaPe offers a privacy dashboard through the Cape Suite, compatible with any mobile device. This system is designed to adhere to legal requirements outlined in the GDPR. It incorporates consent-based data management, technical mechanisms for verifying compliance with data handling prescriptions, the right to obtain a copy of personal data, the right to be forgotten, and transparency tools on data usage. The consent record maintained by CaPe details who consented, when the consent was given, what was consented, how the consent was granted, and any instances of withdrawn consent. CaPe supports two types of consenting: (1) consenting to process within a service for a specific purpose and (2) consenting to share data from a service (source) to be processed in another service (sink) for a specific purpose. The Cape Suite features two frontend dashboards, catering to end-users (data subjects) and service providers (data controllers), respectively. The User Self-Service Dashboard serves as a centralized point for end-users to overview, verify, and modify data usage settings, understand the purpose of data processing, view event logs, and adjust linked services and consents previously granted. On the other hand, the Data Controller Dashboard is the entry point for service providers, allowing them to manage semantic descriptions and registrations of their provided services and view and manage service linking and consent status given by all users of their registered services. Some screenshots of the dashboard are shown in Figure 2.
- *Smartphone App and Chatbot*: The e-VITA project provides a smartphone app for end-users that functions as the control center. From there, users can access all relevant apps and interventions. Furthermore, apps that offer control over system settings, such as the privacy dashboard, can be reached via the control center. Specific e-VITA apps (e.g., social platform), but also external apps, are represented on the dashboard. The app requires a user profile to be accessed. After opening the app, users will observe an introduction to app which can be skipped to the landing page (see Figure 3A). From there, e-VITA users can create a profile using their email address and a secure password (see Figure 3B). Additional information is not needed for the sign-up process. The email and password will be used to log in and access the individual account (see Figure 3C).

Further system control tasks, such as changing the language, password, or location, can also be handled via the smartphone app. The language settings can either be accessed via the landing page (see Figure 4A) or the general app settings (see Figure 4B). The general app settings are always accessible via a menu icon on the top left (see Figure 4C).

The core function of the app is a control center through which various training interventions (e.g., cognitive training) and chatbots can be started. For this, the dashboard functions as a single point of contact (see Figure 5A). From there, other components of the e-VITA architecture can be accessed (see Figure 5B). The dashboard will provide links to, for instance, data analytics, profile data, performance indicators, status of the different interactive devices, privacy, and security.

Users may want to use chatbots, social platforms, privacy dashboards, or other applications outside their home. To enable this, components of e-VITA that can be reached via URL can be accessed from outside the home, given that an internet connection is available. The dashboard consists of a grid layout with labeled tiles that link to other components of the e-VITA architecture. It is available in all languages of the e-VITA project. Users will observe this page after logging into their account. It offers a quick overview of all contents that can be accessed from the app.

Chatbots are software agents that use a dialog function, such as a text or speech interface, and are based on natural language processing (NLP). The chatbot can be used to extract information from a user's statement or input. The chatbot is also connected to the e-VITA dashboard. The chatbot in itself is a Telegram account that can automatically answer the text messages sent to it. To start a conversation with these chatbots, the user can either type '/start' or press the start button on the screen. Once a piece of text is sent by the user to the chatbot, the message, the system starts to search for the intent and extracts entities from the user's sentence. At the same time, the previous messages are also taken into consideration for extracting information that the user might have asked for before. Information is then returned to the middleware, where the request is further processed.

- *Social Platform*: The social platform allows the users to register and enroll in groups. Groups are meant to be interest areas. Users may either contact or create groups, based on their personal interests (e.g., nord walking and cooking classes), and may also get located to set up feeds, based on the country. Furthermore, users may be notified of upcoming meetings from groups and agenda updates of meetings. The main purpose is to establish a bridge between youth and older adults and between individuals and communities by creating a social platform in which different types of activities (e.g., cultural, sport, cooking, repairing, sewing, and gardening) are carried out to stimulate the users in remaining active. To make it efficient and easy to get connected, living labs, coaches, and those who offer their services will operate based on their location, which will be available only for the local community. Social platform application is maintained based on the countries and different communities (more specifically the local location and helping community directly around the primary end-users), to offer user services in the interest of the area. Living laboratories and international study site locations will be available to offer suitable activities to the users based on their location. For this purpose, in HumHub, Google location services will be used. Social platform operates as a website that can be accessed easily on any smartphone, tablet, and computer.
- Sign up: The application will ask to get permission of location to detect the user's country to set up feeds based on the country. The user will enter credentials on the homepage, once registered.
- Registration: Upon registration, the user has designated roles such as administrator, service provider, or community organization (secondary stakeholders). Administrators are users who have technical responsibilities for the maintenance of the website, while service providers are users who offer either voluntary help or coaching. Community organizers are users who arrange local activities, such as meetups.
- Groups: There are different interest areas based on groups. Users may contact these groups or create groups based on their interests by themselves.
- Notification: In this section, the system will notify upcoming meetings from groups and agenda updates of meetings (update about the new updates of the app also). Notifications can be turned off in Settings.
- Messages: Users may contact people who initiate the activities or get contacted by the manager of those activities by getting detailed information through the chat system. When the users receive a message, they will be notified by message, such as email, and it will be marked on the top of the page. When a user clicks on the "Message" button, he/she will get a short description of the message, and in order to reply, users have to go to the "Conversation."
- Feed: On feeds, users observe a variety of group meetings in the upcoming week. Moreover, they can review that volunteer announcements offer different services. The feed page is also considered as the main page, and users observe a review of the last activities.
- Settings: Users will be able to change location, language, and password and be able to log out. Furthermore, it is possible for the user to change or delete profiles on this page. Users can offer different types of services and, at the same time, benefit from offered services. Types of services will be offered under different categories. Users can also change their personal information on this page. This information includes profile photo, Email, and location. To make different changes to the profile directly, users have to click on their username, which is on the top of the page. The pop-up list will be shown, in which users choose "Settings" to make desired changes. On these settings, user can choose their desired language to use the application. To change the language, users have to choose "Settings," and a core settings list will be shown, in which the "Language option" will be listed. Figure 6 shows some screenshots of the Social Platform.

Use case configurator (UCC)

The Use Cases Configurator (UCC) stands as an independent software component within the e-VITA platform, which is tasked with translating user needs, environmental requirements, and configuration settings into technical specifications for the sensing and coaching system. This configurator prioritizes the creation of a smart living environment that balances cost-effectiveness and sensor efficiency, ensuring accurate measurements while identifying optimal devices for virtual coaching. The overarching goal is to deliver a service tailored to users' needs and preferences. The UCC features a graphical interface, offering insights of end-users into the composition of the e-VITA platform based on their selected information, preferences, and goals. Inputs for the configurator include the needs and requirements of older adults, encompassing details about the living environment (house architecture, rooms, etc.), living situation (single or multiple residents), sensor acceptance (wearable or stationary sensors), privacy settings, and personal information (gender, age, and religion).

Emotion detection system (EDS) module

The e-VITA Emotion Detection System (EDS) module will serve as one of the basic foundations for an empathic coaching system. That is, by accurately detecting the end-users' emotional state, the EDS enables subsequent, high-level components to flexibly adjust their functioning and end-user interaction, in order to achieve a higher level of acceptance, usability, and well-being. The EDS layer imports audio samples from the current speech of the user (pseudonymized) during the interaction with the coaching devices via speech. Then, it pre-processes these data and decomposes the audio signal into its

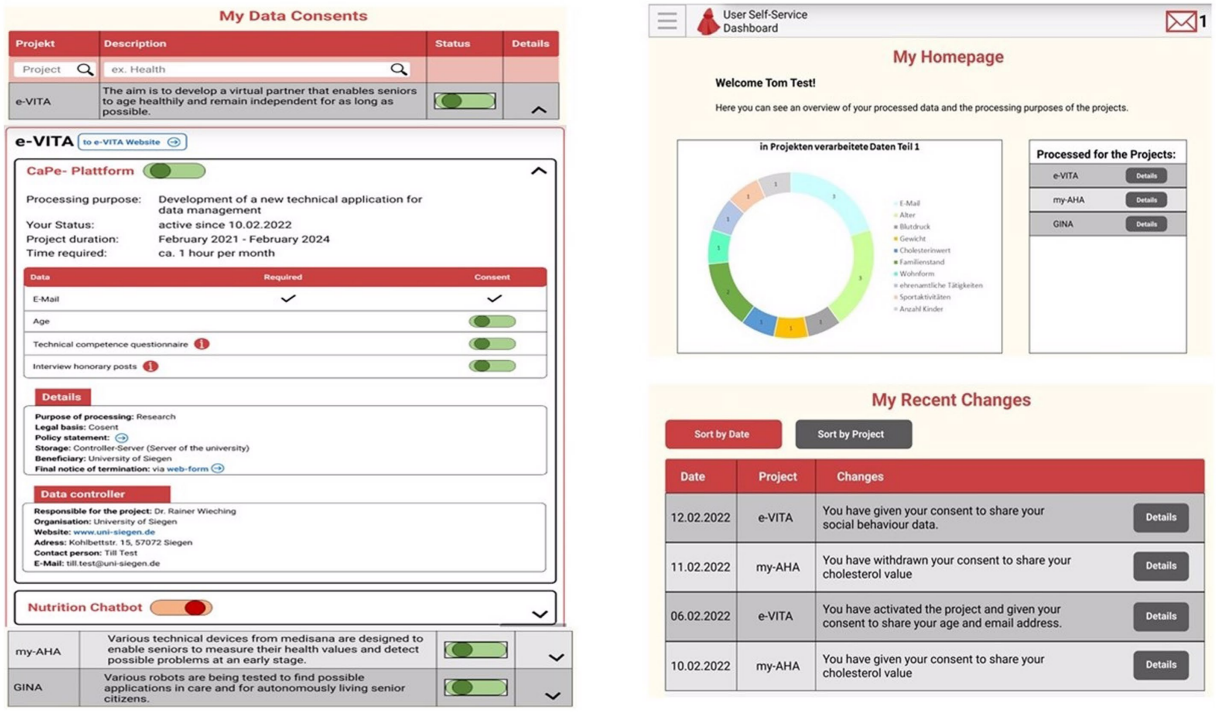


FIGURE 2
Screenshots of the privacy dashboard, where user can manage permissions and find information about data sharing.

statistical sub-components (anonymized, no reverse-engineering possible). Based on this, a classification layer detects the currently most prominent emotion from a fixed set of basic emotions. Another approach will be to add a sentiment analysis to the EDS. This means, that in addition to the acoustic features of the audio data coming from the participant, information is extracted that is related to the participant's sentiment or opinion, based on Natural Language Processing (NLP). For this, the audio data will be transcribed to a text, which will be then analyzed based on keywords, that represent a basic emotion. This information will be then added to the results of the acoustic analysis, leading to a final model with labels of basic emotions such as anger, disgust, fear, joy, neutral, and sadness. As a result, components, directly modeling the interaction with the end-user, for instance, dialog management, can then be augmented to fit the user's emotional state.

Outcome measures

All outcomes will be measured following a standardized operating procedure. The primary endpoint of the study is constituted by the improvement in the quality of life after the use of the e-VITA system, to be measured through the EQ-5D-5L, after 6 months of training.

The secondary endpoints encompass: (1) adherence to the coaching intervention, measured by the frequency of technological device usage, and collected through semi-structured interviews and technical data; (2) usability and the user experience of the overall system assessed using the System Usability Scale (SUS) (62) at both the midpoint and the conclusion of the experiments, along with the User Experience Questionnaire [UEQ (63) and UEQ+ (64)] in the middle and at the end of the experiments; (3) improvement in eHealth literacy, to be addressed through the eHealth Literacy Scale (eHEALS) (65), social connectedness through the UCLA Loneliness scale (UCLA) (66), nutritional state through the short version of Food Frequency Questionnaire (FFQ) (67) to estimate the frequency of daily food intake over a period, cognitive status, through Montreal Cognitive Assessment (MoCA) (39), psychological mood through the Geriatric Depression Scale (GDS) (40), functional status through Short Physical Performce Battery (SPPB) (41), participation to leisure activities through an *ad-hoc* checklist; meets the participant's objectives through ADTPA-5 (scale B and E adapted) (68). A semi-structured interview will be used to complement the information collected by questionnaires, focusing on acceptability, attitude, usability, and cost–benefit analysis; other questionnaires will be used to better understand our participants' sociodemographics questionnaire, Clinical Frailty Scale (CFS) (38), Big Five Inventory – 10 (BFI-10) (69), and Affinity for Technology Interaction (ATI) (70).

Table 3 presents a concise overview of all collected data and their respective collection time points.

The scales which will be used during the evaluations are described below.

Clinical frailty scale (CFS)

This descriptive scale divides the older participants into nine classes based on the information provided by them and their relatives:

10.3389/fpubh.2024.1256734

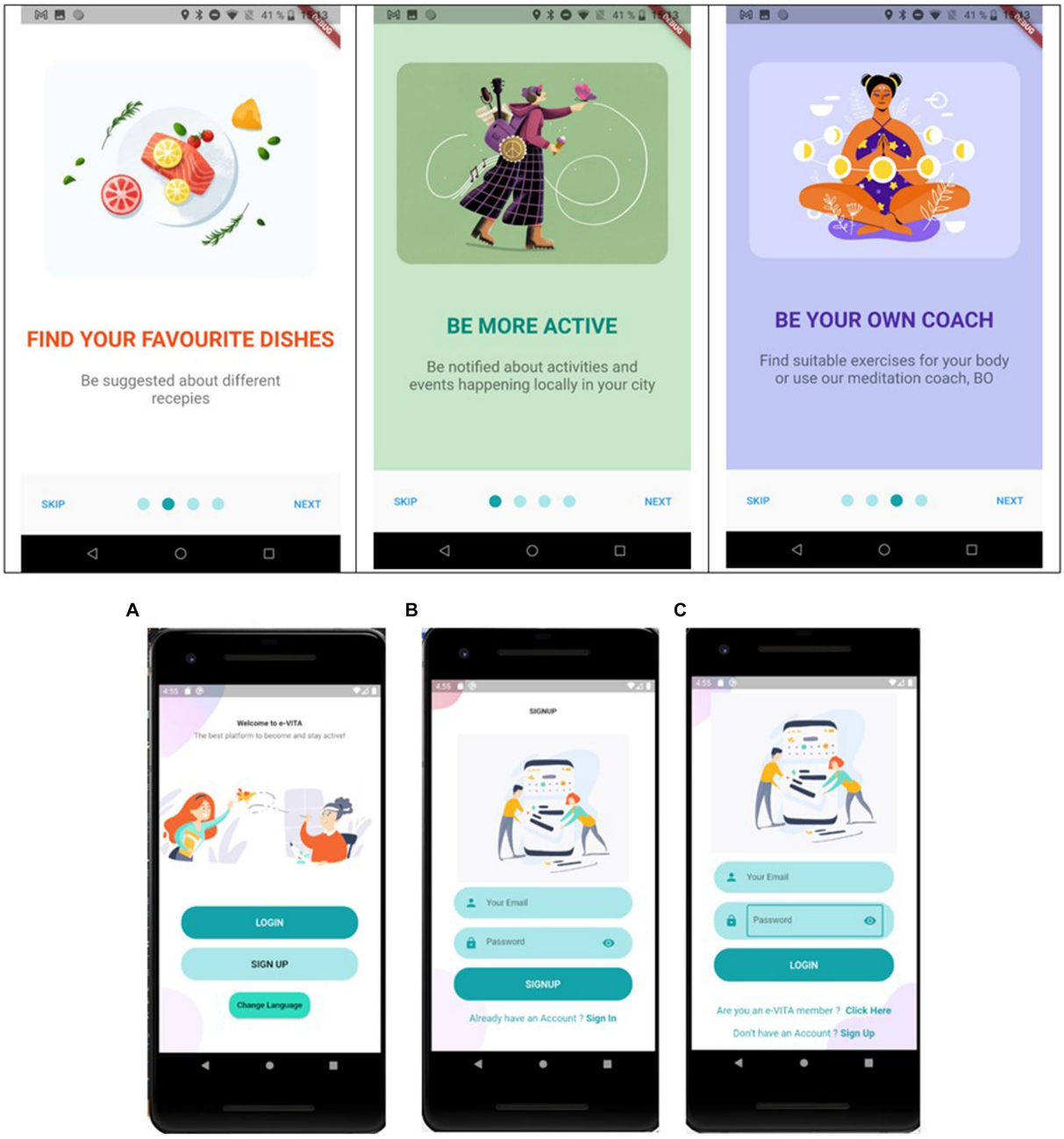


FIGURE 3
e-VITA dashboard access page that is shown when opening the app **(A)** landing page, **(B)** login page, and **(C)** sign up page.

between 1 and 3, the patient is non-frail, pre-frail if 4, and he is frail from 5 to 9.

Montreal cognitive assessment (MoCA)

Montreal Cognitive Assessment (MoCA) serves as a validated cognitive test, which is recognized for its high sensitivity in the early detection of mild cognitive impairment (MCI). MoCA efficiently assesses various cognitive domains, including short-term memory, visuospatial abilities, executive functions, attention, concentration, working memory, language, and orientation to time and place. The final version of MoCA, accessible at www.mocatest.org, is a 1-page, 30-point test that can be administered in just 10 min. Specific details regarding the MoCA items are as follows: (1) Short-Term Memory Recall Task (5 points): involves two learning trials of five nouns and delayed recall after approximately 5 min; (2) Visuospatial Abilities (4 points): clock-drawing task (3 points), three-dimensional cube copy (1 point); (3) Executive Functions (4 points): alternation task adapted from the Trail Making B task (1 point), phonemic fluency task (1 point), two-item verbal abstraction task (2 points); (4) Attention, Concentration, and Working Memory (6 points): sustained attention task (target detection using tapping; 1 point), serial subtraction task (3 points), digits forward and backward (1 point each); (5) Language (8 points): three-item confrontation naming task with

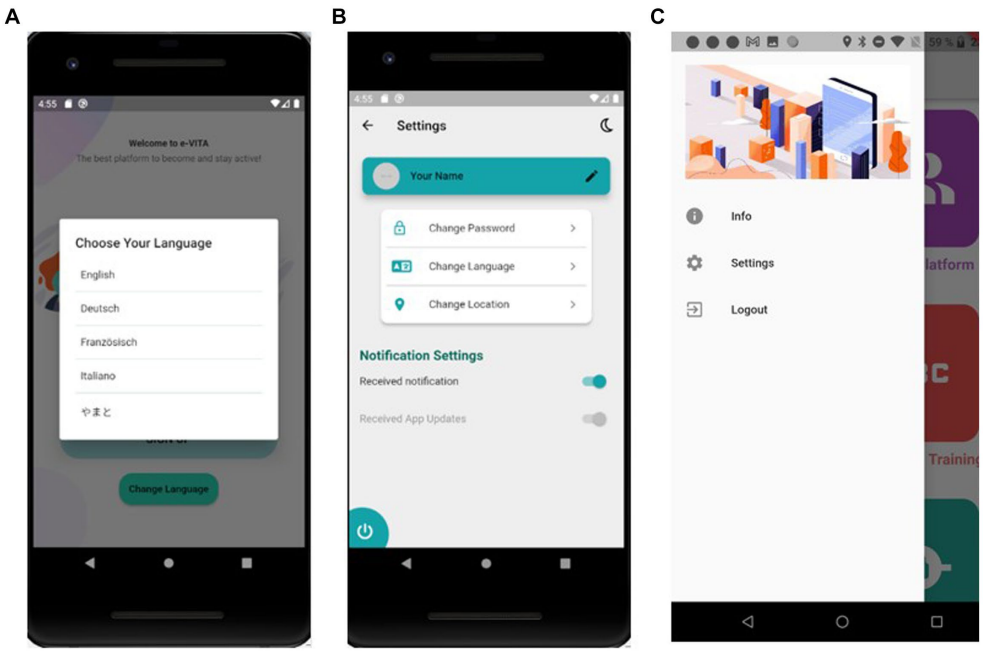


FIGURE 4
e-VITA dashboard settings control—**(A)** language settings, **(B)** settings page, and **(C)** dashboard lateral menu to access settings.

low-familiarity animals (lion, camel, and rhinoceros; 3 points), repetition of two syntactically complex sentences (2 points), phonemic fluency task; (6) Orientation to Time and Place (6 points): assessment of orientation across various dimensions. The comprehensive nature of MoCA allows for a thorough examination of cognitive abilities in a relatively short time frame.

Geriatric depression scale (GDS) 5-item version

This questionnaire assesses the current condition of the patient's mood. For the screening required by our study, only the first five items of the scale can be used. The answers highlighted indicate the statements expected by a non-depressed subject.

Short physical performance battery (SPPB)

It assesses physical performance on the basis of three criteria by testing balance, walking speed, and chair-raising abilities. This scale is used for the inclusion of participants (40).

EQ-5D-5L

The scale consists of five dimensions: mobility, independence, usual activities, pain/discomfort, and anxiety/depression. Each dimension has five levels: no problems, mild problems, moderate problems, severe problems, and extreme problems. The participant is asked to indicate his/her health status by ticking the box corresponding to the most appropriate statement in each of the five dimensions. The numbers from the five dimensions can be combined into a 5-digit number that describes the health status of the participant.

Assistive technology device predisposition assessment (ATDPA-5 – scales B and E)

This scale assesses the person's need for technology. It has two parts. A part on the individual with 9 items assessing functional capacities and 11 items on well-being. These first 20 items are to be filled in on a five-point Likert scale, ranging from 1: poor/not satisfied to 5: excellent/very satisfied. Finally, this last part also assesses personal and psychosocial characteristics. There is no threshold value for these last items. The second part deals with technological tools with 12 items, highlighting their expectations in terms of benefits toward three technological tools. There is no threshold for this scale, but the scores range from 0 to 60 (sum of the statements). The tool with the highest score is considered the most important. This scale is used at the beginning of the experiment. Only parts B and E will be used and adapted for the project (68).

Big five inventory – 10 (BFI-10)

The BFI-10 (69) is a concise 10-item scale designed to assess the Big Five personality traits: extraversion, agreeableness, conscientiousness, emotional stability, and openness. Participants rate each item on a scale ranging from 1 (disagree strongly) to 5 (agree strongly).

Short food frequency questionnaire (FFQ)

FFQ serves as a scale to estimate the frequency of daily food intake over a specified period. This questionnaire seeks information on how often certain foods are consumed (e.g., once daily, once or twice a week, and once or twice a month) and the approximate serving size. It is designed to capture data on habitual food intake rather than quantifying the exact nutrient amount ingested. In Europe, partners will utilize the scale developed by Robinson et al. (67).

eHealth scale

The eHEALS is an 8-item assessment designed to gauge eHealth literacy, measuring consumers' collective knowledge, comfort, and perceived skills in finding, evaluating, and applying electronic health information to address health-related issues.

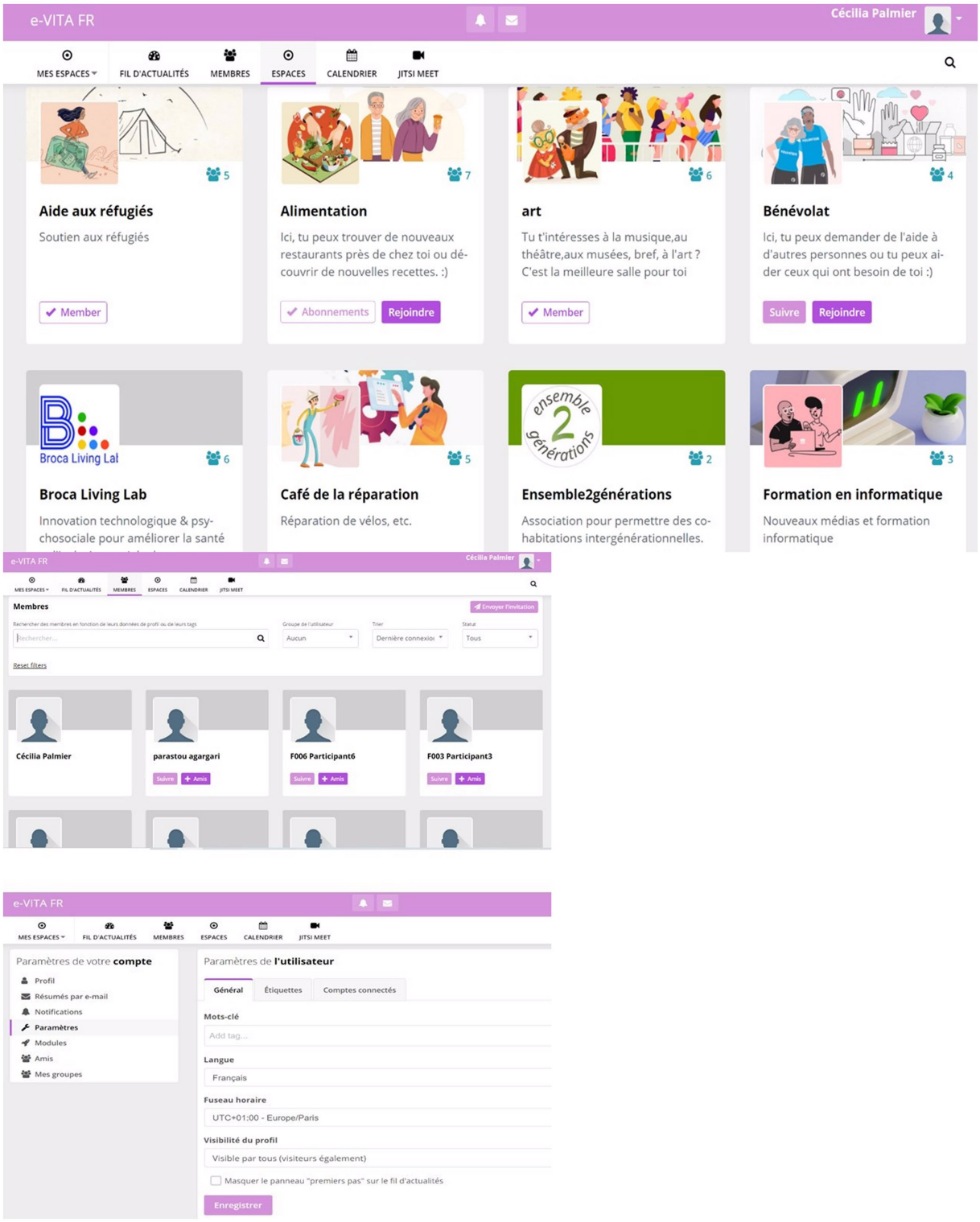


FIGURE 5
e-VITA dashboard homepage where all the apps and services are shown and accessible.

Revised UCLA loneliness scale version 3

The revised UCLA Loneliness Scale Version 3 is a dependable and consistent questionnaire-based measure designed to assess trait loneliness (66). Comprising 20 items, respondents rate each item on a scale from 1 (never) to 4 (often), yielding a loneliness score ranging from 20 to 80. A higher score on the scale indicates a greater level of trait loneliness.

System usability scale (SUS)

The System Usability Scale (SUS) stands as a reliable tool for assessing usability, featuring a 10-item questionnaire with five response options ranging from 'strongly agree' to 'strongly disagree'. This versatile scale enables the evaluation of a diverse range of products and services, spanning hardware, software,

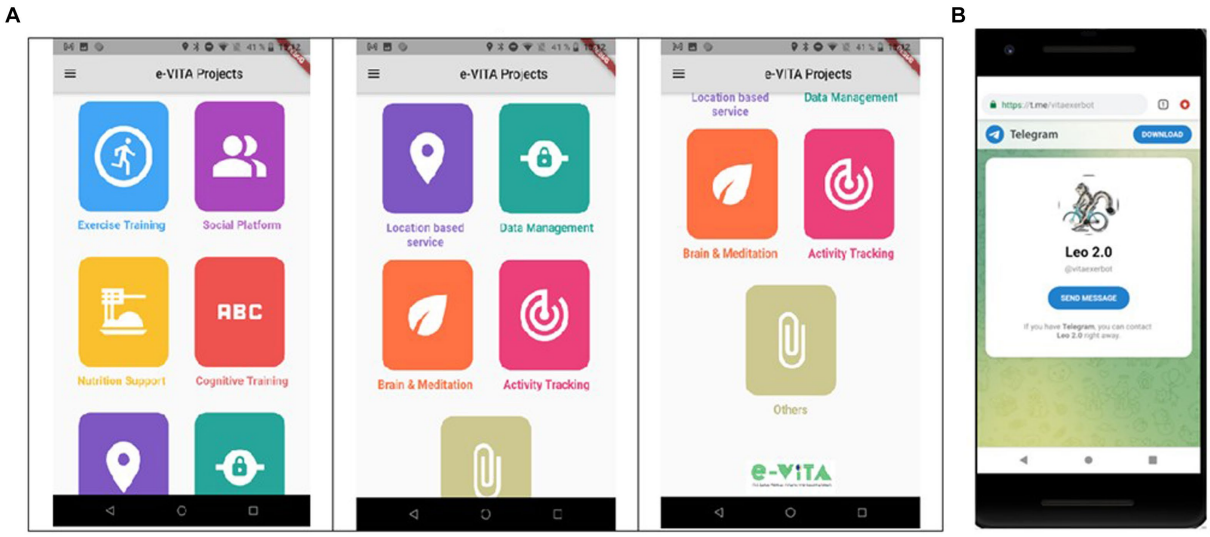


FIGURE 6
Screenshots of social platform—**(A)** thematic groups of interests to which the user can subscribe and **(B)** view of the members of one group.

TABLE 3 **Schedule of assessment and outcome measures.**

Dimension	Scale	R	T0	T1	T2
Clinical frailty scale	CFS	X			
Cognitive status	MoCA	X			X
Psychological status	GDS	X			X
Physical capacity	SPPB	X			X
Overall health status	Clinical anamnesis	X			
General information	Socio-demographics questionnaire	X			
Quality of life	EQ-5D-5L		X		X
Goals and expectation	ATDPA-5 (Scale B and E)		X		X (Scale B)
eHealth literacy	eHEALS		X		X
Social connectedness	UCLA		X	X	X
Personality	Big Five Inventory – 10 items		X		
Nutrition	Short FFQ		X		X
Adherence	Collected through the system and interview			X	X
Leisure activities	Physical and leisure activity checklist		X	X	X
Usability	SUS			X	X
User experience	UEQ, UEQ+			X	X
Attitude, usability, acceptability and cost–benefit analysis	Semi-structured interview				X
Affinity for technology interaction	ATI		X		

R, recruitment; T0, first evaluation; T1, intermediate evaluation; T2, final evaluation; CFS, Clinical Frailty Scale; MoCA, Montreal Cognitive Assessment; GDS, Geriatric Depression Scale; SPPB, Short Physical Performance Battery; ATDPA, Assistive Technology Device Predisposition Assessment; FFQ, Food frequency questionnaires; SUS, System Usability Scale; UEQ, User Experience Questionnaire; ATI, Affinity for Technology Interaction.

mobile devices, websites, and applications. Its ease of administration to participants, suitability for small sample sizes, and ability to effectively distinguish between usable and unusable systems contribute to its widespread applicability and reliability in usability assessments.

User experience questionnaire (UEQ)

The questionnaire incorporates scales that provide a comprehensive assessment of the user experience. It encompasses classical usability dimensions such as efficiency, perspicuity, and dependability while also evaluating user experience aspects, such as

originality and stimulation. This holistic approach ensures a well-rounded understanding of the overall user experience, considering both functional and experiential aspects of interaction with the system or product.

User experience questionnaire + (UEQ+)

To measure the user experience of the voice interaction in particular, additional scales such as response behavior or response quality from the UEQ+ can be added.

Affinity for technology interaction (ATI)

The scale, evaluated in 2019 from the study by Franke et al., measures a person's interaction-related affinity with technology. It consists of nine items and uses a six-point Likert scale ranging from 1 = completely disagree to 6 = completely agree (71).

Physical and leisure activity checklist

An *ad-hoc* checklist has been developed to collect information on engagement in leisure and physical activities of the participants during the e-VITA trial. It contains questions, which are rated on a six-point Likert scale, about common physical and leisure activities and a section to report the personal practices and frequency put in place by the participants.

Scales at T0 and T2 for the control group

These two scales are necessary to better understand our participants. The scale at T0 focuses on the dimensions of daily life, social, and prevention. The T2 scale focuses on the participants' feelings, following the experiment, their experience with the information booklet and its usability, and their well-being.

Risk–benefit analysis

During the use of robotic platforms or, in wider terms of technological applications, a general difficulty in distinguishing between the artificial world and reality may occur. Especially, in the case of vulnerable older adults, the interaction may generate a general feeling of attachment and dependency. To avoid this, e-VITA has been designed to not look like a human but to preserve artificial aesthetics, as suggested by the guidelines. In addition, during the first contact with the participants but also during all the interventions, researchers will be in contact with the users, continuously stimulating awareness about the technological applications and monitoring the appropriateness of the use of the solution in terms of autonomy of the users, specific needs, and personal preferences. In particular, following the recommendations provided by Comitato nazionale di bioetica (Cnb) of the Ministry of Health (71) on robotics and roboethics, the exit strategy of e-VITA will aim to:

- promote adequate experimentation of robotics in the field assistance in order to ensure conditions for the physical and psychological integrity of the user, explaining the risks and benefits, which was highlighted also in the informed consent;
- ensure both equitable access to robotic and general technologies and the use of robots to assist and not to replace humans, in order to avoid delegating the irreplaceable human task of care and assistance to the machine;
- the need that the introduction of robotics in medicine entails always the real consideration of the benefits, of the complexity of the change complete with the structure of the services and the economic burden that this entails.

There is a risk that the older adults may wish to stop interacting with the technological devices (for example, because they do not like the NAO robot). In this case, the experiment will be immediately stopped and terminated.

The presence and use of technological devices (virtual coaches and sensors) in participants' homes can be a source of discomfort. Therefore, pre-studies with end-users (older adults) and stakeholders (informal carers, health professionals, family, NGOs etc.) have been carried out in order to propose virtual coaches that meet the needs of older adults. In addition, safety procedures were also designed to limit the risks as much as possible.

To protect the safety of participants:

- participants will be informed about the appropriate use of the virtual coach or technological device (e.g., cannot lean on the technological device or make a movement that could destabilize it);
- the researcher will train the participant in the use of the sensors and be available in case of problems;
- the technological devices will be placed in the participant's home in a configuration that allows them to be used safely.

In the case of adverse events occurring despite the precautions described above:

- participants will be instructed to press the "off" button on the device or to disconnect it, according to the instructions in the user manual;
- participants will call the researcher, who will assist the participant in case of problems;
- participants will be able to call the researcher, who will come and ensure that no damage has been caused to the participants or to any other person.

To mitigate potential technological dependency, especially with humanoid or theomorphic robotic systems, participants will undergo instruction and training for the appropriate and limited use of virtual coaches. Researchers will maintain contact with participants to ensure proper guidance. Despite the existing risk, it is crucial to acknowledge that current technology has not reached the level of sophistication, which is necessary for natural human–robot interaction. Presently, there is limited progress in developing coaching devices that are capable of minimal social interaction, involving emotional and psychological engagement in controlled conditions. However, precautions, including the provision of adequate training and daily support/monitoring by researchers, are essential to safely use coaching devices in emotional, social, and psychological terms and prevent potential future dependency.

Finally, if after the experimentation, the participants would ask for a longer use of the system, they will be asked to be involved in similar studies, to ensure the continued use of the technology. Moreover, after

the end of the study, the opportunity to receive personalized support on everyday technology will be offered to the participants about eHealth literacy and similar solutions for health.

Data management

The project is dedicated to upholding the anonymity and confidentiality of participants throughout all stages, encompassing screening, recruitment, testing, evaluation, and dissemination procedures. Data collection, usage, and storage strictly adhere to national laws, the General Data Protection Regulation (GDPR) of EU, and APPI. Participants retain rights, such as access, information, withdrawal, and data erasure. Additionally, servers are situated in the European Union and comply with the GDPR standards. Data collection follows the principle of data minimization, ensuring that personal information collected is directly relevant and necessary for the specific goals of testing and evaluation. Specific software with blocks and data entry checks is employed to minimize entry errors. All screening data are discarded upon project completion. During testing procedures, any visual, auditory, and sensory data processed by the robot are discarded after completing the procedures, except for the number of interactions logged with each participant, which remains anonymous. After the conclusion of this project, all research data will be openly available for secondary analysis after 3 years.

Data analysis

A comprehensive analysis plan will be established to serve as the foundation for conducting subsequent analyses. This plan will outline the methodologies, procedures, and criteria for conducting the analyses, ensuring a systematic and well-organized approach to data interpretation and result generation.

Data collected by the researchers

The first step of the data analysis will deal with the description of the sample. Continuous variables will be reported as either mean and standard deviation or median and interquartile range based on their distribution (assessed using the Kolmogorov–Smirnov test). Categorical variables will be expressed as an absolute number and percentage. Comparison of baseline measurements between groups will be evaluated by unpaired t-test (for normal distribution), Mann–Whitney U tests (for non-normal distribution), or chi-square tests (for categorical variables). Within each group, independent and dependent variables will be compared between the pre-conditions and post-conditions using the same tests as appropriate. The treatment effect on the outcome variables will be evaluated by using repeated measures ANOVA, in order to compare the changes over time in the outcome measures between the intervention group and control group. Moreover, a linear regression model on the outcome variation between baseline and follow-up will be estimated in order to evaluate the effect of the treatment adjusted for all potential confounders. For the analysis of the results, the two types of subjects, stratified according to the MoCA cutoff (score $\geq$ 26 for cognitively healthy subjects, score 22 to 25 for subjects with mild cognitive decline), will be considered separately. Descriptive statistical analyses will be performed on the quantitative data with SPSS or R studio.

Data collected by the technological devices

One of the uses of the data collected from the sensors is to infer the activity of the user and know his or her location so that the voice coach carries out personalized dialogs adapted to the contexts of the user. The environmental data will be used to identify dangerous situations and difficulties and inform the user by giving him the right recommendation to remedy this situation. The aggregation of activity data from several testing centers will serve to motivate users and strengthen their adherence to the experiment. The analysis of user activity data and their interactions at well-defined milestones in the experiment will make it possible to detect system failures as early as possible, in order to prevent the user from dropping out.

Ethical consideration

The study received approval from the Ethics Committee of the Istituto Nazionale Ricovero e Cura per Anziani (IRCCS INRCA) (CE INRCA 23005), the German Association for Nursing Science (Deutsche Gesellschaft für Pflegewissenschaft e.V.) for the Diocesan Caritas Association of the Archdiocese of Cologne, and the Research Ethics Committee (Comité Ethique de la Recherche) for Assistance Publique – Hôpitaux de Paris. It was registered in ClinicalTrials.gov on 28 April 2023, with the number NCT05835856.

The study will be adhered to regulatory and legal requirements, which were initiated after receiving evaluation and approval from an independent ethics committee and completing administrative requirements at the conducting institution.

Additionally, all potentially eligible participants will receive comprehensive information about the study and must provide consent to participate.

Participants are required to consent to the processing of personal data in anonymous and aggregate form, aligning with EU Regulation 2016/679 (GDPR)/APPI on the protection of individuals and concerning the processing of personal data and Legislative Decree No. 101/2018. The participant must be informed that his or her data may be examined by authorized personnel or members of the competent ethics committee and officials of the competent regulatory authorities;

The participant is also informed and asked to provide *ad-hoc* informed consent to participate in the study, including data retention for up to 10 or 15 years (depending on the country's rules) after completion of the study.

Each signature must be personally dated by each signatory, and the informed consent and any additional patient information must be retained by the investigator. A signed copy of the informed consent and information sheet will be given to each patient.

Participant information and consent forms are included in the documentation attached to the request for approval by the local ethical committee.

[Optional] The Participant has the opportunity to indicate his or her agreement to the retention and use of his or her data long after the end of the project under the OPEN ACCESS TO SCIENTIFIC PUBLICATIONS AND OPEN RESEARCH DATA as requested by the European Commission.

In the documentation submitted for approval by the IRCCS INRCA Ethics Committee, patient information and consent forms are integral components. These documents play a crucial role in

ensuring that participants receive detailed information about the study and have the opportunity to provide informed consent before their involvement. This approach aligns with ethical standards and regulatory requirements to safeguard participants' rights and well-being.

Dissemination of research findings

The study findings will be utilized for publication in peer-reviewed scientific journals, contributing to the academic and research community's knowledge. Additionally, the results will be presented in scientific meetings, fostering discussions and knowledge sharing within the academic and professional spheres. Summaries of the outcomes will be provided to investigators, enabling them to disseminate key findings within their clinics, further promoting the practical application of the study results in relevant healthcare settings.

Discussion

In the face of an aging population, interventions are needed to reduce or minimize the consequences of various diseases related to advancing age (6), support the healthcare system, and promote active aging, in which the senior is allowed to maintain their autonomy as long as possible. One such solution has been identified in virtual coaches (16) which, through a personalized system that constantly keeps the senior constantly monitored (23) identify situations in which it would be desirable to intervene and propose to the user different solutions and activities adapted to his or her needs and requirements, allowing the person to maintain a healthy and active lifestyle. Despite the advantages that these technologies bring, they also have some limitations: in fact, there are several coaches of this type, but it is obviously necessary for them to be perfectly integrated into the lives of the older adults so that they take into account their real needs that are also due to belonging to different cultures. It is from this premise that the e-VITA project begins, in which different technological devices were proposed to consider people's actual needs; the present study adopts a randomized, single-blind controlled trial design to enlist healthy older adults aged 65 years and older. Its primary objective is to assess the effectiveness of the e-VITA platform in this demographic. This robust research design allows for rigorous examination and comparison of outcomes, ensuring a comprehensive evaluation of the platform's impact on the health and well-being of the participants. Participants will be selected from the four sites described above. In this study, the primary goal is to assess the improvement in the quality of life (QoL) of older individuals, which was measured after 6 months. To evaluate the effectiveness of the treatment, the study population will be stratified into two groups. The experimental group will engage with the e-VITA platform, comprising a virtual coach, various monitoring sensors, a smartphone for home use, and a booklet. In contrast, the control group will receive the booklet alone. This design enables a comparative analysis, allowing for the examination of the impact of the e-VITA platform on enhancing the quality of life in older adults. The virtual coaching system will detect daily physical, cognitive, psychological, and social changes in the older person and provide useful advice and recommendations accordingly. In this way, although the primary goal is to improve the person's quality of life, the system will also act on other dimensions, such as mood, cognitive status, nutrition, social connectedness, and eHealth literacy. In this study, the intervention will be regularly monitored by the research team, which will conduct evaluations in order to ensure its quality. In addition, researchers will be constantly over the call for any doubts or difficulties from users to support their motivation and participation in the trial.

Limitations

Participants will be selected from the Neurology Operating Unit and the Rehabilitation Medicine Operating Unit of IRCCS INRCA, so the results may not be generalizable to the general population. In addition, the e-VITA system is composed of several types of technological equipment, which could be a limitation for those older adults who, while meeting the inclusion criteria, are not particularly familiar with these types of devices. These problems could be solved by incorporating user-friendly interfaces with clear and intuitive navigation to enhance ease of use. In addition, comprehensive guides and tutorials could be developed to help participants familiarizing themselves with the system. Moreover, users could attend training sessions to be guided through initial set-up and use, to accommodate those who may need further assistance.

Conclusion

The study aims to introduce users to a cross-cultural and customizable virtual coach, which was designed to address various aspects of the older person's well-being, including social relationships, physical activity, autonomy, and safety. The ultimate goal is to enhance the overall quality of life for older individuals. To rigorously assess the true potential and identify any potential issues with the intervention, a randomized controlled trial is deemed essential. This research design will provide valuable insights into the effectiveness and challenges associated with the implementation of the virtual coach in improving the well-being of older adults.

Author contributions

RoB: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. VS: Conceptualization, Writing – review & editing. GA: Data curation, Formal analysis, Writing – review & editing. AM: Data curation, Writing – review & editing. MB: Data curation, Writing – review & editing. FB: Data curation, Formal analysis, Writing – review & editing. EM: Methodology, Writing – original draft, Writing – review & editing. A-SR: Conceptualization, Writing – review & editing. SD: Writing – review & editing. CP: Conceptualization, Writing – review & editing. JM: Conceptualization, Writing – review &

editing. RyB: Conceptualization, Writing – review & editing. TO: Conceptualization, Writing – review & editing. RW: Conceptualization, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research is based on data collected for the "EU-Japan Virtual Coach for Smart Ageing - e-Vita" project funded by the European Union H2020 Program under grant agreement no. 101016453 and the Japanese Ministry of Internal Affairs and Communication (MIC), Grant no. JPJ000595.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Forette F. Les enjeux de la prévention. *Gérontologie et société*. (2012) 351:27–40. doi: 10.3917/gs.hs01.0027

2. Rae MJ. The demographic and bio-medical case for late-life interventions in aging. *Sci Transl Med*. (2010) 2:1–6. doi: 10.1126/scitranslmed.3000822

3. Andrieu S. Évaluer les programmes de prévention de la dépendance des personnes âgées: Approche méthodologique. *Gérontologie et société*. (2012) 351:75–80. doi: 10.3917/gs.hs01.0075

4. Wrobel J, Pino M, Wargnier P, Rigaud AS. Robots et agents virtuels au service des personnes âgées: une revue de l'actualité en gérontechnologie. *NPG Neurologie-Psychiatrie-Gériatrie*. (2014) 14:184–93. doi: 10.1016/j.npg.2014.02.007

5. World Health Organization. World report on ageing and health. (2016). Available at: https://apps.who.int/iris/handle/10665/186463

6. Cameirão MS, Smailagic A, Miao G, Siewiorek DP. Coaching or gaming? Implications of strategy choice for home based stroke rehabilitation. *J Neuro Engineering Rehabil*. (2016) 13:18. doi: 10.1186/s12984-016-0127-8

7. Institut national de la statistique et des études économiques. (2020). Espérance de vie et indicateurs de mortalité dans le monde: Données annuelles 2020–2025. Available at: https://www.insee.fr/fr/statistiques/2383448

8. Vie publique. (2019). Espérance de vie en bonne santé: 64,5 ans pour les femmes, 63,4 pour les hommes. Available at: https://www.vie-publique.fr/en-bref/20016-esperance-de-vie-en-bonne-sante-pour-les-femmes-et-les

9. Fratiglioni L, Wang H, Ericsson K, Maytan M, Winblad B. Influence of social network on occurrence of dementia: a community-based longitudinal study. *Lancet*. (2000) 355:1315–9. doi: 10.1016/S0140-6736(00)02113-9

10. Paul C, Ayis S, Ebrahim S. Psychological distress, loneliness and disability in old age. *Psychol Health Med*. (2006) 11:221–32. doi: 10.1080/13548500500262945

11. Beutel ME, Klein EM, Brahler E, Reiner C, Jünger MM, Wiltink J, et al. Loneliness in the general population: prevalence, determinants and relations to mental health. *BMC Psychiatry*. (2017) 17:97. doi: 10.1186/s12888-017-1262-x

12. Hawton A, Green C, Dickens AP, Richards SH, Taylor RS, Edwards R, et al. The impact of social isolation on the health status and health-related quality of life of older people. *Qual Life Res*. (2011) 20:57–67. doi: 10.1007/s11136-010-9717-2

13. Afilalo J, Karunananthan S, Eisenberg MJ, Alexander KP, Bergman H. Role of frailty in patients with cardiovascular disease. *Am J Cardiol*. (2009) 103:1616–21. doi: 10.1016/j.amjcard.2009.01.375

14. Chang H-Y, Chiou C-J, Chen N-S. Impact of mental health and caregiver burden on family caregivers' physical health. *Arch Gerontol Geriatr*. (2010) 50:267–71. doi: 10.1016/j.archger.2009.04.006

15. Kyriazakos S, Schlieter H, Gand K, Caprino M, Corbo M, Tropea P, et al. A novel virtual coaching system based on personalized clinical pathways for rehabilitation of older adults—requirements and implementation plan of the vCare project. Frontiers in digital. *Health*. (2020) 2:1–16. doi: 10.3389/fdgth.2020.546562

16. Siewiorek D. P., Smailagic A., Dey A. Architecture and applications of virtual coaches. *Quality of life technology handbook*, (2012); 100, 2472–2488.

17. Op Den Akker H., Klaassen R., Op Den Akker R., Jones V. M., Hermens H. J. Opportunities for smart & tailored activity coaching. Proceedings - IEEE Symposium on Computer-Based Medical Systems, (2013); 546–547.

18. Fasola J, Mataric M. A socially assistive robot exercise coach for the elderly. *J Hum. Robot Interact*. (2013) 2:3–32. doi: 10.5898/JHRI.2.2.Fasola

19. Chopik WJ. The benefits of social technology use among older adults are mediated by reduced loneliness. *Cyberpsychol Behav Soc Netw*. (2016) 19:551–6. doi: 10.1089/cyber.2016.0151

20. Roupa Z, Nikas M, Gerasimou E, Zafeiri V, Giasyrani L, Kazitori E, et al. The use of technology by the elderly. *Health Sci J*. (2010) 4:118.

21. Ahmed H, Haq I, Rahman A, Tonner E, Abbass R, Sharif F, et al. Older people and technology: time to smarten up our act. *Future Healthc J*. (2021) 8:e166–9. doi: 10.7861/fhj.2020-0015

22. Fung KK, Hung SS, Lai DWL, Shum MHY, Fung HW, He L. Access to information and communication technology, digital skills, and perceived well-being among older adults in Hong Kong. *Int J Environ Res Public Health*. (2023) 20:6208. doi: 10.3390/ijerph20136208

23. Chatterjee A., Gerdes M., Martinez S. eHealth initiatives for the promotion of healthy lifestyle and allied implementation difficulties. International Conference on Wireless and Mobile Computing, Networking and Communications, (2019); 7–14.

24. Yousuf H, Reintjens R, Slipszenko E, Blok S, Somsen GA, Tulevski II, et al. Effectiveness of web-based personalised e-coaching lifestyle interventions. *Neth Hear J*. (2019) 27:24–9. doi: 10.1007/s12471-018-1200-7

25. Kamphorst BA. E-coaching systems: what they are, and what they aren't. *Pers Ubiquit Comput*. (2017) 21:625–32. doi: 10.1007/s00779-017-1020-6

26. Boh B, Lemmens LHJM, Jansen A, Nederkoorn C, Kerkhofs V, Spanakis G, et al. An ecological momentary intervention for weight loss and healthy eating via smartphone and internet: study protocol for a randomised controlled trial. *Trials*. (2016) 17:1–12. doi: 10.1186/s13063-016-1280-x

27. Mostajeran F., Katzakis N., Ariza O., Freiwald J. P., Steinicke F. Welcoming a holographic virtual coach for balance training at home: two focus groups with older adults. 26th IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2019 - Proceedings, (2019); 1465–1470

28. Kulyk O, Op den Akkery R, Klaasseny R, van Gemert-Pijnen L. Personalized virtual coaching for lifestyle support: principles for design and evaluation. *Int J Adv Life Sci*. (2014) 6:300–9.

29. Obdržálek Š, Kurillo G, Seto E, Bajcsy R. Architecture of an automated coaching system for elderly population. *Stud Health Technol Inform*. (2013) 184:309–11.

30. de Vries P. W., Oinas-Kukkonen H., Siemons L., Beerlage-de Jong N., Van Gemert-Pijnen L. *Preface. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, (2017); 10171 LNCS (November), V–VI

31. Kari T., Rinne P. Influence of digital coaching on physical activity: motivation and behavior of physically inactive individuals. 31st Bled eConference: Digital Transformation: Meeting the Challenges, BLED (2018), 127–146

32. Görer B, Salah AA, Akin HL. A robotic fitness coach for the elderly In: *Lecture notes in computer science (including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics)* (2013). 124–39.

33. Venning A, Herd MC, Oswald TK, Razmi S, Glover F, Hawke T, et al. Exploring the acceptability of a digital mental health platform incorporating a virtual coach: the good, the bad, and the opportunities. *Health Informatics J*. (2021) 27:146045822199487. doi: 10.1177/1460458221994873

34. Cooper S., Di Fava A., Vivas C., Marchionni L., Ferro F. ARI: the social assistive robot and companion. 29th IEEE International Conference on Robot and Human Interactive Communication, RO-MAN (2020), 745–751.

35. Nguyen M, Pachana NA, Beattie E, Fielding E, Ramis M-A. Effectiveness of interventions to improve family-staff relationships in the care of people with dementia in residential aged care: a systematic review protocol. *JBI Database Syst Rev Implement Rep*. (2015) 13:52–63. doi: 10.11124/jbisrir-2015-2415

36. Möller J, Bevilacqua R, Browne R, Shinada T, Dacunha S, Palmier C, et al. User perceptions and needs analysis of a virtual coach for active and healthy ageing—an

international qualitative study. *Int J Environ Res Public Health*. (2022) 19:10341. doi: 10.3390/ijerph191610341

37. Stara V, Soraci L, Takano E, Kondo I, Möller J, Maranesi E, et al. Intrinsic capacity and active and healthy aging domains supported by personalized digital coaching: survey study among geriatricians in Europe and Japan on eHealth opportunities for older adults. *J Med Internet Res*. (2023) 25:e41035. doi: 10.2196/41035

38. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ*. (2005) 173:489–95. doi: 10.1503/cmaj.050051

39. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal cognitive assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. (2005) 53:695–9. doi: 10.1111/j.1532-5415.2005.53221.x

40. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res*. (1982) 17:37–49. doi: 10.1016/0022-3956(82)90033-4

41. Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci*. (2000) 55:M221–31. doi: 10.1093/gerona/55.4.M221

42. Summers MJ, Rainero I, Vercelli AE, Aumayr G, de Rosario H, Mönter M, et al. The my active and healthy aging (my-AHA) ICT platform to detect and prevent frailty in older adults: randomized control trial design and protocol. *Alzheimer's Dement*. (2018) 4:252–62. doi: 10.1016/j.trci.2018.06.004

43. Cesari M, Araujo de Carvalho I, Amuthavalli Thiyagarajan J, Cooper C, Martin FC, Reginster JY, et al. Evidence for the domains supporting the construct of intrinsic capacity. *J Gerontol A Biol Sci Med Sci*. (2018) 73:1653–60. doi: 10.1093/gerona/gly011

44. Assad-Uz-Zaman M, Rasedul Islam M, Miah S, Rahman MH. NAO robot for cooperative rehabilitation training. *J Rehabil Assist Technol Eng*. (2019) 6:205566831986215. doi: 10.1177/2055668319862151

45. Burns RB, Lee H, Seifi H, Faulkner R, Kuchenbecker KJ. Endowing a NAO robot with practical social-touch perception. *Front Robot AI*. (2022) 9:840335. doi: 10.3389/frobt.2022.840335

46. Filippini C, Perpetuini D, Cardone D, Merla A. Improving human-robot interaction by enhancing NAO robot awareness of human facial expression. *Sensors*. (2021) 21:6438. doi: 10.3390/s21196438

47. Amirova A, Rakhymbayeva N, Yadollahi E, Sandygulova A, Johal W. 10 years of human-NAO interaction research: a scoping review. *Front Robot AI*. (2021) 8:744526. doi: 10.3389/frobt.2021.744526

48. Blavette L, Rigaud AS, Anzalone SM, Kergueris C, Isabet B, Dacunha S, et al. A robot-mediated activity using the Nao robot to promote COVID-19 precautionary measures among older adults in geriatric facilities. *Int J Environ Res Public Health*. (2022) 19:5222. doi: 10.3390/ijerph19095222

49. Magallán-Ramírez D, Martínez-Aguilar JD, Rodríguez-Tirado A, Balderas D, López-Caudana EO, Moreno-García CF. Implementation of NAO robot maze navigation based on computer vision and collaborative learning. *Front Robot AI*. (2022) 9:834021. doi: 10.3389/frobt.2022.834021

50. Farhat M, Kali Y, Saad M, Rahman MH, Lopez-Herrejon RE. Walking position commanded NAO robot using nonlinear disturbance observer-based fixed-time terminal sliding mode. *ISA Trans*. (2023) S0019-0578:00586–4. doi: 10.1016/j.isatra.2023.12.026

51. Susreeti S, Rakesh KM. A Comparative Study on Various Virtual Assistance Technologies over Newly Proposed Intelligent Hologram. Proceedings in Sur2018ACS, (2018)

52. Miyachi T, Iga S, Furuhata T. Human robot communication with facilitators for care robot innovation. *Procedia Comput Sci*. (2017) 112:1254–62. doi: 10.1016/j.procs.2017.08.078

53. Leo-Liu J, Wu-Ouyang B. A "soul" emerges when AI, AR, and anime converge: a case study on users of the new anime-stylized hologram social robot "Hupo". *New Media Soc*. (2022):146144482211060. doi: 10.1177/14614448221106030

54. Jindong L. Social robots as the Bride? Understanding the construction of gender in a Japanese social robot product. *Hum Mach Commun*. (2021) 2:105–20. doi: 10.30658/hmc.2.5

55. Gao G, Zhang Y, Bu Y, Shih PC, Design exploration on robots to support single women at home in China. 2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), Nanjing, China, (2018), pp. 1–6

56. Trovato G., Lucho C., Ramon A., Ramirez R., Rodriguez L., Cuellar F. The creation of SanTO: a robot with "divine" features. 2018 15th International Conference on Ubiquitous Robots (UR), Honolulu, HI, USA, (2018), pp. 437–442

57. Trovato G., Pariasca F., Ramirez R., Cerna J., Reutskiy V., Rodriguez L., et al. (2019). Communicating with SanTO – the first Catholic robot. 2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), 1–6.

58. Trovato G, Yueh-Hsuan . Retrospective insights on the impacts of the Catholic robot SanTO In: *Frontiers in artificial intelligence and applications*, vol. *366*: Social Robots in Social Institutions (2023). 267–75.

59. Trovato G., Kishi T., Kawai M., Zhong T., Lin J.Y., Gu Z., et al., The creation of DarumaTO: a social companion robot for Buddhist/Shinto elderlies. 2019 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), (2019), Hong Kong, China pp. 606–611

60. Shen Z, Urano N, Chen CP, Feng S, Mitchell S, Katagiri M, et al. Participatory design and early deployment of DarumaTO-3 social robot In: F Cavalloet al, editors. *Social robotics. ICSR 2022. Lecture notes in computer science*. Cham: Springer (2022)

61. Trovato G, Weng YH, Sgorbissa A, Wieching R. Editorial introduction to special issue on religion in robotics. *Int J Soc Robot*. (2021) 13:537–8. doi: 10.1007/s12369-021-00808-3

62. Brooke J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry*, 189, 4–7

63. Laugwitz B, Schrepp M, Held T. Construction and evaluation of a user experience questionnaire In: A Holzinger, editor (2008) USAB 2008, LNCS 5298). 63–76.

64. Klein A., Hinderks A., Schrepp M., Thomaschewski J. Construction of UEQ+ scales for voice quality: measuring user experience quality of voice interaction. In Proceedings of MuC'20, September 6–9 (2020), Magdeburg, Germany

65. Norman CD, Skinner HA. eHEALS: the eHealth literacy scale. *J Med Internet Res*. (2006) 8:e27. doi: 10.2196/jmir.8.4.e27

66. Russell DW. UCLA loneliness scale (version 3): reliability, validity, and factor structure. *J Pers Assess*. (1996) 66:20–40. doi: 10.1207/s15327752jpa6601_2

67. Molina MDB, Faria CP, Cardoso LO, Drehmer M, Velasquez-Meléndez JG, Gomes ALC, et al. Diet assessment in the Brazilian longitudinal study of adult health (ELSA-Brasil): development of a food frequency questionnaire. *Rev Nutr*. (2013) 26:167–76. doi: 10.1590/S1415-52732013000200005

68. Scherer MJ, McKee BG. *Assistive technology device predisposition assessment* Scherer Associates (1990).

69. Rammstedt B, John OP. Measuring personality in one minute or less: a 10-item short version of the big five inventory in English and German. *J Res Pers*. (2007) 41:203–12. doi: 10.1016/j.jrp.2006.02.001

70. Franke T, Attig C, Wessel D. A personal resource for technology interaction: development and validation of the affinity for technology interaction (ATI) scale. *Int J Hum Comput Interac*. (2019) 35:456–67. doi: 10.1080/10447318.2018.1456150

71. Available at: http://www.sossanita.it/doc/2017_08_robotica-cnb.pdf

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 21 March 2024
DOI 10.3389/fpubh.2024.1327734

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Angga Wilandika,
Universitas Aisyiyah Bandung, Indonesia
Angela Freitas,
University of Coimbra, Portugal

*CORRESPONDENCE
Longtao He
lzhlt01@hotmail.com
Weiming Tang
weiming_tang@med.unc.edu
Dan Wu
danwu@njmu.edu.cn
Huachun Zou
zouhuachun@fudan.edu.cn

†These authors have contributed equally to this work and share first authorship

RECEIVED 25 October 2023
ACCEPTED 08 March 2024
PUBLISHED 21 March 2024

CITATION
Peng X, Wang B, Wang Q, Li Y, Sun Y, Li X, Tucker JD, He L, Tang W, Wu D and Zou H (2024) Sexual attitudes and utilization of sexual and reproductive health services among older women in southern China: a qualitative study.
Front. Public Health 12:1327734.
doi: 10.3389/fpubh.2024.1327734

COPYRIGHT
© 2024 Peng, Wang, Wang, Li, Sun, Li, Tucker, He, Tang, Wu and Zou. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Sexual attitudes and utilization of sexual and reproductive health services among older women in southern China: a qualitative study

Xin Peng[1†], Bingyi Wang[1†], Qianyun Wang[2,3†], Yuwei Li[1†], Yinghui Sun[1], Xinyi Li[1], Joseph D. Tucker[2,4], Longtao He[5]*, Weiming Tang[2,6]*, Dan Wu[4,7]* and Huachun Zou[8,9,10,11]*

[1]School of Public Health (Shenzhen), Sun Yat-sen University, Shenzhen, China, [2]University of North Carolina Project-China, Guangzhou, China, [3]Department of Social Welfare, University of California, Los Angeles, Los Angeles, CA, United States, [4]Clinical Research Department, Faculty of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, United Kingdom, [5]Research Institute of Social Development, Southwestern University of Finance and Economics, Chengdu, China, [6]Dermatology Hospital of Southern Medical University, Guangzhou, China, [7]Department of Social Medicine and Health Education, School of Public Health, Nanjing Medical University, Nanjing, China, [8]School of Public Health, Fudan University, Shanghai, China, [9]Shenzhen Campus, Sun Yat-sen University, Shenzhen, China, [10]School of Public Health, Southwest Medical University, Luzhou, China, [11]Kirby Institute, University of New South Wales, Sydney, NSW, Australia

Objective: Sexual health plays a vital role in healthy aging. However, little is known about the sexual attitudes of and the utilization of sexual and reproductive health services by older women in China. This article is based on a qualitative study of older Chinese women in suburban areas to examine their attitudes toward sexuality and their utilization of sexual and reproductive health services.

Methods: Face-to-face semi-structured interviews were conducted with older women (ages 50 to 74) from suburbs of southern China. Participants were purposively sampled on a convenience basis and recruited when they were visiting community health facilities between June and December 2021. Inclusion criteria were older women aged 50 years and older who had sexual experience. A topic guide was used that focused on sexual activity, sexual attitudes, the utilization of sexual and reproductive health services, and the factors that influence these. Interviews were audio recorded and transcribed verbatim. We coded the data inductively and conducted a thematic analysis.

Results: Twenty-six Chinese women participated in the study. These older women had varying attitudes regarding sexual activity and its significance for older adults. The gender norms they held concerning sexual desire deemed that men had higher sexual desire than women. Most asymptomatic women did not actively seek sexual and reproductive health services. In most cases, women only sought professional services when they started to have sexual and reproductive health problems. Factors influencing the uptake of sexual and reproductive health services by older women were cost (affordability), availability, distance (accessibility), and conservative cultural norms towards sexuality.

Conclusion: The attitudes of older women towards sexual activity are diverse. While some view sexual activity as common and essential for maintaining a sense of well-being in older age, others may hold different perspectives, considering it less significant. The utilization of sexual and reproductive health

services by older Chinese women, except for when they were having a specific health issue, was low. Sexual health messages and services tailored for older women are needed.

KEYWORDS

older women, sexual attitudes, sexual and reproductive health services, gender norms, China

Introduction

Sexuality is a complex and multi-dimensional phenomenon, spanning biological, social, and physiological realms (1). As they age, some women become less interested in sexuality and focus more on caregiving (2, 3). However, others continue to have an active sexual life into older age and disapprove of the choice of a sexless lifestyle among older adults (4). The sexuality of older adults plays an important role in their lives (5), having an impact on their relationships with their partners and their quality of life. Sexual health is an integral part of the overall health of older people (6). The World Health Organization (WHO) defines *sexual health* as a state of physical, emotional, spiritual, and social well-being regarding sexuality; it is not just the absence of disease, dysfunction or infirmity. Supporting their sexual health arguably benefits the physical and mental health of older adults.

Previous studies have shown that older women may encounter more ageism than older men (7). Within cis-gender heterosexual couples, men often make critical decisions about sex, reducing opportunities for women to reflect on or have agency in their sexual lives (8). As a result, women are often excluded from discussions about sexuality and sexual health in clinical and other settings. However, contrary to popular assumptions, many older women are significantly sexually active and even engage in high-risk sexual behaviors (e.g., condomless sex) (9). Being sexually active in later life presents many challenges. For example, older adults constitute a growing number of those newly infected with sexually transmitted diseases (STDs) (10, 11), with syphilis diagnoses increasing significantly over time among older women. Because older women have a range of sexual health needs, it is important to focus on their sexual health and to lower the rates at which they are infected with STDs.

Although older adults are becoming more open-minded about their sexual attitudes, stereotypes regarding sexuality and old age persist (12). In traditional Chinese cultures, sexual and reproductive topics are not easily discussed and are sometimes regarded as taboo. In addition, it is difficult for Chinese women in rural areas to access free sexual and reproductive health services, especially after the age of 50 (13). Barriers to access, which are significant, can be both external (the system) and internal (personal). On the one hand, healthcare providers may hold prejudices that sex in later life is inappropriate or that older adults are asexual, and older adults may be aware of these prejudices (14–16). On the other hand, older women can be less likely to talk about sex and sexual health during medical visits (9).

There are very few studies about sex and sexual health attitudes among older women in China. Previous studies have shown that positive sexual attitudes can promote sexual health communication with healthcare providers (16) and encourage continued sexual activity among older women, which contributes to their overall physical and mental well-being (17, 18). In addition, sexual attitudes are sensitive variables in examining sexual function and are related to sexual health among middle-aged and older adults (19, 20). Given the growing recognition of the importance of sexuality to health and well-being, it is crucial to explore sexual attitudes among older women to promote their sexual health. To address the gap in the research, the purposes of our study were to (1) understand the sexual attitudes of and the utilization of sexual and reproductive health services by older women in southern China; (2) to illuminate the potential factors influencing different sexual attitudes and utilization of sexual and reproductive health services.

Methods

Study design

A qualitative study using in-depth semi-structured individual interviews was conducted between June and December 2021 among older women in two suburban areas (Baiyun District and Nansha District) of Guangzhou City, China, to gain a deeper understanding of the sexual attitudes in this population. The study was approved by the ethics committee of Sun Yat-sen University, and informed consent was obtained from the subjects.

Data collection

Women aged 50 to 74 were purposively sampled on a convenience basis and recruited in person from two community health service centers. Inclusion criteria were Chinese women aged 50 or older who have ever had oral, vaginal, or anal sex. In our study, *sexually active* participants were defined as those who reported having engaged in sexual activity (oral, vaginal, or anal sex) in the past year.

Trained investigators introduced the program and invited older women who satisfied the eligibility requirements. Older women who consented to participate were interviewed face-to-face in a quiet and private space. Each interview lasted from 20 to 40 min. The interviews were anonymous and audio recorded after their consent had been obtained. Recordings were transcribed and the transcripts were checked by investigators for accuracy.

The topic guide was based on the relevant literature and developed following the guidance of experts from the local Center for Disease Control and Prevention. Basic demographic information and the general health status of the participants were collected in the interview. The topic guide focused on the following: sexual activity, sexual

attitudes and the importance of sexual health, the utilization and factors influencing utilization of sexual and reproductive health services, and the participant's understanding of sexual health and sources of information used. Given the sensitive nature of the topic of sex, we provided some incentives to relax the participants such as starting the interview with warm-up and non-sensitive questions (the general health status and mood of the participant).

Analysis

We conducted a thematic analysis of the data following steps recommended by Braun and Clarke: becoming familiar with the data, coding data inductively, generating and reviewing themes, and defining and finalizing themes (21). We repeatedly read the preliminary transcripts, paying attention to the reflective and interpretive meanings therein and identifying the code categories list. Allowing these codes to evolve iteratively, preliminary themes were developed and modified as the data was analyzed. While focusing on recurring themes in the text, we also identified and highlighted cases that contradicted the dominant accounts to draw attention to differences in the experiences of older Chinese women. The key thematic categories were developed from summary statements, memos, and repeated reviews of the data. Data analysis was conducted using NVivo 11.0 (QSR International, Melbourne, Australia).

Results

Interviews were conducted with 26 women (21 registered rural and 5 registered urban, median age = 66.5 years) (Table 1). Among them, 12 had a primary school education or below, and seven had a senior high school education or above. The majority were in stable relationships (married/cohabited with a partner, n = 15), and seven older women were in unstable relationships (widowed/currently separated/divorced). Nine older women were sexually active, and 17 were not. The following themes were identified: sexual attitudes, sexual experience, talking about sex, utilization of sexual and reproductive health services, and sources of sexual health information.

TABLE 1 Characteristics of interview participants.

Socio-demographic	Sample (*n* = 26)
Age, median (interquartile range)	66.5 (9.7)
Age group, years	
50–60	6
60–70	14
>70	6
Relationship status	
Stable relationship	15
Unstable relationship	11
Education level	
Primary school or below	12
Middle school	7
High school or above	7
Sexually active*	
No	17
Yes	9

*Sexually active participants were defined as those who reported sexual activity in the past year.

Sexual attitudes

Older women had varying attitudes regarding sexual activity and its significance for older adults, including the degree to which sexual health contributed to healthy aging and whether or not it was normal for older people to engage in sex. Some sexually active older women believed that sexual behavior and sexual health were important among older adults, and they hoped that they could continue engaging in sexual activity for as long as their physical conditions permitted. These women explained that a good sexual experience can bring joy to their lives.

> *I feel that older adults should pay attention to sexual and reproductive health because older adults also have sex. I think that there is no "older adults do not need (sex)" – this statement (NO.17, 54 years old, married, primary school or below education).*

> *I think sexuality is very important for older adults. I now have a good sex life with my husband, about twice a week. I think sex makes our relationship harmonious and makes me happy, and I enjoy it. I also want to be able to keep having sex with my husband as long as our bodies allow (NO.13, 65 years old, married, high school or above education).*

Most single (widowed/divorced) older Chinese women in the study mentioned that older women typically lacked sexual desire or claimed that sexual activity, sexuality and sexual health were unimportant in the lives of older adults.

> *I'm old, I have not had sex for a long time. Women do not want to have sex in their old age. What you said [about the importance of sexuality and sexual health] – I think is not necessary for my life (NO.6, 67 years old, married, primary school or below education).*

> *My husband has been dead for years – I do not know what you mean by sexual health. We [older adults] do not learn about this stuff [sexual health] and do not understand it (NO.11, 74 years old, widowed, primary school or below education).*

Employment and education were considered to be factors influencing sexual health attitudes. In addition, regardless of whether they were sexually active, participants who had chronic medical conditions such as hypertension and diabetes prioritized their physical health over their sexual health.

> *People who are employed, people who are educated, they pay attention to this [sexual health]. But those who come from the countryside to take care of their grandchildren, they do not understand [sexual health]. But I often want to help them or influence them. Where there is a physical examination, I will take them (NO.21, 64 years old, married, high school or above education).*

> *I think physical health is the most important thing for old people. I must take pills [treatment for chronic diseases] every day, which is a hassle. We do not care so much about sexual health. Sexual health for us older adults is not important (NO.24, 60 years old, married, middle school education).*

Gender norms concerning sexual desire, as perceived by older women, held that men had higher sexual desire than women. Only one older woman thought that men were generally under strain, working hard and having little free time and that this explained why their sexual desire was lower than that of women.

Sexual experience

According to the women in our study, men made most of the decisions about cis-gender heterosexual sex rather than women, and women played a passive role. The majority of the sexually active older Chinese women in the study ($n = 9$) indicated that men initiated sex; only one participant reported that sexual activity happens spontaneously and that it did not require a certain party to take the initiative.

> *My husband always actively performs sexual behavior. If he takes the initiative, I will satisfy him, and I rarely take the initiative (NO.22, 63 years old, married, high school or above education).*

> *I still obey him [in terms of our sex life], sometimes two to three times a week. If he wants sex too many times, I will not [be willing]. I told him that someone said that when he reached 60 years old, he would not be able to have much of a sex life and that too much sexual behavior would make the short-lived. But I tell you that now is different from before – older adults who are generally seventy or eighty years old [still have sexual desire]. He [my husband] is now in his 60s, and his sexual desire is still very strong (NO.21, 64 years old, married, high school or above education).*

Most older women reported that they generally felt sexually satisfied and had positive sexual experiences. One participant mentioned she always had orgasms in her sexual encounters and enjoyed the sexual experience. She also believed that a good sex life made her happy and strengthened her relationship with her husband.

> *The quality of sex is fine, and the frequency is just right, like 7 or 8 orgasms out of 10 times. We have a good relationship as a couple – I would not have sex with him if I did not like him, and I think he is very happy when he makes me orgasm. (NO.23, 50 years old, married, middle school education).*

Some older women said they had better sexual experiences when they were younger, but that aging, vaginal dryness, and decreased sexual desire have diminished these experiences. Many of these women with lower sexual desire or minor sex problems had sex only to satisfy the sexual needs of their partners.

> *Vaginal dryness, I sometimes have this situation. When you are old, you may feel not as comfortable [having sex] as you did when you were young. I do not dislike sex. I will be satisfied when he needs it, but sometimes I am uncomfortable (NO.22, 63 years old, married, high school or above education)*

Talking about sex

Whether or not they were sexually active, the majority of older women indicated that they never or hardly talked about sex or sexual health with their husbands or close friends. They even avoided listening to talk on the topic of sexuality because they felt it was too personal and uncomfortable to discuss. Interestingly, however, they claimed that it was acceptable to talk about sex privately with doctors or researchers (interviewers).

> *There's nothing to talk about [concerning sexual health]. We're all healthy. My husband is very traditional. We do not talk about that (NO.25, 55 years old, married, primary school or below education).*

> *I would not talk to my husband and friends about these topics [sexual health]. If I hear somebody talking about sex, I will leave. I think it is too embarrassing to talk about, and it is a very personal thing. But I think talking to you [about sex] is OK because you are a doctor [medical student] (NO.19, 65 years old, married, primary school or below education).*

A few sexually active older women claimed that they would talk about sex with their spouses or close friends to deepen their mutual understanding of their sex life and relationship, and said that they believed it was common for older adults to talk about sex.

> *I would talk about it with my friends and ask about their sex life. I think it's appropriate to talk about sex, and older adults should have a little bit of a sex life, right? (NO.17, 54 years old, married, primary school or below education).*

Utilization of sexual and reproductive health services

Most asymptomatic women did not actively seek sexual and reproductive health services. In most cases, participants only attended gynecological examinations or sought professional services when they started to have sexual and reproductive health problems (e.g., mammary gland hyperplasia, uterine fibroids, and vaginal inflammation). The absence of reproductive system diseases and STDs was considered a crucial part of sexual health for some older women.

> *I think the most important thing about sexual health is that there is no [reproductive] disease, no need to go to the doctor, and no need to take medicine. If I have a problem [disease], I will go to seek help [sexual/reproduction health services]. No matter how far it is, I will go to see them [doctors] (NO.6, 67 years old, married, primary school or below education).*

> *Usually, I do not pay attention to these services [sexual and reproductive health services]. But I have uterine fibroids now, so I must be more concerned about gynecological health and need these services (NO.20, 58 years old, married, middle school education).*

Factors influencing participants' utilization of sexual and reproductive health services were cost (affordability), availability, distance (accessibility), and conservative cultural norms towards sexuality. If the cost of sexual and reproductive health services is too high or if the older women are poor, they will not use such services.

> *The cost [of using sexual and reproductive health services] is something I need to consider because I cannot use these services without money (NO.14, 67 years old, married, middle school education).*

Older women who want to and can afford the use of sexual and reproductive health services might consider the accessibility of the service location and might stop seeking such services if it were too far away or inaccessible. Some older women mentioned being influenced by traditional ideas; having relatively conservative values, they felt embarrassed to ask a doctor for sexual health advice and information.

> *I know someone who would not go to the gynecology department, and then she said that she was afraid of being laughed at by others. At this age, you know, we are relatively conservative. She feels that talking about this topic [sexuality] is embarrassing, and sometimes she does not see a doctor, and she gets sick as a result (NO.26, 58 years old, married, high school or above education)*

Sources of sexual health information

Qualitative results showed that sources participants used for information about sexual health included professionals, social media, relatives/friends, and official medical websites. Sometimes older women did not care or were not sure whether the information on the Internet was true or false – they just wanted to know a little about sexual health. Village committees also regularly informed older women of gynecological physical examinations in printed publicity notices and on social media (WeChat groups).

> *I will search online [for sexual and reproductive health information]. In the doctor's physical examination, he will teach you how to do a self-examination. I do not know whether the information on the Internet is accurate. Anyway, I just want to know how breast cancer occurs, to understand a little" (NO.22, 63 years old, married, high school or above education).*

Discussion

The findings indicated that older women had varying attitudes regarding sexual activity and its significance to older adults. Older women who were sexually active and satisfied more likely to have positive and affirming sexual attitudes, recognize and value the importance of sexual activity and desire to continue sexual activity. In contrast, older women who were sexually inactive tended to have reserved or disinterested sexual attitudes, lack of sexual desire and perceive unimportance in sexual activity. Most older women had low utilization of sexual and reproductive health services and they tended to adopt a passive approach, only accessing professional services when specific issues or problems arose.

According to our findings, employment and education were influential factors influencing attitudes towards sex, consistent with previous studies that variables including social and economic status drive variations in the opinions and attitudes individuals hold toward sexuality (8). Possible explanations were that individuals with higher levels of education often have access to more comprehensive sexual education, and employment might provide opportunities for education and discussion about sexual health and wellness. Our results also demonstrated that high costs of services, and long distances (lack of transportation) to the health facility are barriers to accessing sexual and reproductive health services, which was similar to previous studies (22). These influencing factors need to be actively addressed to improve the utilization of sexual and reproductive health services. Moreover, older women with chronic diseases were more concerned with managing their physical pain or keeping track of their disease status than they were about looking after their sexual health. This resonates with findings from previous studies which indicate that poor physical condition, chronic disease, and related medications may diminish sexual performance and desire (23). In general, women who report having poor health are often less likely to engage in sexual activity, and those who do have sex are prone to report experiencing sexual difficulties (24). Therefore, actively enhancing the general health status of older women may contribute to improving their sexual attitudes and increase sexual engagement.

Among the older Chinese adults in our study, heterosexual sex was more often initiated by men than women, many of whom had little or no desire. Many of the older Chinese women reported that they only had sex to satisfy their partners. International studies are consistent with our findings. For example, according to results from qualitative interviews with 22 older adults from the third British National Survey of Sexual Attitudes and Lifestyles (Natsal-3), the most common sexual difficulty among older women is low or no sexual desire (25). An exploratory study of 454 married older individuals in Greece found that males are more likely to experience sexual desire and exhibit sexual behaviors (26). An existing systematic review of qualitative studies has reported that women are often subordinate and passive in sexual relations with men (8), especially in more conventional countries and societies in which the (hetero) sexual satisfaction of men is often considered to be the women's obligation, and women play a passive role in sexual behavior (27–29).

This study indicated that many older women in China lacked essential sexual health information. This is supported by a survey conducted of 1,686 older rural Chinese women between the ages of 50 and 64. This survey revealed that, even though 54.4% of these women expressed the desire to increase their knowledge about sex and sexual health, only 9.3% of the health education these women had received in the previous 2 years was focused on advice about sex and contraception (13). The findings of our study demonstrated that not all older Chinese women were reserved and uninformed about sexual health; many of them expressed the desire to learn more about this subject. However, there are few resources for older adults to obtain this information, especially for older rural women (13). Appropriate

lectures and publicity should be made more widely available, both online and offline. Sexual health information for older Chinese women should be tailored to their needs and delivered by health professionals and ensure that it is scientific and authentic. Such information should be designed to inform older adults that it is normal to have a sex life and to emphasize the importance of their sexual health.

When we interviewed older Chinese women about sex, we found that they were willing to talk to us about this otherwise unmentionable subject, in part because we were seen as "doctors," after we had broken the ice by chatting informally. Most participants said that they avoided listening to other people discuss sexual topics and only occasionally or never talked about sex with their spouses or close friends. Previous studies have shown that when people have sexual health issues, communication about sex can help them renegotiate their sex lives and reduce feelings of distress (30, 31). Talking to spouses or friends about sensitive health-and relationship-related topics can also be a source of support for sexuality. In addition, as the first point of contact for older adults with sexual issues, healthcare providers play a major role in helping older adults enhance their sexual health (32). However, growing up in a culture in which sex was not openly discussed has been found to have harmed the sexual communication of older Australian adults, including their level of comfort in talking about sex (33). For older Chinese women, who might more conservative and traditional than older men, just talking about sex is taboo. Our study also found that conservative cultural norms may contribute to a sense of shame or embarrassment, preventing older women from openly discussing their sexual concerns with healthcare professionals or utilizing sexual and reproductive health services. It has been noted that healthcare providers can also be reluctant to bring up sexual health topics with patients for many reasons, including lack of time and knowledge, and the perception that the topic is inappropriate (34–36). Participants tended to use sexual and reproductive health services for gynecological examinations only. Such examinations could serve as an important entry point from which patients and doctors could engage in discussions about sexual health.

Our study has several limitations. First, our study design was based on a convenience sample of older women in suburban areas of southern China and all of the women were heterosexual. As such, it is uncertain how representative the attitudes of the participants towards sex are of the entire community or older women with other sexual orientations. Generalizations of results to other settings or populations may be limited. There is certainly scope for further investigation. Second, our study used thematic analysis, which may involve researchers' subjective interpretation of the data. Strategies (37) have been adopted during data collection, analysis, and interpretation, including specialist training of data collectors before data collection; use survey topic guide to ensure consistency and clearly define research questions and objectives to guide data collection; multiple researchers in the coding process independently (XP and BW) and assess inter-coder reliability (QW and YL); share and discuss findings and interpretations with colleagues or experts (LH, WT and DW) to offer valuable insights. Third, our findings also need to be interpreted cautiously as information was collected based on self-reports and did not link participants' views to their medical records, and information about the sexual health status and attitudes towards sex of the participants' partners was not collect, which may have influenced the attitudes of the participants towards sex. Despite these limitations, the subjects of this study had different socio-demographic characteristics, ensuring diverse participant perspectives. Data collectors were well trained and follow standardized data collection protocols, which reduced variability. The researchers not only maintained reflexivity, acknowledging their preconceptions and biases, but also engaged in inter-coder reliability checks to ensure consistency in data interpretation, the investigator triangulation enhanced the credibility of the results (38). The consistency of our findings with existing studies on sexual health among older adults suggested transferability and confirmability. In addition, this qualitative study has given us insights into the sexual experiences and health of older Chinese women and was able to be used as a guide for a subsequent large-sample quantitative study: based on our study, our team conducted a multi-center epidemiological survey on the sexual health of older adults in China (39), to better understand the sexual health of community-dwelling older adults.

Conclusion

In summary, the attitudes and experiences of older women towards sexual activity are diverse. While some view sexual activity as common and essential for maintaining a sense of well-being in older age, others may hold different perspectives, considering it less significant. The utilization of sexual and reproductive health services by older Chinese women, except for when they were having a specific health issue, was low. To improve their knowledge of sexual health and to enable them to achieve their desired sexual health status, it is essential to reduce the costs and enhance the accessibility, availability, and relevance of sexual health education for older adults and promote their use of sexual and reproductive health services.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by the study was approved by the ethics review board, School of Public Health (Shenzhen), Sun Yat-sen University (SYSU-PHS [2019]006) in China. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

XP: Data curation, Formal analysis, Methodology, Writing – original draft. BW: Data curation, Investigation, Methodology, Writing – review & editing. QW: Data curation, Investigation, Methodology, Writing – review & editing. YL: Methodology, Writing – review &

editing. YS: Methodology, Writing – review & editing. XL: Methodology, Writing – review & editing. JT: Data curation, Methodology, Writing – review & editing. LH: Data curation, Investigation, Methodology, Validation, Writing – review & editing. WT: Investigation, Validation, Writing – review & editing. DW: Conceptualization, Data curation, Software, Supervision, Validation, Writing – review & editing. HZ: Conceptualization, Funding acquisition, Resources, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was supported by the Natural Science Foundation of China International/Regional Research Collaboration Project [72061137001] and Natural Science Foundation of China Excellent Young Scientists Fund [82022064]. All funding parties did not have any role in the study design or data explanation.

Acknowledgments

We thank the community staff and all participants, and Bowen, Liang for her contributions to this research interview.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Simpson P, Horne M, Brown LJ, Wilson CB, Dickinson T, Torkington K. Old (Er) care home residents and sexual/intimate citizenship. *Ageing Soc*. (2017) 37:243–65. doi: 10.1017/S0144686x15001105

2. Binfa L, Robertson E, Ransjo-Arvidson AB. Chilean Women's reflections about womanhood and sexuality during midlife in a Swedish or Chilean context. *Health Care Women Int*. (2009) 30:1093–110. doi: 10.1080/07399330903276777

3. Kadri N, Alami KM, Berrada S. Sexuality in Morocco: women Sexologist's point of view. *Theol Sex*. (2009) 19:20–3. doi: 10.1016/j.sexol.2009.03.005

4. Hinchliff S, Gott M. Challenging social myths and stereotypes of women and aging: heterosexual women talk about sex. *J Women Aging*. (2008) 20:65–81. doi: 10.1300/J074v20n01_06

5. Ho PJ, Goh YS. Health care professionals and care staff challenges and experiences of managing sexual expression among older adults >/=60 years in long-term care facilities: a qualitative review and meta-synthesis. *Age Ageing*. (2022) 51:afab230. doi: 10.1093/Ageing/Afab230

6. Ezhova I, Savidge L, Bonnett C, Cassidy J, Okwuokei A, Dickinson T. Barriers to older adults seeking sexual health advice and treatment: a scoping review. *Int J Nurs Stud*. (2020) 107:103566. doi: 10.1016/J.Ijnurstu.2020.103566

7. Raqota B. Aging in America: ageism and general attitudes toward growing old and the elderly. *Open J Soc Sci*. (2017) 5:183. doi: 10.4236/jss.2017.58015

8. Sinkovic M, Towler L. Sexual aging: a systematic review of qualitative research on the sexuality and sexual health of older adults. *Qual Health Res*. (2019) 29:1239–54. doi: 10.1177/1049732318819834

9. Thames A, Hammond A, Ra N, Mahmood Z, Jones F, Sl C, et al. Sexual health behavior and mental health among older African American women: the Sistahs, sexuality, and mental health well-being project. *J Womens Health (Larchmt)*. (2018) 27:1177–85. doi: 10.1089/Jwh.2017.6777

10. Wang C, Zhao P, Xiong M, Tucker JD, Ong JJ, Hall BJ, et al. New syphilis cases in older adults, 2004-2019: an analysis of surveillance data from South China. *Front Med*. (2021) 8:781759. doi: 10.3389/Fmed.2021.781759

11. Minichiello V, Rahman S, Hawkes G, Pitts M. Sti epidemiology in the global older population: emerging challenges. *Perspect Public Health*. (2012) 132:178–81. doi: 10.1177/1757913912445688

12. Syme M. The evolving concept of older adult sexual behavior and its benefits. *Generations*. (2014) 38:35–41.

13. Sun X, Shu X, Zong Z, Mao J, Sun Y, Hearst N. Unmet sexual and reproductive health needs of women aged 50 to 64 years in rural China. *Menopause*. (2015) 22:505–11. doi: 10.1097/Gme.0000000000000346

14. Bauer M, Haesler E, Fetherstonhaugh D. Let's talk about sex: older People's views on the recognition of sexuality and sexual health in the health-care setting. *Health Expect*. (2016) 19:1237–50. doi: 10.1111/Hex.12418

15. Fileborn B, Lyons A, Heywood W, Hinchliff S, Malta S, Dow B, et al. Talking to healthcare providers about sex in later life: findings from a qualitative study with older Australian men and women. *Australas J Ageing*. (2017) 36:E50–6. doi: 10.1111/Ajag.12450

16. Hughes AK, Lewinson TD. Facilitating communication about sexual health between aging women and their health care providers. *Qual Health Res*. (2015) 25:540–50. doi: 10.1177/1049732314551062

17. Yee LA, Sundquist KJ. Older Women's sexuality. *Med J Aust*. (2003) 178:640–3. doi: 10.5694/J.1326-5377.2003.Tb05393.X

18. Inelmen EM, Sergi G, Girardi A, Coin A, Toffanello ED, Cardin F, et al. The importance of sexual health in the elderly: breaking down barriers and taboos. *Aging Clin Exp Res*. (2012) 24:31–4.

19. Sierra JC, Gómez-Carranza J, Álvarez-Muelas A, Cervilla O. Association of sexual attitudes with sexual function: general vs. specific attitudes. *Int J Environ Res Public Health*. (2021) 18:10390. doi: 10.3390/Ijerph181910390

20. Graf AS, Patrick JH. The influence of sexual attitudes on mid-to late-life sexual well-being: age, not gender, As a salient factor. *Int J Aging Hum Dev*. (2014) 79:55–79. doi: 10.2190/AG.79.1.c

21. Virginia B, Victoria C. Using thematic analysis in psychology. *Qual Res Psychol*. (2006) 3:77–101. doi: 10.1191/1478088706qp063oa

22. Nyalela M, Dlungwane T. Men' S utilisation of sexual and reproductive health services in low-and middle-income countries: a narrative review. *South Afr J Infect Dis*. (2023) 38:473. doi: 10.4102/Sajid.V38i1.473

23. Merghati-Khoei E, Pirak A, Yazdkhasti M, Rezasoltani P. Sexuality and elderly with chronic diseases: a review of the existing literature. *J Res Med Sci*. (2016) 21:136. doi: 10.4103/1735-1995.196618

24. Kuhle CL, Zhang X, Kapoor E. Misconceptions about sexual health in older women: why we need to talk about it. *Mayo Clin Proc*. (2021) 96:866–9. doi: 10.1016/J.Mayocp.2020.09.037

25. Hinchliff S, Lewis R, Wellings K, Datta J, Mitchell K. Pathways to help-seeking for sexual difficulties in older adults: qualitative findings from the third National Survey of Sexual Attitudes and Lifestyles (Natsal-3). *Age Ageing*. (2021) 50:546–53. doi: 10.1093/Ageing/Afaa281

26. Papaharitou S, Nakopoulou E, Kirana P, Giaglis G, Moraitou M, Hatzichristou D. Factors associated with sexuality in later life: an exploratory study in a group of Greek married older adults. *Arch Gerontol Geriatr*. (2008) 46:191–201. doi: 10.1016/J.Archger.2007.03.008

27. Yun O, Kim M, SE C. The sexuality experience of older widows in Korea. *Qual Health Res*. (2014) 24:474–83. doi: 10.1177/1049732313518978

28. Baldissera VDA, Bueno SMV, Hoga LAK. Improvement of older Women's sexuality through emancipatory education. *Health Care Women Int*. (2012) 33:956–72. doi: 10.1080/07399332.2012.684986

29. Lagana L, Maciel M. Sexual desire among Mexican-American older women: a qualitative study. *Cult Health Sex*. (2010) 12:705–19. doi: 10.1080/13691058.2010.482673

30. Frederick DA, Lever J, Gillespie BJ, Garcia JR. What keeps passion alive? Sexual satisfaction is associated with sexual communication, mood setting, sexual variety, Oral sex, orgasm, and sex frequency in a National U.S Study. *J Sex Res*. (2017) 54:186–201. doi: 10.1080/00224499.2015.1137854

31. Gillespie BJ. Correlates of sex frequency and sexual satisfaction among partnered older adults. *J Sex Marital Ther*. (2017) 43:403–23. doi: 10.1080/0092623x.2016.1176608

32. Hughes AK, Rostant OS, Curran PG. Improving sexual health communication between older women and their providers: how the integrative model of Behavioral prediction can help. *Res Aging*. (2014) 36:450–66. doi: 10.1177/0164027513500055

33. Hinchliff S, Fileborn B, Alba B, Lyons A, Minichiello V, Barrett C, et al. Talking about sex with friends: perspectives of older adults from the sex, age & me Study in Australia. *Cult Health Sex*. (2021) 23:367–82. doi: 10.1080/13691058.2019.1710568

34. Dyer K, das Nair R. Why Don't healthcare professionals talk about sex? A systematic review of recent qualitative studies conducted in the United Kingdom. *J Sex Med*. (2013) 10:2658–70. doi: 10.1111/J.1743-6109.2012.02856.X

35. Mcgrath M, Lynch E. Occupational Therapists' perspectives on addressing sexual concerns of older adults in the context of rehabilitation. *Disabil Rehabil*. (2014) 36:651–7. doi: 10.3109/09638288.2013.805823

36. Hinchliff S, Gott M. Seeking medical help for sexual concerns in mid-and later life: a review of the literature. *J Sex Res*. (2011) 48:106–17. doi: 10.1080/00224499.2010.548610

37. Castleberry A, Nolen A. Thematic analysis of qualitative research data: is it as easy as it sounds? *Curr Pharm Teach Learn*. (2018) 10:807–15. doi: 10.1016/J.Cptl.2018.03.019

38. Korstjens I, Moser A. Series: practical guidance to qualitative research. Part 4: trustworthiness and publishing. *Eur J Gen Pract*. (2018) 24:120–4. doi: 10.1080/13814788.2017.1375092

39. Wang B, Peng X, Liang B, Fu L, Tian T, Liu J, et al. Sexual well-being among older adults in China (swell): protocol for a Multicenter cross-sectional study. *BMJ Open*. (2023) 13:E67338. doi: 10.1136/Bmjopen-2022-067338

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 02 April 2024
DOI 10.3389/fpubh.2024.1336020

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Filipa Novais,
Santa Maria Hospital, Portugal
Paola Miano,
University of Palermo, Italy

*CORRESPONDENCE
Maciej Kornatowski
✉ m.kornatowski@mazowiecka.edu.pl

RECEIVED 09 November 2023
ACCEPTED 15 March 2024
PUBLISHED 02 April 2024

CITATION
Głowacka M, Polak-Szabela A, Sienkiewicz Z and Kornatowski M (2024) Trait-anxiety, depressive symptoms, family support and life satisfaction as determinants conditioning the degree of adherence of people in pre-older adults and older adults. *Front. Public Health* 12:1336020. doi: 10.3389/fpubh.2024.1336020

COPYRIGHT
© 2024 Głowacka, Polak-Szabela, Sienkiewicz and Kornatowski. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Trait-anxiety, depressive symptoms, family support and life satisfaction as determinants conditioning the degree of adherence of people in pre-older adults and older adults

Mariola Głowacka[1], Anna Polak-Szabela[2], Zofia Sienkiewicz[3] and Maciej Kornatowski[1]*

[1]Collegium Medicum, The Mazovian University in Płock, Płock, Poland, [2]Department of Geriatrics, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, Bydgoszcz, Poland, [3]Department of Nursing Development, Social and Medical Sciences, Medical University of Warsaw, Warsaw, Poland

The objective of the study was to determine the degree of adherence to pharmacological treatment in people in pre-older adults and older adults age groups and to analyse the correlation between selected sociodemographic parameters, severity of anxiety as a trait, symptoms of depression, a sense of family support and satisfaction with life, and adherence in people over 55 years of age. The study was conducted in a group of 2,040 people (1,406 women, 634 men) aged 55 to 100 (the average age was 65.4). The following sociodemographic variables were analysed: age, gender, education. The following scales were used: State–Trait Anxiety Inventory (STAI), Beck Depression Inventory (BDI), Satisfaction With Life Scale (SWLS) and the Multidimensional Scale of Perceived Social Support (MSPSS). The Adherence in Chronic Diseases Scale (ACDS) was used to test adherence, understood as the implementation of the therapeutic plan. The results obtained in the ACDS ranged from 6 to 28 points; the median was 24 points (21–28). The multiple coefficients of determination (multiple $R^2 = 0.11$; $p < 0.001$) indicated an explanation of approximately 11% of the value of the ACDS dependent variable. The total correlation of all variables (multiple R) with the ACDS general variable in the mean correlation was 0.33. Independent factors affecting adherence assessed in the ACDS were: severity of anxiety as a trait ($p = -0.21 \pm 0.03$; $p < 0.001$), family support ($p = 0.10 \pm 0.04$; $p = 0.029$), severity of depression symptoms ($p = -0.08 \pm 0.03$; $p = 0.005$), age of respondents ($p = 0.07 \pm 0.02$; $p = 0.003$) and satisfaction with life ($p = 0.06 \pm 0$ 0.03; $p = 0.027$). Severity of anxiety as a trait, age, severity of depressive symptoms, a sense of satisfaction with life and family support are important factors affecting adherence.

KEYWORDS

older adults, healthy aging, successful aging, adherence, depression, family support, satisfaction with life

1 Introduction

Failure to adhere to therapeutic indications by patients results in the risk of not improving health results and significantly increases the cost of treatment. The effectiveness of therapy depends on the regular use of medications strictly according to medical recommendations (1–4). The quality of cooperation between the patient and the physician is referred to as adherence. This term indicates the extent to which the patient's behavior regarding medication, lifestyle changes or therapy attendance is in accordance with the directives given by their physician (5). The WHO report shows that in the process of treating patients with chronic diseases, every second patient discontinues therapy, and every fifth does not fill the prescriptions at all (6). This contributes to the loss of control over the course of the disease, deterioration of health and quality of life, increase in mortality and the number of rehospitalizations. Therefore, one of the main challenges of modern medicine is to improve therapeutic adherence (7, 8). There is ample evidence that non-compliance with medical recommendations is influenced by many factors (9, 10). The multidimensionality and complexity of adherence generates difficulties in accurately determining its predictors. Moreover, individual factors overlap and affect patients to varying degrees. The concept of adherence is a dynamic phenomenon and requires determining the factors regulating it at each stage of treatment (11). According to the World Health Organization (WHO), factors determining adherence can be classified into 5 groups: socio-economic factors, factors related to treatment, factors related to the patient, factors related to the health care system and factors related to the disease (6, 9). One of the concepts of adherence divides the factors influencing compliance with medical recommendations into intentional and unintentional. Intentional factors result from a patient's conscious decision to disregard medical advice, driven by, for example, negative beliefs about a particular therapy, or false information about the disease. Unintentional factors include barriers that are independent of the patient's will (cognitive dysfunctions, functional disability). In this model, a patient's low level of adherence can be a result of the interaction of both types of factors (12, 13). Due to multiple morbidities in geriatric patients, the implementation of treatment regimens is particularly difficult in this population (14). Specifying the determinants of adherence in pre-older adults and older adults will allow for more effective and individualized interventions aimed at adherence to therapeutic recommendations.

The objective of the study was to present the correlation between the severity of anxiety as a trait, symptoms of depression, a sense of family support and satisfaction with life, and the degree of adherence, as well as to identify factors that affect the co-responsibility of patients in the therapeutic process in people over 55 years of age.

2 Materials and methods

2.1 Participants and study design

The study was carried out as part of the grant "Adherence as co-responsibility of people at pre- and senior age in the therapeutic process," in the period from January to November 2022. Recruitment of study participants was carried out in three stages. The inclusion criteria for the study were: age ≥ 55 years; residence or registration in the city of Płock and no cognitive impairment (assessed using the MMSE scale). In the first stage, consent to participate in the study was obtained from 2,253 people. Participants were recruited from among people attending classes at the University of the Third Age and medical entities (primary health care offices), in the city of Płock—in the Masovian Voivodship, approx. 115 km from the capital of the country—Warsaw. Płock is a city with 113,660 inhabitants (as of December 31, 2022). In the second stage, the MMSE (Mini Mental State Examination) was performed for all participants. People who did not show cognitive impairments, i.e., obtained 27–30 points in the MMSE, were qualified for the third (proper) stage of the study. In total, 2,102 people (93%) were qualified. Participants chose the method of completing the questionnaire—in paper form to be completed at the recruitment site or at home, or electronic form. The electronic questionnaire was prepared and con-ducted on the dedicated LimeSurvey platform (LimeSurvey GmbH, Hamburg, Germany). Finally, the completeness of the questionnaires was analysed, during which incomplete forms were rejected. Only complete questionnaires—2,040 (97%) were selected for analysis. In this group there were 1,406 women (68.9%) and 634 men (31.1%), aged 55 to 100. The average age was 65.4. The research material was collected using the diagnostic survey method and the clinimetric method, i.e., using standardized questionnaires.

2.2 Measures

The results obtained in the adherence scale were related to sociodemographic variables and to the results of questionnaires measuring selected aspects of the respondents' emotional and social functioning. The following sociodemographic variables were analysed: age, gender, education. The following scales were used to measure aspects related to emotional and social functioning:

State–Trait Anxiety Inventory (STAI) is an adaptation of an American questionnaire. The authors of the Polish adaptation are: C. D. Spielberger, J. Strelau, M. Tysarczyk and K. Wrześniewski. This method makes it possible to determine severity of anxiety understood as a permanent internal trait and as a state appearing in response to specific external stimuli. Anxiety as a trait (Anxiety-Trait) is defined by Spielberger as a theoretical construct, meaning an acquired behavioral disposition that makes an individual susceptible to perceiving a broad range of objectively harmless situations as threatening, and reacting to them with anxiety, disproportionately strong in relation to the scope of the objective threat. Anxiety as a trait is a disposition of an anxious way of reacting. Raw results range from 20 (low anxiety) to 80 (high anxiety). The obtained raw result on the scale refers to sten norms (15).

Beck Depression Inventory (BDI) is used to measure the severity of symptoms of depression. It contains 21 questions rated according to the severity of symptoms: 0–3 points. The respondent chooses one answer which, in his/her opinion, best describes his/her condition in the indicated period (the last 7 days were assumed in the study). The severity of depression is calculated by summing the number of points from 21 questions. The following scoring is adopted: up to 11 points—no depression, 12–19 points—mild depression, 20–25 points—average (moderate) depression, 26 and more points—severe depression (16).

Satisfaction With Life Scale (SWLS) in the Polish adaptation by Z. Juczyński consists of five statements. The respondent assesses to what extent each of them relates to his/her life. The assessment of satisfaction with life is the result of comparing one's own situation

with the standards set by oneself. If the result of the comparison is positive, the result is a feeling of satisfaction. The result of the measurement is the general indicator of satisfaction with life. The raw result on the scale refers to sten norms (17).

Multidimensional Scale of Perceived Social Support (MSPSS) is a tool created by G. Zimet et al. The Polish adaptation was created by E. Hornowska and W. J. Paluchowski from 2004, and it takes into account the multidimensionality of perceived social support, dividing it into three basic sources: a significant other, family and friends (18, 19). The scale consists of twelve statements to which the respondent refers using a seven-point Likert scale, where 1 means "I strongly disagree" and 7 means "I strongly agree."

Adherence in Chronic Diseases Scale (ACDS) was used to study adherence, understood as the implementation of the therapeutic plan. ACDS scale is dedicated to adults with chronic diseases. It contains seven questions, of which the first five concern behaviors that directly determine adherence (behaviors related to taking medications), while questions 6 and 7 refer to situations and views that may indirectly affect adherence (they address the doctor-patient relationship). Results range from 0 to 28 points. Obtaining a result below 21 points corresponds to low adherence, between 21 and 26 points to average adherence, and a result above 26 points indicates high adherence (20, 21).

2.3 Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by Bioethical Committee of Masovian University in Płock (statute no. KB/N/BN/P/1.2021). The participants provided their written informed consent to participate in this study.

2.4 Statistical analysis

In the statistical analysis, parametric tests were used to compare the obtained results of the ACDS. Quantitative variables are presented as an arithmetic mean with standard deviation and confidence interval as well as median and quartile ranges. Independent samples t-test (against groups) was used to compare the medians of two data series. To assess the correlation between quantitative variables, the Pearson correlation was used. Multivariate linear regressions analysis was performed using multiple regression. Several models were constructed and the model with the highest coefficient of determination (R^2) was selected. The outcome variable was an ordered qualitative variable. All independent variables were included in the model. $p < 0.05$ values were considered statistically significant. All calculations were made using Statistica 10.0 (Stat Soft Polska) and a Microsoft Excel spreadsheet using standard functions of this program and the PQStat program.

3 Results

3.1 Characteristics of the study group

There were 1,406 women (64.8 ± 8.33) and 643 men (66.8 ± 8.00) aged 55 to 100 in the study population. The average age of the respondents was 65.4 years. The standard deviation was over 12% of the mean value, which indicates an insignificant age difference. The largest group consisted of respondents aged 60 to 75—1,073 people (52.6%), the smallest group consisted of people over 90–24 people (1.2%). The group was dominated by respondents with secondary/post-secondary education—812 people (39.8%) and basic vocational education—567 people (27.8%); a smaller group of people had higher education—486 people (23.8%) and the smallest group had primary education—175 people (8.6%).

The respondents suffered from chronic diseases [hypertension—944 people (46.3%), diseases of the osteoarticular system—939 people (46.0%), vision disorders—897 people (44.0%), urinary system diseases—628 people (30.8%), lung diseases—595 people (29.2%), strokes—80 people (3.9%), permanent balance disorders—74 people (3.6%), tuberculosis—22 people (1 0.1%), AIDS—15 people (0.7%) and venereal diseases—10 people (0.5%)].

3.1.1 Depression

Analyzing the study population in terms of depression symptoms (Table 1), the largest group consisted of those with no symptoms of depression—1,414 people (69.3%), while the smallest group consisted of people with severe symptoms of depression—80 people (3.9%). There was no statistically significant difference between men and women regarding the severity of depression. The highest severity of depression was presented by respondents aged over 90. Severe depression—2 people (8.3%), moderate depression—4 people (16.7%). The lowest severity was indicated by respondents aged up to 60. Severe and moderate depression—12 people each (1.8% each).

3.1.2 Anxiety

The largest group consisted of respondents (Table 2) with low severity of anxiety—927 people (45.4%), the smallest with a high result—268 people (13.1%). Due to the level of significance ($p < 0.05$), there was a statistically significant difference between women and men regarding the severity of anxiety as a trait. Higher severity of anxiety as a trait was obtained by women. A higher rate of high results was obtained by 205 people (14.6%). In the group of men, it was 63 people (9.9%), respectively. The highest severity of anxiety as a trait was obtained by respondents aged 75–90, high results were obtained by 42 people (15.1%) and those aged 60–75, high results—145 people (13.5%). The lowest severity of anxiety as a trait was indicated by respondents aged over 90, high results—3 people (12.5%). The results of depression remained in a statistically significant, average correlation with the results of the severity of anxiety as a trait ($r = 0.453$; $p < 0.05$).

The highest severity of anxiety as a trait was noted in the group with severe depression (Table 3). High results—40 people (50.0%) and moderate depression—49 people (39.8%). The lowest severity was indicated by respondents without depression, high results—79 people (5.6%).

3.1.3 Satisfaction with life

The largest number of respondents obtained high results in satisfaction with life—1,272 people (62.4%), followed by average results—469 (23.0%); the fewest respondents presented low results—299 people (14.7%).

3.1.4 Social support

The mean on the MSPSS was 68.5 points—78.5% of the possible points (Table 4). The standard deviation accounted for over 18% of the

10.3389/fpubh.2024.1336020

TABLE 1 Results of depression symptoms severity in age groups.

Age	Up to 60		60–75		75–90		Above 90	
Severity	Number	%	Number	%	Number	%	Number	%
No depression	551	83.0	720	67.1	131	47.0	12	50.0
Mild depression	89	13.4	229	21.3	99	35.5	6	25.0
Moderate depression	12	1.8	80	7.5	27	9.7	4	16.7
Severe depression	12	1.8	44	4.1	22	7.9	2	8.3
Total	664	100.0	1,073	100.0	279	100.0	24	100.0

TABLE 2 Results of severity of anxiety as a trait in age groups.

Age	Up to 60		60–75		75–90		Above 90	
STAI results	Number	%	Number	%	Number	%	Number	%
Low	348	52.4	459	42.8	107	38.4	13	54.2
Average	238	35.8	469	43.7	130	46.6	8	33.3
High	78	11.7	145	13.5	42	15.1	3	12.5
Total	664	100.0	1,073	100.0	279	100.0	24	100.0

TABLE 3 Results of severity of anxiety as a trait in groups with symptoms of depression measured with the BDI.

Depression	No depression		Mild depression		Moderate depression		Severe depression	
STAI results	Number	%	Number	%	Number	%	Number	%
Low	840	59.4	69	16.3	9	7.3	9	11.3
Average	495	35.0	254	60.0	65	52.8	31	38.8
High	79	5.6	100	23.6	49	39.8	40	50.0
Total	1,414	100.0	423	100.0	123	100.0	80	100.0

TABLE 4 Average results in the MSPSS in the study group.

Support scale	*N*	Mean	SD	Confidence −95.0%	Confidence +95.0%	Min	Max	Q25	Median	Q75
Family	2,040	23.72	4.467	23.52	23.91	4.0	28.0	23.0	24.0	27.0
Friends	2,040	20.68	5.656	20.43	20.92	4.0	28.0	16.0	21.0	24.0
Significant others	2,040	24.10	4.679	23.90	24.31	4.0	28.0	24.0	25.0	28.0
Total	2,040	68.50	12.922	67.93	69.06	12.0	84.0	64.0	70.0	77.0

mean value, which indicates an insignificant differentiation of the results. The minimum result was 12.0 points, the maximum result was 84.0 points. Support from a significant other was rated the highest—24.1 points (83.8%), support from friends—20.68 points (69.5%) was rated the lowest.

3.1.5 Adherence

The largest group consisted of respondents with medium adherence results—1,149 people (56.3%); the smallest group with low results consisted of 298 people (14.6%). Due to the level of significance ($p > 0.05$), there was no statistically significant difference between women and men regarding the results on the adherence scale (Table 5). The highest mean adherence was recorded in the age group 75 to 90—24.12 points and 60 to 75—24.03 points. The lowest mean adherence in the age group over 90 was 21.21 points. In terms of direct behavior, the highest mean was recorded for the age group 60–75 and 75–90, the lowest at the age over 90. In terms of intermediate situations and views, the highest mean was recorded for the age group 75–90 and 60–75, the lowest at the age over 90.

3.2 Analysis of the results

3.2.1 Univariate analysis

To isolate factors that are statistically significant for adherence, a univariate analysis was performed, the results of which are presented in Table 6. Five significant predictors were noted: severity of anxiety

TABLE 5 Mean results of adherence in age groups.

Adherence	Direct behavior			Intermediate situations and views			ACDS		
Education	Mean	SD	Me	Mean	SD	Me	Mean	SD	Me
Up to 60	17.20	3.17	18.00	6.31	1.63	6.00	23.52	4.33	24.00
60–75	17.68	2.61	18.00	6.34	1.49	6.00	24.03	3.63	25.00
75–90	17.62	2.83	18.00	6.51	1.52	7.00	24.12	3.86	25.00
above 90	15.63	5.11	16.50	5.58	2.60	6.00	21.21	7.30	22.50

TABLE 6 Univariate tests of significance for the ACDS variable (sigma-constrained parameterization; decomposition of effective hypotheses).

Effect	SS	df	MS	*F*	*p*
Absolute term	35.133	1	35.133	94.567	0.000
Age	3.223	1	3.223	8.674	0.003
Gender	0.000	1	0.000	0.001	0.980
Education	0.075	1	0.075	0.201	0.654
Severity of depression	2.939	1	2.939	7.912	0.005
Severity of anxiety as a trait	22.080	1	22.080	59.431	0.000
Sense of satisfaction with life	1.819	1	1.819	4.896	0.027
Family	1.784	1	1.784	4.803	0.029
Friends	0.675	1	0.675	1.817	0.178
Significant others	0.110	1	0.110	0.296	0.587
Error	754.179	2030	0.372		

TABLE 7 SS test for full model against SS for residuals (sum).

Dependent variable	Multiple *R*	Multiple R^2	Adjusted R^2	SS Model	df Model	MS Model	SS Residual	df Residual	MS Residual	*F*	*p*
ACDS	0.333	0.111	0.107	94.162	9	10.462	754.179	2030	0.372	28.161	0.000

as a trait, age, severity of depression, sense of satisfaction with life and family support.

3.2.2 Multivariate analysis

Multivariate analysis was performed using multiple regression (Tables 7, 8). A multiple coefficient of determination (multiple R^2) indicates an explanation of approximately 11% of the value of the dependent variable (ACDS). The entire model turned out to be statistically significant. Cumulative correlation of all variables (multiple *R*), with ACDS general variable in average correlation (0.333). Severity of anxiety as a trait, family support, age, severity of depression and a sense of life satisfaction had the greatest impact on the ACDS result in a statistically significant manner.

4 Discussion

The average degree of adherence prevailed in the study population, which was noted in 56.3% of the respondents. Almost one third of the respondents (29.1%) showed a high degree of adherence to the therapeutic plan. A low degree of adherence was noted in 14.6% of the respondents. The above results refer to the self-esteem of the respondents. It would be important to examine the degree of adherence using other methods, independent of the subjective assessment of the respondents, and to make appropriate comparisons. In literature, there are reports indicating a higher percentage of people who do not adhere to medical recommendations (6).

The lowest mean results in the general result on the ACDS scale, as well as in direct behaviors related to taking medications and in intermediate situations and views de-scribing the interaction between a physician and a patient, were recorded in the group of people over 90 years of age. In old age, a decrease in functional efficiency was observed, which could significantly hinder adherence to the therapeutic plan. In addition, the number of comorbidities increasing with age, associated with a higher percentage of cognitive dysfunctions and visual and/or hearing deficits, may have contributed to non-adherence by geriatric patients (22). The highest mean adherence was recorded in the age group 75 to 90—24.12 points and 60 to 75—24.03 points. With age, the number of comorbidities increased (23). Slightly lower average results on the ACDS scale in the group of respondents up to 60 years of age could be due to the presence of fewer diseases, lower severity of individual disease symptoms, and thus less discomfort, in relation to people from older age groups. This may explain the slightly lower level of adherence recorded in the group of the youngest respondents.

10.3389/fpubh.2024.1336020

TABLE 8 Result of multivariate regression analysis with estimation of parameters for predicting adherence.

	Coefficient *b*	Error *b*	−95% CI	+95% CI	Standard *b*	Standard error *b*	*p* value
Absolute term	1.645	0.169	1.313	1.976			<0.001
Age	0.005	0.002	0.002	0.009	0.067	0.023	0.003
Gender	−0.001	0.030	−0.060	0.058	−0.001	0.022	0.980
Education	0.007	0.016	−0.024	0.038	0.010	0.022	0.654
Severity of depression	−0.006	0.002	−0.010	−0.002	−0.079	0.028	0.005
Severity of anxiety as a trait	−0.015	0.002	−0.019	−0.011	−0.207	0.027	<0.001
Sense of satisfaction with life	0.006	0.003	0.001	0.011	0.056	0.025	0.027
Family	0.014	0.006	0.001	0.026	0.097	0.044	0.029
Friends	0.005	0.003	−0.002	0.012	0.041	0.030	0.178
Significant others	−0.003	0.006	−0.014	0.008	−0.022	0.041	0.587

In the polish study by Kosobucka et al., conducted in a group of patients hospitalized for myocardial infarction and treated with percutaneous coronary intervention (PCI), 221 patients participated, including 63 women and 158 men. The average age of the participants was 62.9 years. High adherence to medical recommendations, measured by the ACDS scale, was observed in about 25% of patients 6 months after a heart attack. Factors influencing adherence to therapeutic recommendations were age and a history of heart attack. Patients below the age of 65 achieved higher scores on the ACDS scale, which suggests better compliance with recommendations compared to older individuals. No significant impact of other factors, such as gender or education, on the ACDS score was demonstrated (20).

In the study group, there was no statistically significant difference between women and men regarding the results on the ACDS scale. In their study conducted on a group of approximately 2,194 hypertensive patients over 65 years of age, Holt et al. (24) also observed that the incidence of low adherence rates did not differ by gender. In this study, almost half of the respondents suffered from hypertension (46.3%).

Education had no impact on the degree of adherence. Consistent results were presented by Wu et al. (9, 25), although there are reports indicating a correlation between education and the degree of adherence. People with higher education were more likely to adhere to medical recommendations (26).

In the study, the largest number of people, regardless of age, presented symptoms of mild depression. This corresponds to the data on the specificity of depressive disorders in geriatric patients. This population most often suffers from subclinical and subthreshold depression with moderate or mild severity of disease symptoms (27). Multiple regression analysis showed that the severity of depression is an independent factor affecting the degree of adherence. The greater the severity of depression, the lower the adherence to the therapeutic plan. In a meta-analysis on the impact of anxiety and depression on adherence, DiMatteo et al. (28) showed that, compared to patients without depression, there is a three times greater probability that depressed patients will not adhere to medical recommendations. The impact of depression on adherence is also described by other researchers of the subject. Depression was significantly associated with non-adherence in various diseases (29–32).

Other factors significantly influencing the results on the ACDS scale identified in the multivariate regression analysis model turned out to be family support measured by the MSPSS scale and a sense of satisfaction with life. The higher the perceived support, the higher the degree of adherence in the study group. This corresponds to research on adherence to the therapeutic plan in patients with diabetes. Numerous correlation studies have shown a positive and significant correlation between social support and adherence to recommendations concerning treatment of diabetes. Family and social support are important aspects of adherence to the principles applicable in the treatment of diabetes (33). Family support can therefore help patients implement the therapeutic plan (34, 35). Sayers et al. (36), examining patients after myocardial infarction, assessed the level of emotional and instrumental support received from relatives and its impact on adherence. They found that adherence was associated with receiving emotional support. On the other hand, Wu et al. (25) proved that the lack of family support was perceived by patients with heart failure as a factor hindering adherence to medical recommendations.

The sense of satisfaction with life and positive life balance had a positive impact on adherence to the therapeutic plan. It can be assumed that people with low satisfaction with life and negative life balance do not see the purpose of following medical recommendations and attach less importance to precise adherence to the therapeutic plan.

The predictor that had the greatest impact on adherence turned out to be the severity of anxiety as a trait measured with the STAI scale. Literature data shows that in the case of anxiety disorders, adherence, determined by the frequency of discontinuation of treatment, reaches 50% (25). The results of depression remained in a statistically significant, average correlation with the results of severity of anxiety as a trait ($r = 0.453$; $p < 0.05$). Higher severity of anxiety as a trait correlated positively with severity of depression. The coexistence of depression and anxiety as a trait negatively affected adherence to medical recommendations. The combined occurrence of symptoms of anxiety and depression has a significant impact on social functioning and behaviors focused on seeking help (37, 38). This may explain lower adherence of this group of patients to medical recommendations.

There were several recognized potential limitations affecting results of the study. The data collected was based on self-reporting, which can skew the results based on perception of what respondents think is correct behavior. It's voluntary nature also meant there were limited amount of data points possible to collect while also retaining majority of potential respondents. The data was gathered during COVID-19 pandemic, and while there were no major lockdowns or

other severely disrupting policies put in place during that period, it still might have affected the results.

Effective interventions aimed at increasing the degree of adherence in the pre- and senior population are conditioned by a compilation of important factors. Knowing the patient enables the healthcare professional to identify factors that are critical to adherence. This study highlights the importance of social support, emotional balance, and a sense of satisfaction with life to improve adherence.

5 Conclusion

The study found that severity of anxiety as a trait, a sense of family support, age, severity of depression symptoms and a sense of satisfaction with life are important for adherence. Severity of anxiety as a trait had the greatest impact on the result on the adherence scale. The lower the severity of anxiety as a trait, the higher the degree of adherence. Also severity of depression significantly affected adherence. A significantly higher degree of adherence was observed in people with a greater sense of satisfaction with life. People with lower family support obtained significantly lower adherence results in the study. Gender and education did not significantly affect the degree of adherence in the study group. The obtained results confirm the need for broader cooperation of all members of the therapeutic team, i.e., physicians, nurses, psychologists and pharmacologists, in educating patients on the legitimacy and effectiveness of adherence to therapeutic recommendations and monitoring the level of adherence in patients under care. Future research should focus on developing intervention strategies aimed at reducing the severity of anxiety and depression, as well as enhancing family support and life satisfaction, to improve adherence to therapeutic recommendations. Additionally, exploring methods to facilitate collaboration among various members of the therapeutic team would be valuable for optimizing patient education and monitoring adherence to medical advice.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Bioethical Committee of Masovian University in Płock. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MG: Conceptualization, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. AP-S: Conceptualization, Writing – review & editing. ZS: Data curation, Writing – original draft. MK: Formal analysis, Methodology, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The research was financed from the funds received from the Commune of Płock as part of the grant "Adherence as co-responsibility of people at pre- and senior age in the therapeutic process" (contract No. 1/2022).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Grenard JL, Munjas BA, Adams JL, Suttorp M, Maglione M, McGlynn EA, et al. Depression and medication adherence in the treatment of chronic diseases in the United States: a meta-analysis. *J Gen Intern Med*. (2011) 26:1175–82. doi: 10.1007/s11606-011-1704-y

2. Solmi M, Miola A, Croatto G, Pigato G, Favaro A, Fornaro M, et al. How can we improve antidepressant adherence in the management of depression? A targeted review and 10 clinical recommendations. *Braz J Psychiatry*. (2021) 43:189–202. doi: 10.1590/1516-4446-2020-0935

3. Uchmanowicz I, Gobbens RJJ. The relationship between frailty, anxiety and depression, and health-related quality of life in elderly patients with heart failure. *Clin Interv Aging*. (2015) 10:1595–600. doi: 10.2147/CIA.S90077

4. Uchmanowicz I, Rosano G, Piepoli M, Vellone E, Czapla M, Lisiak M, et al. The concurrent impact of mild cognitive impairment and frailty syndrome in heart failure. *Arch Med Sci*. (2023) 19:912–20. doi: 10.5114/aoms/162369

5. Kosobucka A, Michalski P, Pietrzykowski Ł, Kasprzak M, Fabiszak T, Felsmann M, et al. The impact of readiness to discharge from hospital on adherence to treatment in patients after myocardial infarction. *Cardiol J*. (2022) 29:582–90. doi: 10.5603/CJ.a2020.0005

6. Chaudri NA. Adherence to long-term therapies evidence for action. *Ann Saudi Med*. (2004) 24:221–2. doi: 10.5144/0256-4947.2004.221

7. Martin LR, Williams SL, Haskard KB, DiMatteo MR. The challenge of patient adherence. *Ther Clin Risk Manag*. (2005) 1:189–99.

8. Uchmanowicz B, Chudiak A, Uchmanowicz I, Mazur G. How may coexisting frailty influence adherence to treatment in elderly hypertensive patients? *Int J Hypertens*. (2019) 2019:e5245184:1–8. doi: 10.1155/2019/5245184

9. DiMatteo MR. Variations in patients' adherence to medical recommendations: a quantitative review of 50 years of research. *Med Care*. (2004) 42:200–9. doi: 10.1097/01.mlr.0000114908.90348.f9

10. Kardas P, Lewek P, Matyjaszczyk M. Determinants of patient adherence: a review of systematic reviews. *Front Pharmacol*. (2013) 4:91. doi: 10.3389/fphar.2013.00091

11. O'Donohue W, Levensky E. *Promoting treatment adherence: a practical handbook for health care providers*. Thousand Oaks, CA: SAGE Publications, Inc. (2006).

12. Gast A, Mathes T. Medication adherence influencing factors-an (updated) overview of systematic reviews. *Syst Rev*. (2019) 8:112. doi: 10.1186/s13643-019-1014-8

13. Bae SG, Kam S, Park KS, Kim KY, Hong NS, Kim KS, et al. Factors related to intentional and unintentional medication nonadherence in elderly patients with hypertension in rural community. *Patient Prefer Adherence*. (2016) 10:1979–89. doi: 10.2147/PPA.S114529

14. Roller-Wirnsberger R, Thurner B, Pucher C, Lindner S, Wirnsberger GH. The clinical and therapeutic challenge of treating older patients in clinical practice. *Br J Clin Pharmacol*. (2020) 86:1904–11. doi: 10.1111/bcp.14074

15. Wrześniewski K. STAI state and trait anxiety inventory: Polish adaptation of STAI: Handbook. Laboratory of Psychological Tests of the Polish Psychological Association; (2011).

16. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry*. (1961) 4:561–71. doi: 10.1001/archpsyc.1961.01710120031004

17. Juczyński Z. *Measurement tools in health promotion and psychology*. Warsaw: Prac Testów Psychol Pol Tow Psychol (2001). 152 p.

18. Zimet GD, Dahlem NW, Zimet SG, Farley GK. The multidimensional scale of perceived social support. *J Pers Assess*. (1988) 52:30–41. doi: 10.1207/s15327752jpa5201_2

19. Hornowska E., Paluchowski W. Cultural adaptation of psychological tests. Methodology of Psychological Research. Choice of Tests. Wydawnictwo Naukowe PWN; (2004).

20. Kosobucka A, Michalski P, Pietrzykowski Ł, Kasprzak M, Obońska K, Fabiszak T, et al. Adherence to treatment assessed with the adherence in chronic diseases scale in patients after myocardial infarction. *Patient Prefer Adherence*. (2018) 12:333–40. doi: 10.2147/PPA.S150435

21. Kubica A, Kosubucka A, Michalski P, Pietrzykowski Ł, Jurek A, Wawrzyniak W, et al. The adherence in chronic diseases scale—a new tool to monitor implementation of a treatment plan. *Folia Cardiol*. (2017) 12:19–26. doi: 10.5603/FC.a2016.0105

22. Mac Laughlin EJ, Raehl CL, Treadway AK, Sterling TL, Zoller DP, Bond CA. Assessing medication adherence in the elderly: which tools to use in clinical practice? *Drugs Aging*. (2005) 22:231–55. doi: 10.2165/00002512-200522030-00005

23. Salive ME. Multimorbidity in older adults. *Epidemiol Rev*. (2013) 35:75–83. doi: 10.1093/epirev/mxs009

24. Holt E, Joyce C, Dornelles A, Morisky D, Webber LS, Muntner P, et al. Sex differences in barriers to antihypertensive medication adherence: findings from the cohort study of medication adherence among older adults (CoSMO). *J Am Geriatr Soc*. (2013) 61:558–64. doi: 10.1111/jgs.12171

25. Wu JR, Moser DK, Chung ML, Lennie TA. Predictors of medication adherence using a multidimensional adherence model in patients with heart failure. *J Card Fail*. (2008) 14:603–14. doi: 10.1016/j.cardfail.2008.02.011

26. Jin H, Kim Y, Rhie SJ. Factors affecting medication adherence in elderly people. *Patient Prefer Adherence*. (2016) 10:2117–25. doi: 10.2147/PPA.S118121

27. Parnowski T. Depressive syndromes in the elderly – an archetype of affective disorders? *Adv Med Sci*. (2011) 8:666–70.

28. DiMatteo MR, Lepper HS, Croghan TW. Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient adherence. *Arch Intern Med*. (2000) 160:2101–7. doi: 10.1001/archinte.160.14.2101

29. Zachciał J, Uchmanowicz I, Czapla M, Krajewska M, Banasik M. The association between psychosocial and age-related factors with adherence to immunosuppressive therapies after renal transplantation. *J Clin Med*. (2022) 11:2386. doi: 10.3390/jcm11092386

30. Uchmanowicz I, Pasieczna AH, Wójta-Kempa M, Gobbens RJJ, Młynarska A, Faulkner KM, et al. Physical, psychological and social frailty are predictive of heart failure: a cross-sectional study. *J Clin Med*. (2022) 11:565. doi: 10.3390/jcm11030565

31. Yang Z, Wei XB, Fu BQ, Chen JY, Yu DQ. Prevalence and prognostic significance of malnutrition in hypertensive patients in a community setting. *Front Nutr*. (2022) 9:822376. doi: 10.3389/fnut.2022.822376

32. Wleklik M, Denfeld Q, Lisiak M, Czapla M, Kałużna-Oleksy M, Uchmanowicz I. Frailty syndrome in older adults with cardiovascular diseases-what do we know and what requires further research? *Int J Environ Res Public Health*. (2022) 19:2234. doi: 10.3390/ijerph19042234

33. Mphasha MH, Mothiba TM, Skaal L. Family support in the management of diabetes patients' perspectives from Limpopo province in South Africa. *BMC Public Health*. (2022) 22:2421. doi: 10.1186/s12889-022-14903-1

34. Miller TA, DiMatteo MR. Importance of family/social support and impact on adherence to diabetic therapy. *Diabetes Metab Syndr Obes*. (2013) 6:421–6. doi: 10.2147/DMSO.S36368

35. Kleman C, Turrise S, Winslow H, Alzaghari O, Lutz BJ. Individual and systems-related factors associated with heart failure self-care: a systematic review. *BMC Nurs*. (2024) 23:110. doi: 10.1186/s12912-023-01689-9

36. Sayers SL, Riegel B, Pawlowski S, Coyne JC, Samaha FF. Social support and self-care of patients with heart failure. *Ann Behav Med*. (2008) 35:70–9. doi: 10.1007/s12160-007-9003-x

37. Porzych K, Szabela AP, Hadzik K, Porzych M, Augustynska B, Kornatowska KK. Depression and anxiety as a valid issue in geriatric patients. *Neuropsychiatry*. (2018) 8:1210–5. doi: 10.4172/Neuropsychiatry.1000449

38. Kupferberg A, Hasler G. The social cost of depression: investigating the impact of impaired social emotion regulation, social cognition, and interpersonal behavior on social functioning. *J Affect Disord Rep*. (2023) 14:100631. doi: 10.1016/j.jadr.2023.100631

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 04 April 2024
DOI 10.3389/fpubh.2024.1354263

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Manacy Pai,
Kent State University, United States
Fatjona Kamberi,
University of Vlorë, Albania

*CORRESPONDENCE
Gwi-Ryung Son Hong
✉ grson@hanyang.ac.kr

RECEIVED 12 December 2023
ACCEPTED 12 March 2024
PUBLISHED 04 April 2024

CITATION
Oh E, Moon S, Chung D, Choi R and Hong G-RS (2024) The moderating effect of care time on care-related characteristics and caregiver burden: differences between formal and informal caregivers of dependent older adults.
Front. Public Health 12:1354263.
doi: 10.3389/fpubh.2024.1354263

COPYRIGHT
© 2024 Oh, Moon, Chung, Choi and Hong. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

The moderating effect of care time on care-related characteristics and caregiver burden: differences between formal and informal caregivers of dependent older adults

Eunmi Oh[1], SeolHwa Moon[2], Daum Chung[3], Rina Choi[3] and Gwi-Ryung Son Hong[3]*

[1]Research Institute of Nursing Science, Hanyang University, Seoul, Republic of Korea, [2]Department of Nursing, Hoseo University, Cheonan-si, Republic of Korea, [3]College of Nursing, Hanyang University, Seoul, Republic of Korea

Objective: This study examined differences in care burden between formal and informal caregivers of dependent older adults according to care-related characteristics, and whether care time had a moderating effect on the relationship between care-related characteristics and caregiver burden.

Methods: Participants were formal ($n = 520$) and informal caregivers ($n = 142$) of dependent older adults in South Korea. Caregiver burden was measured using the Korean version of the Zarit Burden Interview. Data were analyzed using hierarchical regression with interaction terms and moderation analysis.

Results: Caregiver burden was higher for informal caregivers than formal caregivers. Factors associated with an increased risk of caregiver burden in both formal and informal caregiver of dependent older adults were caregivers' stress, physical strain, and care time. Care time significantly moderated the relationship between care attitude and care burden only among formal caregivers. When formal caregivers' care time was 1 standard deviation higher than the mean value, care attitude was significantly associated with care burden ($b_{simple} = -0.903$, SE = 0.106, $p < 0.001$).

Conclusion: The caregiver burden of dependent older adults can be reduced by providing interventions to attenuate the effects of modifiable risk factors that were identified in this study. And to weaken the relationship between care attitude and burden of formal caregivers who have long care hours, a positive social atmosphere for care should be provided in addition to education. To realize sustainable care, policy considerations that reflect the results of this study will help solve the problem of formal and informal caregiver burden of dependent older adults.

KEYWORDS

older adults, caregiver burden, formal caregivers, informal caregivers, care time, care attitude, moderating effect

1 Introduction

The proportion of the global population that is older adult is increasing rapidly, and accordingly, the need for care for dependent older adults with reduced ability to perform activities of daily living (ADL) is increasing (1). There are two main types of care for older people who are aging and need help taking care of themselves. The first is formal care, which generally refers to paid care provided by medical institutions or medically trained individuals for those in need (2). The second type of care is informal care, which refers to unpaid care provided by family, close relatives, friends, and neighbors. Both formal and informal care involve a variety of tasks, but informal caregivers rarely receive adequate training for these tasks (2). Informal care remains the most common source of home care in the United States, with the use of informal home care by older adults with disabilities increasing from 2004 to 2016; nearly three-quarters of older adults with disabilities received informal home care in 2016. In Korea, family members account for the highest percentage of main caregivers, but the proportion of formal caregivers is increasing continuously (3).

Caregiver burden refers to the multifaceted strain that a caregiver experiences over time while caring for others (4, 5), and if high, can have negative consequences such as decreased quality of care, decreased caregiver quality of life, and poor physical and psychological health of the caregiver (5). Previous reviews reported various factors related to the care burden of formal (6) and informal care givers (7–10). In a systematic review study (10), factors related to care burden were classified into three categories: care-recipient-, caregiver-, and society-related factors. Care-recipient factors influencing care burden were physical disability (11–13), mental dependency (11), and behavioral and psychological symptoms of dementia (13). Caregiver factors were gender (11), age (13–15), satisfaction with care (16), caring time (10, 17, 18), duration of caregiving (11), care attitude (19), and stress (6, 11). Lastly, the utilization of community services (20) and perceived social support (11, 20) were social factors reported to affect caregiver burden of care.

In Korea, due to the low birth rate and rapid increase in the older adult population, the aged population ratio is expected to reach more than 40% in 2050 (21). With the increase in the aged population, social demand for care has increased. Korea is based culturally on Confucian familism (patriarchal tradition), founded on the rule of filial piety (ideology) that believes that caring for parents is a duty. Because of this, families, mainly women, traditionally have provided older adults care within the home (22). In a recent survey, older adults who are receiving informal care by family members living with them, especially children and spouses, still account for 74.5% of those in need of care (23). However, due to changes in social situations such as changes in family structure (smaller families), women's labor force participation, and an increase in the number of older adults living alone, care by children is expected to decrease in the future (24). Long-term informal care is a tremendous burden for informal caregivers (11), both older adults and caregivers of their family caregivers were found to be at increased risk of suicide based on a systematic literature review in Korea (9).

Under such a situation, to reduce the functional decline or gap in older adult care provided by families and the burden on informal caregivers, the long-term care insurance system was introduced as a public care system in 2008. As part of this system, the government developed and systematized jobs for formal caregivers to provide national long-term care benefits to older adults and their families (25). However, formal caregivers endure poor working conditions, low wages, unstable employment, high job intensity, and stress. In addition, formal care jobs are considered non-professional, non-respected jobs for women (25). In particular, the burden on formal caregivers in long-term care facilities (LTCFs) is remarkably high and is becoming a social problem in Korea (26). Despite this expansion of care infrastructure and an increase in the number of formal caregivers, criticism has been raised regarding poor quality in care services (27). In addition, rapid aging is considered a major cause of increasing national economic burden, and ensuring financial sustainability while providing stable older adult care is an important policy task for Korea.

Among the various factors identified in previous studies, care-related characteristics of caregivers are consistently the most important contributor to the care burden of formal and informal caregivers (6, 10). According to a national representative cross-sectional study in United States, the characteristics of the caregiver and the provision of care work were stronger determinants of caregiver burden than the characteristics of the care-recipients (28). Especially longer caring hours and the physically strenuous nature of formal and informal caregiver work increased in the past few years due to COVID-19, with a concomitant increase in psychosocial burden (29–31). The World Health Organization (WHO) emphasized the importance of continuity of care for providing integrated people-centered health services (32). Previous studies have suggested that an increase in caregiver burden has a negative effect on the continuity of care (6, 10). Existing studies on caregiver burden have focused primarily on family caregivers, with fewer studies of formal caregivers.

Recently, although many studies have been conducted on the caregiver burden of older adults in Korea, they separately have analyzed formal caregivers (26) or informal caregivers (9, 17). There were limitations in exploring and comparing the differences in the degree of care burden and influencing factors between formal and informal caregivers. Therefore, in this time of increasing caregiver diversity, we performed this study to examine differences in care burden between formal and informal caregivers of dependent older adults in terms of care-related characteristics and explored the moderating effect of daily care time on the relationship between caregivers' care-related characteristics and caregiver burden. In Korea, culturally, the family functions as the basic system of society, and female-centered family care has been common for older adults. However, with the accelerating aging and diversification of society, the national need for formal care is being emphasized. Therefore, in Korea, reducing the burden of formal and informal care is an important policy task that can support stable care for older adults and ensure the sustainability of national finances. Based on this, we suggest practical measures to reduce caregiver burden and secure the continuity and quality of care services. This study will provide cultural, familial, and economic context that can provide new insight into older adult care in Korea.

2 Materials and methods

2.1 Study design

This study was a descriptive research study. Data analyzed for the current study were selected from a survey on caring status for dependent older adults and people with severe disabilities (PI, *corresponding author), that was conducted from August 2021 to October 2022. This study involved a total of 1,375 participants composed of 1,174 caregivers (665 caregivers for the dependent older adults, 509 caregivers for the disabled), and 201 care-recipients. To access formal and informal caregivers, we reached out to several healthcare facilities and centers that provide care services to older adults. Our selection criteria for these healthcare facilities were based on (1) location and accessibility, (2) proportion of older adults (≥ 65 years) residing in LTCFs (e.g., nursing homes, geriatric hospitals) versus community settings, and (3) proportion of primary caregivers in each setting. At the start of the survey, we aimed to recruit facilities and centers in Gyeonggi-do, Incheon, Seoul, Chungcheong-do, Jeolla-do, and Gyeongsang-do in proportion to the number of older adults in each area. However, due to challenges in recruiting facilities during the COVID-19 pandemic, we reached out to healthcare facilities located in Gyeonggi-do, Seoul, Chungcheong-do, and Jeolla-do. As a result, total participants were recruited from eight nursing homes, six geriatric hospitals, 20 community home visit centers, seven facilities for disabled people, 17 community-welfare centers, and seven other facilities in Seoul, Gyeonggi, Chungcheong, and Jeolla provinces in Korea.

The sample size for multiple regression analysis was assessed using G*Power 3.1 software (33) with a significance level (α) of 0.05, power (1- β) of 80%, medium effect size (f^2) of 0.15, and 13 predictive factors. The minimum sample size was 131. In this study, data from 662 caregivers (520 formal caregivers, 142 informal caregivers) were used in the final analysis, excluding three incomplete responses (missing data for the Korean version of the Zarit Burden Interview) from a total of 665 participants.

2.2 Participants

The inclusion criteria uniformly applied to both formal and informal caregivers were as follows: (1) taking care of an adult aged 65 or older who was dependent in ADLs (graded 1–4 based on the Korean long-term care grade or not yet graded but difficulty in daily life with decreased mobility) (34) and (2) had been providing care for more than 1 month.

2.2.1 Formal caregivers

In this study, formal caregivers were identified as individuals offering direct paid care services to older adults across diverse settings including homes, community settings, and institutions (2). This category encompassed care workers, unlicensed assistive personnel, and personal assistant services for dependent older adults in Korea.

2.2.2 Informal caregivers

In this study, informal caregivers were defined as family members (spouses, children, siblings), friends, or neighbors who provide care to older adults without payment (2).

2.3 Data collection

The initial research plan involved in-person data collection from all caregivers. However, due to the COVID-19 pandemic, this became unrealistic. Consequently, strategic participant recruitment and data collection were carried out based on caregiver types and settings. Face-to-face and online surveys (through Google forms) were conducted concurrently. Of the total 662 participants, 322 (48.6%) participated in the online survey, while 340 (51.4%) took part in the research through face-to-face interactions.

2.3.1 Formal caregivers

Formal caregivers working in facilities or centers underwent a systematic data collection process. Initially, contact was made with each facility and center, involving the distribution of official documents and research protocols. Upon approval, an individual, such as nurse, social worker, case manager, or director, was assigned to each facility for data collection. These designated individuals received training using a data collection manual and assisted other caregivers in the same facility to ensure a smooth response to the survey. Subsequently, research recruitment notices were posted, and for those who agreed to participate, data collection took place through printed or online surveys. The online survey link was shared with the personnel managing data collection within the facility for accessibility. All caregivers in the facilities were able to contact the principal investigator and researchers by phone for any clarifications. An optional step included communication with facility personnel to verify the reliability and accuracy of data on specific aspects as needed.

2.3.2 Informal caregivers

For informal caregivers, the following process was employed. Initial contact with home care centers, public health centers, welfare agencies, and public hospitals was made to assess the possibility of coordinating with families of older adults. Upon obtaining consent, either home visits or center meetings were scheduled for one-on-one interviews with researchers or research assistants. For informal caregivers who preferred remote engagement, an online survey was administered as a Google form distributed via text message or email. Similar to the process with formal caregivers, a review of the entered data was conducted; if additional clarification was needed, informal caregivers were contacted for verification.

2.4 Measurements

2.4.1 Care-recipient factors (adjustment variables)

Cognitive impairment was considered present if dementia was the main diagnosis or comorbidity of dependent older adults, and absent if no diagnosis of dementia was present. Activities of daily living (ADLs) of older adults were assessed using the Korean version of the Barthel Activities of Daily Living index (ADL index) (35), a standardized version of the Barthel ADL index in Korean (36). The Barthel ADL index consists of a total of 10 items: bowel control, bladder control, toilet use, grooming, eating, dressing, transfer, mobility, climbing stairs, and bathing. Each item has a score ranging from 0 (total dependence) to 1 (total independence), 0 (total dependence) to 2 (total independence) or 0 (total dependence) to 3 (total independence), with the total score ranging from 0 to 20. The

10.3389/fpubh.2024.1354263

higher the score, the more independent the care recipient is in daily living activities. Cronbach's alpha of the Korean version of the Barthel ADL index was 0.92 in this study.

2.4.2 Caregiver factors

Formal caregivers were defined as those who provided paid care (e.g., paid health-care assistants, long-term care workers, etc.) while informal caregivers referred to caregivers who provided unpaid care (e.g., family members, relatives, etc.). Gender and age of caregivers were included as adjustment variables.

Care-related characteristics of caregivers included relationship satisfaction, perceived stress, care attitude, and physical strain. Relationship satisfaction was measured by asking the question, "How satisfied are you with the mutual relationship you have with the older adult who is receiving care?" The score ranged from 1 (very dissatisfied) to 10 (very satisfied), and the higher the score, the higher the relationship satisfaction.

Perceived stress in daily life was measured using the Korean Version of the Perceived Stress Scale-10 (KPSS-10) (37), which is a standardized Korean version of PSS-10 (38). KPSS-10 consists of a total of 10 items, including negative responses (items 1, 2, 3, 6, 9, and 10) and positive responses (items 4, 5, 7, and 8). Each item is measured on a five-point Likert scale with a score ranging from 0 (not at all) to 4 (very frequent), with the total score ranging from 0 to 40. The higher the score, the higher the perceived stress. The reported Cronbach's alpha at the time of development of the KPSS-10 was 0.75 (37) and it was calculated to be 0.74 in this study.

Care attitudes toward older adults (39) was used to assess caregivers' care attitude, and were based on the Youth's Attitudes Toward the Elderly (40) and the Maxwell-Sullivan Attitudes Scale Toward the Geriatric Patient (41). Care attitudes for older adults were assessed using a total of 17 items. Each item was measured on a 5-point Likert scale and had a score ranging from 1 (very negative) to 5 (very positive), with a total score range from 17 to 85. The higher the score, the more positive the care attitude. Cronbach's alpha for this scale was 0.93 in this study.

Physical strain was measured by asking the question, "How do you rate the physical difficulty of the overall caring work you are currently doing?" The score ranged from 1 (not at all physically difficult) to 4 (very physically difficult); the higher the score, the higher the physical burden.

2.4.3 Moderating factor

Daily care time was measured by asking the caregiver how many average caring hours they provided per day.

2.4.4 Dependent factors

Caregiver burden was measured by the Korean version of ZBI (ZBI-K) (42); the reliability of this tool was verified in caregivers of care-recipients with dementia (43). ZBI-K has also been used to measure caregiver burden of caregivers caring for severely disabled adults and older adults (44, 45). ZBI-K consists of a total of 22 item. Each item is measured on a 5-point Likert scale and is scored from 0 (not at all) to 4 (almost always), with the total score ranging from 0 to 88; the higher the score, the greater the burden of caregiving. Cronbach's alpha of ZBI-K was previously calculated to be 0.93 (42), and it was 0.93 in this study as well.

2.5 Statistical analysis

Characteristics of care-recipients and caregivers were summarized as frequencies. The significance of differences in the characteristics of formal and informal caregivers were analyzed by independent t-test and Chi-square test. Pearson's correlation coefficients were used to identify bivariate relationships between the main variables. Hierarchical regression analysis was conducted to assess if daily care time had a moderating effect on the relationship between care-related characteristics (relationship satisfaction, perceived stress, care attitude, and physical strain) and care burden. Care-recipients' cognitive impairment, ADLs, and caregivers' gender and age were adjusted for in the first step, and four care-related variables (relationship satisfaction, perceived stress, care attitude, and physical strain) were entered into the regression model. In the second step, the moderating variable (care time) was entered into the model to investigate the effect of care time on care burden. In the third step, interaction terms between care-related characteristics (relationship satisfaction, perceived stress, care attitude, and physical strain) and care time were added into the model to confirm the moderating effect of care time on the relationship between care-related characteristics and care burden. All interaction term variables were standardized by centering the score at the mean in consideration of the multicollinearity problem that may occur when verifying interaction effects.

Simple slope analysis was used to investigate significant interaction terms; the results of this analysis are presented in Figure 1. The relationship between care-related characteristics and caregiver burden was evaluated at three levels of the moderator, namely care time: low level (mean − 1 standard deviation, SD), average level (mean), and high level (mean + 1 SD) (46). All analyses were executed using IBM SPSS, version 23.0 (IBM Corp., Armonk, NY, United States) software and the Jamovi (47) medmod package (Tables 1–3).

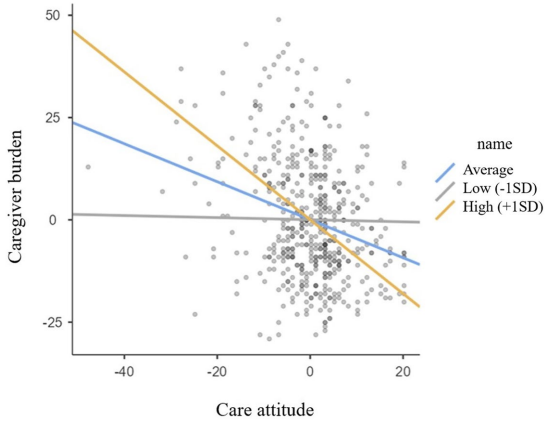


FIGURE 1
Simple slop plot for the moderation effect of daily care time on the relationship between care attitude and caregiver burden in formal caregivers.

3 Results

3.1 Descriptive statistics and preliminary analysis

Dependent older adults cared for by formal caregivers had more cognitive decline and were more dependent in ADLs than older adults cared for by informal caregivers.

Most caregivers were female (89.4%) and mean age was 61.15 (SD ± 7.87) years among all caregivers without a difference in gender ($p = 0.404$) or age ($p = 0.645$) between formal and informal caregivers. Relationship satisfaction had an average score of 7.45 ± 1.78 for all participants, with no significant difference between formal and informal caregivers ($p = 0.817$). Formal caregivers had lower perceived stress scores than informal caregivers (formal 17.41 ± 4.42 vs. informal 21.31 ± 4.80) and higher care attitude scores (formal 64.87 ± 8.75 vs. informal 58.74 ± 7.33). However, they reported less physical strain (formal 3.84 ± 0.89 vs. informal 4.14 ± 0.81; all $p < 0.001$).

Daily care time was 8.70 ± 6.77 h per day on average for all participants and was similar between formal and informal caregivers ($p = 0.482$). Caregiver burden of formal caregivers (29.17 ± 14.76) was significantly lower than that of informal caregivers (45.20 ± 15.61; $p < 0.001$).

3.2 Correlation analysis

According to Pearson's correlation analyses, caregiver burden was significantly negatively associated with relationship satisfaction ($r = -0.18$, $p < 0.001$ vs. $r = -0.24$, $p = 0.004$) and care attitude ($r = -0.28$, $p < 0.001$ vs. $r = -0.23$, $p = 0.007$), and positively associated with perceived stress ($r = 0.51$ vs. $r = 0.62$, $p < 0.001$), physical strain ($r = 0.46$ vs. $r = 0.50$, $p < 0.001$), and care time ($r = 0.13$, $p < 0.001$ vs. $r = 0.25$, $p = 0.003$) in both formal and informal caregivers.

3.3 Hierarchical regression analysis

Four care-related characteristics, namely relationship satisfaction, perceived stress, care attitude, and physical strain were entered in the regression model for formal caregivers in step 1 and accounted for 35.9% of the variance in caregiver burden. Perceived stress ($\beta = 0.38$, $p < 0.001$) and physical strain ($\beta = 0.34$, $p < 0.001$) positively predicted caregiver burden ($F = 36.30$, $p < 0.001$).

Introduction of the moderating variable of care time in step 2 accounted for an additional 1.5% of the variance in caregiver burden ($\beta = 0.14$, $p < 0.001$), with 37.4% of the variance accounted for (F change = 12.43, $p < 0.001$). Perceived stress ($\beta = 0.40$, $p < 0.001$) and

TABLE 1 Characteristics of participants ($N = 662$).

Factors and variables	Total ($N = 662$) n (%) or M ± SD	Formal caregivers ($n = 520$) n (%) or M ± SD	Informal caregivers ($n = 142$) n (%) or M ± SD	t or χ^2	p
Care-recipient factors					
Cognitive impairment				1.03	0.338
Yes	390 (58.9)	312 (60.0)	78 (54.9)		
No	272 (41.1)	208 (40.0)	64 (45.1)		
Activities of daily living	7.27 ± 6.00	6.64 ± 6.00	9.57 ± 5.25	−5.72	<0.001
Caregiver factors					
General characteristics					
Gender				0.68	0.404
Male	70 (10.6)	52 (10.0)	18 (12.7)		
Female	592 (89.4)	468 (90.0)	124 (87.3)		
Age (years)	61.15 ± 7.87	61.06 ± 6.93	61.49 ± 10.65	−0.46	0.645
Care-related characteristics					
Relationship satisfaction	7.45 ± 1.78	7.16 ± 1.74	7.49 ± 1.75	−2.01	0.817
Perceived stress	18.24 ± 4.77	17.41 ± 4.42	21.31 ± 4.80	−9.16	<0.001
Care attitude	64.25 ± 8.61	64.87 ± 8.75	58.74 ± 7.33	3.54	<0.001
Physical strain	3.91 ± 0.88	3.84 ± 0.89	4.14 ± 0.81	−2.21	<0.001
Moderating factor					
Care time (hours/day)	8.70 ± 6.77	8.59 ± 6.20	9.13 ± 8.57	−0.75	0.482
Dependent factor					
Caregiver burden	32.61 ± 16.33	29.17 ± 14.76	45.20 ± 15.61	−11.39	<0.001

physical strain ($\beta = 0.32$, $p < 0.001$) still positively predicted caregiver burden ($F = 34.39$, $p < 0.001$).

In step 3, when the four interaction terms were introduced, only the interaction between care attitude and care time accounted for an additional component of the variance (1.7% of the variance in caregiver burden, $\beta = -0.17$, $p < 0.001$, F change = 4.56, $p < 0.001$). Even after adding the interaction terms into the regression model, perceived stress ($\beta = 0.38$, $p < 0.001$), physical strain ($\beta = 0.32$, $p < 0.001$), and care time ($\beta = 0.11$, $p = 0.010$) positively predicted caregiver burden with a total explained variance of 39.1% ($F = 25.89$, $p < 0.001$).

For informal caregivers, the four care-related characteristics accounted for 46.6% of the variance in caregiver burden (step 1). Perceived stress ($\beta = 0.50$, $p < 0.001$) and physical strain ($\beta = 0.24$, $p = 0.002$) positively predicted caregiver burden ($F = 15.62$, $p < 0.001$).

When care time was introduced in step 2, it explained an additional 1.4% of the variance in caregiver burden ($\beta = 0.15$, $p = 0.038$) (F change = 4.41, $p = 0.038$). Perceived stress ($\beta = 0.48$, $p < 0.001$) and physical strain ($\beta = 0.22$, $p = 0.004$) still positively predicted caregiver burden. The total explained variance was 48.0% ($F = 14.75$, $p < 0.001$).

Introduction of the four interaction terms in step 3 did not explain any additional variance in caregiver burden; rather, the total variance in caregiver burden decreased compared to step 2 (46.6%). Even after adding the interaction terms to the regression model, however, perceived stress ($\beta = 0.49$, $p < 0.001$), physical strain ($\beta = 0.21$, $p = 0.007$), and care time ($\beta = 0.14$, $p = 0.048$) still positively predicted caregiver burden ($F = 9.99$, $p < 0.001$).

3.4 Further analysis of the moderating effect of care time in formal caregivers

We further explored the moderating effect of care time using a simple slope analysis. Figure 1 depicts the moderating effect of care time on the relationship between care attitude and caregiver burden in formal caregivers. This analysis evaluated the relationship between care attitude and caregiver burden according to care time (low, average, or high). When care time was low, the relationship between care attitude and caregiver burden was negative, but not significant ($b_{simple} = -0.026$, SE = 0.106, $p = 0.809$). When care time level was average, this relationship was again negative, but significantly increased in magnitude ($b_{simple} = -0.464$, SE = 0.072, $p < 0.001$) and it further significantly increased in magnitude when care time was high ($b_{simple} = -0.903$, SE = 0.106, $p < 0.001$). The care time of formal caregivers moderated the relationship between care attitude and caregiver burden, and the effect of care attitude on care burden was also moderated differently according to the amount of care time. In other words, care attitude was most strongly associated with lower caregiver burden when the formal caregiver reported high levels of care time.

4 Discussion

We examined the differences in care burden between formal and informal caregivers of dependent older adults according to care-related characteristics, and analyzed whether daily care time has a moderating effect on the relationship between caregivers' care-related characteristics and care burden. This study is, to the best of our knowledge, the first study to identify differences in these associations between formal and informal caregivers of dependent older adults.

Importantly, we confirmed that perceived stress, physical strain, and care time, in descending order, increased the care burden of formal and informal caregivers, indicating that the effects of care time on caregiver burden are lower than those of stress and physical strain. This finding is consistent with existing studies that have reported that perceived stress and physical burden affect caregiver burden (6, 48).

Our results are similar to those of a previous study that analyzed differences in caregiver burden and potential overload between formal and informal caregivers in Australia (4); that study reported eight subthemes related to caregiver burden. Both formal and informal caregivers reported psychological burden as the most serious burden, followed by physical burden (e.g., back pain), whereas limited time resources, such as limited private time, were the subtheme least related to care burden.

Caregiver burden is widely accepted as a stress-related concept in caregiving studies. In a recent conceptual analysis, care burden of formal caregivers of vulnerable older adults in nursing home was understood as a complex response to the physical, psychological, emotional, social, and financial stressors associated with the care experience (49). The authors defined the care burden of a nursing home's formal caregiver as "the demands of caring for dependent older adults with a level of competency and responsibility within the context of perceived stress" (49). In a review study on the determinants of burden in informal caregivers, multidimensional determinants of objective and subjective care burden were explained based on the Adapted Stress Model (ASM) (11). General stressors such as caregiving duration and recipient's functional status contributed to care burden, in addition to intrapsychic stressors such as role conflict and role overload due to restrictions on caregivers' time (11).

More importantly, moderation analysis of formal caregivers confirmed a significant interaction between care attitude and care time on caregiver burden. Care time appears to moderate the relationship between care attitude and care burden in formal caregivers of older adults, with higher care burden related to longer caring time. This suggests that caregiver burden may be buffered by a positive care attitude when care time is longer. This is a new finding that for the first time establishes a direct link between caregiver burden and care time as a predictor of caregiver burden in both formal and informal caregivers. Furthermore, our findings indicate that care time also moderates the relationship between care attitude and caregiver burden in formal caregivers.

Previous studies have examined the relationship between care time and care burden (18, 50). Increased caregiver time was found to be associated with negative outcomes (51). In particular, as caregiving time increased, the physical and mental burden caused by the care activities increased, causing fatigue, and primary caregivers of stroke survivors who provide care for more than 6 h a day were 2.8 times more likely to be depressed than caregivers who spent less than 6 h a day caregiving (51).

During COVID-19 in Korea, interpersonal contact was minimized to prevent the spread of this disease, and preventive cohort isolation (all staff and care-recipients had to live and work only at the facility and were prohibited from having direct contact with the outside world) was implemented at facilities for older adults (e.g., LTCFs, geriatric hospitals). In addition, as most types of community care services provided to the older adults were discontinued, formal and informal caregivers' working hours increased. These changes unsurprisingly increased caregiver burden (52, 53). Globally, caregivers complained of increased job stress, anxiety, and depression

TABLE 2 Correlations among the main variables ($N = 662$).

Variables		Formal caregiver ($n = 520$)					
		r (p)					
		1	2	3	4	5	6
1	Relationship satisfaction	1					
2	Stress	−0.150 (0.001)	1				
3	Care attitude	0.298 (0.001)	−0.342 (<0.001)	1			
4	Physical strain	−0.130 (0.003)	0.296 (<0.001)	−0.251 (<0.001)	1		
5	Care time	−0.059 (0.186)	−0.067 (0.127)	−0.172 (<0.001)	0.173 (<0.001)	1	
6	Caregiver burden	−0.184 (<0.001)	0.505 (<0.001)	−0.280 (<0.001)	0.463 (<0.001)	0.132 (<0.001)	1

Variables		Informal caregiver ($n = 142$)					
		r (p)					
		1	2	3	4	5	6
1	Relationship satisfaction	1					
2	Stress	−0.231 (0.006)	1				
3	Care attitude	0.232 (0.006)	−0.238 (0.004)	1			
4	Physical strain	−0.210 (0.014)	0.445 (<0.001)	−0.083 (0.327)	1		
5	Care time	0.048 (0.575)	0.117 (0.169)	0.122 (0.153)	0.225 (0.008)	1	
6	Caregiver burden	−0.241 (0.004)	0.624 (<0.001)	−0.227 (0.007)	0.496 (<0.001)	0.245 (0.003)	1

due to lack of manpower, overtime, and work overload during the COVID-19 pandemic (29–31, 54).

A positive attitude is part of the coping process that is the primary defense for protecting mental health in situations that are rated as stressful. During the COVID-19 pandemic, nurses' positive attitudes improved quality of professional life, reduced burnout and secondary traumatic stress, and improved compassion satisfaction (55). In addition, healthcare professionals' positive attitude was a strong protective factor against stress (56).

In psychology, attitude refers to an individual's willingness to respond in a particular way to a person, situation, or idea as reflected in the cognitive, affective, and behavioral domains based on experience (57). Social psychologists have long been interested in understanding attitudes because of the belief that attitudes strongly influence behaviors, decisions, and judgments. Quality of care depends on caregivers' attitudes toward caring for older adults in LTCFs (58). In a study to understand the impact of knowledge and attitude on the care quality of the caregivers of older adults residing in LTCFs in China, it was found that caregivers' knowledge and attitudes affected their practice, and quality of care improved with an improvement in the knowledge and attitude of caregivers (58).

Therefore, based on the results of previous studies, formal caregivers in this study likely experienced increased caregiver burden due to physical strain, stress, and increased care time during the COVID-19 pandemic period, but the group with longer working hours used positive attitude as a means of coping, thereby reducing their caregiver burden.

Consistent with existing literature related to care time as an important contributor to caregiving burden (17, 18, 50), increased care time predicted an increase in the care burden of informal caregivers in this current study. Furthermore, 13 of 32 studies considered in a systematic review on care burden in families with dementia reported that care time had a significant negative relationship to family care burden (10). The current study was conducted during the COVID-19 pandemic (August 2021 to October 2022), and average care time per day was 8.70 h (formal caregivers 8.59 h, informal caregiver 9.13 h), compared to 7.50 h in Australia (4) and 7.34 h in Korea (17) in family caregivers before COVID-19.

Contrary to our findings, informal caregivers' care time did not affect caregiving burden in community-dwelling older adults and family caregivers living in the United States based on a nationally representative survey (28), and a study from Brazil reported that even daily care times of more than 12 h did not affect caregiver burden. Since the level of care burden may vary depending on the age of the informal caregiver, differences in the ages of informal caregivers in this study and previous studies may have resulted in the discrepant findings; careful interpretation of our research results is therefore necessary. However, there is no dispute that the longer the care time, the greater the negative effects; as informal caregivers increase their care time, they tend to report poorer health status, are more often current smokers, less physically active, and more obese (59).

In Korea, although the Labor Standards Act limits the maximum working hours for formal caregivers to 52 h per week, actual working hours in reality are still longer than legal regulations, including shift time and handover time (53); the daily working hours of formal caregivers at LTCFs was reported to be 9.5 h/day (60). In addition, among informal caregivers in Korea, poor quality of life due to caregiving is particularly evident among women, and as care time increases, negative consequences such as reduced labor participation, increased likelihood of

10.3389/fpubh.2024.1354263

TABLE 3 Hierarchical regression analysis results ($N = 662$).

	Predictable variable	Formal caregiver ($n = 520$)														
		Step 1					Step 2					Step 3				
		β	SE	t	p	VIF	β	SE	t	p	VIF	β	SE	t	p	VIF
Model 1	Relationship satisfaction	−0.06	0.32	−1.67	0.096	1.11	−0.06	0.32	−1.74	0.083	1.11	−0.06	0.32	−1.68	0.093	1.14
	Stress	0.38	0.13	9.46	<0.001	1.24	0.40	0.13	10.00	<0.001	1.27	0.38	0.13	9.40	<0.001	1.33
	Care attitude	−0.05	0.07	−1.14	0.254	1.30	−0.02	0.07	−0.60	0.548	1.33	−0.04	0.07	−1.03	0.305	1.35
	Physical strain	0.34	0.82	8.79	<0.001	1.15	0.32	0.82	8.41	<0.001	1.17	0.32	0.81	8.48	<0.001	1.17
Model 2	Care time						0.14	0.10	3.53	<0.001	1.31	0.11	0.10	2.58	0.010	1.45
Model 3	Relationship satisfaction x Care time											0.03	0.06	0.67	0.504	1.37
	Stress x Care time											0.01	0.02	0.01	0.996	1.72
	Care attitude x Care time											−0.17	0.01	−3.82	<0.001	1.64
	Physical strain x Care time											−0.05	0.13	−1.13	0.259	1.32
	R^2	0.369					0.385					0.407				
	Adjusted R^2	0.359					0.374					0.391				
	F (p)	36.30 (< 0.001)					34.39 (< 0.001)					25.89 (< 0.001)				
	F change (p)	12.34 (< 0.001)					12.43 (< 0.001)					4.56 (< 0.001)				

	Predictable variable	Informal caregiver ($n = 142$)														
		Step 1					Step 2					Step 3				
		β	SE	t	p	VIF	β	SE	t	p	VIF	β	SE	t	p	VIF
Model 1	Relationship satisfaction	−0.05	0.61	−0.82	0.416	1.14	−0.07	0.60	−1.04	0.300	1.15	−0.07	0.61	−1.03	0.303	1.15
	Stress	0.50	0.24	6.73	<0.001	1.39	0.48	0.24	6.56	<0.001	1.40	0.49	0.25	6.43	<0.001	1.44
	Care attitude	−0.10	0.15	−1.44	0.153	1.18	−0.11	0.15	−1.63	0.105	1.18	−0.10	0.15	−1.49	0.139	1.23
	Physical strain	0.24	1.38	3.22	0.002	1.41	0.22	1.38	2.93	0.004	1.44	0.21	1.42	2.73	0.007	1.49
Model 2	Care time						0.15	0.13	2.10	0.038	1.26	0.14	0.13	2.00	0.048	1.29
Model 3	Relationship satisfaction x Care time											−0.01	0.03	−0.10	0.922	1.77
	Stress x Care time											0.05	0.02	0.71	0.478	1.22
	Care attitude x Care time											−0.01	0.16	−0.16	0.876	1.40
	Physical strain x Care time											−0.02	0.07	−0.34	0.732	1.22
	R^2	0.498					0.515					0.518				
	Adjusted R^2	0.466					0.480					0.466				
	F (p)	15.62 (< 0.001)					14.75 (< 0.001)					9.99 (<0.001)				
	F change (p)	29.82 (< 0.001)					4.41 (0.038)					0.17 (0.954)				

Adjustment variables: care-recipient factors: cognitive impairment, activities of daily living; caregiver factors-gender: age. β, standardized coefficients derived from the final step; R^2, explanation rate.

quitting, and decreased quality of life are increased (24). Therefore, the implication of this study in Korea is that the formal caregiver burden can be buffered if the group with high care time experiences a positive care attitude. Additionally, based on this study, we suggest that formal caregivers with long care hours make efforts to have a positive care attitude (e.g., by receiving education and creating a social atmosphere) to decrease the care burden on formal caregivers.

This study has some limitations. In terms of research design, we analyzed antecedent variables for care burden using cross-sectional analysis, thus we were unable to assess causal relationships, as longitudinal studies are required to determine cause and effect. Additionally, because our sample was based on convenience sampling, a more representative sample should be used to confirm our findings. Limitations related to the research method including measurement tools and survey questions are as follows. In previous studies, conflict relationships with care recipients were a major risk factor for stress among family caregivers of older adults (31), and caregiver burden differed depending on the relationship between the caregiver and the older adults (61). However, we did not examine differences in burden according to the relationship between informal caregivers and older adults; this should be done in future studies. Additionally, the caregiving satisfaction of informal caregivers caring for older adults who need full-time help on basic daily activities was shown to have a significant impact on the burden of care (16). In previous studies, caregiving satisfaction was evaluated with the Caregiver Satisfaction Assessment Index (CSAI), which consists of 30 statements about positive aspects of caregiving. However, in this study, only one question was used to evaluate relationship satisfaction; more comprehensive evaluations of caregiving satisfaction should be incorporated in future studies.

Having family members assisting with daily care would help ease the burden on those responsible for primary care. Therefore, future study on caregiver burden should include any types of supports including available secondary caregivers, perceived social support (18), and community services (20). Empirical studies have shown that caregivers who perform physical care-related tasks (bathing, using the toilet, etc.) are more likely to experience stress compared to caregivers who help with less personal tasks (cleaning, mowing the lawn, etc.) (62). However, as current study only measured the responses to overall physical care and not those specifically related to care tasks, future research about physical strain is suggested to measure and to reflect the types of tasks performed by caregivers.

In previous studies, disease type (10, 61) and trajectory (63) were reported to affect the caregiver burden. In particular, the caregiver burden is high for dementia (61), stroke (12), and schizophrenia (19). In cases of dementia, the caregiver burden differs depending on the type of dementia (Lewy body disease > Alzheimer's disease) (61). Additionally, in dementia, the burden of care increased over time according to the disease trajectory (63). Therefore, future research is suggested to include variables for disease type and trajectory. Finally, the COVID-19 pandemic and associated containment measures likely functioned as situational stressors and may have affected our findings. Future research should be conducted to confirm our findings under common stressors and life situations.

Despite these limitations, this study provides evidence that stress, physical strain, and care time were risk factors for caregiver burden in both formal and informal caregivers, but that care time had a moderating effect between care attitude and caregiver burden only in formal caregivers. As the demand for formal and informal care gradually increases due to the rapid aging of the population, the caregiver burden is also increasing. The caregiver burden has negative consequences on caregivers and care recipients. Until now, economic growth based on efficiency has been the goal of Korean society. However, the caregiver burden accompanying a low birth rate and aging is becoming a social problem, and the sustainability of society is threatened by limited national finances. Therefore, to provide sustainable care, based on the results of this study, we propose provide interventions to reduce the effects of modifiable risk factors for care burden. This study also suggests that a policy is needed to expand formal and informal care support policies and differentially support care time depending on the characteristics of the caregiver. The results of this study will have a positive impact on reducing the burden of care on care providers, including informal care providers who provide mainly care in a patriarchal culture. In addition, from a financial perspective, the study could have a positive impact on the employment rate of informal family caregivers or on the effective use of the government's formal care-related finances.

Data availability statement

The dataset presented in this document is not immediately available due to informed consent of the research participants and did not include public data deposition. Requests for access to datasets should be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Hanyang University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

EO: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SM: Formal analysis, Writing – review & editing. DC: Data curation, Visualization, Writing – review & editing. RC: Visualization, Writing – review & editing. GR-H: Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was supported by the Translational Research Program for Care Robots funded by the Ministry of Health and Welfare, Republic of Korea (Grant no. HK21C0008010021, PI, GR-H).

Acknowledgments

The authors would like to thank the study participants, both formal and informal caregivers, who provided valuable information for the study.

Conflict of interest

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. The Organization for Economic Co-operation and Development. *OECD Health Statistics*. (2022). https://www.oecd.org/els/health-systems/health-data.htm

2. Li J, Song Y. Formal and informal care In: D Gu and ME Dupre, editors. *Encyclopedia of gerontology and population aging*. Cham: Springer International Publishing (2019). 1–8.

3. Ministry of Health and Welfare, Korea Institute for Health and Social Affairs Kim S, Yi MG, Oh U, Oh D, Hwang JH, Oh M, et al. *2020 National survey on persons with disabilities Report No.: 11–1352000–000568–12*. (2020). Available at: https://www.prism.go.kr/homepage/entire/researchDetail.do?researchId=1351000-202000241

4. Krutter S, Schaffler-Schaden D, Essl-Maurer R, Wurm L, Seymer A, Kriechmayr C, et al. Comparing perspectives of family caregivers and healthcare professionals regarding caregiver burden in dementia care: results of a mixed methods study in a rural setting. *Age Ageing*. (2019) 49:199–207. doi: 10.1093/ageing/afz165

5. Liu Z, Heffernan C, Tan J. Caregiver burden: a concept analysis. *Int J Nurs Sci*. (2020) 7:438–45. doi: 10.1016/j.ijnss.2020.07.012

6. Kunkle R, Chaperon C, Berger AM. Formal caregiver burden in nursing homes: an integrative review. *West J Nurs Res*. (2021) 43:877–93. doi: 10.1177/0193945920979691

7. Cham CQ, Ibrahim N, Siau CS, Kalaman CR, Ho MC, Yahya AN, et al. Caregiver burden among caregivers of patients with mental illness: a systematic review and meta-analysis. *Healthcare (Basel)*. (2022) 10:423. doi: 10.3390/healthcare10122423

8. Collins RN, Kishita N. Prevalence of depression and burden among informal caregivers of people with dementia: a meta-analysis. *Ageing Soc*. (2020) 40:2355–92. doi: 10.1017/S0144686X19000527

9. Kong JW, Park JY. Understanding suicide risk in people with dementia and family caregivers in South Korea: a systematic review. *Behav Sci*. (2022) 12:97. doi: 10.3390/bs12040097

10. Wang L, Zhou Y, Fang X, Qu G. Care burden on family caregivers of patients with dementia and affecting factors in China: a systematic review. *Front Psych*. (2022) 13:13. doi: 10.3389/fpsyt.2022.1004552

11. Lindt N, van Berkel J, Mulder BC. Determinants of overburdening among informal carers: a systematic review. *BMC Geriatr*. (2020) 20:304. doi: 10.1186/s12877-020-01708-3

12. Shamoun C, Harris MA. Impact of stroke survivors' physical disability on the presence of caregiver burden: a systematic review. *J Neurosci Nurs*. (2022) 54:146–50. doi: 10.1097/JNN.0000000000000651

13. Tsai CF, Hwang WS, Lee JJ, Wang WF, Huang LC, Huang LK, et al. Predictors of caregiver burden in aged caregivers of demented older patients. *BMC Geriatr*. (2021) 21:59. doi: 10.1186/s12877-021-02007-1

14. Egan C, Dalton CT. An exploration of care-burden experienced by older caregivers of adults with intellectual disabilities in Ireland. *Br J Learn Disabil*. (2019) 47:188–94. doi: 10.1111/bld.12273

15. Phetsitong R, Vapattanawong P, Mayston R, Prince M, Chua KC. In caring for older people in low- and middle-income countries, do older caregivers have a high level of care burden and psychological morbidity compared to younger caregivers? *Int J Environ Res Public Health*. (2022) 19:405. doi: 10.3390/ijerph192416405

16. Da Marinho JS, Batista IB, Da Nobre RAS, Guimarães MSA, Dos Santos-Orlandi AA, Brito TRP, et al. Burden, satisfaction caregiving, and family relations in informal caregivers of older adults. *Front Med (Lausanne)*. (2022) 9:467. doi: 10.3389/fmed.2022.1059467

17. Lee HS, Kim C. Factors affecting family caregivers' burden and depression in home-based long-term care service under the long-term care insurance system. *J Korean Acad Community Health Nurs*. (2018) 29:530–8. doi: 10.12799/jkachn.2018.29.4.530

18. Nemcikova M, Katreniakova Z, Nagyova I. Social support, positive caregiving experience, and caregiver burden in informal caregivers of older adults with dementia. *Front Public Health*. (2023) 11:11. doi: 10.3389/fpubh.2023.1104250

19. Sustrami D, Yusuf A, Fitryasari R, Suhardiningsih AVS, Arifin H. Determinants of burden in family caregivers of individuals with schizophrenia: a systematic review. *J Psychosoc Nurs Ment Health Serv*. (2023) 61:38–43. doi: 10.3928/02793695-20220804-02

20. Liu Z, Sun W, Chen H, Zhuang J, Wu B, Xu H, et al. Caregiver burden and its associated factors among family caregivers of persons with dementia in Shanghai, China: a cross-sectional study. *BMJ Open*. (2022) 12:e057817. doi: 10.1136/bmjopen-2021-057817

21. Statistics Korea. *Future population projections: 2022 to 2072*. (2023). Available at: https://kostat.go.kr/boardDownload.es?bid=207&list_no=428476&seq=6

22. Park J, Choi SY, Kim Y, Byoun SJ, Cho SH, Kim JH, et al. *Family changes in Korea and their policy implications, Report No.: 2020–54*. Sejong: Korea Institute for Health and Social Affairs (2020). 455 p.

23. Lee YK, Kim SJ, Hwang NH, Lim JM, Joo BH, Namgung EH, et al. 2020 the Korean elderly survey. Sejong: Ministry of Health and Welfare. (2021). Available at: https://www.mohw.go.kr/board.es?mid=a10411010100&bid=0019&act=view&list_no=366496

24. Lee YW. *Policy issues and challenges in welfare policies for elderly care*. KDI Policy Study (2020).

25. Yoon JH, Ma KH, No DY. *Research to develop a social care agenda, Report No.: 12-1074800-000045–01*. Seoul: Korea Labour and Society Institute. (2021). Available at: https://www.korea.kr/common/download.do?fileId=195194664&tblKey=GMN

26. Song JA, Oh YJ. The association between the burden on formal caregivers and behavioral and psychological symptoms of dementia (BPSD) in Korean elderly in nursing homes. *Arch Psychiatr Nurs*. (2015) 29:346–54. doi: 10.1016/j.apnu.2015.06.004

27. Yi GJ, Seok JE. Is the quality of service better with higher competition among long-term care institutions? *Health Soc Welfare Rev*. (2019) 39:425–55. doi: 10.15709/hswr.2019.39.4.425

28. Riffin C, Van Ness PH, Wolff JL, Fried T. Multifactorial examination of caregiver burden in a national sample of family and unpaid caregivers. *J Am Geriatr Soc*. (2019) 67:277–83. doi: 10.1111/jgs.15664

29. Hering C, Gangnus A, Budnick A, Kohl R, Steinhagen-Thiessen E, Kuhlmey A, et al. Psychosocial burden and associated factors among nurses in care homes during the COVID-19 pandemic: findings from a retrospective survey in Germany. *BMC Nurs*. (2022) 21:41. doi: 10.1186/s12912-022-00807-3

30. Schulze S, Merz S, Thier A, Tallarek M, König F, Uhlenbrock G, et al. Psychosocial burden in nurses working in nursing homes during the Covid-19 pandemic: a cross-sectional study with quantitative and qualitative data. *BMC Health Serv Res*. (2022) 22:949. doi: 10.1186/s12913-022-08333-3

31. Zucca M, Isella V, Lorenzo RD, Marra C, Cagnin A, Cupidi C, et al. Being the family caregiver of a patient with dementia during the coronavirus disease 2019 lockdown. *Front Aging Neurosci*. (2021) 13:13. doi: 10.3389/fnagi.2021.653533

32. World Health Organization. *WHO global strategy on people-centred and integrated health services: Interim report*. Geneva: World Health Organization (2015).

33. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*power 3.1: tests for correlation and regression analyses. *Behav Res Methods*. (2009) 41:1149–60. doi: 10.3758/BRM.41.4.1149

34. Ministry of Health and Welfare. *Criteria for determining the severity of a disability [internet]*. Seoul: The Government of the Republic of Korea (2023) Available at: https://www.mohw.go.kr/board.es?mid=a10107010100&bid=0039&act=view&list_no=1479481&tag=&cg_code=&list_depth=1

35. Kim SY, Won CW, Rho YG. The validity and reliability of Korean version of Barthel ADL index. *J Fam Med*. (2004) 25:534–41.

36. Collin C, Wade DT, Davies S, Horne V. The Barthel ADL index: a reliability study. *Int Disabil Stud*. (1988) 10:61–3. doi: 10.3109/09638288809164103

37. Hong GRS, Kang HK, Oh E, Park YO, Kim H. Reliability and validity of the Korean version of the perceived stress scale-10 (K-PSS-10) in older adults. *Res Gerontol Nurs*. (2016) 9:45–51. doi: 10.3928/19404921-20150806-72

38. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav*. (1983) 24:385–96. doi: 10.2307/2136404

39. Joung HY, Hyun HJ. The effects of senior simulation programs on elderly care facilities employees' attitudes for elderly care, understanding of the aged, job satisfaction, and job performance. *J Korean Acad Community Health Nurs*. (2012) 23:222–30. doi: 10.12799/jkachn.2012.23.2.222

40. Sanders GF, Montgomery JE, Pittman JF, Balkwell C. Youth's attitudes toward the elderly. *J Appl Gerontol*. (1984) 3:59–70. doi: 10.1177/073346488400300107

41. Maxwell AJ, Sullivan N. Attitudes toward the geriatric patient among family practice residents. *J Am Geriatr Soc*. (1980) 28:341–5. doi: 10.1111/j.1532-5415.1980.tb01095.x

42. Lee H, Kim D, Ko H, Ku H, Kwon E, Kim J. Measurement of stress in the caregivers of dementia patients: reliability and validity of the revised-memory and behavior problem checklist and the burden interview. *J Clin Psychol*. (2004) 23:1029–50.

43. Zarit SH, Reever KE, Bach-Peterson J. Relatives of the impaired elderly: correlates of feelings of burden. *Gerontologist*. (1980) 20:649–55. doi: 10.1093/geront/20.6.649

44. Ong HL, Vaingankar JA, Abdin E, Sambasivam R, Fauziana R, Tan ME, et al. Resilience and burden in caregivers of older adults: moderating and mediating effects of perceived social support. *BMC Psychiatry*. (2018) 18:27. doi: 10.1186/s12888-018-1616-z

45. Tough H, MWG B, Siegrist J, Fekete Cfor the SwiSCI Study Group. Social inequalities in the burden of care: a dyadic analysis in the caregiving partners of persons with a physical disability. *Int J Equity Health*. (2019) 19:1112. doi: 10.1186/s12939-019-1112-1

46. Aiken LS, West SG, Reno RR. *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications, Inc (1991).

47. The Jamovi Project. *Jamovi (Version 2.3) [Computer Software]*. (2023). Available at: https://www.jamovi.org

48. Smith S, Murphy E, Hannigan C, Dinsmore J, Doyle J. Supporting older people with multimorbidity: the care burden of home health-care assistants in Ireland. *Home Health Care Servs Q*. (2019) 38:241–55. doi: 10.1080/01621424.2019.1614506

49. Kunkle R, Chaperon C, Hanna KM. Formal caregiver burden in nursing homes: a concept analysis. *J Gerontol Nurs*. (2020) 46:19–24. doi: 10.3928/00989134-20200706-02

50. Cao Y, Yang F. Objective and subjective dementia caregiving burden: the moderating role of immanent justice reasoning and social support. *Int J Environ Res Public Health*. (2020) 17:455. doi: 10.3390/ijerph17020455

51. Eriku GA, Bekele G, Yitayal MM, Belete Y, Girma Y. Depressive symptoms and its associated factors among primary caregivers of stroke survivors at Amhara regional state tertiary hospitals: multicenter study. *Neuropsychiatr Dis Treat*. (2023) 19:1675–84. doi: 10.2147/NDT.S418074

52. Ministry of Health and Welfare. *Korean government pushes for sustainable care system in the face of COVID-19*. (2020). Available at: https://www.mohw.go.kr/board.es?mid=a10501010100&bid=0003

53. Seok JE. Vulnerability and social challenges of long-term care workers revealed in the COVID-19 phase. *Korean J Soc Welf*. (2020) 72:125–49. doi: 10.20970/kasw.2020.72.4.005

54. Chen H, Cao Y, Lu Y, Zheng X, Kong B, Dong H, et al. Factors associated with mental health outcomes among caregivers of older adults in long-term care facilities during COVID-19 post-epidemic era in Shandong, China. *Front Psych*. (2022) 13:13. doi: 10.3389/fpsyt.2022.1011775

55. Calegari JG, Russo S, Luciani M, Strepparava MG, Di Mauro S, Ausili D. Association between coping strategies and professional quality of life in nurses and physicians during COVID-19: a cross-sectional study. *J Nurs Manag*. (2022) 30:4054–63. doi: 10.1111/jonm.13845

56. Babore A, Lombardi L, Viceconti ML, Pignataro S, Marino V, Crudele M, et al. Psychological effects of the COVID-2019 pandemic: perceived stress and coping strategies among healthcare professionals. *Psychiatry Res*. (2020) 293:113366. doi: 10.1016/j.psychres.2020.113366

57. Rosenberg MJ. Cognitive, affective, and behavioral components of attitudes In: MJ Rosenburgh and CI Hovland, editors. *Attitude organization and change: An analysis of consistency among attitude components*. New Haven: Yale University Press (1960). 1–14.

58. Zeng Y, Hu X, Li Y, Zhen X, Gu Y, Sun X, et al. The quality of caregivers for the elderly in long-term care institutions in Zhejiang province, China. *Int J Environ Health Res*. (2019) 16:164. doi: 10.3390/ijerph16122164

59. Fuchs J, Gaertner B, Rommel A, Starker A. Informal caregivers in Germany – who are they and which risks and resources do they have? *Front Public Health*. (2023) 11:517. doi: 10.3389/fpubh.2023.1058517

60. Jang J, Yoon J, Jeon J, King E, Eun G, Peng I, et al. *Economic value and social significance of caring labor*. Sejong: Korea Labor Institute (2020).

61. Huang WC, Chang MC, Wang WF, Jhang KM. A comparison of caregiver burden for different types of dementia: an 18-month retrospective cohort study. *Front Psychol*. (2022) 12:12. doi: 10.3389/fpsyg.2021.798315

62. Calasanti TM, Slevin KF. *Gender, social inequalities, and aging*. Lanham: AltaMira Press (2001). 248 p.

63. Conde-Sala JL, Turró-Garriga O, Calvó-Perxas L, Vilalta-Franch J, Lopez-Pousa S, Garre-Olmo J. Three-year trajectories of caregiver burden in Alzheimer's disease. *J Alzheimers Dis*. (2014) 42:623–33. doi: 10.3233/JAD-140360

frontiers | Frontiers in Public Health

TYPE Systematic Review
PUBLISHED 09 April 2024
DOI 10.3389/fpubh.2024.1250299

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Begoña Polonio-López,
University of Castilla-La Mancha, Spain
Jaime Andres Garcia,
University of Technology Sydney, Australia

*CORRESPONDENCE
Pablo Valdés-Badilla
✉ valdesbadilla@gmail.com

RECEIVED 29 June 2023
ACCEPTED 29 February 2024
PUBLISHED 09 April 2024

CITATION
Hernandez-Martinez J, Ramos-Espinoza F, Muñoz-Vásquez C, Guzman-Muñoz E, Herrera-Valenzuela T, Branco BHM, Castillo-Cerda M and Valdés-Badilla P (2024) Effects of active exergames on physical performance in older people: an overview of systematic reviews and meta-analysis. *Front. Public Health* 12:1250299. doi: 10.3389/fpubh.2024.1250299

COPYRIGHT
© 2024 Hernandez-Martinez, Ramos-Espinoza, Muñoz-Vásquez, Guzman-Muñoz, Herrera-Valenzuela, Branco, Castillo-Cerda and Valdés-Badilla. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Effects of active exergames on physical performance in older people: an overview of systematic reviews and meta-analysis

Jordan Hernandez-Martinez[1,2], Francisco Ramos-Espinoza[3], Cristopher Muñoz-Vásquez[4], Eduardo Guzman-Muñoz[5,6], Tomas Herrera-Valenzuela[7], Braulio Henrique Magnani Branco[8], Maria Castillo-Cerda[1] and Pablo Valdés-Badilla[9,10]*

[1]Department of Physical Activity Sciences, Universidad de Los Lagos, Osorno, Chile, [2]Programa de Investigación en Deporte, Sociedad y Buen Vivir, Universidad de los Lagos, Osorno, Chile, [3]Doctoral Program in Psychology, Faculty of Health Sciences, Universidad Católica del Maule, Talca, Chile, [4]Department of Health, Programa de Prevención y Rehabilitación Cardiovascular, CESFAM Dr. Juan Carlos Baeza, San Clemente, Chile, [5]Faculty of Health, School of Kinesiology, Universidad Santo Tomás, Talca, Chile, [6]Faculty of Health Sciences, School of Kinesiology, Universidad Autónoma de Chile, Talca, Chile, [7]Department of Physical Activity, Sports and Health Sciences, Faculty of Medical Sciences, Universidad de Santiago de Chile (USACH), Santiago, Chile, [8]Graduate Program in Health Promotion, Cesumar University (UniCesumar), Maringá, Brazil, [9]Department of Physical Activity Sciences, Faculty of Education Sciences, Universidad Católica del Maule, Talca, Chile, [10]Sports Coach Career, School of Education, Universidad Viña del Mar, Viña del Mar, Chile

This overview assessed the available body of published peer-reviewed systematic reviews and meta-analyses related to the effects of active exergames compared with active/passive control on physical performance outcomes in older people. The methodological quality and certainty of evidence were assessed using PRISMA, AMSTAR 2, and GRADE. The protocol was registered in PROSPERO (code: CRD42023391694). The main outcomes indicate that 4,477 records, five systematic reviews, and 10 meta-analyses were included. The AMSTAR-2 reported six meta-analyses with high methodological quality, four moderate quality, two systematic reviews with low quality, and three very-low quality. Meta-analysis was performed on balance using the Berg Balance Scale (BBS) and Timed Up-and-Go (TUG) tests, on cardiorespiratory fitness using the 6-min walk test, and on upper and lower limbs muscle strength using the handgrip strength, knee extension, and 30-s chair stand tests. Significant differences in favor of the active exergames groups concerning active/passive groups were reported in BBS (SMD = 0.85; 95% CI = 0.12–1.58; I^2 = 96%; p = 0.02), TUG (SMD = 1.44; 95% CI = 0.71–2.16; I^2 = 97%; $p < 0.0001$), and 30-s chair stand test (SMD = 0.79; 95% CI = 0.33–1.25; I^2 = 88%; p = 0.0008). However, no significant differences were reported in favor of the active exergames groups in 6-min walk (SMD = 0.93; 95% CI = −0.64 to 2.50; I^2 = 95%; p = 0.24), handgrip strength (SMD = 0.67; 95% CI = −0.04 to 1.38; I^2 = 84%; p = 0.06), and knee extension tests (SMD = 0.20; 95% CI = −0.05 to 0.44; I^2 = 95%; p = 0.12) compared to active/passive control. However, it was impossible to perform a meta-analysis for the variables of walking speed as a fall risk due to the diversity of instruments and the small number of systematic reviews with meta-analysis. In conclusion, interventions utilizing active exergames have shown significant improvements in the static and dynamic balance and lower limb muscle strength of apparently healthy older people, compared to control groups of active/inactive participants, as measured by BBS, TUG, and 30-s chair stand tests. However, no significant differences were found in the 6-min walk, HGS, and knee extension tests.

Systematic review registration: PROSPERO, CRD42023391694.

KEYWORDS

exergaming, virtual reality, physical functional performance, postural balance, muscle strength dynamometer, aged

1 Introduction

The aging process leads to different physical changes in older people, such as a 59% decrease in balance (1), 73% loss of walking speed (2), 35% lower mobility (2), 30% decrease in muscle strength (3), and 80% increased fall risk (4). Elements that together increase frailty and reduce functional independence (5) affect the quality of life in older people (6).

On the contrary, regular physical activity practice has reported improvements of 54% in physical fitness in older people after interventions that include balance, resistance training, and endurance exercises (7), a fact that aligns with international physical activity recommendations that indicate performing between 150 and 300 min of moderate-intensity physical activity or 75–150 min of vigorous-intensity physical activity a week (8), which include at least two weekly sessions of resistance training in older people (9). However, the COVID-19 pandemic has forced a rethinking of physical activity strategies for the general population (10), particularly in older people (11). Thus, performing physical activity in small spaces while maintaining distance and safety in practice has become indispensable (10, 11); in such a context, active exergames are presented as alternatives that meet these requirements and are also entertaining for older people (12, 13).

The active exergames can be developed in health, community, and sports centers or a homeroom individually or in groups using a screen (14) through active exergames that involve the movement of the whole body, similar to the real world with or without the use of a controller allowing the movements to be executed within a reduced space and interacting with the game scenario (14). Conversely, the cost to acquire a game console is affordable and ranges from US$100 to US$299, while annual healthcare costs amount to US$2,000 in the United States of America (15) and €2,337 in England, according to the National Health Service of the Kingdom United (16). The most popular consoles and active exergames used by older people are Nintendo Wii® with the Wii sports, Wii balance, and Wii Fit games (17–19); Microsoft's Xbox Kinect® with the Kinect Sports, Adventure, and Your Shape games (18, 19); and Sony's PlayStation Move® with the Sports Champions Move game (13).

Specifically, Wii Fit has demonstrated a 34% increase in lower limb muscle strength, a 23.6% increase in balance, a 35.1% reduction in fall risk, and an 8% lower risk of frailty in Hong Kong in older people compared to patients undergoing a 6-week conventional balance training intervention (20). Similarly, using a 5-week Xbox Your Shape intervention, Yang et al. (21) reported a 14.3% improvement in dynamic balance and a 16% improvement in static balance in Taiwan's older people over a conventional balance intervention. Another study by Hernandez-Martínez et al. (22) reported notable enhancements in physical performance among older Chilean people following an 8-week Xbox Kinect Sports intervention. The researchers observed a 4.1% increase in walking speed, an 8.5% improvement in the timed up-and-go test (TUG), and a remarkable 16% enhancement in lower limb muscle strength. These findings are in line with a study conducted by Yu et al. (23) on Taiwanese older people, who experienced a 15.6% increase in lower limb muscle strength and a 5.4% improvement in cardiorespiratory fitness after engaging in a 10-week intervention utilizing Xbox Kinect Adventure. These results collectively indicate the potential benefits of utilizing Xbox Kinect-based interventions to promote physical fitness and performance among older populations.

The results that active exergames report on the physical functional and physical fitness in older people (23, 24), added to the increase of studies with high-quality design (randomized controlled trials), have allowed the development of several systematic reviews with and without meta-analysis that synthesize this evidence (19, 25–28). However, to the best of our knowledge, a study that condenses all these systematic reviews into a single document has not yet been published. In this sense, the main aim of this overview was to assess the available body of published peer-reviewed systematic reviews and meta-analyses related to the effects of active exergames compared with active/passive controls on physical performance outcomes in older people.

2 Materials and methods

2.1 Protocol and record-keeping

This overview followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines (29). The protocol was registered in PROSPERO (International Prospective Register of Systematic Reviews; code: CRD42023391694).

2.2 Eligibility criteria

The inclusion criteria for this overview were original peer-reviewed systematic reviews and meta-analyses without any language or publication date restrictions, published up to 23 February 2024. Excluded records were conference abstracts, books, book chapters, editorials, letters to the editor, trial records, case studies, and trials. In addition, the population, intervention, comparator, outcome, and study design (PICOS) framework were followed to incorporate studies into an overview (see Table 1).

2.3 Information search process and databases

The search process used seven databases: PubMed, Web of Science (core collection), Scopus, CINAHL, Cochrane Library, MEDLINE, and Psychology and Behavioral Sciences (EBSCO). Medical Subject Headings (MeSH) from the National Library of Medicine of the

TABLE 1 Selection criteria used in the overview.

Category	Inclusion criteria	Exclusion criteria
Population	Older people with a mean age of 60 years or more, according to the World Health Organization WHO (2021), are healthy and without distinction of sex.	People with a mean age of fewer than 60 years old.
Intervention	Systematic reviews and meta-analysis of interventions with active exergames (i.e., Wii sports, balance and fit, Kinect Sports, Adventure and Your Shape, Sports Champions Move) of 2 weeks or more.	Systematic reviews and meta-analyses of interventions that do not use active exergames as an intervention.
Comparator	Systematic reviews with and without meta-analysis with control groups with (other than active exergames) or without supervised physical activity.	Absence of control groups.
Outcomes	At least one physical performance assessment (i.e., handgrip strength, walking speed, fall risk, Berg Balance Scale), pre- and post-intervention.	Lack of reference and/or follow-up data.
Study design	Systematic reviews or meta-analyses with the inclusion of studies using an experimental design (randomized controlled trial and non-randomized controlled trial) with pre- and post-assessments.	Systematic reviews or meta-analyses with cross-sectional, retrospective, and prospective studies.

United States of America were used as free language terms related to active exergames, physical performance, and older people. The search string used was as follows: ("exergames" OR "exergaming" OR "active video games" OR "virtual reality" OR "wii" OR "Kinect" OR "play station") AND ("physical function" OR "physical performance" OR "physical fitness" OR "functionality" OR "functional Independence" OR "functional dependency" OR "functional mobility" OR "health condition" OR "falls" OR "fall risk" OR "risk of fall" OR "falling risk" "balance" OR "static balance" OR "dynamic balance" OR "walking speed" OR "gait speed" OR "mobility" OR "strength" OR "muscle strength" OR "upper body strength "OR "lower body strength" OR "muscle power") AND ("elderly" OR "older adults" OR "older people" OR "older subject" OR "aging" OR "ageing" OR "aged").

2.4 Study selection and data collection process

Studies were exported to the EndNote reference manager (version X9. Bld.12062, Clarivate Analytics, Philadelphia, PA, United States). Two authors (JHM and PVB) independently searched, removed duplicates, reviewed titles and abstracts, and analyzed full texts. The process was repeated for searches within reference lists and suggestions provided by external experts. Subsequently, potentially eligible studies were reviewed in full text, and the reasons for excluding those not meeting the selection criteria were reported.

2.5 Assessment of methodological quality

The methodological quality of the selected studies was assessed using the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews 2) (30). This instrument is composed of 7 domains, which are as follows: (*i*) protocol recorded prior to the review; (*ii*) adequate literature search; (*iii*) justification of excluded studies; (*iv*) risk of bias of individual included studies; (*v*) appropriate meta-analytic methods; (*vi*) consideration of risk of bias in the interpretation of review results; and (*vii*) assessment of the presence and likely impact of publication bias. Sixteen items are included to rate the methodological quality of the reviews according to the following confidence criteria (30): (*i*) high: no critical weaknesses and up to one non-critical (the systematic review provides an accurate and complete summary of the results of the available studies); (*ii*) medium: no critical weaknesses and more than one non-critical weakness (although, if there are many, a low confidence could be justified): the systematic review has weaknesses, but no critical flaws, being able to provide an accurate summary of the results of the available studies; (*iii*) low: up to one critical weakness, with or without non-critical weaknesses: the systematic review may not provide an accurate and complete summary of the available studies; and (*iv*) critically low: more than one critical weakness, with or without non-critical weaknesses: the systematic review is not reliable. Two authors (JHM and CMV) independently assessed the quality of the reports using PRISMA in a 27-item checklist (29), and a third author (PVB) acted as referee for borderline cases, which were then validated by another author (THV). Each item was assessed according to whether it was reported and received 1 point for full reporting, 0.5 points for partial reporting, and 0 points for not reporting. Less than 15 points indicate relatively severe reporting defects, between 15 and 21 points indicate some reporting defects, and between 21.5 and 27 points indicate a relatively complete report.

2.6 Certainty of evidence

Using the GRADE scale, the degree of certainty of evidence was evaluated, and it was determined whether the studies' degree was high, moderate, low, or very low (31). Due to the inclusion of studies with experimental designs (randomized controlled trials and non-randomized controlled trials), all analyses began with a grade of high certainty and were downgraded if there were issues with consistency, precision, directness of the results, or risk of publication bias (31). Two authors (JHM and CMV) independently assessed the studies, and any discrepancies were resolved through consensus with a third author (PVB). The criteria for downgrading the certainty of evidence were as follows: (*i*) limitation of included studies: one level of a downgrade if 25% or more of the included articles had a high risk of bias as assessed by AMSTAR-2; (*ii*) inconsistency: one level of downgrade was applied if there was high heterogeneity ($I^2 \geq 90\%$); (*iii*) indirectness: One level of downgrade was applied if there were differences between participants, interventions, outcome measures, or indirect comparisons; (*iv*) imprecision: one level of downgrade was considered if there was a wide confidence interval, crosses the line of no effect, and/or small sample size ($n < 300$); (*v*) risk of publication bias: one level of downgrade was applied if there was asymmetry in the doi plot.

2.7 Data synthesis

The following data were obtained and analyzed from the selected studies: (*i*) author and year; (*ii*) study design (systematic reviews and/or meta-analysis); (*iii*) baseline health status of the sample; (*iv*) the number of studies and participants in the intervention and control groups; (*v*) mean age of the sample; (*vi*) activities performed in the consoles, active exergames, and control groups; (*vii*) training volume (total duration, weekly frequency, and time per game); (*viii*) physical performance data collection instruments; (*ix*) main outcomes of the systematic reviews and/or meta-analysis; (*x*) quality assessment; and (*xi*) PRISMA score.

2.8 Summary measures for meta-analysis

A meta-analysis was performed to explore the effect of different systematic reviews or meta-analyses on the same outcome; this was done using data from systematic reviews or meta-analysis reports included in the overall review. The pooled effect that was calculated is the standardized mean difference (SMD), 95% confidence interval (95% CI), and the inverse variance weighting method with a random effect was used. When only the median and extreme or quartiles were reported in systematic reviews or meta-analyses whose mean and standard deviation (SD) could not be obtained from systematic reviews, neither the mean nor the SD was estimated because the sample size is too small for an accurate estimated value (32). Heterogeneity was quantified by I^2, where a value >50% indicates substantial heterogeneity (33). Low-quality systematic reviews were excluded from the sensitivity analysis, following the recommendations of previous overviews (33). These were meta-analyzed using RevMan 5.4 following the findings of previous studies (34, 35). Finally, publication bias was measured using Egger's regression asymmetry test to assess small study effects as proposed by Sterne et al. (36). Statistical analyses were performed with StataMP, version 17 (StataCorp, College Station, TX, United States).

3 Results

3.1 Study selection

Figure 1 details the process of searching for systematic reviews and meta-analyses. In the identification phase, a total of 4,477 records were found. Subsequently, duplicates were eliminated, and studies were filtered by selecting title, abstract, and keywords, resulting in 2,106 references. A total of 165 systematic reviews and meta-analysis were included in the next phase of analysis: 24 descriptive systematic reviews, five systematic reviews conducted in people with a mean age less than 60 years, two systematic reviews that reported anthropometric results, 28 systematic reviews of studies with interventions without active exergames, 21 studies that were not systematic reviews (other types of review), 68 systematic reviews of active exergames in patients with cardiac or respiratory neurological pathologies, one review of the study in exergames in older people with balance problems, and one systematic review because the text was inaccessible (the authors of the systematic review were contacted requesting a copy of their manuscript, estimating 30 days as maximum response time). After this process, the total number of systematic reviews and meta-analysis that met all the selection criteria was 15 (17–19, 25–28, 37–44).

3.2 Methodological quality

According to the AMSTAR-2, the mean score of the selected systematic reviews and meta-analysis was 12.6 points; in particular, six meta-analyses obtained a high quality with values between 15 and 16 points (18, 28, 37, 38, 41, 43), four meta-analysis obtained a moderate quality with values between 13 and 14 points (17, 26, 27, 42), two systematic reviews were of low quality with values between 10 and 11 points (19, 44), and three systematic reviews achieved a critically low quality located between 7 and 8 points (25, 39, 40). These results can be seen in Table 2.

3.3 Certainty of evidence

In the certainty of the evidence, it was reported that for the balance variable in the Berg Balance Scale (BBS) and TUG tests, there was a moderate certainty of evidence (18, 26–28, 37, 41, 42), similar to the 30-s chair stand test (27, 37, 41, 42). While in the cardiorespiratory fitness variable through the 6-min walk test (18, 41), a high certainty of evidence was reported. On the contrary, in the direct muscle strength variables through handgrip strength (HGS) (41, 43) and knee extension (41, 43) tests, a very low certainty of the evidence was reported. The certainty of evidence is shown in Table 3; this allows us to recommend using active exergames in variables of balance and muscle strength, such as BBS, TUG, and 30-s chair stand tests in older people.

3.4 Studies characteristics

The characteristics of systematic reviews and meta-analyses analyzed in the overview indicated that 12 systematic reviews and meta-analyses were randomized controlled trials (17, 18, 25, 26, 28, 37–42, 44) and three systematic reviews and meta-analysis were non-randomized controlled trials (19, 27, 43). A total of 290 studies were analyzed in the selected systematic reviews and meta-analysis, totaling 15,832 participants with a mean age of 75.2 years (17–19, 25–28, 37–44). In general, older people who participated in the active exergames were apparently healthy (17, 18, 25–28, 37, 39, 41), pre-frail, and frail (19, 40, 44), which was determined by bone mineral densitometry and functional physical performance (19, 40, 44) and who participated in active exergames through the system with Xbox Kinect 360 (18, 19, 25, 26, 37, 38, 43), Nintendo Wii (17–19, 25, 27, 28, 37–44), and Play Station Movie (17, 18). The reviews analyzed report active control groups, specifically those that participated in traditional physical activity (17–19, 25, 26, 28, 37–42, 44), inactive control groups (no physical activity) (27, 28, 38, 41, 43), or who killed the basic activities of daily living (17, 18, 25, 41). More information about this topic is presented in Table 4.

3.5 Active exergames dosage

The dosage of the interventions with active exergames was diverse, ranging from 2 to 26 weeks with a frequency of one to five sessions per week with a duration of 30–60 min per session with moderate-to-vigorous intensities ranging from three to six in the 10-point rating of perceived exertion (RPE) (17–19, 25–28, 37–44).

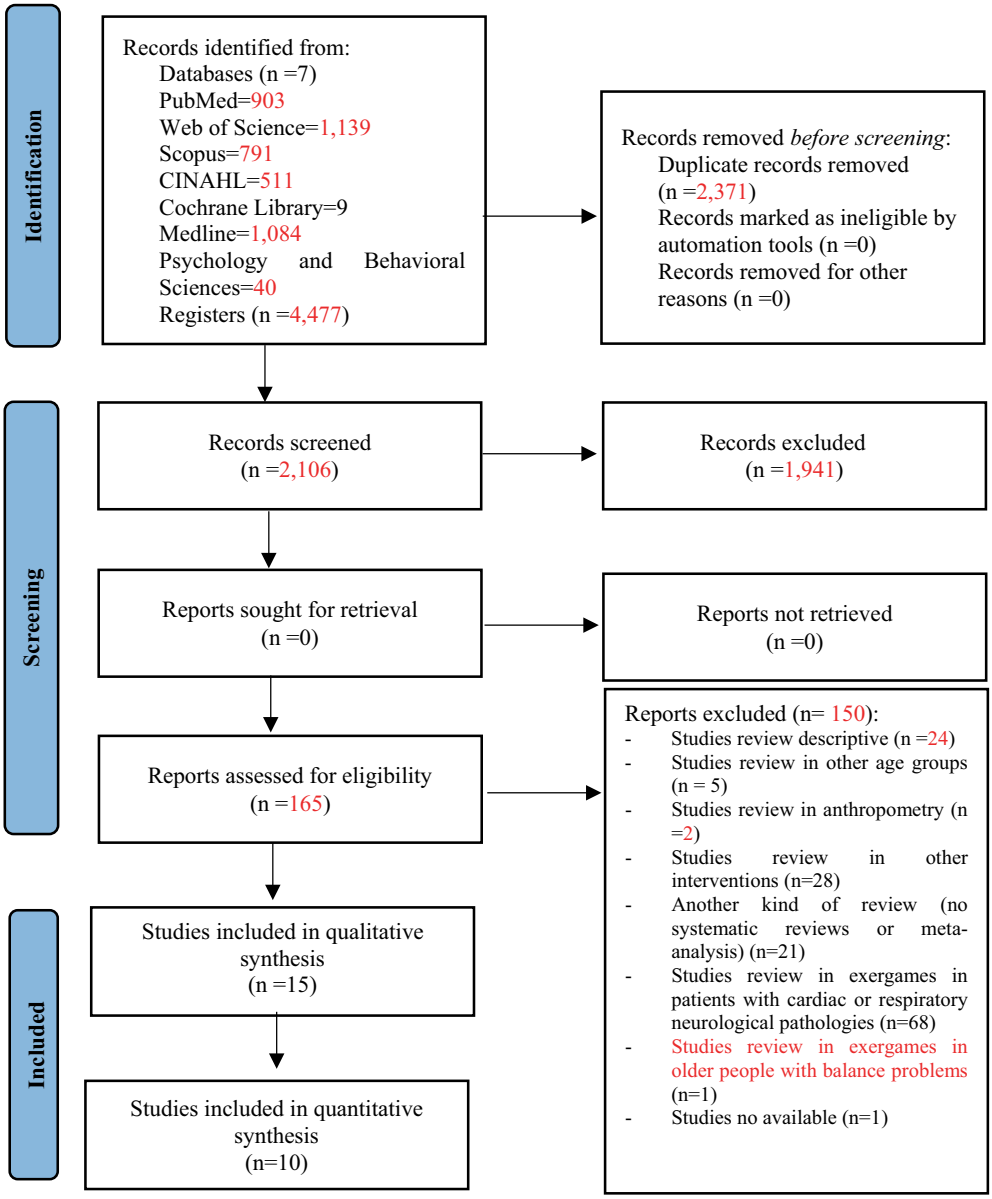


FIGURE 1
Flowchart of the review process. Based on the PRISMA-P recommendations (29).

3.6 Outcomes of overview

The results of systematic reviews and meta-analyses were synthesized. First, we qualitatively summarized the results of the systematic reviews and meta-analysis that reported the individual effects of different types of active exergames on physical performance in older people, then extracted data from the meta-analysis to better explain the effects of active exergames. Only 10 systematic reviews and meta-analyses qualified for meta-analysis that presented moderate and high methodological qualities.

3.7 Fall risk

Only four systematic reviews reported the fall risk measured through Tinetti's falls efficacy scale (25), falls efficacy scale (19, 25, 44), short falls efficacy scale-international (19), efficacy scale-international, and iconographical fall efficacy scale (26). The individual results from systematic reviews indicate significant improvements in the groups with active exergames. However, conducting a meta-analysis was impossible due to the diversity of instruments and the small number of systematic reviews with meta-analysis; these findings cannot be confirmed.

3.8 Walking speed

Two reviews reported walking speed measures assessed through functional gait assessment (17, 38) and gait speed test (17). The individual results from systematic reviews indicate significant improvements in the groups with active exergames. However, conducting a meta-analysis was impossible due to the diversity of

TABLE 2 Methodological quality.

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Did the review report contain an explicit statement that the review methods were established prior to the review, and did the report justify any significant deviations from the protocol?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
3. Did the review authors explain their selection of the study designs for inclusion in the review?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Continued)

10.3389/fpubh.2024.1250299

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
4. Did the review authors use a comprehensive literature search strategy?	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Did the review authors perform study selection in duplicate?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Did the review authors perform data extraction in duplicate?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Did the review authors provide a list of excluded studies and justify the exclusions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Did the review authors describe the included studies in adequate detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Continued)

10.3389/fpubh.2024.1250299

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies included in the review?	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
10. Did the review authors report on the funding sources for the studies included in the review?	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No
11. If meta-analysis was performed, did the review authors use appropriate methods for the statistical combination of results?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No

(Continued)

10.3389/fpubh.2024.1250299

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (37)	Ge et al. (19)	Janhunen et al. (38)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
14. Did the review authors provide a satisfactory explanation for and discussion of any heterogeneity observed in the review results?	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No

(Continued)

10.3389/fpubh.2024.1250299

TABLE 2 (Continued)

Questions	References														
	Afridi et al. (25)	Chen et al. (26)	Corregidor-Sánchez et al. (18)	Corregidor-Sánchez et al. (17)	Fang et al. (57)	Ge et al. (19)	Janhunen et al. (58)	Laufer et al. (39)	Liu et al. (27)	Molina et al. (40)	Pacheco et al. (28)	Suleiman-Martos et al. (41)	Taylor et al. (42)	Viana et al. (43)	Zheng et al. (44)
15. If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Total score	8	14	15	14	15	10	16	7	14	8	15	15	13	15	11
Methodological quality rating	Critically low	Moderate	High	Moderate	High	Low	High	Critically low	Moderate	Critically low	High	High	Moderate	High	Low

10.3389/fpubh.2024.1250299

TABLE 3 GRADE assessment for the certainty of evidence.

Outcome	Review design	Risk of bias in individual review	Risk of publication bias	Inconsistency	Indirectness	Imprecision	Certainty of evidence
Balance							
BBS	4 RCT and 1 RCT/NRCT with 82 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate
TUG	4 RCT and 1 RCT/NRCT with 98 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate
Cardiorespiratory fitness							
6-min walk test	2 RCT with 40 studies	low	Not assessed	Moderate	Low risk	Moderate	High
Upper limb muscle strength							
HGS	1 RCT and 1 NRCT with 69 studies	High	Not assessed	High	Moderate	High	Very low
Lower limb muscle strength							
Knee extension test	1 RCT and 1 NRCT with 69 studies	High	Not assessed	High	Moderate	High	Very low
30-s chair stand test	3 RCT and 1 NRCT with 66 studies	Moderate	Not assessed	Moderate	Low risk	Moderate	Moderate

BBS, berg balance scale; TUG, timed up and go; HGS, handgrip strength; RCT, randomized controlled trial; NRCT, non-randomized controlled trial.

instruments and the small number of systematic reviews with meta-analysis; these findings cannot be confirmed.

3.9 Berg balance scale

Static balance was measured through the Berg Balance Scale (BBS) score. Five systematic reviews with meta-analysis analyzed the effect of active exergames on this measure (26–28, 41, 42), with 493 participants in the active exergames groups and 488 participants in the control groups. The results of the meta-analysis suggested that the active exergames significantly improved BBS score compared to control groups (SMD = 0.85; 95% CI = 0.12–1.58; I^2 = 96%; p = 0.02), with high-level heterogeneity and using a fixed-effects model (Figure 2).

3.10 Timed up-and-go test

Dynamic balance was measured using TUG. Five systematic reviews with meta-analysis were pooled for meta-analysis (18, 27, 28, 37, 41), with 675 participants in the active exergames groups and 678 participants in the control groups. Results indicate that active exergames significantly reduced time in TUG compared to control groups (SMD = 1.44; 95% CI = 0.71–2.16; I^2 = 97%; $p < 0.0001$), with high-level heterogeneity using a fixed-effects model (Figure 3).

3.11 6-min walk test

Cardiorespiratory fitness was measured through the 6-min walk test. Two systematic reviews with meta-analysis were detected for meta-analysis (18, 41), with 122 participants in the active exergames groups and 111 participants in the control groups. The results indicate that the active exergames did not significantly differ in the 6-min walk test when compared to control groups (SMD = 0.93; 95% CI = −0.64 to 2.50; I^2 = 95%; p = 0.24), with high-level heterogeneity using a fixed-effects model (Figure 4).

3.12 Handgrip strength

The HGS test measured maximal upper limb muscle strength. Two systematic reviews with meta-analysis were detected for meta-analysis (41, 43), with 161 participants in the active exergames groups and 144 participants in the control groups. The results indicate that the active exergames did not significantly differ in HGS when compared to control groups (SMD = 0.67; 95% CI = −0.04 to 1.38;

TABLE 4 Systematic reviews and meta-analysis reporting outcomes in active exergames on physical performance.

References	Study design (SR and/or MA)	Baseline health status of the sample	Number of studies and participants in the intervention and control groups	The mean age of the sample	Activities performed in the consoles and active exergames and control groups	Training volume (total duration, weekly frequency, and time per game)	Physical performance data collection instruments	Main outcomes of the systematic reviews and meta-analysis	Quality assessment	Meta-analysis	PRISMA score
Chen et al. (26)	RCT	Older people, apparently healthy	20 (795; EG: 423; CG: 372).	EG: age 73.2 ± 5.3 years; CG: 73.8 ± 5.4 years.	EG: Xbox 360 Kinect. CG: Physical therapy exercises.	6/20 wk.; 2/3 wk. of 30/90 min.	BBS; FES-1 and Icon-FES	BBS↔; FES-1↑; Icon-FES↑	The Cochrane risk-of-bias tool	Yes	27
Fang et al. (37)	RCT	Older people, apparently healthy	16 (632; EG: 318; CG: 318).	EG: age 72.8 ± 7.0 years; CG: age 72.1 ± 6.5 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	6/15 wk.; 2/3 wk. of 30/50 min.	TUG and 30-s chair stand	TUG↓; 30-s chair stand↑	PEDro	Yes	25
Corregidor-Sánchez et al. (17)	RCT	Older people, apparently healthy	14 (Both groups: 491).	Both groups: age 77.2 ± 6.5 years.	EG: Nintendo Wii and Play Station movie. CG: traditional physical exercise or daily activities.	2/24 wk.; 1/5 wk.; no reported min.	FGA and GST.	FGA↔; GST↑.	Not reported	Yes	27
Janhunen et al. (38)	RCT	Older people, apparently healthy	58 (Both groups: 3.774)	Both groups: age 74.3 ± 6.8 years	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/26 wk.; 2/3 wk. of 11/90 min.	FGA↑	FGA↑	The Cochrane Risk of Bias 2 tool	Yes	26
Laufer et al. (39)	RCT	Older people, apparently healthy	7 (285; EG: 126; CG:159).	EG: age 71.5 ± 26.3 years; CG: age 76 ± 21.9 years.	EG: Nintendo Wii. CG: traditional physical exercise or daily activities.	6/20 wk.; 1/3 wk. of 30/60 min.	TUG	TUG↓	PEDro	No	13
Taylor et al. (42)	RCT	Older people, apparently healthy	18 (1.263; EG: 704; GC: 559).	EG: age 78.3 ± 10; GC: age 75 ± 8 years.	EG: Nintendo Wii. CG: traditional physical exercise or no intervention	3/20 wk.; 2/3 wk. of 40 min.	BBS	BBS↑	The Cochrane collaboration's risk of bias tool	Yes	22
Pacheco et al. (28)	RCT	Older people, apparently healthy	12 (1.423; EG: 704; GC: 719).	EG: age 76 ± 6 years; 719 GC: age 76 ± 5 years.	EG: Nintendo Wii. CG: traditional physical exercise or no intervention	4/16 wk.; 2/3 wk. of 30/70 min.	BBS and TUG	BBS↑; TUG↑	The Cochrane Handbook for Systematic reviews of interventions	Yes	26
Suleiman-Martos et al. (41)	RCT	Older people, apparently healthy	22 (Both groups: 1.208).	Both groups: age 74.9 ± 6.1 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or no intervention.	3/24 wk.; 2/3 wk. of 15/120 min.	BBS; TUG; 6WMT; HGS; Knee extension and 30-s chair stand.	BBS↑; TUG↓; 6MWT↑; HGS↑; Knee extension ↔ and 30-s chair stand↑.	The Cochrane risk-of-bias tool	Yes	25

(Continued)

10.3389/fpubh.2024.1250299

TABLE 4 (Continued)

References	Study design (SR and/or MA)	Baseline health status of the sample	Number of studies and participants in the intervention and control groups	The mean age of the sample	Activities performed in the consoles and active exergames and control groups	Training volume (total duration, weekly frequency, and time per game)	Physical performance data collection instruments	Main outcomes of the systematic reviews and meta-analysis	Quality assessment	Meta-analysis	PRISMA score
Zheng et al. (44)	RCT	Older people; frail and pre-frail.	7 (243; EG: 171; CG: 72).	EG: age 80.0 ± 6.2 years; CG: age 83.1 ± 5.0 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/15 wk.; 2/3 wk. of 20/50 min.	FE	FES↔	The Cochrane Collaboration's tool for assessing the risk of bias	No	21
Afridi et al. (25)	RCT	Older people, apparently healthy	10 (Both groups: 442).	Both groups: age 65.8 ± 4.9 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	8/12 wk.; 2/3 wk. of 30/60 min.	Tinetti's falls efficacy scale and FES	Tinetti's falls efficacy scale↔; FES↑	Not reported	No	12
Corregidor-Sánchez et al. (18)	RCT	Older people, apparently healthy	18 (Both groups: 772).	Both groups: age 71.1 ± 6.8 years.	EG: Nintendo Wii, Play Station movie, and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	2/24 wk.; 2/3 wk. of 20/50 min.	TUG and 6WMT	TUG↓; 6WMT↔	The Cochrane Collaboration's tool for assessing the risk of bias	Yes	25
Ge et al. (19).	RCT/ NRCT	Older people; frail and pre-frail.	23 (2.071; EG: 1.044; GC: 1.027).	EG: age 75 ± 5.5 years; CG: age 74.8 ± 5.1 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise or daily activities.	4/12 wk.; 1/3 wk. of 60 min.	FES, Icon-FES and Short FES-1	FES↑; Icon-FES↑; Short FES-1↑	PEDro	No	17
Liu et al. (27)	RCT/ NRCT	Older people, apparently healthy	10 (Both groups: 379).	Both groups: age 73.8 ± 6.2 years.	EG: Nintendo Wii. CG: No intervention	3/10 wk.; 2/3 wk. of 30/60 min.	BBS; TUG and 30-s chair stand.	BBS↑; TUG↓; 30-s chair stand↑	PEDro	Yes	23
Viana et al. (43)	RCT/ NRCT	Older people; apparently healthy.	47 (Both groups: 1.760).	Both groups: age 84.1 ± 7.6 years.	EG: Nintendo Wii and Xbox 360 Kinect. CG: traditional physical exercise.	6/14 wk.; 1/5 wk. of 30/60 min.	HGS and knee extensión.	HGS↑; Knee extensión↑	PEDro	Yes	25
Molina et al. (40)	RCT	Older people; frail and pre-frail.	8 (Both groups: 294).	Both groups: age 77.3 ± 4.4 years.	EG: Nintendo Wii. CG: traditional physical exercise or daily activities.	3/20 wk.; 1/5 wk. of 25/60 min.	BBS; TUG; ABC and LOB.	BBS↑; TUG↓; ABC↑	PEDro	No	19

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analysis; SR, systematic review; MA, Meta-analysis; RCT, randomized controlled trial; NRCT, non-randomized controlled trial; EG, experimental groups; CG, control group; wk, week; Min, minutes; BBS, balance Berg scale; TUG, timed up and go test; HGS, handgrip strength; 6MWT, 6-min walk test; FGA, functional Gait assessment; GS, gait speed test; FES, falls efficacy scale; FES-1, falls efficacy scale-international; Icon-FES, Iconographical Falls Efficacy Scale; Short FES-1, short falls efficacy scale-international; ABC Scale, The Activities-specific Balance; , high methodological quality; , moderate methodological quality; , low methodological quality; very low methodological quality; ↑, significant improvement; ↓ significant decrease; ↔, no significant difference.

10.3389/fpubh.2024.1250299

$I^2 = 84\%$; $p = 0.06$), with high-level heterogeneity using a fixed-effects model (Figure 5).

3.13 30-s chair stand

The 30-s chair stand test measured lower limb muscle strength. Four systematic reviews with meta-analysis were detected for meta-analysis (27, 37, 41, 42), with 352 participants in the active exergames groups and 339 participants in the control groups. Results indicate that the active exergames significantly improved in the 30-s chair stand test concerning control groups (SMD = 0.79; 95% CI = 0.33–1.25; $I^2 = 88\%$; $p = 0.0008$), with high-level heterogeneity using a fixed-effects model (Figure 6).

3.14 Knee extension

Two systematic reviews with meta-analysis were detected for the meta-analysis (41, 43), with 103 participants in the active exergames groups and 179 participants in the control groups. The results indicate that the active exergames, when compared to the control groups, did not significantly differ in knee extension (SMD = 0.20; 95% CI = −0.05 to 0.44; $I^2 = 95\%$; $p = 0.12$), with high-level heterogeneity using a fixed effects model (Figure 7).

Egger's regression asymmetry test observed no significant publication bias in the 30-s chair stand ($p = 0.90$) and in the TUG ($p = 0.36$). However, significant publication bias was observed in the following tests: 6-min walk ($p = 0.001$), HGS ($p = 0.04$), knee extension ($p = 0.01$), and BBS ($p = 0.00$). These results are presented in the funnel plot in Figure 8.

3.15 Adverse events

Only two systematic reviews and meta-analyses reported adverse events (25, 42). Specifically, the systematic review of Taylor et al. (42) reported minor musculoskeletal injuries (musculoskeletal strain) and vertigo sensation in both active exergames and control groups. For his part, Afridi et al. (25) reported that dropouts were due to back pain in some interventions with active exergames without requiring medical attention.

4 Discussion

This overview aimed to assess published peer-reviewed systematic reviews and meta-analyses concerning the effects of active exergames compared to active/passive controls on physical performance outcomes in older people. Fifteen systematic reviews and meta-analyses were identified, of which 10 provided sufficient information for meta-analysis and demonstrated moderate-to-high methodological quality. The main findings of the meta-analysis revealed statistically significant improvements in the BBS, TUG, and 30-s chair stand tests among the active exergames intervention groups compared to the control groups. However, no significant differences were found in the

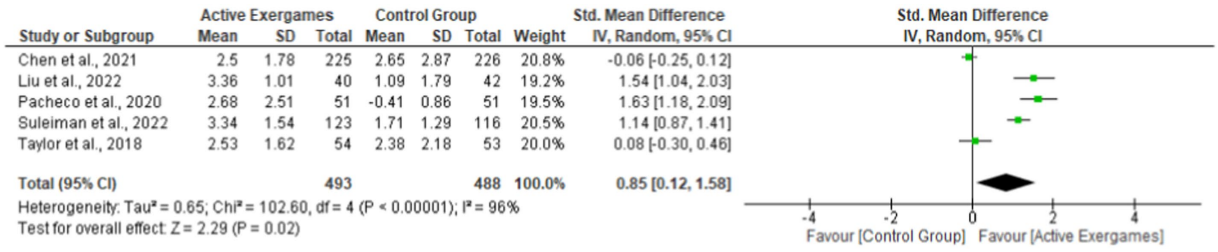


FIGURE 2
Effect of active exergames compared to control groups on the following outcome: Berg Balance Scale. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

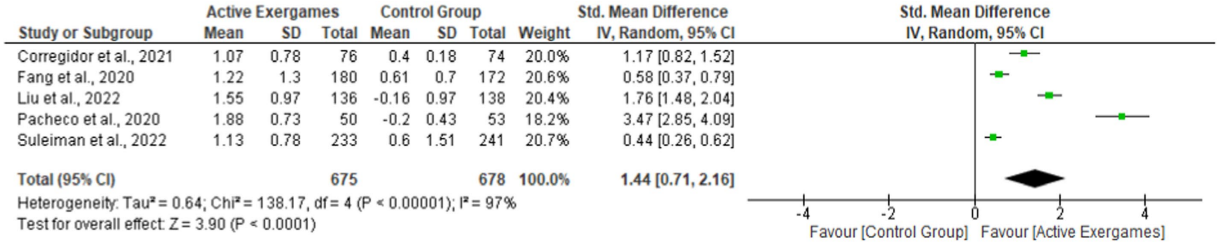


FIGURE 3
Effect of active exergames compared to control groups on the outcome: Timed up-and-go. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

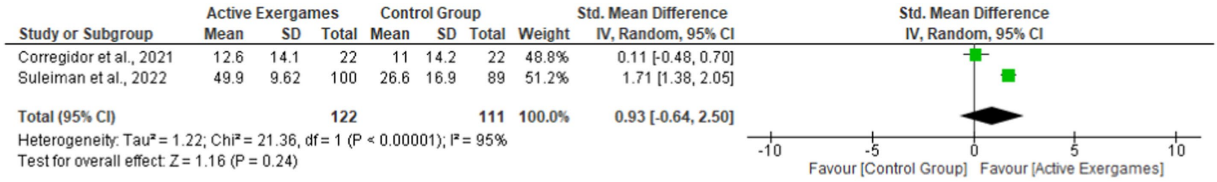


FIGURE 4
Effect of active exergames compared to control groups on 6-min walk test. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

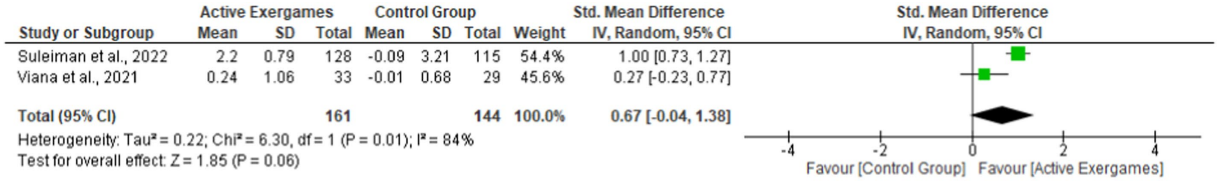


FIGURE 5
Effect of active exergames in comparison to the control group on handgrip strength. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

6-min walk, HGS, and knee extension tests when comparing the two groups.

4.1 Balance

In the present overview, significant differences were detected in favor of the active exergames groups in static balance measured through the BBS (SMD = 0.85; 95% CI = 0.12–1.58; I^2 = 96%; p = 0.02) concerning the control groups. This is similar to that reported in a meta-analysis by Lesinski et al. (45), which shows statistically significant improvements (p = 0.03) in BBS in favor of interventions in older people through balance training concerning active/inactive control groups. Similarly, Lemos et al. (46), in a meta-analysis of older people, showed statistically significant improvements (p = 0.010) in BBS in favor of multicomponent training interventions concerning active/inactive control groups. Aging leads to alterations in the vestibular, sensory, and proprioceptive systems that lead to decreased balance, which increases the fall risk in older people (47). In active exergames interventions, actions involving visual, auditory, and proprioceptive feedback movements are performed, which would favor the balance of older people; in the same way, to advance in the game phases, the difficulty increases; this implies a greater complexity in the movements to be executed and the intensity of the game (48). Therefore, early detection of balance changes or alterations is significant. In this sense, the BBS is a simple indirect test, easy to apply, with widespread use, low cost, and high reliability (0.96–0.98) and validity (0.97–0.99) to assess older people (49).

Regarding dynamic balance, the meta-analysis reported significant differences in favor of the active exergames groups for control groups measured through the TUG (SMD = 1.44; 95% CI = 0.71–2.16; I^2 = 97%; p < 0.0001). Similarly, interventions using elastic bands in older people have shown statistically significant improvements (p < 0.01) in TUG compared to active/inactive control groups in previous meta-analyses performed (50, 51). In the same way, Labata-Lezaun et al. (7), in a meta-analysis of older people, showed statistically significant improvements in TUG (p = 0.0001) in favor of multicomponent training interventions regarding active/inactive control groups. However, interventions using active exergames in a shorter period range from 3 to 20 weeks with 2–3 sessions per week for 30–60 min, compared to interventions using elastic bands, which range from 8 to 28 weeks with 1–3 sessions per week for 30–90 min (51), and multicomponent training, which range from 9 to 48 weeks with 2–5 sessions for 30–90 min (7); this can lead to an increase in lower limb muscle strength along with balance related to improvements in BBS and TUG; these adaptations can reduce the risk of fear and falls in older people (22). Limitations in lower limb mobility, such as alterations in dynamic balance, actions such as walking, getting up from a chair, or both, are indicators of impaired functional independence (22). The TUG has demonstrated high reliability (0.98) and validity (0.98) for measuring dynamic balance indirectly in older people (52).

The previously mentioned measurements to assess balance (BBS and TUG) present high reliability, validity, and wide use in the scientific literature related to older people (49, 52). On the other hand, direct methods such as oscillography have higher reliability and validity values (0.99) and provide values of the center of pressure (53). However, having oscillography equipment is more expensive, and it is difficult for some care centers for older people (residences, neighborhood councils, and groups of older people) to have access to this instrumentation, while health and sports science professionals cannot always move this material to the spaces where older people practice physical activity (53). Therefore, having evidence of the benefits of active exergames on balance, even if measured indirectly, provides relevant information for its use in the clinical and health context (22, 54, 55).

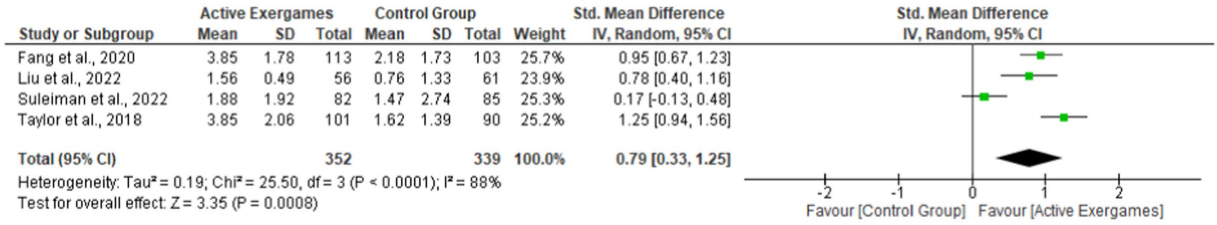


FIGURE 6
Effect of active exergames compared to the control group on the following outcome: 30-s chair stand. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

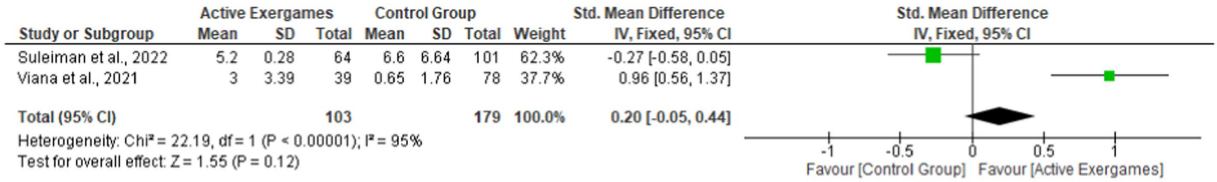


FIGURE 7
Effect of active exergames compared to the control group on the following outcome: knee extension. The squares indicate the study-specific effect estimate. Bars indicate the width of the corresponding 95% confidence interval. The diamond centered on the summary effect estimate and the width indicate the corresponding 95% confidence interval.

4.2 Cardiorespiratory fitness

In the present overview, no significant differences in cardiorespiratory fitness measured by the 6-min walk test were reported in the active exergames group compared to control groups (SMD = 0.93; 95% CI = −0.64 to 2.50; I^2 = 95%; p = 0.24). In contrast to active exergames, a meta-analysis in older people by Stern et al. (56) reported statistically significant improvements (p = 0.01) in the 6-min walk test in favor of high-intensity interval training (HIIT) interventions concerning active/inactive control groups. Similar to that reported by Labata-Lezaun et al. (7) in a meta-analysis, statistically significant improvements (p = 0.01) were detected in favor of multicomponent training interventions concerning active/inactive control groups in 6-min walk test in older people; this may be because active exergames interventions are performed at a low-to-moderate intensity during most games, in the first weeks of neuromuscular adaptation to the intervention, and along with short minutes performed during the game stage that cannot be individualized for each person (57). During aging, neuromuscular deterioration occurs, accompanied by a decrease in cardiorespiratory fitness associated with decreased mobility, which can affect independence in older people (58). The 6-min walk test is an indirect method to measure cardiorespiratory fitness in older people, unlike ergospirometry, which assesses cardiorespiratory fitness directly in older people by maximum oxygen consumption, showing a high reliability and validity of 0.95 (59). However, this is a method of high economic cost and not easily accessible compared to the 6-min walk test, which has proven to be a simple, easy, and quick application test with a high reliability and validity of 0.96 that measures cardiorespiratory fitness in older people (60).

4.3 Upper limb muscle strength

In the present overview, no significant differences were detected in maximal upper limb muscle strength measured by HGS between active exergames and control groups. Similar to that reported by Daryanti Saragih et al. (61) in a meta-analysis, no statistically significant improvements (p = 0.40) in HGS were observed in interventions using elastic band training concerning active/inactive control groups in older people. However, a meta-analysis in older people by Khalafi et al. (62) reported statistically significant improvements (p = 0.001) in HGS in concurrent training interventions to active/inactive control groups. Interventions using active exergames, unlike strategies using traditional physical activity (i.e., concurrent training), do not produce an increase in the load used because only bodyweight movements are executed, which may lead to less neuromuscular activation, muscle hypertrophy, strength, and muscle quality in wrist flexor-extensor muscles (41, 43, 63, 64); this may be because interventions using Xbox Kinect do not manipulate any control in hand hence do not grasp or hold any control, because the sensor that tracks the movements executed in the game is in a camera that is in front of the player (65).

In contrast to the Nintendo Wii, the movements to perform the games are executed by a controller that must be grasped and held by hand because the sensor is on the controller (65). In neither of the two interventions using active exergames is there an improvement in HGS because there is no stimulus that leads to an increase in the load used in the upper limbs, mainly in the wrist flexor-extensor muscles that leads to an increase in HGS (65). The HGS is an effective direct method for assessing upper limb muscle strength of the wrist flexor-extensor muscles in older people, with a high reliability and validity

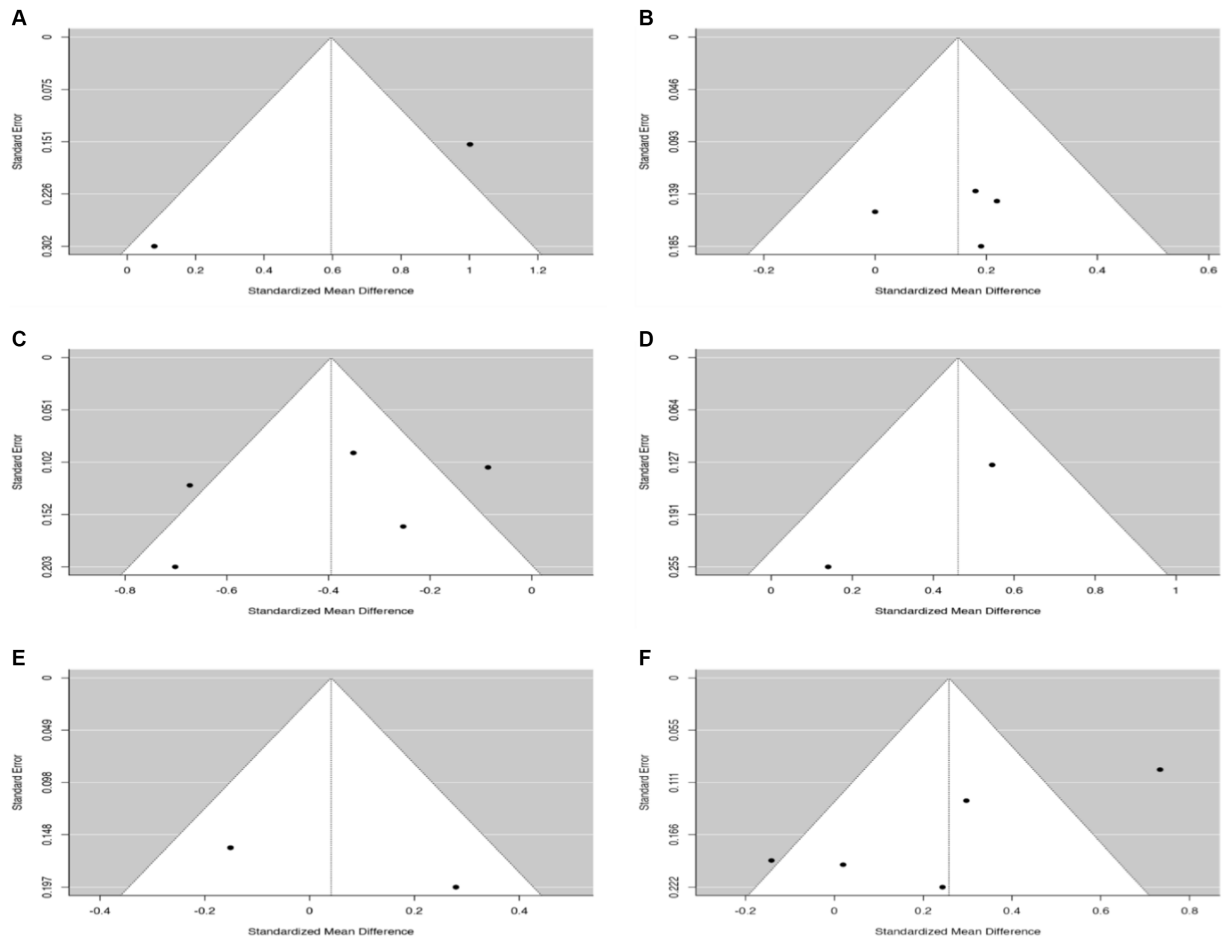


FIGURE 8
Egger's test for assessment of potential publication bias. **(A)** 6-min walk test. **(B)** 30-s chair stand. **(C)** Timed up-and-go test. **(D)** Handgrip strength. **(E)** Knee extension. **(F)** Berg Balance Scale.

of 0.98 (66). A good performance on this test is considered a good predictor of a lower risk of all-cause mortality (67).

4.4 Lower limb muscle strength

Similarly, the overview did not detect significant differences in lower limb muscle strength measured by the knee extension test between the active exergames groups compared to the control groups. However, a meta-analysis by Khalafi et al. (62) reported statistically significant improvements ($p = 0.001$) in favor of multicomponent training interventions concerning active/inactive control groups in older people. Neural adaptations and/or alterations at the muscle fiber level or changes in the main components of excitation-contraction coupling may explain strength gains in traditional physical activities such as resistance training (43). However, the lack of overload in active exergames interventions may have limited the significant isometric strength gains for the lower limbs in the knee extension test (43). The knee extension test is a direct method that measures maximal isometric strength in the knee extensor muscles in older people with a high reliability and validity of 0.98 (68).

Another result reported in the present overview had significant differences in favor of the active exergames groups in the 30-s chair stand test (SMD = 0.79; 95% CI = 0.33–1.25; I^2 = 88%; $p = 0.0008$) compared to control groups. Similar to that reported by Labata-Lezaun et al. (7) in a meta-analysis, statistically significant improvements ($p = 0.002$) in the 30-s chair stand test were observed in interventions through multicomponent training regarding active/inactive control groups in older people. Similarly, de Oliveira et al. (69), in a meta-analysis, reported statistically significant improvements in the 30-s chair stand test in favor of interventions using elastic band training concerning active/inactive control groups in older people. Some games that are performed through interventions with active exergames such as bowling, table tennis, athletics, volleyball, soccer, Kinect adventure, and Wii fit participants adopt a knee angle at 90°, similar to the angle considered for the realization of the 30-s chair stand test, which can generate adaptations at the neuromuscular level that can lead to improvements in this test (70). Getting up from a chair independently is essential for safe performance in activities of daily living (71). Community-dwelling older people with and without health problems stand and sit from a chair between 33 and 71 times daily (72). The 30-s chair stand test measures lower limb muscle strength indirectly by the number of repetitions a person can execute

by standing and sitting from a chair for 30 s (71), with high reliability and validity of 0.97 for measuring older people (73).

4.5 Methodological quality and certainty of evidence

The AMSTAR-2 program has been used to measure and evaluate the methodological quality, while certainty of evidence was obtained using GRADE (30, 74). Importantly, it allows us to deliver conclusive information on the variables analyzed (30, 74). A review by El-Kotob et al. (75) on the effect of resistance training in adults showed a low methodological quality with AMSTAR-2; this is similar to that reported by Leung et al. (76) in an abstract that analyzed the effect of Tai Chi training on indicators of functionality in older people showing low methodological quality with AMSTAR-2. However, in the present overview, a moderate (13–14 points)-to-high (15–16 points) methodological quality was reported in the 10 meta-analyses detected for the analysis (17, 18, 26–28, 37, 38, 41–43). In comparison, there was moderate-to-high certainty of evidence in the BBS, TUG, 30-s chair stand, and 6-min walk tests. Similar to the findings in the study by Shen et al. (77), which demonstrated moderate-to-high quality evidence on physical performance through resistance, balance, and aerobic training in older people through GRADE, this allows us to recommend interventions using active exergames to improve the BBS, TUG, and 30-s chair stand tests in apparently healthy older people.

4.6 Active exergames dosage

Regarding the dose used by the interventions with active exergames that report results for the BBS, TUG, and 30-s chair stand tests, a duration between 3 and 20 weeks was reported with 2–3 weekly sessions for 30–60 min, with moderate-to-vigorous intensities ranging from 3 to 6 in the 10-point RPE (78). Another type of training with elastic bands has shown statistically significant improvements on these variables with interventions ranging from 8 to 28 weeks with 1–3 sessions per week for 30–90 min with intensities of 25–80% of the one-repetition maximum (1RM) from 1 to 2 sets per session of 5–20 repetitions per set in upper and lower limbs exercises as reported in various meta-analyses in older people (50, 51, 61, 69). As the multicomponent training has shown statistically significant improvements in these previously mentioned variables (BBS and TUG), the following is a good example with interventions ranging from 9 to 48 weeks with 2 to 5 sessions per week for 30–90 min with upper and lower limbs exercises, as reported in different meta-analyses (7, 46). However, no significant differences were reported regarding active exergames in HGS and knee extension tests in the present overview. However, the 30-s chair stand test was significant. In other types of interventions, such as concurrent training with a duration of 4 weeks to 12 months with 3–5 sessions per week for 30–140 min with intensities of 60–90% of 1RM and 60–90% of maximum heart rate (HR_{max}) with upper and lower limbs exercises, statistically significant improvements have been reported in HGS and knee extension tests as demonstrated in a meta-analysis in older people (62). However, HIIT training has demonstrated statistically significant improvements in the 6-min walk test with interventions of 6–28 weeks of 2–7 sessions per week for 30–60 min with intervals of 6–30 at intensities ≥90% of the HR_{max} as demonstrated in a meta-analysis in older people (56). However, these interventions (HIIT) have shown low adherence due to the high intensities at which the intervals are performed as the repetitive actions executed (79). In contrast, active exergames have shown high adherence to the interventions with high enjoyment of the activity performed due to the diversity of games that are executed during the interventions (80); therefore, it could serve as a complement to other physical activity strategies.

4.7 Strengths and limitations of the overview

The limitations of the present overview are as follows: (*i*) the low number of similar assessments among the systematic reviews and meta-analysis available to meta-analyze the data, limiting the recommendations for some assessments analyzed, and (*ii*) the high heterogeneity found in the group analyses may limit the recommendations of the results obtained; however, finding low heterogeneity in systematic reviews and meta-analyses is unlikely as well as the optimal size of information due to the diversity in the number of population found in the available studies (81–83). Afonso et al. (81) recommended being careful in misinterpreting the concept of publication bias in meta-analyses (i.e., using definitive rather than provisional statements), misusing funnel plots and associated statistical tests to assess potential publication bias, and misinterpreting subsequent results. The main strengths are as follows: (*i*) the use of 7 (PubMed, Web of Science, Scopus, CINAHL, Cochrane Library, MEDLINE, and Psychology and Behavioral Sciences) generic databases, which broadens the scope of the search; (*ii*) performing meta-analysis which allows quantifying what is reported in the systematic reviews and meta-analysis; (*iii*) comparison with active/inactive control groups which increases the quality in the comparator on its effect on the variables analyzed; (*iv*) meta-analyzing only systematic reviews with moderate-to-high methodological quality this allows recommending intervention on the variables analyzed; and (*v*) analyzing different consoles and virtual reality games that allow a broader vision of their impact on health status in older people. Future overviews could analyze systematic reviews on the effect of active exergames on psychoemotional and physiological variables or see if there are differences between the type of consoles or games on physical performance in older people.

4.8 Practical applications

This overview of systematic reviews with meta-analysis highlights the potential impact of active exergames to improve physical performance in the BBS, TUG, and 30-s chair stand tests in apparently healthy older people with interventions ranging from 3 to 20 weeks, the improvement in the indicated tests being related to greater functional independence and lower fall risk (18, 26–28, 37, 41, 42). Therefore, active exergames could serve as a complementary physical activity strategy in clinical practice and could be used in primary healthcare, community centers, nursing homes, and physical activity programs oriented to older people.

5 Conclusion

Interventions utilizing active exergames have shown significant improvements in the static and dynamic balance and lower limb

muscle strength of apparently healthy older people, compared to control groups of active/inactive participants, as measured by the BBS, TUG, and 30-s chair stand tests. However, no significant differences were found in the 6-min walk, HGS, and knee extension tests. The certainty of the evidence was rated as moderate-to-high, thus suggesting that active exergames can be recommended as a physical activity strategy to enhance the performance of older people in terms of balance and lower limb muscle strength. Nevertheless, it is essential to supplement this intervention with activities focusing on improving cardiorespiratory fitness and upper limb muscle strength.

Data availability statement

The datasets generated during and/or analyzed during the current research are available from the Corresponding author upon reasonable request.

Author contributions

JH-M and PV-B: conceptualization, software, writing-original draft preparation. JH-M, CM-V, and PV-B: methodology. JH-M, CM-V, FR-E, and PV-B: formal analysis. JH-M, FR-E, CM-V, EG-M, TH-V, BB, MC-C, and PV-B: investigation and writing-review and editing. PV-B, EG-M, TH-V, and BB: supervision. All authors have read and agreed to the published version of the manuscript.

Acknowledgments

PV-B thanks the Chile's National Research and Development Agency (in Spanish, ANID) for the award of the FONDECYT (code: 11220035) project.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Değer TB, Saraç ZF, Savaş ES, Akçiçek SF. The relationship of balance disorders with falling, the effect of health problems, and social life on postural balance in the elderly living in a district in Turkey. *Geriatrics*. (2019) 4:37. doi: 10.3390/geriatrics4020037

2. Freiberger E, Sieber CC, Kob R. Mobility in older community-dwelling persons: a narrative review. *Front Physiol*. (2020) 11:881. doi: 10.3389/fphys.2020.00881

3. Khodadad Kashi S, Mirzazadeh ZS, Saatchian V. A systematic review and meta-analysis of resistance training on quality of life, depression, muscle strength, and functional exercise capacity in older adults aged 60 years or more. *Biol Res Nurs*. (2022) 25:88–106. doi: 10.1177/10998004221120945

4. WHO. (2021). *World Health Organization falls*. Available at: https://www.who.int/news-room/fact-sheets/detail/falls

5. Romero-Ortuño R, Martínez-Velilla N, Sutton R, Ungar A, Fedorowski A, Galvin R, et al. Network physiology in aging and frailty: the grand challenge of physiological reserve in older adults. *Front Netw Physiol*. (2021) 1:712430. doi: 10.3389/fnetp.2021.712430

6. Valdés-Badilla PA, Gutiérrez-García C, Pérez-Gutiérrez M, Vargas-Vitoria R, López-Fuenzalida A. Effects of physical activity governmental programs on health status in independent older adults: a systematic review. *J Aging Phys Act*. (2019) 27:265–75. doi: 10.1123/japa.2017-0396

7. Labata-Lezaun N, González-Rueda V, Llurda-Almuzara L, López-De-Celis C, Rodríguez-Sanz J, Bosch J, et al. Effectiveness of multicomponent training on physical performance in older adults: a systematic review and meta-analysis. *Arch Gerontol Geriatr*. (2023) 104:104838. doi: 10.1016/j.archger.2022.104838

8. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. (2020) 54:1451–62. doi: 10.1136/bjsports-2020-102955

9. Fragala MS, Cadore EL, Dorgo S, Izquierdo M, Kraemer WJ, Peterson MD, et al. Resistance training for older adults: position statement from the national strength and conditioning association. *J Strength Cond Res*. (2019) 33:2019–52. doi: 10.1519/JSC.0000000000003230

10. Schöttl SE, Schnitzer M, Savoia L, Kopp M. Physical activity behavior during and after Covid-19 stay-at-home orders-a longitudinal study in the Austrian, German, and Italian Alps. *Front Public Health*. (2022) 10:901763. doi: 10.3389/fpubh.2022.901763

11. De Maio M, Bratta C, Iannaccone A, Castellani L, Foster C, Cortis C, et al. Home-based physical activity as a healthy aging booster before and during Covid-19 outbreak. *Int J Environ Res Public Health*. (2022) 19:317. doi: 10.3390/ijerph19074317

12. Buyle M, Jung Y, Pavlou M, Gonzalez SC, Bamiou D-E. The role of motivation factors in exergame interventions for fall prevention in older adults: a systematic review and meta-analysis. *Front Neurol*. (2022) 13:903673. doi: 10.3389/fneur.2022.903673

13. Ismail NA, Hashim HA, Ahmad Yusof H. Physical activity and exergames among older adults: a scoping review. *Games Health J*. (2022) 11:1–17. doi: 10.1089/g4h.2021.0104

14. Jinhui L, Li L, Huo P, Ma C, Wang L, Theng YL. Wii or Kinect? A pilot study of the Exergame effects on older Adults' physical fitness and psychological perception. *Int J Environ Res Public Health*. (2021) 18:12939. doi: 10.3390/ijerph182412939

15. Jacobson G. (2021). *When costs are a barrier to getting health care: reports from older adults in the United States and other high-income countries*. Available at: https://www.commonwealthfund.org/publications/surveys/2021/oct/when-costs-are-barrier-getting-health-care-older-adults-survey

16. National Health Service of the Kingdom United (2015). *This article is more than 7 years old analysis ageing Britain: two-fifths of Nhs budget is spent on over-65s*. Available at: https://www.theguardian.com/society/2016/feb/01/ageing-britain-two-fifths-nhs-budget-spent-over-65s

17. Corregidor-Sánchez AI, Segura-Fragoso A, Rodríguez-Hernández M, Criado-Alvarez JJ, González-Gonzalez J, Polonio-López B. Can exergames contribute to improving walking capacity in older adults? A systematic review and meta-analysis. *Maturitas*. (2020) 132:40–8. doi: 10.1016/j.maturitas.2019.12.006

18. Corregidor-Sánchez AI, Segura-Fragoso A, Rodríguez-Hernández M, Jiménez-Rojas C, Polonio-López B, Criado-Álvarez JJ. Effectiveness of virtual reality technology on functional mobility of older adults: systematic review and meta-analysis. *Age Ageing*. (2021) 50:370–9. doi: 10.1093/ageing/afaa197

19. Ge L, Su TT, An Y, Mejía ST. The effectiveness of exergames on fear of falling in community-dwelling older adults: a systematic review. *Aging Ment Health*. (2022) 26:1306–17. doi: 10.1080/13607863.2021.1950615

20. Fu AS, Gao KL, Tung AK, Tsang WW, Kwan MM. Effectiveness of exergaming training in reducing risk and incidence of falls in frail older adults with a history of falls. *Arch Phys Med Rehabil*. (2015) 96:2096–102. doi: 10.1016/j.apmr.2015.08.427

21. Yang C-M, Chen Hsieh JS, Chen Y-C, Yang S-Y, Lin H-CK. Effects of Kinect exergames on balance training among community older adults: a randomized controlled trial. *Medicine*. (2020) 99:e21228. doi: 10.1097/MD.0000000000021228

22. Hernandez-Martínez J, Ramirez-Campillo R, Álvarez C, Valdés-Badilla PA, Moran J, Izquierdo M. Effects of active exergames training on physical functional performance in older females (Efectos del entrenamiento de exergames activos sobre el rendimiento físico funcional en mujeres mayores). *Cult Cien Dep*. (2022) 17:77–84 doi: 10.12800/ccd.v17i51.1658

23. Yu T-C, Chiang C-H, Wu P-T, Wu W-L, Chu IH. Effects of Exergames on physical fitness in middle-aged and older adults in Taiwan. *Int J Environ Res Public Health*. (2020) 17:2565. doi: 10.3390/ijerph17072565

24. Liao YY, Chen IH, Hsu WC, Tseng HY, Wang RY. Effect of exergaming versus combined exercise on cognitive function and brain activation in frail older adults: A randomised controlled trial. *Ann Phys Rehabil Med*. (2021) 64:101492. doi: 10.1016/j.rehab.2021.101492

25. Afridi A, Rathore FA, Nazir SNB. Wii fit for balance training in elderly: a systematic review. *J Coll Physicians Surg Pak*. (2021) 30:559–66. doi: 10.29271/jcpsp.2021.05.559

26. Chen Y, Zhang Y, Guo Z, Bao D, Zhou J. Comparison between the effects of exergame intervention and traditional physical training on improving balance and fall prevention in healthy older adults: a systematic review and meta-analysis. *J Neuroeng Rehabil*. (2021) 18:164. doi: 10.1186/s12984-021-00917-0

27. Liu H, Xing Y, Wu Y. Effect of Wii fit exercise with balance and lower limb muscle strength in older adults: a meta-analysis. *Front Med*. (2022) 9:812570. doi: 10.3389/fmed.2022.812570

28. Pacheco TBF, De Medeiros CSP, De Oliveira VHB, Vieira ER, De Cavalcanti FAC. Effectiveness of exergames for improving mobility and balance in older adults: a systematic review and meta-analysis. *Syst Rev*. (2020) 9:163. doi: 10.1186/s13643-020-01421-7

29. Page M, Mckenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The Prisma 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. (2021) 372:n71. doi: 10.1136/bmj.n71

30. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. Amstar 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*. (2017) 358:j4008. doi: 10.1136/bmj.j4008

31. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. Grade guidelines: 1. Introduction-grade evidence profiles and summary of findings tables. *J Clin Epidemiol*. (2011) 64:383–94. doi: 10.1016/j.jclinepi.2010.04.026

32. Weir CJ, Butcher I, Assi V, Lewis SC, Murray GD, Langhorne P, et al. Dealing with missing standard deviation and mean values in meta-analysis of continuous outcomes: a systematic review. *BMC Med Res Methodol*. (2018) 18:25. doi: 10.1186/s12874-018-0483-0

33. Stogiannis D, Siannis F, Androulakis E. Heterogeneity in meta-analysis: a comprehensive overview. *Int J Biostat*. (2023). doi: 10.1515/ijb-2022-0070

34. Jiantong S, Wenming F, Yike W, Qiyuan Z, Billong Laura F, Jingya L. Efficacy and safety of aliskiren combination therapy: a protocol for an umbrella review. *BMJ Open*. (2021) 11:e043807. doi: 10.1136/bmjopen-2020-043807

35. Li X, Wei W, Wang Y, Wang Q, Liu Z. Touching-bone acupuncture in the treatment of chronic pain: a protocol for an overview of systematic reviews and meta-analysis. *Medicine*. (2021) 100:e27195. doi: 10.1097/MD.0000000000027195

36. Sterne JA, Egger M, Smith GD. Systematic reviews in health care: investigating and dealing with publication and other biases in meta-analysis. *BMJ*. (2001) 323:101–5. doi: 10.1136/bmj.323.7304.101

37. Fang Q, Ghanouni P, Anderson SE, Touchett H, Shirley R, Fang F, et al. Effects of exergaming on balance of healthy older adults: a systematic review and meta-analysis of randomized controlled trials. *Games Health J*. (2020) 9:11–23. doi: 10.1089/g4h.2019.0016

38. Janhunen M, Karner V, Katajapuu N, Niiranen O, Immonen J, Karvanen J, et al. Effectiveness of Exergame intervention on walking in older adults: a systematic review and meta-analysis of randomized controlled trials. *Phys Ther*. (2021) 101:pzab152. doi: 10.1093/ptj/pzab152

39. Laufer Y, Dar G, Kodesh E. Does a Wii-based exercise program enhance balance control of independently functioning older adults? A systematic review. *Clin Interv Aging*. (2014) 9:1803–13. doi: 10.2147/CIA.S69673

40. Molina KI, Ricci NA, De Moraes SA, Perracini MR. Virtual reality using games for improving physical functioning in older adults: a systematic review. *J Neuroeng Rehabil*. (2014) 11:156. doi: 10.1186/1743-0003-11-156

41. Suleiman-Martos N, García-Lara R, Albendín-García L, Romero-Béjar JL, Cañadas-De La Fuente GA, Monsalve-Reyes C, et al. Effects of active video games on physical function in independent community-dwelling older adults: a systematic review and meta-analysis. *J Adv Nurs*. (2022) 78:1228–44. doi: 10.1111/jan.15138

42. Taylor LM, Kerse N, Frakking T, Maddison R. Active video games for improving physical performance measures in older people: a meta-analysis. *J Geriatr Phys Ther*. (2018) 41:108–23. doi: 10.1519/JPT.0000000000000078

43. Viana RB, De Oliveira VN, Dankel SJ, Loenneke JP, Abe T, Da Silva WF, et al. The effects of exergames on muscle strength: a systematic review and meta-analysis. *Scand J Med Sci Sports*. (2021) 31:1592–611. doi: 10.1111/sms.13964

44. Zheng L, Li G, Wang X, Yin H, Jia Y, Leng M, et al. Effect of exergames on physical outcomes in frail elderly: a systematic review. *Aging Clin Exp Res*. (2020) 32:2187–200. doi: 10.1007/s40520-019-01344-x

45. Lesinski M, Hortobágyi T, Muehlbauer T, Gollhofer A, Granacher U. Effects of balance training on balance performance in healthy older adults: a systematic review and meta-analysis. *Sports Med*. (2015) 45:1721–38. doi: 10.1007/s40279-015-0375-y

46. Lemos ECWM, Guadagnin EC, Mota CB. Influence of strength training and multicomponent training on the functionality of older adults: systematic review and meta-analysis. *Rev Bras Cineantrop Desemp Hum*. (2020) 22:1–20 doi: 10.1590/1980-0037.2020v22e6070

47. Cuevas-Trisan R. Balance problems and fall risks in the elderly. *Phys Med Rehabil Clin N Am*. (2017) 28:727–37. doi: 10.1016/j.pmr.2017.06.006

48. Cordeiro HIP, De Mello Alves Rodrigues AC, Alves MR, Gatica-Rojas V, Maillot P, De Moraes Pimentel D, et al. Exercise with active video game or strength/balance training? Case reports comparing postural balance of older women. *Aging Clin Exp Res*. (2020) 32:543–5. doi: 10.1007/s40520-019-01219-1

49. Downs S, Marquez J, Chiarelli P. The Berg balance scale has high intra- and inter-rater reliability but absolute reliability varies across the scale: a systematic review. *J Physiother*. (2013) 59:93–9. doi: 10.1016/S1836-9553(13)70161-9

50. Efendi F, Tonapa SI, Has EMM, Ho KHM. Effects of chair-based resistance band exercise on physical functioning, sleep quality, and depression of older adults in long-term care facilities: systematic review and meta-analysis. *Int J Nurs Sci*. (2023) 10:72–81. doi: 10.1016/j.ijnss.2022.12.002

51. Yeun YR. Effectiveness of resistance exercise using elastic bands on flexibility and balance among the elderly people living in the community: a systematic review and meta-analysis. *J Phys Ther Sci*. (2017) 29:1695–9. doi: 10.1589/jpts.29.1695

52. Aslankhani MA, Farsi A, Fathirezaie Z, Zamani Sani SH, Aghdasi MT. Validity and reliability of the timed up and go and the anterior functional reach tests in evaluating fall risk in the elderly. *Salmand Iran J Ageing*. (2015) 10:16–25. Available at: http://salmandj.uswr.ac.ir/article-1-720-en.html

53. Li Z, Liang YY, Wang L, Sheng J, Ma SJ. Reliability and validity of center of pressure measures for balance assessment in older adults. *J Phys Ther Sci*. (2016) 28:1364–7. doi: 10.1589/jpts.28.1364

54. Karahan AY, Tok F, Taşkın H, Kuçuksaraç S, Başaran A, Yıldırım P. Effects of Exergames on balance, functional mobility, and quality of life of geriatrics versus home exercise programme: randomized controlled study. *Cent Eur J Public Health*. (2015) 23:S14–8. doi: 10.21101/cejph.a4081

55. Padala KP, Padala PR, Lensing SY, Dennis RA, Bopp MM, Parkes CM, et al. Efficacy of Wii-fit on static and dynamic balance in community dwelling older veterans: a randomized controlled pilot trial. *J Aging Res*. (2017) 2017:4653635. doi: 10.1155/2017/4653635

56. Stern G, Psycharakis SG, Phillips SM. Effect of high-intensity interval training on functional movement in older adults: a systematic review and meta-analysis. *Sports Med Open*. (2023) 9:5. doi: 10.1186/s40798-023-00551-1

57. Berg J, Haugen G, Wang AI, Moholdt T. High-intensity exergaming for improved cardiorespiratory fitness: a randomised, controlled trial. *Eur J Sport Sci*. (2022) 22:867–76. doi: 10.1080/17461391.2021.1921852

58. Gabrielle Dupuy E, Besnier F, Gagnon C, Breton J, Vincent T, Grégoire C-A, et al. Cardiorespiratory fitness moderates the age-related association between executive functioning and mobility: evidence from remote assessments. *Innova Aging*. (2022) 7:igac077. doi: 10.1093/geroni/igac077

59. Dougherty RJ, Lindheimer JB, Stegner AJ, Van Riper S, Okonkwo OC, Cook DB. An objective method to accurately measure cardiorespiratory fitness in older adults who cannot satisfy widely used oxygen consumption criteria. *J Alzheimers Dis*. (2018) 61:601–11. doi: 10.3233/JAD-170576

60. Guerra-Balic M, Oviedo GR, Javierre C, Fortuño J, Barnet-López S, Niño O, et al. Reliability and validity of the 6-min walk test in adults and seniors with intellectual disabilities. *Res Dev Disabil*. (2015) 47:144–53. doi: 10.1016/j.ridd.2015.09.011

61. Daryanti Saragih I, Yang YP, Saragih IS, Batubara SO, Lin CJ. Effects of resistance bands exercise for frail older adults: a systematic review and meta-analysis of randomised controlled studies. *J Clin Nurs*. (2022) 31:43–61. doi: 10.1111/jocn.15950

62. Khalafi M, Sakhaei MH, Rosenkranz SK, Symonds ME. Impact of concurrent training versus aerobic or resistance training on cardiorespiratory fitness and muscular strength in middle-aged to older adults: a systematic review and meta-analysis. *Physiol Behav*. (2022) 254:113888. doi: 10.1016/j.physbeh.2022.113888

63. Speed CA, Campbell R. Mechanisms of strength gain in a handgrip exercise programme in rheumatoid arthritis. *Rheumatol Int*. (2012) 32:159–63. doi: 10.1007/s00296-010-1596-x

64. Stojanović MDM, Mikić MJ, Milošević Z, Vuković J, Jezdimirović T, Vučetić V. Effects of chair-based, low-load elastic band resistance training on functional fitness and metabolic biomarkers in older women. *J Sports Sci Med*. (2021) 20:133–41. doi: 10.52082/jssm.2021.133

65. Marotta N, Demeco A, Indino A, De Scorpio G, Moggio L, Ammendolia A. Nintendo Wiitm versus Xbox Kinecttm for functional locomotion in people with Parkinson's disease: a systematic review and network meta-analysis. *Disabil Rehabil*. (2022) 44:331–6. doi: 10.1080/09638288.2020.1768301

66. Benton MJ, Spicher JM, Silva-Smith AL. Validity and reliability of handgrip dynamometry in older adults: a comparison of two widely used dynamometers. *PLoS One*. (2022) 17:e0270132. doi: 10.1371/journal.pone.0270132

67. Wu Y, Wang W, Liu T, Zhang D. Association of grip strength with risk of all-cause mortality, cardiovascular diseases, and cancer in community-dwelling populations: a meta-analysis of prospective cohort studies. *J Am Med Dir Assoc*. (2017) 18:551.e17–35. doi: 10.1016/j.jamda.2017.03.011

68. Van Driessche S, Van Roie E, Vanwanseele B, Delecluse C. Test-retest reliability of knee extensor rate of velocity and power development in older adults using the isotonic

mode on a Biodex system 3 dynamometer. *PLoS One*. (2018) 13:e0196838. doi: 10.1371/journal.pone.0196838

69. De Oliveira SN, Leonel L, Sudatti Delevatti R, Heberle I, Moro ARP. Effect of elastic resistance training on functional capacity in older adults: a systematic review with meta-analysis. *Physiother Theory Pract*. (2022) 39:2553–68. doi: 10.1080/09593985.2022.2085219

70. Sato K, Kuroki K, Saiki S, Nagatomi R. Improving walking, muscle strength, and balance in the elderly with an Exergame using Kinect: a randomized controlled trial. *Games Health J*. (2015) 4:161–7. doi: 10.1089/g4h.2014.0057

71. Rikli RE, Jones CJ. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years. *Gerontologist*. (2013) 53:255–67. doi: 10.1093/geront/gns071

72. Bohannon RW. Daily sit-to-stands performed by adults: a systematic review. *J Phys Ther Sci*. (2015) 27:939–42. doi: 10.1589/jpts.27.939

73. Özkeskin M, Özden F, Ar E, Yüceyar N. The reliability and validity of the 30-second chair stand test and modified four square step test in persons with multiple sclerosis. *Physiother Theory Pract*. (2022) 39:2189–95. doi: 10.1080/09593985.2022.2070811

74. Martis R, Crowther CA, Shepherd E, Alsweiler J, Downie MR, Brown J. Treatments for women with gestational diabetes mellitus: an overview of Cochrane systematic reviews. *Cochrane Database Syst Rev*. (2018) 8:Cd012327. doi: 10.1002/14651858.CD012327.pub2

75. El-Kotob R, Ponzano M, Chaput JP, Janssen I, Kho ME, Poitras VJ, et al. Resistance training and health in adults: an overview of systematic reviews. *Appl Physiol Nutr Metab*. (2020) 45:S165–s179. doi: 10.1139/apnm-2020-0245

76. Leung LYL, Tam HL, Ho JKM. Effectiveness of tai chi on older adults: A systematic review of systematic reviews with re-meta-analysis. *Arch Gerontol Geriatr*. (2022) 103:104796. doi: 10.1016/j.archger.2022.104796

77. Shen Y, Shi Q, Nong K, Li S, Yue J, Huang J, et al. Exercise for sarcopenia in older people: a systematic review and network meta-analysis. *J Cachexia Sarcopenia Muscle*. (2023) 14:1199–211. doi: 10.1002/jcsm.13225

78. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. (1982) 14:377–81.

79. Santos A, Lonsdale C, Lubans D, Vasconcellos D, Kapsal N, Vis-Dunbar M, et al. Rates of compliance and adherence to high-intensity interval training in insufficiently active adults: a systematic review and meta-analysis protocol. *Syst Rev*. (2020) 9:56. doi: 10.1186/s13643-020-01301-0

80. Freed SA, Sprague BN, Stephan AT, Doyle CE, Tian J, Phillips CB, et al. Feasibility and enjoyment of exercise video games in older adults. *Front Public Health*. (2021) 9:751289. doi: 10.3389/fpubh.2021.751289

81. Afonso J, Ramirez-Campillo R, Clemente FM, Büttner FC, Andrade R. The perils of misinterpreting and misusing "publication Bias" in meta-analyses: an education review on funnel plot-based methods. *Sports Med*. (2023). doi: 10.1007/s40279-023-01927-9

82. Garcia-Alamino JM, Bankhead C, Heneghan C, Pidduck N, Perera R. Impact of heterogeneity and effect size on the estimation of the optimal information size: analysis of recently published meta-analyses. *BMJ Open*. (2017) 7:e015888. doi: 10.1136/bmjopen-2017-015888

83. Higgins JPT, Li T. Exploring heterogeneity. *System Rev Health Res*. (2022). doi: 10.1002/9781119099369.ch10

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 18 April 2024
DOI 10.3389/fpubh.2024.1338079

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Chong Zhang,
University of Electronic Science and Technology of China, China
Azadeh Lak,
Shahid Beheshti University, Iran

*CORRESPONDENCE
Zhu Huijie
✉ zhuhuijie@njau.edu.cn
Yao Zhaoyu
✉ yaozhaoyu@njau.edu.cn

RECEIVED 14 November 2023
ACCEPTED 13 March 2024
PUBLISHED 18 April 2024

CITATION
Huijie Z, Haojun J, Zhiping Z and Zhaoyu Y (2024) Association between residential environment and emotional wellbeing among older adults in China: the mediating effect of health lifestyle. *Front. Public Health* 12:1338079. doi: 10.3389/fpubh.2024.1338079

COPYRIGHT
© 2024 Huijie, Haojun, Zhiping and Zhaoyu. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Association between residential environment and emotional wellbeing among older adults in China: the mediating effect of health lifestyle

Zhu Huijie[1,2,3]*, Jiang Haojun[4], Zhu Zhiping[1] and Yao Zhaoyu[1,3]*

[1]College of Humanities and Social Development, Nanjing Agricultural University, Nanjing, China, [2]Center for Social Research, Nanjing Agricultural University, Nanjing, China, [3]Jin Shanbao Institute for Agricultural and Rural Development Research Institute, Nanjing, China, [4]Tourism and Social Management College, Nanjing Xiaozhuang University, Nanjing, China

Introduction: The association between the residential environment and emotional wellbeing (EWB) in older adults has received extensive attention from gerontologists, especially during the COVID-19 pandemic; however, the mediating mechanism of how residential environment affects emotional wellbeing has not been fully explored. This study examined the effects of the residential environment on EWB and the mediating role of health lifestyle.

Methods: This study analyzed the survey data of 493 rural and 515 urban older adults from 2021 Chinese General Social Survey. General linear regression and structural equation models were used to examine the effects of residential environment and health lifestyle.

Results: Urban participants exhibited clear advantages in EWB, residential environment, and physical activity. Residential environment significantly affected the EWB of older adults, and health lifestyle played a mediating role in this relationship. The residential environment and health lifestyle did not significantly affect EWB in rural participants.

Discussion: This study revealed differences in the effects of health lifestyles and residential environments on EWB among older adults in rural and urban settings in China. This study provided empirical evidence of mental health disparities between older rural and urban Chinese residents.

KEYWORDS

emotional wellbeing, residential environment, older adults, mediating effect, health lifestyle, mental health disparity

1 Introduction

With the deepening of aging globally, the health of the older population has received widespread attention. Population aged 65 and older accounts for 10% of the total population in 2023. Although life expectancy has generally increased, mental health problems among the older adults are becoming increasingly apparent. Researches have shown that, one in three individuals aged 65–84 years has experienced mental disorders within the past year, and one in four currently has a mental disorder (1). Emotional wellbeing (EWB) is one of the indicators measures a person's mental health status, refers to the emotional quality of an individual's

everyday experience (2). EWB is related to a positive balance between pleasant and unpleasant affect and a cognitive appraisal of satisfaction with life in general (3). Emotional wellbeing can protect individuals against physical declines in old age (4). High levels of EWB have been associated with physical health, healthy aging, and longevity (5).

EWB has been examined from two perspectives: as a psychological aspect of wellbeing (6) and as a public health target (7, 8). As a psychological aspect of wellbeing, EWB is considered an indicator of an individual's mental health, typically encompassing both positive and negative emotions (2). As a public health target, EWB is regarded as an indicator of health-related quality of life (9). EWB is closely related to the general health or wellbeing of individuals or populations (10, 11). Describing the general level of EWB among older population and analyzing its influencing factors is a meaningful public health issue, especially in the context of worldwide aging. Among the factors that affect the EWB of older adults, we focused on examining the effect of residential environment. After older adults leave their jobs, they mainly live in the community residents, which plays an important role in their later life.

1.1 EWB of older adults and emotional aging

EWB run exists throughout one's lifespan (12) and is closely related to age (13). Research has focused on the EWB of children (14) and students (15). With the acceleration of global aging, EWB has become an important issue concerning health in old age. Emotional aging is an inevitable process experienced by older adults. Studies have examined the developmental logic of EWB across the lifespan (16) which have reached two opposing conclusions (17). On one hand, the emotional health of the older adults is on a continuous decline trend. Dynamic Integration Theory (DIT) argue that the efficiency of emotion systems is a dynamic interplay and flexible trade-off between contextual variables and individual characteristics (18). Limitations or poor regulation strategies foster compensatory processes that compromise integration later in life (19). Older adults are at high risk for mental illnesses, such as loneliness (20) and depression (21). Depressive symptoms predict increased social and emotional loneliness in older adults (22), resulting in poor mental health (23).

On the other hand, older people benefit from emotional aging (12, 24). Older adults exhibited a better EWB than young and middle-aged people (25, 26). The Socioemotional Selectivity Theory (SST) posits those changes in time perception cause changes in motivation for social interaction among older adults, thereby improving the quality of social networks (27). Charles (28) argued that aging should be considered an adaptation that sheds light on resilience, wellbeing, and emotional stress in adulthood.

Although there is no consensus on the level of emotional health of the older adults throughout their life span, the emotional health of the older population and its influencing factors have received attention from researchers. Research on the differences in the EWB of older adults has investigated factors affecting emotional health, including individual behavior, social resources, and family factors. Individual behavior includes exercise (29), social media use (30), volunteerism (31) and discrimination based on age (32). Social resources include social support (33), social cohesion (34), personal and mobility resources (35), and long-term care insurance (36). Family factors include intimate relationship strain (37), intergenerational family relationships (38), and family support (39). For older adults, individual behavior, social resources, and family factors exist in their residential environments; however, these factors relate more to behavioral consequences and action resources.

1.2 Residential environment and EWB

Community-dwelling older adults are mainly active in the community after retirement (40). The effect of community environment on the health of older adults is lasting and stable. Community is an important factor in analyses of the EWB of older adults. Community psychology provides a disciplinary basis for analyzing the relationship between the residential environment and EWB. From the perspective of community psychology, community residents are not atomized individuals but, rather, community participants and practitioners (41). Health is affected by the community-built environment (42), community participation (43), and the neighborhood environment (44). Community participation enhances the subjective wellbeing of older adults by increasing their sense of community (45). Social contact has a positive effect on the health of older people who live alone, especially in-person contact with non-family members (46).

Research has examined the mechanisms by which the community environment affects EWB. The verified mediating variables included social cohesion, neighborhood security (47), social support (48), and sense of community (49). These mediating variables play a role at the psychological or behavioral level, focusing on the impact path of the residential environment on EWB from a psychological perspective.

From a public health perspective, EWB is both a right to health and a health outcome. EWB is related to the health equity of the older population. Residential environment is related to an individual's social status and resources and is affected by the social structure. EWB, as a health outcome, is influenced by residential environment. Focusing on the mediating mechanism of the EWB of residential environment among older adults reveals the social logic of health inequality. Therefore, exploring how inequality in residential environments translates into disparity in EWB among older adults in China is an important public health issue. The current literature focuses on the effect of socioeconomic factors on EWB, but insufficient attention is paid to residential environments. There are few studies on the mediating mechanism of EWB in older adults affected by living environment. We used data from CGSS 2021 to focus on the impact of residential environment on EWB among older adults in urban and rural areas, with a focus on the mediating role of health lifestyles. The study revealed the residential environment factors and mechanisms that affect EWB of older adults. The conclusion shows that EWB of the old adults is an emerging public health issue in Mainland China. It is necessary to intervene in the inequality in EWB from the perspective of community environment and health lifestyle.

2 Theoretical model and hypotheses

2.1 Theoretical model

The socio-ecological model provides theoretical support for understanding the positive role of communities in health. McLeroy et al. (50) introduced the social-ecological model into health research,

noting that behavior is determined by intrapersonal factors, interpersonal processes, primary groups, institutional factors, community factors, and public policies. The socio-ecological model is often used to analyze the influencing factors of health-related factors, such as eating behaviors (51), physical activity (52), and mental wellbeing (53). The socio-ecological model differs from traditional psychological models in that it explicitly combines direct external influences with peripheral factors, making the socio-ecological model popular in the public health realm (54). Communities play a key role in the social system of community-dwelling older adults. Community is the main space for the social activities of older people and is closely related to their life quality (55). In Mainland China, older people in rural and urban areas tend to remain in their communities rather than moving to nursing homes (56). Therefore, residential environments may play an important role in the wellbeing of older adults in both urban and rural areas in China (Figure 1).

The health lifestyle theory reveals the microscopic mechanism of health disparity from the perspective of social stratification and introduces structure (57) to understand the mediating mechanism of residential environment's effect on the EWB of older adults. Health lifestyles are collective patterns of health-related behaviors based on choices among options available to people according to their life opportunities (58). Health lifestyles include smoking, drinking, sleep, physical activity, and other daily behaviors related to health (59). Health is the outcome of social shaping in which health lifestyle plays a key role (60). According to the health lifestyle theory, health lifestyle is an important medium shaping individual health (61), and residential environment sets the social and cultural standards (62). Residential environment is an external feature of social class (63), and health lifestyles act as an intermediary variable affecting EWB (64). Therefore, lifestyle positively affects individual health.

2.2 Hypotheses

Given that the association between residential environment and EWB among the older adults has not been thoroughly explored, this study attempts to construct hypothesizes on the association between residential environment and EWB, and tests the mediating effect of health lifestyles.

According to the disengagement theory, most older adults return from public engagement to community life toward the end of their careers (65). They live in a community environment long term and interact closely with their neighbors; therefore, the residential environment is a key factor affecting their quality of life. Residential environment exerts a strong impact on the subjective wellbeing of older adults (66, 67). Variables of residential environment conclude internal and external conditions of the home (68), Interior living environments (69), out-of-home activities (70). Based on the analysis framework set earlier and the results of existing literatures, we have set the hypothesis 1.

> *H1: Residential environment is associated with older adults' EWB.*

The health lifestyle theory provides theoretical support for the mediating effect of health lifestyle on the relationship between residential environment and EWB. Studies have suggested that health lifestyles are closely related to EWB of older adults. According to the theory of healthy lifestyle, a person's health situation is outcome of their health lifestyle (60). The health status of older adults living in the community is influenced by community activities (71), while the quality of community life is influenced by the residential environment (42). Healthy lifestyle variables generally include physical activity and sleep quality. Physical activity promotes psychological wellbeing in older adults (72–74), and higher sleep quality indicates better EWB and quality of life (75, 76). Thus, health lifestyles significantly affect EWB.

Health lifestyles are closely related to residential environments. Based on the socio-ecological model, the residential environment is an objective aspect of health lifestyle. According to the health lifestyle theory, the residential environment is a community factor that forms an individual's health lifestyle. Moreover, environmental factors influence physical activity (77). Studies have provided empirical evidence for the association between the residential environment and health lifestyle variables, such as physical exercise (78) and sleep quality (79). Residential environment and health lifestyle affect EWB, and residential environment affects health lifestyle, providing empirical data to support the mediating effect of health lifestyle.

> *H2: Health lifestyle plays a mediating role in the relationship between the residential environment and EWB.*

Hypotheses 1 and 2 address the association between the residential environment and EWB and the mediating effect of health lifestyle. Considering the particularity of the Chinese context, the study also examined the mediating effect of health lifestyle in urban and rural settings. Significant differences exist in the residential environment, health lifestyles, and wellbeing of urban and rural older adults (80, 81). Most rural adults work in agriculture when they are young and live in relatively traditional farming communities later in life (82). Most adults in urban areas work in non-farm jobs in factories or units and live in relatively modern urban communities when they are old (83). The mediating effects of health lifestyle may differ between urban and rural older adults. Therefore, we proposed the following hypothesis:

> *H3*: The mediating effect of health lifestyle among older adults differs between urban and rural areas.

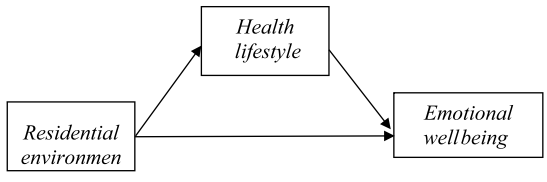


FIGURE 1
Theoretical model.

3 Methods

3.1 Data and sample

This study used secondary data from the Chinese General Social Survey (CGSS). The CGSS is part of the International Social Survey Programme (ISSP). Users can utilize these open-source data after

TABLE 1 Characteristics of the total sample.

	Measurement	MIN	MAX	Mean	SD
Urban	Urban = 1, rural = 0	0	1	0.510	0.500
Age	The difference between year of survey minus year of birth	60	99	70.410	7.081
Male	Male = 1, female = 0	0	1	0.491	0.500
Marital status	Married = 1, not married = 0	0	1	0.701	0.458
Education	Years of schooling	0	19	6.732	4.424
Family economic	1 = well below the average; 5 = well above the average	1	5	2.550	0.808

obtaining permission (84). This study has been authorized to use the data in question. The 2021 Chinese General Social Survey was conducted using a multi-stage stratified probability proportionate-to-size (PPS) random sampling method. A total of 8,148 valid samples were recovered from 320 communities and 19 provinces. The target population for this study consisted of Chinese adults over the age of 60 years living in urban and rural areas. Because the mobility of Chinese older adults is low and this study takes residential environment as the key variable, the definition of older adults in urban and rural areas is mainly based on the living area where the survey is conducted. After removing samples with missing core variables, 1,008 valid samples were obtained (493 rural and 515 urban older adults) (Table 1).

3.2 Measurement

3.2.1 Dependent variable

EWB was measured using a scale containing a set of questions regarding the emotional state of the respondents. Five questions were asked: (1) Are you unable to complete expected work or daily activities due to emotional problems? (2) Do you have emotional problems that distract you at work or during other daily activities? (3) In the past 4 weeks, to what extent have your physical health or emotional problems affected your social activities, such as visiting friends and relatives? (4) Do you feel calm? (5) Are you full of energy? Responses were rated on a five-point Likert scale (1 = never; 5 = always). Items in the scale relate to both negative and positive emotions. To facilitate the analysis, the negative emotion rating was reversed: the lower the frequency, the less frequently the individual experienced negative emotions. The Cronbach's alpha coefficient of this scale was 0.787, indicating good reliability. To reduce the dimensions of the scale, we performed a factor analysis. The KMO score was 0.754, indicating that this scale was suitable for factor analysis. Factor analysis was performed, and the cumulative variance contribution rate was 55.376%, which was named the EWB factor. As the mean value of the extracted common factors was 0, it could not be used to compare differences in EWB among different populations. We converted the common factors into a percentage system (the converted factor value = (factor value + B) * A, $A = 99/(MAX_{factor} - MIN_{factor})$, $B = (1/A) - MIN_{factor}$), and the interval was between 0 and 99.

3.2.2 Independent variables

Residential environments were measured using the respondents' subjective evaluations. A four-item scale was designed as follows: (1) Where I live is suitable for physical exercise, such as jogging and walking; (2) There are many fresh vegetables and fruits to choose from where I live; (3) There are enough public facilities where I live; and (4) Where I live is safe. Responses were rated on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). The Cronbach's alpha coefficient of the scale was 0.585, indicating acceptable reliability. The KMO score was 0.682. Factor analysis was performed, and the cumulative variance contribution rate was 46.039%. A common factor was extracted and named the residential environment factor.

Physical activity and sleep quality were used to measure health lifestyles. When operationalizing health lifestyles, this study did not select variables such as smoking, drinking, eating habits and sedentary behaviors, mainly for the following two reasons: on the one hand, there are significant regional and cultural differences in the eating habits in China, especially for Chinese older adults, which will to some extent offset the impact of living environment on emotional health; on the other hand, the dataset we used did not investigate variables related these behaviors, physical activity and sleep quality can to some extent reflect a person's health lifestyle. Physical activity was measured using self-reported frequency of physical exercise. Respondents were asked the following question: In the past year, have you often participated in physical exercise in your leisure time? Responses were rated on a five-point Likert scale (1 = never; 5 = every day). Sleep quality was self-rated on a four-point Likert scale (1 = very poor; 4 = very good).

3.2.3 Control variables

Sociodemographic variables, including age, gender, marital status, education, and family economic status, were used as control variables. Age was obtained by subtracting the year of survey from the year of birth. Gender was converted to a dummy variable representing men. Marital status was converted to having a spouse. Education was converted into the number of years of schooling. Family economic status was self-rated, with higher values indicating better family economic status. The control variables were not key variables, and their significance was not listed in the model. The regression model reported whether control variables were selected.

3.3 Statistical analyses

As this study aimed to explore the relationship between multiple variables, we used a structural equation model (SEM). SPSS 24.0 and AMOS were used for statistical analyses. SPSS was used to analyze the relationships between variables. The differences between urban and rural areas in these core variables were tested using a one-way analysis of variance (ANOVA). General linear regression (OLS) was used. In addition, AMOS was used to analyze SEMs.

4 Results

4.1 Residential environments and EWB of the older adults

Table 2 presents the key variables. Older adults in urban areas had better EWB, residential environments, and physical activity than those

in rural areas. There was no significant difference in sleep quality between older adults in urban and those in rural areas.

The correlations between EWB and related variables were tested to analyze the complex relationships among the key variables (Table 3). There was no significant correlation between the urban dummy variable and sleep quality, whereas the other variables exhibited significant correlations. These results were used for the regression and SEM analyses.

Five linear regression models of EWB among older adults were established (Table 4). Model 1 included residential environment, physical activity, and sleep quality. Model 2 included the urban variable in addition to the Model 1 variables. Model 3 further added the control variables. In Models 4 and 5, the core and control variables were added as independent variables. Models 4 and 5 were urban and rural models, respectively. The adjusted coefficient of determination for Model 1 was 14.5%. The explanatory power of Model 3 was the highest at 18.1%.

In Model 1, residential environment, physical activity, and sleep quality showed significant positive relationships. This indicated that better residential environment, higher frequency of physical activity, and higher sleep quality were associated with better EWB. All variables in Model 2 were significant. The urban dummy variable was significant, indicating that EWB was higher in urban than rural areas. In Model 3, the significance of the independent variables did not change after introducing the control variables, indicating a stable and significant correlation between EWB and these independent variables. Thus, Hypothesis 1 was supported.

According to Model 4, residential environment, physical activity, and sleep quality positively affected EWB in urban areas. According to Model 5, only sleep quality positively affected EWB in rural areas. The explanatory power of independent variables differed in the urban and rural models; therefore, urban and rural samples were analyzed separately.

TABLE 2 Key variables of urban and rural older adults.

	Urban		Rural		All		*F* (*p*)
	Mean	SD	Mean	SD	Mean	SD	
EWB	75.10	18.72	68.32	20.89	71.78	20.09	29.453 (0.000)
RE	70.34	19.01	64.63	18.55	67.56	18.98	23.305 (0.000)
PA	3.23	1.74	2.17	1.65	2.71	1.78	99.541 (0.000)
SQ	2.81	0.831	2.86	0.885	2.84	0.858	0.802 (0.371)

EWB, emotional wellbeing; RE, residential environment; PA, physical activities; SQ, sleep quality. The same below.

TABLE 3 Correlation analysis results for EWB and related variables.

	Urban	RE	PA	SQ	EWB
Urban	1				
RE	0.150***	1			
PA	0.300***	0.222***	1		
SQ	−0.028	0.149***	0.085**	1	
EWB	0.169***	0.192***	0.221***	0.313***	1

***$p < 0.001$, **$p < 0.05$, *$p < 0.01$.

4.2 Mediating effect of health lifestyle

To test the mediating effect of health lifestyles on residential environments and EWB, we conducted an SEM analysis. The chi-square value of the default model was 2.963 ($p = 0.085$), the root mean square error of approximation (RMSEA) was 0.044, the comparative fit index (CFI) was 0.992, and the Tucker-Lewis index (TLI) was 0.949. These indicators showed that the mediation model met the requirements of the SEM, and the mediation effect model was valid and effective.

Figure 2 shows the mechanism through which residential environments affected EWB. Physical activity and sleep quality mediated the relationship between residential environment and EWB. The model revealed a mediating effect of health lifestyles.

The variable effects of the SEM are presented in Table 5. Physical activity and sleep quality had mediating effects, supporting Hypothesis 2.

TABLE 4 OLS models of the participants' EWB.

	Model 1	Model 2	Model 3	Model 4-urban	Model 5-rural
RE	0.119 (0.032)***	0.106 (0.032)**	0.104 (0.031)***	0.128 (0.040)**	0.083 (0.049)
EB	1.953 (0.339)***	1.566 (0.350)***	1.210 (0.356)***	1.774 (0.448)***	0.549 (0.566)
SQ	6.588 (0.691)***	6.777 (0.688)***	6.369 (0.687)***	6.867 (0.914)***	5.959 (1.033)***
Urban		4.828 (1.226)***	4.691 (1.282)***		
Age			−0.193(0.086)*	−0.090(0.106)	−0.331(0.140)*
Male			3.220(1.244)*	1.735(1.621)	4.719(1.919)*
Marital status			1.540(1.335)	1.735(1.735)	1.283(2.062)
Education			0.349(0.152)	0.365(0.181)*	0.327(0.260)
Family economic			−0.349(0.040)*	−0.037(0.046)	−0.057(0.069)
(Constant)	39.797 (2.738)***	38.679 (2.734)***	49.790 (6.898)***	42.739 (8.834)***	62.978 (10.986)***
Adjusted R^2	0.145	0.157	0.181	0.193	0.126

***$p < 0.001$, **$p < 0.05$, *$p < 0.01$.

An SEM was used to analyze urban and rural samples. The variable effects are shown in Table 6. The urban model revealed five influence paths. In the rural model, the EWB ← PA and EWB ← RE paths were not significant, indicating that the residential environment did not affect EWB. Physical activity, which was a healthy lifestyle variable, had no significant effect on the EWB of rural older adults.

In the urban model, health lifestyle variables play a partial mediating effect between Residential environments and EWB, while in the rural model, only sleep quality plays a complete mediating effect. By comparing the urban and the rural model, it was found that health lifestyle plays a mediating role, but the mechanism behind the difference among the urban and rural models needs further analysis.

5 Discussion

Our study highlights the mediating role of health lifestyle in the residential environment affecting EWB among older adults in China. This study found that residential environments have a positive impact on EWB among the Chinese older-adult population, which is consistent with the consensus of community psychology (85). Based on the health lifestyle theory, we raised this mechanism from the individual level to the hierarchical level. Health lifestyle does not refer to an individuals' health lifestyle; it represents the collective lifestyle of a certain social stratum (57). Living conditions are a structural variable that can impair, maintain, or promote health (86). Socioeconomic status has the strongest effect on health (87, 88). This study found that for older adults with lower socioeconomic status, who tend to have low-quality residential environments and relatively unhealthy lifestyles, socioeconomic status negatively impacted EWB. This revealed the mechanism by which status affects older adults' mental health. Numerous studies have focused on the health hazards caused by natural environmental hazards (89); however, few studies have examined the cumulative effects of the built (90) and humanistic environments (91) on mental health. The health lifestyle theory focuses more on lifestyles conducive to health promotion than environmental exposure to health hazards.

Our study confirmed that mental health disparities are widespread among the older population in China. The role of residential environment and health lifestyle in the formation of EWB disparity in the older population is significant, and prior exposure to housing disadvantage may impact mental health later in life (92). The living environment extends the living disadvantage to the community level beyond housing conditions. Macrosocial structure has a profound influence on mental health through community life as a mesoscopic path and daily life as a microcosmic path. Thus, promoting health equity in the relationship between class structure and individual EWB requires improving the residential environment and fostering good health lifestyles through public health policies implemented by the government. Old age is the later stage of life, and health disparities are the outcome of the accumulation of health behaviors, resources, and risks (93). Mental health disparities in old age are difficult to overcome using individual resources and require

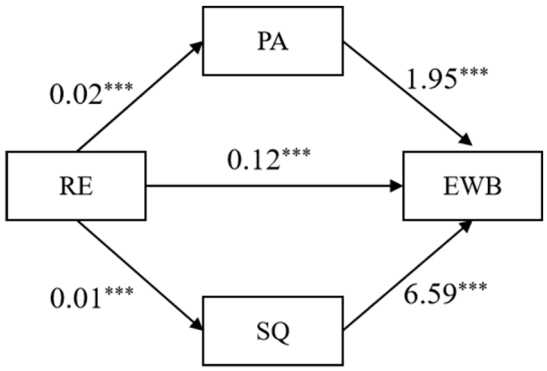


FIGURE 2
The mechanism of residential environments affecting EWB.

TABLE 5 Variable effects in the SEM model.

	Estimate	SE	CR	*p*-value	Total effect	Direct effect	Indirect effect
SQ ← RE	0.007	0.001	4.797	<0.001	0.149	0.149	0.000
PA ← RE	0.021	0.003	7.220	<0.001	0.222	0.222	0.000
EWB ← RE	0.119	0.032	3.719	<0.001	0.193	0.112	0.081
EWB ← SQ	6.588	0.689	9.559	<0.001	0.282	0.282	0.000
EWB ← PA	1.953	0.338	5.781	<0.001	0.173	0.173	0.000

TABLE 6 Variable effects in urban and rural models.

	Urban model			Rural model		
	Standardized estimate	Total effect	Indirect effect	Standardized estimate	Total effect	Indirect effect
SQ ← RE	0.126**	0.126	0.000	0.185***	0.185	0.000
PA ← RE	0.192***	0.192	0.000	0.182***	0.182	0.000
EWB ← RE	0.132***	0.209	0.077	0.072	0.137	0.065
EWB ← SQ	0.318***	0.318	0.000	0.276***	0.276	0.000
EWB ← PA	0.192***	0.192	0.000	0.078	0.078	0.000

***$p < 0.001$, **$p < 0.05$.

broader public health policies and social synergies. Health equity should include health throughout the lifecycle, and health equity in old age should not be ignored.

This study examined the urban–rural differences in the mediating effects of health lifestyles. Widespread mental health disparities exist between urban and rural areas in China (94). In China, urban and rural areas exhibit regional differences and are a key element of the social structure that affects health and healthcare (95, 96). Chinese adults over the age of 60 were affected by the reform and opening-up policy in their early adulthood. Older adults in urban areas live in more modern communities than rural older adults, and their lifestyle is becoming relatively healthier and more modern (80). The effects of residential environment and health lifestyle were observed only in modern urban communities, with no significant effect on EWB among older people in rural areas. As China continues to modernize, the effects of health lifestyles may emerge in rural areas.

The effects of the residential environment and health lifestyle on EWB differed between urban and rural areas. This effect exists among the urban older population but does not apply to the rural older population. We believe that the differences in the mediating effects of health lifestyles between urban and rural areas can be analyzed from both resource perspective and culture perspective. From the resource perspective, China have created a two-class society based on hukou status with sharp rural–urban distinctions in the public provision of health care and housing (97). the payment ability and residential environment quality of urban older adults are better than those of rural older adults (98). Most rural older adults generally have poor residential environments, which do not affect their EWB. Urban communities have developed public infrastructure, making urban communities generally liveable; however, rural communities are mainly composed of natural landscapes, and there is little difference in living environment. Older adults in urban communities showed advantages in terms of residential environment, health lifestyle, and EWB compared to those in rural communities. In addition, the heterogeneity of these variables in the urban older population was higher than that in the rural older population; therefore, older adults in rural communities exhibited disadvantages in terms of EWB and health lifestyle. From a cultural perspective, cities and rural areas are different cultural systems. In *Peasant Society and Culture: An Anthropological Approach to Civilization*, Redfield (99)proposes the great tradition represented by cities and the little tradition represented by the countryside. "The great tradition" implies the heterogeneity of personal characteristics and means that to pursuit a healthy lifestyle. In contrast, older adults in "the little tradition" have strong homogeneity and follow traditional and conventional lifestyles. Therefore, resources and culture are two possible explanatory paths. Further research is needed to verify these two explanatory pathways.

There are several limitations in this study. EWB has not been clarified (5). The study was based on the analysis of secondary data, and the operationalization and measurement of variables were limited. In addition, the study only analyzed community-dwelling older adults and did not include older people living in nursing homes. The reasons for the differences between urban and rural areas in the effects of residential environment and the mediating effects of health lifestyle also need to be further analyzed and verified.

6 Conclusion

This study examined the effects of the residential environment on EWB and the mediating role of health lifestyles among older adults in urban and rural communities in China. Our findings revealed that older adults in urban areas had better EWB, residential environment, and physical activity than those in rural areas. The effect of residential environment on EWB were demonstrated, and health lifestyle played an important mediating role. Residential environment and health lifestyle did not have a significant effect on EWB in rural older adults. This study provided empirical evidence of mental health disparities among older adults in rural and urban areas of China. The study reveals the important role of health lifestyle in translating inequality in residential environments into disparity in EWB. To counter the effects of such health inequalities, it is necessary to foster healthier lifestyles and improve the quality of the residential environment within communities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ZH: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. JH: Data curation, Methodology, Writing – review & editing. ZZ: Methodology, Visualization, Writing – review & editing. YZ: Conceptualization, Formal analysis, Project administration, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by the Jin Shanbao Institute for Agriculture & Rural Development (No. YZKKT2022014, No. YZZKT2023016) and Jiangsu Provincial Health Development Research Center (No. JSHD2022023).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Andreas S, Schulz H, Volkert J, Dehoust M, Sehner S, Suling A, et al. Prevalence of mental disorders in elderly people: the European MentDis_ICF65+ study. *Br J Psychiatry*. (2017) 210:125–31. doi: 10.1192/bjp.bp.115.180463

2. Li H, Ji Y, Chen T. The roles of different sources of social support on emotional well-being among Chinese elderly. *PloS one*, (2014). 9:e90051. doi: 10.1371/journal.pone.0090051

3. Keyes CLM. Complete mental health: an agenda for the 21th century In: CLM Keyes and J Haidt, editors. *Flourishing: positive psychology and the life well-lived*. Washington, DC: American Psychological Association (2003). 293–312.

4. Ostir GV, Markides KS, Black SA, Goodwin JS. Emotional well-being predicts subsequent functional independence and survival. *J Am Geriatr Soc*. (2000) 48:473–8. doi: 10.1111/j.1532-5415.2000.tb04991.x

5. Koslouski JB, Wilson-Mendenhall CD, Parsafar P, Goldberg S, Martin MY, Chafouleas SM. Measuring emotional well-being through subjective report: a scoping review of reviews. *BMJ Open*. (2022) 12:e062120. doi: 10.1136/bmjopen-2022-062120

6. Park CL, Kubzansky LD, Chafouleas SM, Davidson RJ, Keltner D, Parsafar P, et al. Emotional well-being: What it is and why it matters. *Affective Science*, (2023) 4:10–20. doi: 10.1007/s42761-022-00163-0

7. OECD. How's Life? 2020: Measuring Well-being, Paris: OECD Publishing (2020).

8. Trudel-Fitzgerald C, Millstein RA, von Hippel C, Howe CJ, Tomasso LP, Wagner GR, et al. Psychological well-being as part of the public health debate? Insight into dimensions, interventions, and policy. *BMC Public Health*. (2019) 19:1712. doi: 10.1186/s12889-019-8029-x

9. Feller SC, Castillo EG, Greenberg JM, Abascal P, Van Horn R, Wells KB, University of California, Los Angeles Community Translational Science Team, et al. Emotional well-being and public health: Proposal for a model national initiative. *Public Health Reports*. (2018) 133:136–41. doi: 10.1177/0033354918754542

10. Gross JJ, Uusberg H, Uusberg A. Mental illness and well-being: an affect regulation perspective. *World Psychiatry*. (2019) 18:130–9. doi: 10.1002/wps.20618

11. Hernandez R, Bassett SM, Boughton SW, Schuette SA, Shiu EW, Moskowitz JT. Psychological well-being and physical health: associations, mechanisms, and future directions. *Emot Rev*. (2018) 10:18–29. doi: 10.1177/1754073917697824

12. Charles ST, Rush J, Piazza JR, Cerino ES, Mogle J, Almeida DM. Growing old and being old: emotional well-being across adulthood. *J Pers Soc Psychol*. (2023) 125:455–69. doi: 10.1037/pspp0000453

13. Mroczek DK. Age and emotion in adulthood. *Curr Dir Psychol Sci*. (2001) 10:87–90. doi: 10.1111/1467-8721.00122

14. Christner N, Essler S, Hazzam A, Paulus M. Children's psychological well-being and problem behavior during the COVID-19 pandemic: an online study during the lockdown period in Germany. *PLoS One*. (2021) 16:e0253473. doi: 10.1371/journal.pone.0253473

15. Kohls E, Baldofski S, Moeller R, Klemm S-L, Rummel-Kluge C. Mental health, social and emotional well-being, and perceived burdens of university students during COVID-19 pandemic lockdown in Germany. *Front Psych*. (2021) 12:643957. doi: 10.3389/fpsyt.2021.643957

16. Ready RE, Akerstedt AM, Mroczek DK. Emotional complexity and emotional well-being in older adults: risks of high neuroticism. *Aging Ment Health*. (2012) 16:17–26. doi: 10.1080/13607863.2011.602961

17. Mikels, JA and Young, NA. New directions in theories of emotion and aging. *Oxford research encyclopedia of psychology*. (2018). doi: 10.1093/acrefore/9780190236557.013.339

18. Labouvie-Vief G, GrÜhn GD, Studer J. Dynamic Integration of Emotion and Cognition: Equilibrium Regulation in Development and Aging. In (eds.). Lerner Richard M, Lamb Michael E and Freund Alexandra M. *The Handbook of Life-Span Development*. Hoboken, NJ: John Wiley and Sons. (2010).

19. Labouvie-Vief G. Dynamic integration: affect, cognition, and the self in adulthood. *Curr Dir Psychol Sci*. (2003) 12:201–6. doi: 10.1046/j.0963-7214.2003.01262.x

20. Fakoya OA, McCorry NK, Donnelly M. Loneliness and social isolation interventions for older adults: a scoping review of reviews. *BMC Public Health*. (2020) 20:129. doi: 10.1186/s12889-020-8251-6

21. Atzendorf J, Gruber S. Depression and loneliness of older adults in Europe and Israel after the first wave of covid-19. *Eur J Ageing*. (2022) 19:849–61. doi: 10.1007/s10433-021-00640-8

22. Power JMH, Hannigan C, Hyland P, Brennan S, Kee F, Lawlor BA. Depressive symptoms predict increased social and emotional loneliness in older adults. *Aging Ment Health*. (2020) 24:110–8. doi: 10.1080/13607863.2018.1517728

23. Wei J, Hou R, Zhang X, Xu H, Xie L, Chandrasekar E, et al. The association of late-life depression with all-cause and cardiovascular mortality among community-dwelling older adults: systematic review and meta-analysis. *Br J Psychiatry*. (2019) 215:449–55. doi: 10.1192/bjp.2019.74

24. Scheibe S, Carstensen LL. Emotional aging: recent findings and future trends. *J Gerontol Psychol Sci*. (2010) 65B:135–44. doi: 10.1093/geronb/gbp132

25. Carstensen LL, Shavit YZ, Barnes JT. Age advantages in emotional experience persist even under threat from the COVID-19 pandemic. *Psychol Sci*. (2020) 31:1374–85. doi: 10.1177/0956797620967261

26. Lopez J, Perez-Rojo G, Noriega C, Carretero I, Velasco C, Martinez-Huertas JA, et al. Psychological well-being among older adults during the COVID-19 outbreak: a comparative study of the young–old and the old–old adults. *Int Psychogeriatr*. (2020) 32:1365–70. doi: 10.1017/s1041610220000964

27. Carstensen LL. The influence of a sense of time on human development. *Science*. (2006) 312:1913–5. doi: 10.1126/science.1127488

28. Charles ST. Strength and vulnerability integration: a model of emotional well-being across adulthood. *Psychol Bull*. (2010) 136:1068–91. doi: 10.1037/a0021232

29. Windle G, Hughes D, Linck P, Russell I, Woods B. Is exercise effective in promoting mental well-being in older age? A systematic review. *Aging Ment Health*. (2010) 14:652–69. doi: 10.1080/13607861003713232

30. Cotten SR, Schuster AM, Seifert A. Social media use and well-being among older adults. *Curr Opin Psychol*. (2022) 45:101293. doi: 10.1016/j.copsyc.2021.12.005

31. Yang HL, Zhang S, Zhang WC, Shen Z, Wang JH, Cheng SM, et al. Volunteer service and well-being of older people in China. *Front Public Health*. (2022) 10:777178. doi: 10.3389/fpubh.2022.777178

32. Kang H, Kim H. Ageism and psychological well-being among older adults: a systematic review. *Gerontol. Geriatr. Med.* (2022) 8:233372142210870. doi: 10.1177/23337214221087023

33. Chen Y, Feeley TH. Social support, social strain, loneliness, and well-being among older adults: an analysis of the health and retirement study. *J Soc Pers Relat*. (2014) 31:141–61. doi: 10.1177/0265407513488728

34. Cramm JM, Nieboer AP. Social cohesion and belonging predict the well-being of community-dwelling older people. *BMC Geriatr*. (2015) 15:30–10. doi: 10.1186/s12877-015-0027-y

35. Gagliardi C, Marcellini F, Papa R, Giuli C, Mollenkopf H. Associations of personal and mobility resources with subjective well-being among older adults in Italy and Germany. *Arch Gerontol Geriatr*. (2010) 50:42–7. doi: 10.1016/j.archger.2009.01.007

36. Lei X, Bai C, Hong J, Liu H. Long-term care insurance and the well-being of older adults and their families: evidence from China. *Soc Sci Med*. (2022) 296:114745. doi: 10.1016/j.socscimed.2022.114745

37. Ermer AE, Proulx CM. The association between relationship strain and emotional well-being among older adult couples: the moderating role of social connectedness. *Aging Ment Health*. (2021) 26:1198–206. doi: 10.1080/13607863.2021.1910786

38. Katz R. Intergenerational family relations and subjective well-being in old age: a cross-national study. *Eur J Ageing*. (2009) 6:79–90. doi: 10.1007/s10433-009-0113-0

39. Poulin J, Deng R, Ingersoll TS, Witt H, Swain M. Perceived family and friend support and the psychological well-being of American and Chinese elderly persons. *J Cross Cult Gerontol*. (2012) 27:305–17. doi: 10.1007/s10823-012-9177-y

40. Gough C, Lewis LK, Barr C, Maeder A, George S. Community participation of community dwelling older adults: a cross-sectional study. *BMC Public Health*. (2021) 21:612. doi: 10.1186/s12889-021-10592-4

41. Dalton JH, et al. *Community psychology: linking individuals and communities*. Belmont: Wadsworth Cengage Learning (2012).

42. Mouratidis K. Urban planning and quality of life: a review of pathways linking the built environment to subjective well-being. *Cities*. (2021) 115:103229. doi: 10.1016/j.cities.2021.103229

43. Ding N, Berry HL, O'Brien LV. One-year reciprocal relationship between community participation and mental wellbeing in Australia: a panel analysis. *Soc Sci Med*. (2015) 128:246–54. doi: 10.1016/j.socscimed.2015.01.022

44. Dong H, Qin B. Exploring the link between neighborhood environment and mental wellbeing: a case study in Beijing, China. *Landsc Urban Plan*. (2017) 164:71–80. doi: 10.1016/j.landurbplan.2017.04.005

45. Chen L, Zhang Z. Community participation and subjective well-being of older adults: the roles of sense of community and neuroticism. *Int. J. Environ. Res. Public Health*. (2022) 19:3261. doi: 10.3390/ijerph19063261

46. Fingerman KL, Ng YT, Zhang S, Britt K, Colera G, Birditt KS, et al. Living alone during COVID-19: social contact and emotional well-being among older adults. *J. Gerontol. B.* (2021) 76:e116–21. doi: 10.1093/geronb/gbaa200

47. Ji Q, Yin M, Li Y, Zhou X. Exploring the influence path of high-rise residential environment on the mental health of the elderly. *Sustain Cities Soc*. (2023) 98:104808. doi: 10.1016/j.scs.2023.104808

48. Tsai WL, Silva RA, Nash MS, Cochran FV, Prince SE, Rosenbaum DJ, et al. How do natural features in the residential environment influence women's self-reported general health? Results from cross-sectional analyses of a U.S. national cohort. *Environ Res*. (2020) 183:109176. doi: 10.1016/j.envres.2020.109176

49. Zhang Z, Zhang J. Perceived residential environment of neighborhood and subjective well-being among the elderly in China: a mediating role of sense of community. *J Environ Psychol*. (2017) 51:82–94. doi: 10.1016/j.jenvp.2017.03.004

50. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q*. (1988) 15:351–77. doi: 10.1177/109019818801500401

51. Wang X, Wu Y, Miao J, Pu K, Ming WK, Zang S. Factors associated with eating behaviors in older adults from a socioecological model perspective. *BMC Public Health*. (2023) 23:1726. doi: 10.1186/s12889-023-16651-2

52. Wang Y, Li N, Zhu J, Deng Q, Hu J, Xu J, et al. Association between socio-ecological factors and leisure time physical activity (LTPA) among older adults in Sichuan, China: a structural equation modeling analysis. *BMC Geriatr*. (2022) 22:60. doi: 10.1186/s12877-021-02730-9

53. Guzman V, Doyle F, Foley R, Craven P, Crowe N, Wilson P, et al. Socio-ecological determinants of older people's mental health and well-being during COVID-19: a qualitative analysis within the Irish context. *Front Public Health*. (2023) 11:1148758. doi: 10.3389/fpubh.2023.1148758

54. Linke SE, Robinson CJ, Pekmezi D. Applying psychological theories to promote healthy lifestyles. *Am J Lifestyle Med*. (2013) 8:4–14. doi: 10.1177/1559827613487496

55. Gouveia ÉRQ, Gouveia BR, Ihle A, Kliegel M, Maia JA, i Badia SB, et al. Correlates of health-related quality of life in young-old and old–old community-dwelling older adults. *Qual Life Res*. (2017) 26:1561–9. doi: 10.1007/s11136-017-1502-z

56. He X. Mutual aid for the aged: the way out for the aged in China's rural areas. *J. Nanjing Agric. Univ. (social science)* (2020) 20:1–8. doi: 10.19714/j.cnki.1671-7465.2020.0070

57. Cockerham WC. Health lifestyles: bringing structure Back In: WC Cockerham, editor. *The new Blackwell companion to medical sociology*: John Wiley & Sons Inc (2021). 159–83.

58. Cockerham WC, Rütten A, Abel T. Conceptualizing contemporary health lifestyles: moving beyond Weber. *Sociol Q*. (1997) 38:321–42. doi: 10.1111/j.1533-8525.1997.tb00480.x

59. Maenhout L, Peuters C, Cardon G, Compernolle S, Crombez G, DeSmet A. The association of healthy lifestyle behaviors with mental health indicators among adolescents of different family affluence in Belgium. *BMC Public Health*. (2020) 20:958–13. doi: 10.1186/s12889-020-09102-9

60. Cockerham WC. Health lifestyle theory and the convergence of agency and structure. *J Health Soc Behav*. (2005) 46:51–67. doi: 10.1177/002214650504600105

61. Cockerham WC. Bourdieu and an update of health lifestyle theory In: WC Cockerham, editor. *Medical sociology on the move: new directions in theory*: Springer Dordrecht (2013). 127–54.

62. Korp P. The symbolic power of "healthy lifestyles." *Health Sociol Rev*. (2008) 17:18–26. doi: 10.5172/hesr.451.17.1.18

63. Alvarez CH, Evans CR. Intersectional environmental justice and population health inequalities: a novel approach. *Soc Sci Med*. (2021) 269:113559. doi: 10.1016/j.socscimed.2020.113559

64. Xue Y, Lu J, Zheng X, Zhang J, Lin H, Qin Z, et al. The relationship between socioeconomic status and depression among the older adults: the mediating role of health promoting lifestyle. *J Affect Disord*. (2021) 285:22–8. doi: 10.1016/j.jad.2021.01.085

65. Cumming E, Dean LR, Newell DS. Disengagement, a tentative theory of aging. *Sociometry*. (1960) 23:23–35. doi: 10.2307/2786135

66. Liu Y, Dijst M, Geertman S. The subjective well-being of older adults in Shanghai: the role of residential environment and individual resources. *Urban Stud*. (2017) 54:1692–714. doi: 10.1177/0042098016630512

67. Lawton MP. Three functions of the residential environment. *J Hous Elder*. (1989) 5:35–50. doi: 10.1300/j081v05n01_04

68. Fernández-Portero C, Alarcón D, Barrios Padura Á. Dwelling conditions and life satisfaction of older people through residential satisfaction. *J Environ Psychol*. (2016) 49:1–7. doi: 10.1016/j.jenvp.2016.11.003

69. Tawil N, Sztuka IM, Pohlmann K, Sudimac S, Kühn S. The living space: psychological well-being and mental health in response to interiors presented in virtual reality. *Int J Environ Res Public Health*. (2021) 18:12510. doi: 10.3390/ijerph182312510

70. Heyl V, Wahl HW, Mollenkopf H. Visual capacity, out-of-home activities and emotional well-being in old age: basic relations and contextual variation. *Soc Indic Res*. (2005) 74:159–89. doi: 10.1007/s11205-005-6522-3

71. Schroeer C, Voss S, Jung-Sievers C, Coenen M. Digital formats for community participation in health promotion and prevention activities: a scoping review. *Front Public Health*. (2021) 9:713159. doi: 10.3389/fpubh.2021.713159

72. Trabelsi K, Ammar A, Masmoudi L, Boukhris O, Chtourou H, Bouaziz B, et al. Sleep quality and physical activity as predictors of mental wellbeing variance in older adults during COVID-19 lockdown: ECLB COVID-19 international online survey. *Int J Environ Res Public Health*. (2021) 18:4329. doi: 10.3390/ijerph18084329

73. Ye L, Elstgeest LEM, Zhang X, Alhambra-Borrás T, Tan SS, Raat H. Factors associated with physical, psychological, and social frailty among community-dwelling older persons in Europe: a cross-sectional study of urban health Centres Europe (UHCE). *BMC Geriatr*. (2021) 21:422. doi: 10.1186/s12877-021-02364-x

74. McAuley E, Blissmer B, Marquez DX, Jerome GJ, Kramer AF, Katula J. Social relations, physical activity, and well-being in older adults. *Prev Med*. (2000) 31:608–17. doi: 10.1006/pmed.2000.0740

75. Hanson BL, Ruthig JC. The unique role of sleep quality in older adults' psychological well-being. *J Appl Gerontol*. (2012) 31:587–607. doi: 10.1177/0733464810392226

76. Gothe NP, Ehlers DK, Salerno EA, Fanning J, Kramer AF, McAuley E. Physical activity, sleep and quality of life in older adults: influence of physical, mental and social well-being. *Behav Sleep Med*. (2020) 18:797–808. doi: 10.1080/15402002.2019.1690493

77. Carlson JA, Sallis JF, Conway TL, Saelens BE, Frank LD, Kerr J, et al. Interactions between psychosocial and built environment factors in explaining older adults' physical activity. *Prev Med*. (2012) 54:68–73. doi: 10.1016/j.ypmed.2011.10.004

78. Chaudhury H, Campo M, Michael Y, Mahmood A. Neighborhood environment and physical activity in older adults. *Soc Sci Med*. (2016) 149:104–13. doi: 10.1016/j.socscimed.2011.12.039

79. Zhu X, Gao M, Cheng X, Zhao W. Sleep–the guarantee of health! Does the environmental perception characteristics of urban residential areas affect residents' sleep quality? *Front Public Health*. (2023) 10:1017790. doi: 10.3389/fpubh.2022.1017790

80. Gong P, Liang S, Carlton EJ, Jiang Q, Wu J, Wang L, et al. Urbanisation and health in China. *Lancet*. (2012) 379:843–52. doi: 10.1016/s0140-6736(11)61878-3

81. Tang D, Lin Z, Chen F. Moving beyond living arrangements: the role of family and friendship ties in promoting mental health for urban and rural older adults in China. *Aging Ment Health*. (2020) 24:1523–32. doi: 10.1080/13607863.2019.1602589

82. He C, Ye J. Lonely sunsets: impacts of rural-urban migration on the left-behind elderly in rural China. *Popul Space Place*. (2013) 20:352–69. doi: 10.1002/psp.1829

83. Zhang L, Ding Z, Qiu L, Li A. Falls and risk factors of falls for urban and rural community-dwelling older adults in China. *BMC Geriatr*. (2019) 19:379–17. doi: 10.1186/s12877-019-1391-9

84. Yang HL, Wu YY, Lin XY, Xie L, Zhang S, Zhang SQ, et al. Internet use, life satisfaction, and subjective well-being among the elderly: evidence from 2017 China general social survey. *Front Public Health*. (2021) 9:677643. doi: 10.3389/fpubh.2021.677643

85. Trickett EJ. Community psychology: individuals and interventions in community context. *Annu Rev Psychol*. (2009) 60:395–419. doi: 10.1146/annurev.psych.60.110707.163517

86. Cockerham WC. Health lifestyles and the search for a concept of a gender-specific habitus. *Soc Theory Health*. (2017) 16:142–55. doi: 10.1057/s41285-017-0048-z

87. Darin-Mattsson A, Fors S, Kåreholt I. Different indicators of socioeconomic status and their relative importance as determinants of health in old age. *Int J Equity Health*. (2017) 16:173. doi: 10.1186/s12939-017-0670-3

88. Steptoe A, Zaninotto P. Lower socioeconomic status and the acceleration of aging: an outcome-wide analysis. *Proc Natl Acad Sci U S A*. (2020) 117:14911–7. doi: 10.1073/pnas.1915741117

89. Morello-Frosch R, Zuk M, Jerrett M, Shamasunder B, Kyle AD. Understanding the cumulative impacts of inequalities in environmental health: implications for policy. *Health Aff*. (2011) 30:879–87. doi: 10.1377/hlthaff.2011.0153

90. Tang S, Lee H, Feng J. Social capital, built environment and mental health: a comparison between the local elderly people and the 'laopiao' in urban China. *Ageing Soc*. (2022) 42:179–203. doi: 10.1017/S0144686X2000077X

91. Joseph S. How humanistic is positive psychology? Lessons in positive psychology from Carl Rogers' person-centered approach—It's the social environment that must change. *Front Psychol*. (2021) 12:709789. doi: 10.3389/fpsyg.2021.709789

92. Singh A, Daniel L, Baker E, Bentley R. Housing disadvantage and poor mental health: a systematic review. *Am J Prev Med*. (2019) 57:262–72. doi: 10.1016/j.amepre.2019.03.018

93. Barnes TL, MacLeod S, Tkatch R, Ahuja M, Albright L, Schaeffer JA, et al. Cumulative effect of loneliness and social isolation on health outcomes among older adults. *Aging Ment Health*. (2022) 26:1327–34. doi: 10.1080/13607863.2021.1940096

94. Zhang J, Chandola T, Zhang N. Understanding the longitudinal dynamics of rural–urban mental health disparities in later life in China. *Aging Ment Health*. (2023) 27:1419–28. doi: 10.1080/13607863.2022.2098912

95. Chen Y, Yin Z, Xie Q. Suggestions to ameliorate the inequity in urban/rural allocation of healthcare resources in China. *Int J Equity Health*. (2014) 13:34. doi: 10.1186/1475-9276-13-34

96. Xu J, Wang J, King M, Liu R, Yu F, Xing J, et al. Rural–urban disparities in the utilization of mental health inpatient services in China: the role of health insurance. *Int J Health Econ Manag*. (2018) 18:377–93. doi: 10.1007/s10754-018-9238-z

97. Treiman DJ. The "difference between heaven and earth": urban–rural disparities in well-being in China. *Res Soc Stratif Mobil*. (2012) 30:33–47. doi: 10.1016/j.rssm.2011.10.001

98. Zhou K, Tan J, Watanabe K. How does perceived residential environment quality influence life satisfaction? Evidence from urban China. *J Community Psychol*. (2021) 49:2454–71. doi: 10.1002/jcop.22545

99. Redfield, R. *Peasant society and culture: an anthropological approach to civilization*. Chicago: University of Chicago Press (1956).

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 22 April 2024
DOI 10.3389/fpubh.2024.1360285

Check for updates

OPEN ACCESS

EDITED BY
Cyrille Delpierre,
INSERM Public Health, France

REVIEWED BY
Riccardo Manca,
Brunel University London, United Kingdom
Andrzej Klimczuk,
Warsaw School of Economics, Poland
Anne Ouma,
Umeå University, Sweden

*CORRESPONDENCE
Ieva Reine
✉ ieva.reine@pubcare.uu.se

RECEIVED 22 December 2023
ACCEPTED 25 March 2024
PUBLISHED 22 April 2024

CITATION
Reine I, Miķelsone M, Tomsone S, Guðmundsson H, Ivanovs A, Guðmundsson HS and Koroļeva I (2024) Unraveling the dynamics of loneliness in the Baltic-Nordic region: a comparative analysis in the wake of COVID-19.
Front. Public Health 12:1360285.
doi: 10.3389/fpubh.2024.1360285

COPYRIGHT
© 2024 Reine, Miķelsone, Tomsone, Guðmundsson, Ivanovs, Guðmundsson and Koroļeva. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Unraveling the dynamics of loneliness in the Baltic-Nordic region: a comparative analysis in the wake of COVID-19

Ieva Reine[1,2]*, Madara Miķelsone[1], Signe Tomsone[3], Helgi Guðmundsson[4], Andrejs Ivanovs[1], Halldór S. Guðmundsson[5] and Ilze Koroļeva[1,6]

[1]Statistics Unit, Riga Stradiņš University, Riga, Latvia, [2]Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden, [3]Faculty of Rehabilitation, Riga Stradiņš University, Riga, Latvia, [4]Social Science Research Institute, University of Iceland, Reykjavik, Iceland, [5]Faculty of Social Work, University of Iceland, Reykjavik, Iceland, [6]Institute of Philosophy and Sociology, Latvia University, Riga, Latvia

Introduction: The primary aim of this study is to thoroughly investigate the prevalence and determinants of loneliness among older adults in the Baltic-Nordic region. Utilizing high-quality data sources and employing a methodologically rigorous approach, the study endeavors to enhance our understanding of how loneliness manifests and varies across different cultural and socio-economic contexts within these regions. By identifying key factors influencing loneliness, including demographic, social, and economic variables, the research seeks to contribute significantly to the existing body of knowledge on loneliness and inform targeted public health strategies and interventions tailored to the unique needs of older adults in the Baltic and Nordic countries.

Material and methods: This research, centered on older adults aged 67 and above within the Baltic-Nordic region, draws upon data from the Survey of Health, Ageing and Retirement in Europe (SHARE), specifically its eighth wave conducted between June and August 2020. The demographic analysis of this study covers a diverse sample of 5,313 participants from the Baltic and Nordic regions. Specifically, the sample includes 2,377 participants from Nordic countries, namely Sweden, Denmark, and Finland, and 2,936 from the Baltic countries of Estonia, Latvia, and Lithuania. The investigation extends to the financial well-being of households, involving an analysis of 3,925 individuals, with 1,748 from Nordic countries and 2,177 from Baltic countries. Although Iceland is categorized as a Nordic country, the analysis within this study is conducted separately due to the unavailability of SHARE data for this region. Instead, the HL20 study, focusing on the health and well-being of the older adult population in Iceland, contributes data for 1,033 respondents. This methodological distinction allows for a comprehensive understanding of regional differences, highlighting the importance of specialized approaches to examine the intricate dynamics of loneliness and well-being across the Baltic-Nordic region.

Results: The study reveals significant regional variations in loneliness among older adults during the COVID-19 outbreak, with the Baltic countries (Estonia, Latvia, Lithuania) reporting a lower prevalence of loneliness compared to the Nordic countries (Sweden, Denmark, Finland). Iceland, while grouped with the Nordic countries, was analysed separately. Employment emerges as a key factor in reducing loneliness across all regions, suggesting the benefits of social

interactions and structured routines. Gender and marital status significantly influence loneliness, with notable disparities in the Baltic region and smaller gaps in the Nordic countries, reflecting the impact of societal and cultural norms. Additionally, educational attainment and health status show varied associations with loneliness, highlighting the complex interplay of individual and societal factors in these regions.

KEYWORDS

SHARE, loneliness, demographic, health, socio-economic status, Latvia, Iceland, older adult

Introduction

At the heart of this study is the exploration of loneliness, a complex and subjective state where individuals perceive a discrepancy between desired and actual social connections. This encompasses not only the absence of meaningful personal bonds, often termed emotional loneliness, but also the perceived lack of a wider supportive social network, known as social loneliness (1–3). The Baltic and Nordic regions, with their unique socio-cultural landscapes, offer a distinct backdrop for investigating loneliness. These areas are characterized by strong social welfare systems and a cultural emphasis on independence, which play significant roles in shaping individuals' experiences of loneliness. By delving into these regional peculiarities, this study aims to shed light on the multifaceted nature of loneliness and its varied implications for public health within these contexts.

Loneliness, a multifaceted public health issue, extends its impact beyond the realm of emotional well-being, significantly influencing physical and mental health, as well as the overall quality of life (1, 2, 4, 5). The dynamics of loneliness, along with its determinants, exhibit substantial variation across different regions and countries, necessitating a deeper understanding of its global and regional nuances (6).

This variation is particularly evident in the Baltic and Nordic countries, where a range of factors uniquely shapes the prevalence of loneliness among their population (4, 6–10). Factors such as robust social support networks, marital status, and household composition have been identified as protective against loneliness (6, 11). Nonetheless, loneliness emerges as a significant predictor of depressive symptoms and a key determinant in the erosion of quality of life, even when other factors are accounted for (12, 13). Moreover, its association with adverse health outcomes such as cognitive decline, depression, and increased mortality further underscores its severity (5).

In-depth studies in the Baltic and Nordic regions reveal the multifaceted nature of loneliness. Estonia and Latvia, for instance, experience elevated levels of loneliness attributed to financial hardships and disrupted family communications (4, 14). Latvia, in particular, has shown a linkage between increased loneliness and factors like heightened irritability and reduced familial contact (15–17).

Within the Nordic countries, the frequency of social interactions and living arrangements significantly influence the experience of loneliness. Lower social contact frequencies and solitary living arrangements are strongly associated with higher levels of loneliness (18). Each Nordic country also faces unique challenges; for example, concerns about neighborhood safety in Sweden and Denmark, and income-related worries in Sweden and Finland. Emotional support scarcity has been noted as a factor in Denmark, Finland, and Sweden (19).

As we delve deeper into the intricacies of loneliness in the Baltic and Nordic countries, a complex web of individual, societal, and cultural factors becomes evident. Research spanning 25 European countries indicates geographical distinctions in loneliness experiences, with Northern European countries typically reporting lower loneliness rates compared to their Eastern counterparts (3). When comparing these findings at a broader European level, the distinct nature of loneliness within the Baltic and Nordic regions becomes even more apparent. Nordic countries like Finland, Norway, Sweden, and Denmark generally report lower levels of loneliness compared to Eastern European countries such as Latvia, which exhibit the highest prevalence (9, 18).

A global meta-analysis spanning over 113 countries further corroborates these regional trends (20). Moreover, loneliness's implications extend beyond emotional distress. In Sweden, for example, older individuals experiencing loneliness have shown a higher propensity to utilize outpatient healthcare services, highlighting loneliness as a significant factor in healthcare utilization and costs (21, 22).

The COVID-19 pandemic has brought additional attention to the vulnerability of ageing populations to loneliness, particularly in the Baltic states. In Latvia, increased anxiety and disrupted familial interactions have been identified as noteworthy predictors of loneliness among older adults (14, 23).

This article aims to explore and elucidate the complex dynamics of loneliness within the Baltic and Nordic countries. By examining various factors influencing loneliness, identifying at-risk populations, and proposing evidence-based interventions, we seek to contribute to the growing body of knowledge on this crucial public health issue.

A significant aspect of this study is to examine the results from Iceland, particularly in the context of loneliness, and compare them with findings from the Nordic countries (24). This comparison aims to determine if Iceland's patterns align with those observed in the Nordic region or if they present distinct trends. Through this analysis, we hope to not only validate our methodological approach (16, 25) but also contribute to a deeper understanding of regional dynamics in these European countries (18). This effort reflects a broader aim to enhance the comparability of data across different national contexts, thereby enriching the scope and depth of regional studies.

Primary objective and scope

The primary objective of our research is to undertake a thorough comparative analysis of loneliness across demographic, socio-economic, and health domains, with an emphasis on the impact of the COVID-19 pandemic in the Baltic-Nordic region. Given the scarcity of research in this area, our study aims to fill a significant gap in the understanding of loneliness among older adults in this region.

Building on the insights from our comparative study of loneliness in Latvia and Iceland (16, 25), we aim to extrapolate these findings to the wider Baltic-Nordic context. This extension is crucial in determining whether the patterns and determinants of loneliness identified in the initial Latvia-Iceland comparison are consistent and applicable across the broader region.

A key challenge in our study is the examination of loneliness factors within the individual Nordic countries, particularly due to the variance in databases used in each country. To overcome this, we are committed to developing and employing robust constructs that enable meaningful and reliable comparisons between the diverse datasets. These constructs are specifically designed to harmonize different data collection methods and metrics, ensuring the comparability and validity of our analysis.

By successfully addressing these challenges, we anticipate that our study will significantly enhance the understanding of the dynamics of loneliness in the Baltic-Nordic region, especially in light of the recent global health crisis. The findings are expected to inform the development of targeted interventions and policies, tailored to the unique needs and circumstances of the older adult population in this region. Ultimately, our research aims to contribute valuable insights into the prevalence and determinants of loneliness, facilitating informed and effective public health responses in the Baltic-Nordic context.

Our study is primarily guided by the question, "How do the patterns and determinants of loneliness among older adults during the COVID-19 pandemic compare across the Baltic and Nordic regions, and what implications do these findings have for public health policy and interventions in these areas?"

Building upon our preceding research (16, 25), we further explore whether the patterns of loneliness prevalence and its determinants, as observed in the Latvia-Iceland comparative study, are consistent across the broader Nordic-Baltic region and within individual Nordic countries. This inquiry is particularly significant in the context of the methodological challenges presented by the use of different databases. To address these research questions, our study will focus on harmonizing data from various sources, ensuring comparability of variables and constructs across the datasets. This harmonization is crucial for drawing valid conclusions from diverse data sources.

Methodology

Data sources and population

The data for this study were obtained from two sources utilizing secondary data: The Survey of Health, Ageing and Retirement in Europe (SHARE) for the Nordic countries and the Health and Life conditions of the population of Iceland aged 67 and older (HL20) study for Iceland.

Thus, this study draws upon robust data from two distinct sources to comprehensively assess the prevalence and determinants of loneliness among older adults in the Baltic-Nordic region. The research leveraged data from the eighth wave of the Survey of Health, Ageing, and Retirement in Europe (SHARE), conducted between June and August 2020. SHARE is internationally renowned for its rigorous data collection practices and its profound influence on elevating research standards in the realm of social sciences (26). SHARE's significance transcends the boundaries of the European Union. Notably, it meticulously encompasses all EU member countries through stringent harmonization processes, ensuring the comparability and reliability of data across countries. Furthermore, SHARE contributes to a global network of related studies, extending its reach from the Americas to Eastern Asia, and thus enhancing its impact and relevance beyond the European context. The utilization of SHARE data not only ensured the comprehensive coverage of the study population but also upheld the highest standards in research and scientific data collection, aligning with SHARE's reputation for excellence in these domains.

The study population included older adults aged 67 and above within the Baltic-Nordic region, drawing participants from the Nordic countries of Sweden, Denmark, and Finland, and the Baltic states of Estonia, Latvia, and Lithuania. The total sample comprised 5,313 individuals, with 2,377 from the Nordic countries and 2,936 from the Baltic states. The research also delved into the financial well-being of 3,925 participants, including 1,748 from the Nordic region and 2,177 from the Baltic states.

It is crucial to note the separate analysis of Iceland, a Nordic country, due to the lack of SHARE data availability. Instead, the HL20 study provided insights into the health and well-being of 1,033 older adult Icelandic individuals, enriching the study's comparative perspective on regional differences in loneliness and well-being within the Baltic-Nordic area. Furthermore, to facilitate meaningful comparisons, this study narrowed its focus to respondents aged 67 and older, ensuring that the sample aligns with the age range studied in Iceland.

The HL20 study, known as "Health and Life conditions of the population of Iceland aged 67 and older," was conducted over a three-month period from November 2020 to January 2021. The study targeted Icelandic citizens who had reached retirement age and employed a simple random sample approach, selecting 1,800 individuals from the national registry. Ultimately, 1,033 respondents completed the survey.

The overarching aim of the HL20 study was to explore various aspects of well-being among older individuals in Iceland. It delved into physical and mental health, social participation, and financial stability, offering comprehensive insights into the conditions of the older adult population in Iceland. This initiative was part of a broader endeavour to better understand the needs and challenges faced by ageing individuals in Iceland, contributing valuable data for public health planning and policy-making. The findings from the HL20 study have been instrumental in shaping our understanding of loneliness and its determinants, particularly within the Icelandic context.

In our analysis, we draw upon the insights provided by Rapeli et al. (24), offering a comparative perspective on the response of the Nordic countries, Iceland included, to the COVID-19 pandemic, with a particular focus on older adult care strategies. This will help us illustrate Iceland's approach to maintaining social connections amidst

pandemic restrictions. Guðmundsson (27) provides an analysis of the circumstances of senior citizens in Iceland in 2020, offering valuable data on how the pandemic and related containment measures affected the well-being and social isolation of the older population. By comparing these findings with those from the Baltic and Nordic regions, we can discern unique socio-cultural and economic factors influencing loneliness among the older population in Iceland.

In comparing older populations in Latvia and Iceland, we have employed a standardized approach to ensure data comparability. This involved individuals aged 67 and above, utilizing SHARE for Latvia and HL20 data for Iceland (16, 25). Key demographic variables—gender, age, marital status, education, employment, financial stability, and health—were harmonized. The categorization of responses was also restructured for consistency, as outlined in previous research (16). This methodological framework is not only insightful for Latvia and Iceland but is now being applied to other populations in the Nordic-Baltic region, expanding its scope and enriching the understanding of ageing across diverse cultural and socio-economic contexts.

In summary, by judiciously harmonizing data sources and adopting a consistent age criterion, this study has harnessed the power of SHARE alongside Icelandic data to facilitate a meaningful and insightful comparison of loneliness prevalence and associated factors among older adults in the Baltic-Nordic region and Iceland. This methodological approach ensures both the reliability of findings and the ability to draw insightful cross-country comparisons.

Assessment of variables

Loneliness, as the outcome variable, was categorized based on the available measures in each participating country, reflecting the diversity in data collection approaches. For countries utilizing the SHARE (Survey of Health, Ageing and Retirement in Europe) data, loneliness was assessed with the question, "How often do you feel lonely?" This allowed for a nuanced understanding of the frequency and intensity of loneliness experiences among respondents. In contrast, the loneliness indicator for Iceland, which relied on data from a different source, was determined by a more direct query, "Would you say that you are lonely?" This dichotomy in measurement approaches highlights the need to carefully consider and adapt to the specific methodologies employed in each country, ensuring that the loneliness assessments are both accurate and contextually relevant.

Demographic variables including gender, age groups, marital status, education, employment, financial situation, and health and wellbeing were standardized for comparative purposes. Health-related variables encompassed self-reported measures of physical and mental health status and self-assessment of change over time.

Response options underwent meticulous review and graphical arrangement to ensure consistency across countries. This standardization facilitated effective categorization of loneliness as an outcome variable, adhering to available measures in each country, enabling a coherent comparison.

These methodologies were selected for their reliability and validity in capturing the multifaceted nature of loneliness, mental health, and physical health within the studied population, aiming to achieve a comprehensive understanding of the factors influencing loneliness and its association with mental and physical health.

Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics v.27, Jamovi v. 2.3.18, and R v.4.3.0. We began with descriptive statistics to summarize the characteristics of the study population and the distribution of key variables. This provided an overview of the sample and highlighted preliminary patterns in the data.

For inferential analyses, we employed a combination of techniques to examine the associations between loneliness and the variables of interest. The Pearson Chi-square test was utilized to assess categorical variables, allowing us to explore relationships between socio-demographic factors and loneliness levels.

Results

Feelings of loneliness and demographic factors in the Baltic region, Nordic countries, and Iceland

Figure 1 illustrates the distribution of loneliness among older adults in the Baltic region, Nordic countries, and Iceland, divided into two age brackets: 67–75 years and those 76 years and above. In the Baltic region, 40% of the older age group and 28% of the younger group report experiencing loneliness often or sometimes. The Nordic countries show lower prevalence, with 28% of the older group and 18% of the younger group reporting loneliness. In Iceland, the rates are similar across age groups, with about 30% reporting loneliness.

Statistical analysis confirms the significance of these findings for the Baltic and Nordic regions. However, the Icelandic data, with its higher p-value, indicates less certainty about the age-related differences in loneliness.

Both the Nordic and Baltic regions show a statistically significant difference in loneliness between the two age groups, with a greater proportion of individuals aged 76 and above reporting loneliness compared to the 67–75 age group. This trend is consistent in both regions, albeit with slightly lower percentages in the Nordic countries.

Conversely, Iceland's data does not show a significant difference between age groups, with roughly 30% of individuals in both age brackets reporting loneliness. This suggests a more uniform experience of loneliness across ages in Iceland, unlike the Baltic and Nordic regions where age-related differences are more pronounced.

Therefore, while the Baltic and Nordic regions share similar patterns in how age influences loneliness, the actual percentages reveal that the loneliness experience in the Nordic countries is closer to that of Iceland, marked by a less pronounced age-related disparity.

Figure 2 illustrates the gender-based differences in loneliness within the Baltic region, Nordic countries, and Iceland. The data indicate that women consistently report higher levels of loneliness compared to men across these regions. Specifically, in the Baltic region, 41% of women report often feeling lonely, in contrast to 22% of men. In the Nordic countries, the figures are 27% for women and 17% for men, while in Iceland, 35% of women and 26% of men report feelings of loneliness. These differences are statistically significant, highlighting a gender disparity in loneliness, with the smallest gap observed in Iceland.

Our statistical analysis across the Baltic region, Nordic countries, and Iceland revealed distinct patterns of loneliness influenced by

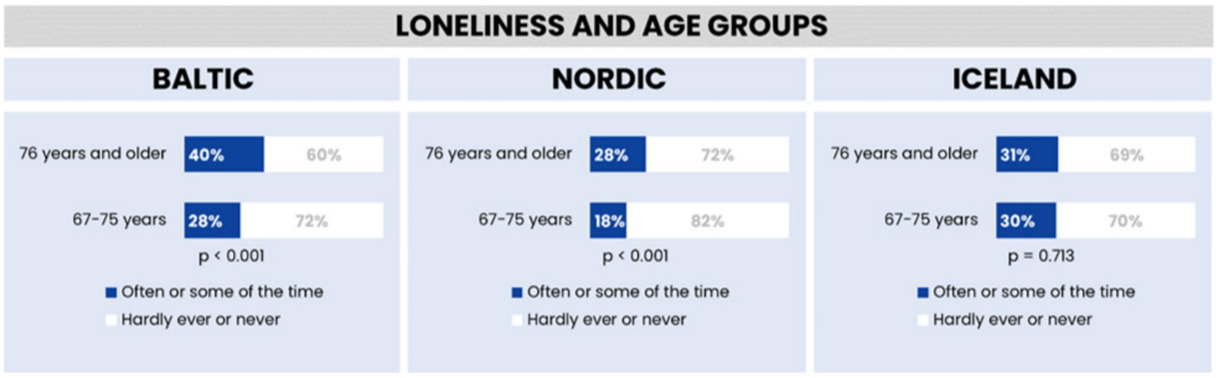


FIGURE 1
Feelings of loneliness across different age groups in the Baltic region, Nordic countries, and Iceland.

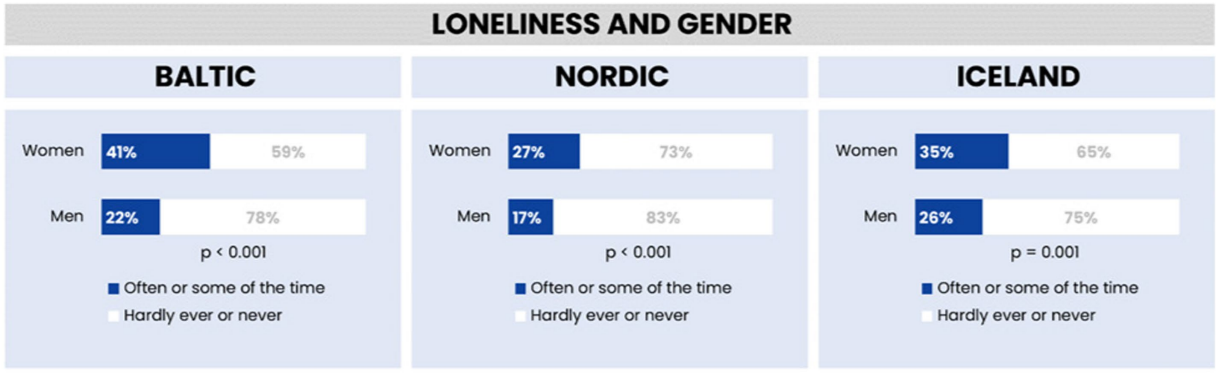


FIGURE 2
Feelings of loneliness by gender in the Baltic region, Nordic countries, and Iceland.

gender and marital status. The analysis showed that, across all regions, women are more likely to report feelings of loneliness compared to men. The gender disparity in reported loneliness was most pronounced in the Baltic region and least pronounced in Iceland, with the Nordic countries showing intermediate levels.

Furthermore, the relationship between marital status and loneliness was examined, revealing significant variations across the three regions. In the Baltic region, there was a notable difference in reported loneliness between individuals living with a partner (19% reported feeling lonely) and those not living with a partner (49% reported feeling lonely). The Nordic countries exhibited a similar trend, though with lower overall percentages (15% for those living with partners and 38% for those not living with partners). In Iceland, while the percentage of those living with partners reporting loneliness (24%) was higher than in the Nordic countries, the pattern remained consistent, with higher loneliness reported among those not living with partners (44%).

The statistical significance of these findings was confirmed with a *p*-value of less than 0.001 across all regions, indicating a robust association between marital status and loneliness. This suggests that living with a partner may be associated with lower levels of reported loneliness, pointing to the potential protective role of cohabitation against loneliness (see Figure 3).

The analysis of loneliness in relation to marital status across the Baltic region, Nordic countries, and Iceland reveals distinct regional variations, highlighting the influence of different social and cultural contexts.

In the Baltic region, the disparity in loneliness between those living with and without a partner is particularly striking. Nearly half (49%) of individuals not living with a partner report feeling lonely often or some of the time, a rate significantly higher than that observed in the Nordic countries and Iceland. This high level of loneliness among single individuals could reflect cultural, social, or economic factors unique to the Baltic region. In contrast, those living with a partner in this region report the lowest rate of loneliness compared to their counterparts in the other regions, indicating the strong protective effect of cohabitation against feelings of loneliness.

The Nordic countries display the lowest overall loneliness rates. Here, only 15% of those living with a partner and 38% of those not living with a partner report feeling lonely. These lower rates across both groups suggest the presence of robust social support systems in these countries, which may help mitigate feelings of loneliness regardless of marital status. The Nordic region's emphasis on social welfare, community support, and overall high quality of life could contribute to these lower rates of loneliness.

Iceland occupies a middle ground, with 24% of individuals living with a partner reporting loneliness, the highest rate for this group among the three regions. However, when considering individuals not living with a partner, Iceland's rate of loneliness is lower than in the Baltic region yet higher than in the Nordic countries. This pattern

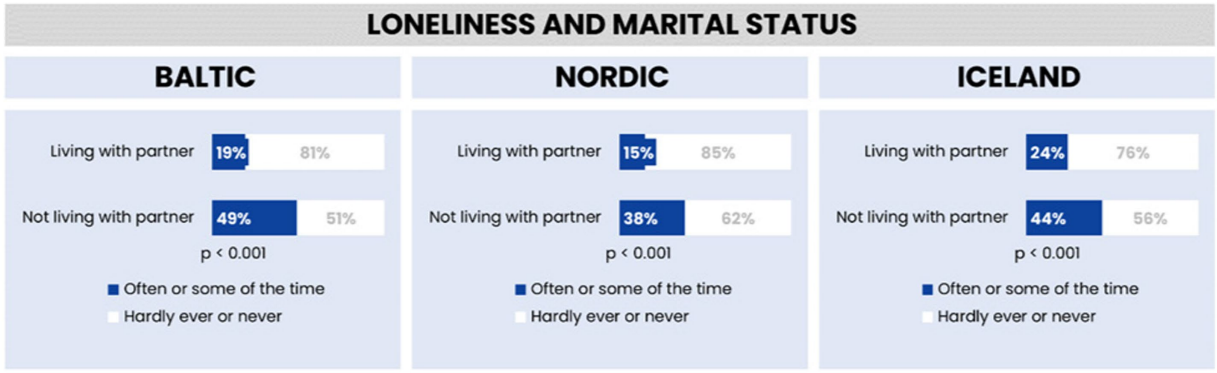


FIGURE 3
Feelings of loneliness by marital status in the Baltic region, Nordic countries, and Iceland.

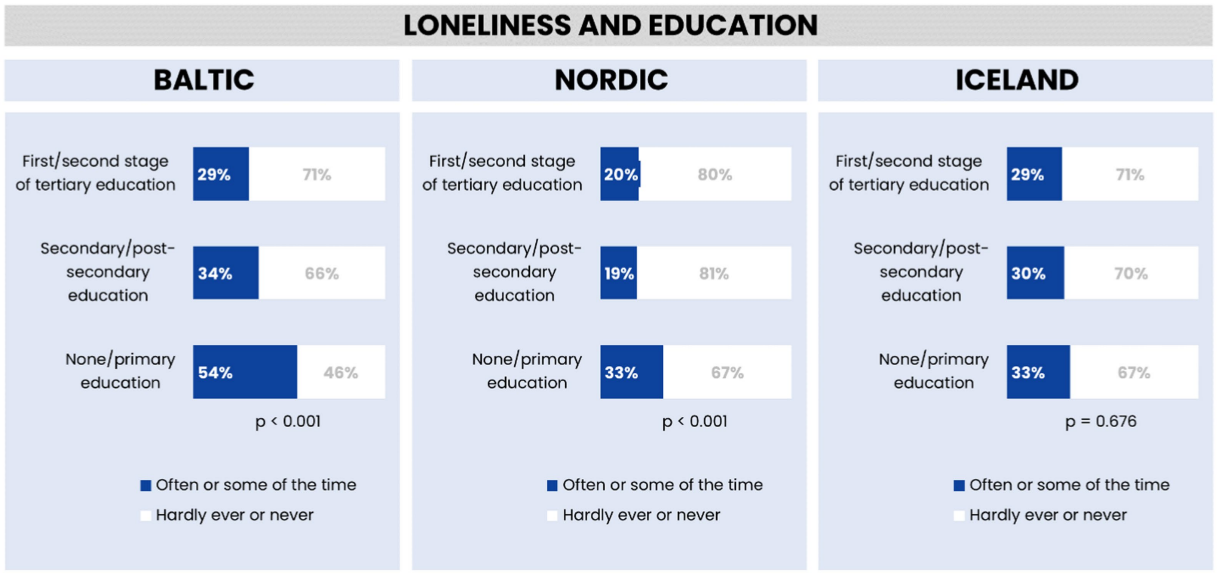


FIGURE 4
Feelings of loneliness by education in the Baltic region, Nordic countries, and Iceland.

might reflect Iceland's unique social fabric, where tight-knit communities possibly play a significant role in influencing feelings of loneliness.

These findings collectively underscore the complex relationship between marital status and loneliness, which varies significantly across different geographic and cultural settings. The differences point to the need for region-specific strategies in addressing loneliness, taking into consideration the unique social dynamics and support systems present in each area.

Feelings of loneliness and socio-economic factors in the Baltic region, Nordic countries, and Iceland

Figure 4 shows an association between educational levels and loneliness in the Baltic region, Nordic countries, and Iceland. Higher levels of education are linked to lower reports of loneliness in the Baltic and Nordic regions. In the Baltic, those with no or primary education report the highest loneliness at 54%, followed by those with secondary education at 34%, and tertiary educated individuals at 29%. A similar trend is observed in the Nordic countries, with 33% of the least educated feeling lonely, 19% with secondary education, and 20% with tertiary education. In contrast, Iceland shows an equal percentage of loneliness (33%) among those with no or primary education and secondary education, with a slightly lower rate (29%) for those with tertiary education, but the differences are not statistically significant, suggesting education may not be a strong factor in loneliness there.

The Nordic countries have the lowest reported loneliness among the highly educated (20%) compared to the Baltic and Iceland (both at 29%). Statistically, education seems to affect loneliness in the Baltic and Nordic regions, but not significantly in Iceland. The Nordic region generally shows less loneliness across all education levels, hinting at stronger social support systems.

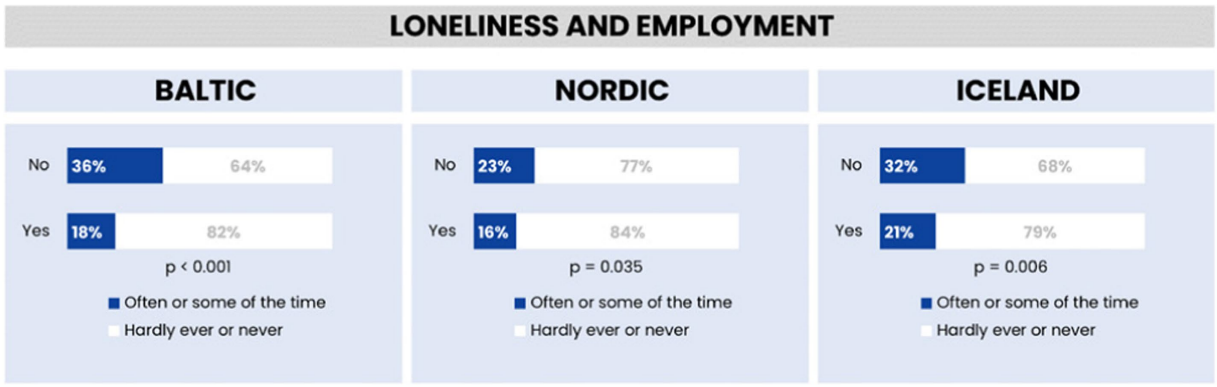


FIGURE 5
Feelings of loneliness by employment in the Baltic region, Nordic countries, and Iceland.

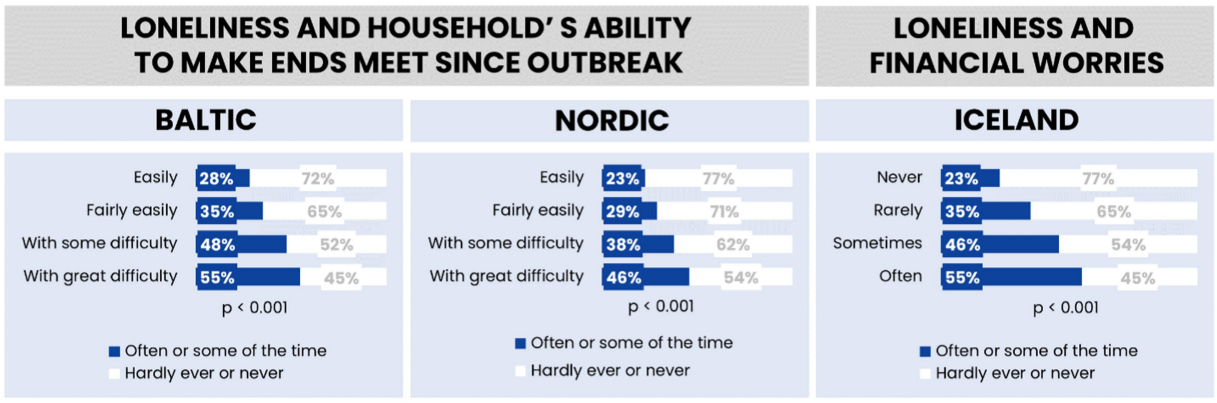


FIGURE 6
Feelings of loneliness by the household's ability to make the ends meet/financial worries in the Baltic region, Nordic countries, and Iceland.

Figure 5 provides a summary of loneliness prevalence in the Baltic, Nordic, and Icelandic regions, illustrating a spectrum of loneliness experiences among the populations. A majority of respondents in each region report experiencing loneliness infrequently, with a smaller portion feeling lonely more regularly.

The analysis highlights regional differences in the occurrence of occasional and frequent loneliness, confirming the statistical significance of these findings with *p*-values less than 0.05. This indicates a clear variation in loneliness experiences across the regions, underscoring the nuanced nature of this emotional state within different cultural and geographic contexts. Detailed percentages and comparisons across the regions are depicted in Figure 6 providing a comprehensive visual representation of the data.

The data highlights the adverse effects of financial stress on feelings of isolation and social disconnection, underscoring the need for interventions aimed at improving financial security among vulnerable populations. These findings contribute to the existing body of research on the impact of economic factors on mental health and social relationships, reinforcing the importance of addressing financial stability as a key determinant of loneliness.

Figure 6 demonstrates a significant relationship between financial worries and loneliness in the Baltic and Nordic countries. The analysis indicates that individuals experiencing financial concerns report higher levels of loneliness compared to those without such worries. This trend is consistent across all countries studied, with statistical significance confirmed, suggesting that financial stability plays a crucial role in social well-being.

Feelings of loneliness and physical health in the Baltic region, Nordic countries, and Iceland before the COVID-19 outbreak

Figure 7 compares self-assessed physical health and the prevalence of loneliness in three different regions before the COVID-19 pandemic. In all three regions, individuals who rate their health as "Excellent" tend to feel lonely less often, with more than half reporting they hardly ever or never feel lonely. Conversely, a significant portion of those who rate their health as "Poor" tend to feel lonely more often. This trend is consistent across the Baltic, Nordic, and Iceland graphs, indicating a clear association between better self-perceived physical health and lower levels of loneliness.

The data is statistically significant for each region, strongly suggesting that the observed relationship between physical health and

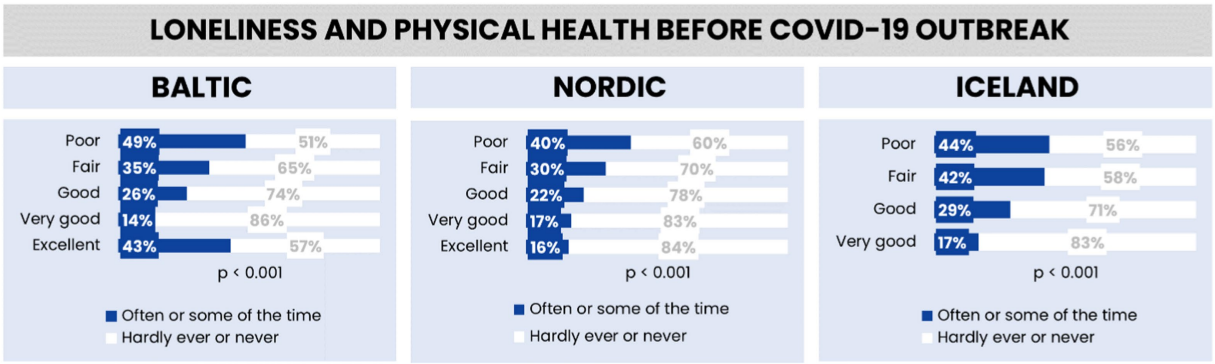


FIGURE 7
Feelings of loneliness by employment in the Baltic region, Nordic countries, and Iceland.

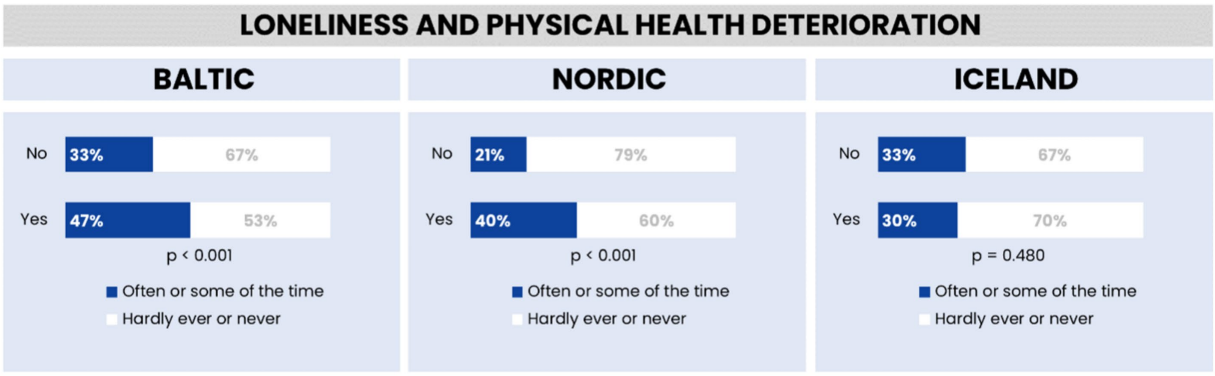


FIGURE 8
Feelings of loneliness and physical health deterioration in the Baltic region, Nordic countries, and Iceland.

the frequency of loneliness is not due to random chance. This implies that in these regions, there is a notable association between how healthy people feel and how often they experience feelings of loneliness.

When comparing the Baltic, Nordic regions, and Iceland, the data reveals that the Baltic region reports the highest levels of loneliness among those with "Poor" and "Excellent" physical health. The Nordic region exhibits lower levels of loneliness across health categories compared to the Baltic region. Iceland shows the lowest percentage of loneliness in the "Excellent" health category but has levels similar to the Baltic region for those with "Poor" health. Overall, as the health status improves from "Poor" to "Excellent", the frequency of loneliness decreases in all regions, with the Nordic region and Iceland showing a stronger negative correlation between good physical health and loneliness than the Baltic region.

Feelings of loneliness and health in the Baltic region, Nordic countries, and Iceland during the COVID-19 outbreak

Figure 8 presents an analysis of the relationship between physical health deterioration and loneliness across the Baltic region, Nordic countries, and Iceland. The data illustrates a notable trend where individuals experiencing health deterioration report higher levels of loneliness compared to those without such deterioration in the Baltic and Nordic regions. This association is statistically significant in these areas, indicating a strong link between health deterioration and increased feelings of loneliness. Conversely, in Iceland, the relationship between health status and loneliness does not show statistical significance, suggesting that other factors may be more influential in the experience of loneliness within this region.

The results in Figure 9 indicate that Iceland has the highest reported levels of loneliness, with 67% of individuals who reported a decline in mental health after the COVID-19 pandemic began ($n = 185$) felling lonely often or sometimes. This is in contrast to 43% in the Baltic region and 35% in the Nordic region. In terms of linking loneliness with mental health deterioration, 86% of respondents in the Nordic region acknowledge this correlation, compared to 78% in Iceland and 79% in the Baltic region. The association between loneliness and mental health deterioration is statistically significant across all regions.

Discussion

This study presents a comparative analysis of loneliness in relation to employment across the Baltic, Nordic regions, uncovering regional

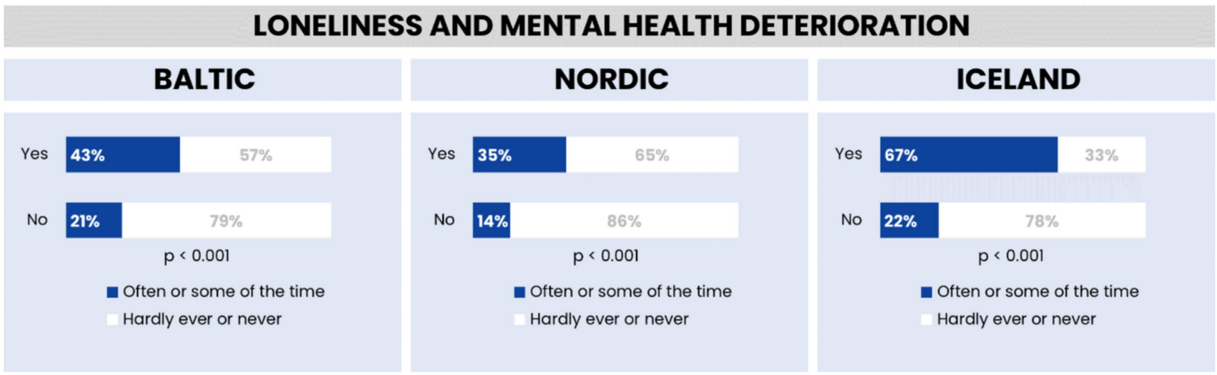


FIGURE 9
Feelings of loneliness and mental health deterioration in the Baltic region, Nordic countries, and Iceland.

variations that are statistically significant. Our methodological approach, integrating diverse data sets, including the distinct Icelandic data and the SHARE survey data, has set a new benchmark for future comparative studies.

In the Baltic region, fewer reports of loneliness may reflect cultural or economic factors fostering community and belonging, as supported by the strong statistical significance of our findings. The Nordic countries, known for their high quality of life and robust social welfare, report the lowest levels of loneliness, potentially due to social trust and community engagement (3, 10). Iceland, despite a higher proportion of loneliness, shows a majority still feeling seldom lonely, influenced possibly by its tight-knit communities (16).

Employment appears to play a beneficial role in reducing loneliness across all regions, associated with structured routines and social interactions (28). However, the cross-sectional nature of our data precludes definitive conclusions about causation between employment and loneliness, indicating a direction for future longitudinal studies (29).

Our findings also highlight the need for region-specific strategies to combat loneliness, particularly concerning employment. The differences in the prevalence and experience of loneliness in the Baltic, Nordic, and Icelandic regions underscore the complexity of this social phenomenon.

Gender disparities in loneliness are notable. In the Baltic region, a higher rate of loneliness among women compared to men suggests potential societal and cultural influences (8). The Nordic countries exhibit a smaller gender gap in loneliness, possibly due to more inclusive social policies (30). Iceland's closer rates of loneliness between genders may be attributed to its communal ties and social norms (31).

Marital status also correlates with loneliness. The Baltic region shows a higher loneliness rate among individuals not living with a partner, possibly due to social and economic transitions (12, 18). The Nordic countries, with their strong welfare policies, report lower loneliness rates regardless of marital status (32). Iceland's unique social structure reflects the importance of broader social networks beyond intimate relationships (16, 33). These differences highlight how social and cultural factors, along with individual relationships, can influence feelings of loneliness. The significantly higher rates of loneliness in the Baltic region for those not living with a partner could reflect cultural, economic, or policy differences that might affect social connectedness and support systems. The Nordic countries seem to be doing better in terms of combating loneliness, potentially due to their emphasis on social welfare and community programs. In Iceland, the relatively higher rate of loneliness among those living with a partner compared to the Nordic countries might suggest different societal norms or expectations in personal relationships. Overall, marital status appears to be a strong indicator of loneliness across all regions, but its impact varies by region.

Educational attainment shows varied associations with loneliness across regions. An inverse correlation between education and loneliness in the Baltic and Nordic regions suggests protective benefits of higher education levels (8). However, in Iceland, education level does not significantly predict loneliness, indicating other influential factors (16).

Health status and loneliness also share a significant relationship. While the Baltic and Nordic regions show an inverse relationship between perceived health and loneliness (4, 8), Iceland's findings suggest the importance of community bonds (16, 34).

The multifaceted nature of loneliness, as revealed by regional studies, underscores the critical interplay between individual emotional states, personality traits, and broader socio-economic and familial contexts. In countries like Estonia and Latvia, elevated loneliness levels, attributed to financial hardships and disrupted family communications, highlight the significant impact of socio-economic factors (4, 14). Moreover, the association of increased loneliness with heightened irritability in Latvia points to the influential role of emotional and personality characteristics in the experience of loneliness.

This study's findings on loneliness across different regions emphasize the complexity of this issue, influenced by individual, cultural, and societal factors. These insights are vital for developing tailored public health strategies to address loneliness and its mental health implications.

Limitations of the study

This study has several limitations that should be acknowledged. Firstly, the integration of distinct Icelandic data with the SHARE survey data may have introduced inconsistencies due to different data collection methods and structures. The study's cross-sectional design

limits the ability to establish causal relationships between factors like employment and loneliness, highlighting the need for longitudinal studies to explore these relationships over time. The findings are specific to the Baltic, Nordic, and Icelandic regions and may not be applicable to other contexts because of cultural, economic, and social differences.

Additionally, the study relies on self-reported measures, which could lead to biases as responses may be influenced by personal perceptions and cultural norms. Focusing predominantly on individuals aged 67 and above excludes younger age groups, who may have different experiences of loneliness. Cultural norms and gender roles within the surveyed regions could impact the reporting of loneliness, potentially leading to skewed results.

The data for this study were obtained from two primary sources: The Survey of Health, Ageing and Retirement in Europe (SHARE) for the Nordic countries and the Health and Life conditions of the population of Iceland aged 67 and older (HL20) study for Iceland. The sample sizes differed between the Baltic and Nordic countries, with 2,936 individuals from Baltic countries and 2,377 from Nordic countries. Despite the higher population in Nordic countries, the sample size was smaller, which merits discussion.

The disparity in sample sizes can be attributed to methodological constraints and the specific focus of the studies used. SHARE, being a multi-national project, includes various countries with different sampling frames and response rates, leading to variations in sample sizes across countries. Additionally, the HL20 study focused solely on Iceland and employed a simple random sample of 1,800 individuals from the national registry, with 1,033 respondents completing the survey. These differences reflect the specific research objectives and resources available for each study.

The disparities in sample sizes between Baltic and Nordic countries, while potentially introducing selection bias, were addressed through methodological adjustments. Statistical techniques, including weighted analyses, were employed to mitigate the impact of sample size differences, ensuring proportional contributions from each country's data to the overall analysis. Additionally, harmonization of key demographic variables facilitated meaningful cross-country comparisons.

These methodological considerations provide a solid foundation for the study's cross-country comparisons. However, it's essential to acknowledge the limitations associated with sample size disparities and recognize the need for future research to strive for more balanced samples across countries to enhance the validity and generalizability of findings.

Regarding the issue of selection bias, while the random sampling approach and relatively high response rate minimize the risk, it's essential to acknowledge potential biases, particularly among individuals residing in care facilities for older adults. Future research should explore strategies to mitigate such biases and further enhance the robustness of findings.

Bidirectionality in relationships

An important consideration in interpreting the findings of our study is the potential bidirectionality of relationships, particularly for self-reported variables such as self-reported health. Bidirectionality refers to the reciprocal influence between variables, where the relationship between two factors may operate in both directions over time.

For example, while our analysis identified a significant association between self-reported health and loneliness, it's essential to recognize that this relationship may be bidirectional. On one hand, poor self-reported health may contribute to increased feelings of loneliness, as individuals facing health challenges may experience social isolation, reduced mobility, or limitations in participating in social activities.

Conversely, loneliness itself can also impact self-reported health outcomes. Studies have shown that chronic loneliness is associated with adverse health consequences, including increased risk of chronic diseases, impaired immune function, and accelerated ageing. Therefore, individuals experiencing loneliness may be more likely to report poorer health status, reflecting the psychosocial impact of loneliness on overall well-being.

While bidirectionality provides important insights into the complex interplay between variables, it also poses challenges for causal inference and interpretation of findings. In our study, the bidirectional relationship between self-reported health and loneliness highlights the need for caution in drawing causal conclusions from the observed associations.

Moreover, the paucity of details provided in the methods section regarding the assessment of self-reported variables limits our ability to fully explore bidirectional relationships. Future research should incorporate longitudinal designs and more comprehensive measures to assess the temporal sequence and directionality of relationships between variables. The statistical methods used to align different data sets have inherent limitations and might not fully address all variations in the data. The study might not have accounted for all relevant factors influencing loneliness, such as individual health conditions or local community dynamics. Variations in social welfare policies and community support structures across the studied regions, which might affect experiences of loneliness, are not extensively examined. Finally, the representativeness of the study's sample size for capturing a broad range of experiences related to loneliness might be limited. These limitations are important for understanding the scope of the study and for guiding future research in this area.

Conclusion

While this study primarily focuses on the Baltic and Nordic regions, it contributes significantly to the broader understanding of loneliness as a global public health issue. The research illuminates the intricate nature of loneliness and its profound impact on both individuals and communities. By integrating various data sources, the study captures the nuanced experiences of loneliness in distinct geographical contexts, offering valuable insights that pave the way for future research and the formulation of public health initiatives aimed at mitigating loneliness.

The heightened loneliness observed among ageing populations in the Baltic states, particularly exacerbated by the ongoing COVID-19 pandemic, underscores the urgent need for targeted interventions. Policymakers and social workers must grasp the complexities of these findings to develop effective strategies for alleviating loneliness. Emphasis should be placed on creating programs tailored to the specific needs and challenges of different demographics within each region.

Future research endeavors should explore longitudinal studies to understand the temporal dynamics and causal relationships of loneliness. Such studies would provide insights into how loneliness

evolves in response to changes in socio-demographic, economic, and health-related factors. Comparative studies across various cultural contexts are also crucial for identifying both universal and culture-specific factors that influence loneliness. This knowledge can guide the development of culturally sensitive interventions. Moreover, there is an essential need to develop, implement, and rigorously evaluate interventions aimed at reducing loneliness, especially among vulnerable populations, to enhance social connectedness.

The implications of this research extend beyond academic inquiry, offering practical guidance for public health policy, clinical practice, and community engagement. Insights from the study can inform the development of targeted public health policies and programs that promote social inclusion and reduce loneliness by addressing the identified determinants. Healthcare providers are encouraged to integrate loneliness screening and interventions into routine care practices, thus enhancing patient care by addressing the psychosocial aspects associated with loneliness. Community organizations and social services agencies can leverage the study's findings to create initiatives that strengthen community bonds and promote social interaction, addressing loneliness at the grassroots level.

In conclusion, by highlighting the importance of loneliness as a public health issue, this study lays the groundwork for future research and practical interventions designed to alleviate loneliness and its associated challenges. This work contributes to the well-being of individuals in the Baltic and Nordic regions, especially during challenging times like the current pandemic, and has implications for addressing loneliness on a global scale.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

IR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. MM: Data curation, Formal analysis, Investigation, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. ST: Conceptualization, Supervision, Validation, Writing – original draft, Writing – review & editing. HeG: Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. AI: Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. HaG: Conceptualization, Investigation, Supervision, Validation, Writing – original draft, Writing – review & editing. IK: Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. Funding for this collaboration between Riga Stradiņš University and the University of Iceland was provided by the EEA initiative FM2021/23 (EEZ/NOFI/DIV) under the project titled "Modelling of the Impact of COVID-19 on Public Health of Elderly People in Latvia and Iceland." The use of Icelandic data from HL20 was conducted with consent from all funders, and the utilization of the HL20 dataset was contingent upon approval from public bodies and other entities that originally organized and financed the research. NordForsk supports parts of the study within the project No: 139986 Sustainable working-life for ageing populations in the Nordic-Baltic region.

Acknowledgments

We gratefully acknowledge the invaluable contributions of all individuals and organizations involved in the completion of this study. We extend our heartfelt appreciation to the participants for their willingness to take part in this research and for sharing their valuable insights. Furthermore, we would like to express our sincere gratitude to the reviewers for their thoughtful comments and suggestions, which greatly enhanced the quality and rigor of our manuscript. Their expertise and insights have been instrumental in shaping the final version of this paper. We also acknowledge the contributions of our colleagues and collaborators who provided valuable guidance and support during various stages of this research project. Their expertise and encouragement have been invaluable in advancing our understanding of the topic. This paper uses data from SHARE Waves 1, 2, 3, 4, 5, 6, 7, 8 and 9 (DOIs: 10.6103/SHARE.w1.800, 10.6103/SHARE.w2.800, 10.6103/SHARE.w3.800, 10.6103/SHARE.w4.800, 10.6103/SHARE.w5.800, 10.6103/SHARE.w6.800, 10.6103/SHARE.w7.800, 10.6103/SHARE.w8.800, 10.6103/SHARE.w8ca.800, 10.6103/SHARE.w9ca800), see Börsch-Supan et al. (35) for methodological details. The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through *VS* 2015/0195, *VS* 2016/0135, *VS* 2018/0285, *VS* 2019/0332, and *VS* 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Cacioppo JT, Cacioppo S. The growing problem of loneliness. *Lancet*. (2018) 391:426–6. doi: 10.1016/S0140-6736(18)30142-9

2. Holt-Lunstad J, Smith TB, Baker M, Harris T, Stephenson D. Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspect Psychol Sci*. (2015) 10:227–37. doi: 10.1177/1745691614568352

3. Victor C, Yang K. Age and loneliness in 25 European nations. *Ageing Soc*. (2011) 31:1368–88. doi: 10.1017/S0144686X1000139X

4. Aslan Y., Zengin O. (2022). "COVID-19 Pandemi Döneminde Türkiye Ve Doğu Avrupa Ülkelerinin Yaşam Kalitelerine Dair Kapsamlı Bir Değerlendirme." Odü Sosyal Bilimler Araştırmaları Dergisi (Odüsobiad).

5. Gadbois EA, Jiménez F, Brazier JF, Davoodi NM, Nunn A, Mills WL, et al. Findings from talking tech: a technology training pilot intervention to reduce loneliness and social isolation among homebound older adults. *Innov Aging*. (2022) 6:1–12. doi: 10.1093/geroni/igac040

6. Groarke JM, Berry E, Graham-Wisener L, McKenna-Plumley PE, McGlinchey E, Armour C. Loneliness in the UK during the COVID-19 pandemic: cross-sectional results from the COVID-19 psychological wellbeing study. *PLoS One*. (2020) 15:1–18. doi: 10.1371/journal.pone.0239698

7. Barreto M, Victor C, Hammond C, Eccles A, Richins MT, Qualter P. Loneliness around the world: age, gender, and cultural differences in loneliness. *Pers Individ Dif*. (2021) 169:110066. doi: 10.1016/j.paid.2020.110066

8. Hansen T, Slagsvold B. Late-life loneliness in 11 European countries: results from the generations and gender survey. *Soc Indic Res*. (2016) 129:445–64. doi: 10.1007/s11205-015-1111-6

9. Nyqvist F, Nygård M, Scharf T. Loneliness amongst older people in Europe: a comparative study of welfare regimes. *Eur J Ageing*. (2019) 16:133–43. doi: 10.1007/s10433-018-0487-y

10. Rapolienė G, Aartsen M. Lonely societies: low trust societies? Further explanations for National Variations in loneliness among older Europeans. *Eur J Ageing*. (2021) 19:485–494. doi: 10.1007/s10433-021-00649-z

11. Fernández-Carro C, Gumà J. A life-course approach to the relationship between education, family trajectory and late-life loneliness among older women in Europe. *Soc Indic Res*. (2022) 162:1345–63. doi: 10.1007/s11205-022-02885-x

12. Cohen-Mansfield J, Hazan H, Lerman Y, Shalom V. Correlates and predictors of loneliness in older-adults: a review of quantitative results informed by qualitative insights. *Int Psychogeriatr*. (2016) 28:557–76. doi: 10.1017/S1041610215001532

13. Hyland KA, Small BJ, Gray JE, Chiappori A, Creelan B, Tanvetyanon T, et al. Loneliness as a mediator of the relationship of social cognitive variables with depressive symptoms and quality of life in lung Cancer patients beginning treatment. *Psycho-Oncology*. (2019) 28:1234–42. doi: 10.1002/pon.5072

14. Pasupathy R, Sazevari R, Queen C. Loneliness among the elderly in Baltic nations during the beginning of the Covid-19 pandemic. *Eur J Pub Health*. (2023) 33:641. doi: 10.1093/eurpub/ckad160.1608

15. Reine I. Factors predicting loneliness among ageing populations in the Baltic States during Covid-19. *Eur J Pub Health*. (2021) 31:379. doi: 10.1093/eurpub/ckab165.110

16. Reine I, Miķelsone M, Guðmundsson H, Ivanovs A, Tomsone S, Guðmundsson HS. Loneliness, social isolation and ageing: a methodological approach to compare Latvian and Icelandic older populations in the course of COVID-19 pandemic. *Res Sq*. [Preprint] (2023). doi: 10.21203/rs.3.rs-2870118/v1

17. Reine I., Reine A, Aleksandrovs A, Ivanovs A, Baltmane D, Balodis G, et al. (2021). Sabiedrības veselības politikas rekomendācijas gados vecāku cilvēku populācijai Latvijā: COVID-19 seku mazināšana. VPP-COVID-2020: Pētījuma pārskats. VPP-COVID-2020: Pētījuma pārskats. Mininstry of Health of Latvia. Riga: 157.

18. European, Parliament, Policy department. Directorate-General for Internal Policies (2015). Elderly women living alone – An update of their living conditions, Publications Office.

19. Nygård M, Härtull C, Wentjärvi A, Jungerstam S. Poverty and old age in Scandinavia: a problem of gendered injustice? Evidence from the 2010 GERDA survey in Finland and Sweden. *Soc Indic Res*. (2016) 132:681–698. doi: 10.1007/s11205-016-1313-6

20. Surkalim DL, Luo M, Eres R, Gebel K, Buskirk JV, Bauman A, et al. The prevalence of loneliness across 113 countries: systematic review and meta-analysis. *BMJ*. (2022) 376:e067068. doi: 10.1136/bmj-2021-067068

21. Sundström G, Fransson E, Malmberg B, Davey A. Loneliness among older Europeans. *Eur J Ageing*. (2009) 6:267–75. doi: 10.1007/s10433-009-0134-8

22. Szebehely M, Meagher G. Nordic eldercare – weak universalism becoming weaker? *J Eur Soc Policy*. (2017) 27:294–308. doi: 10.1093/eurpub/ckx187.611

23. Reine I., Miķelsone M., Tomsone S., Guðmundsson H., Ivanovs A., Guðmundsson S. H., et al. (2024). Loneliness in the Baltic-Nordic region. Determinants of Loneliness [Working Title]. doi: 10.5772/intechopen.1004199

24. Rapeli M, Carlstedt J, Hergeirsdóttir R, Guðmundsson HS, Cuadra CB, Hatakka I. Three Nordic countries responding to covid-19 – eldercare perspectives. *Int J Disaster Risk Reduct* (2023) 84:103442. doi: 10.1016/j.ijdrr.2022.103442

25. Miķelsone M, Reine I, Tomsone S, Guðmundsson H, Ivanovs A, Guðmundsson HS. Construction of healthy aging index from two different datasets. *Front Public Health*. (2023) 11:1231779. doi: 10.3389/fpubh.2023.1231779

26. Börsch-Supan A. (2022). Survey of health, ageing and retirement in Europe (SHARE) wave 2. Release version: 8.0.0. SHARE-ERIC Data set. doi: 10.6103/SHARE.w2.800

27. Guðmundsson H. S. (2021). Virðing og reisn: Samþætt heilbrigðis-og félagsþjónusta fyrir eldra fólk. [Drög að stefnu um heilbrigðisþjónustu fyrir aldraða, unnið fyrir heilbrigðisráðuneytið í júní 2021].

28. Wang, S, Quan, L, Chavarro, JE, Slopen, N, Kubzansky, LD, Koenen, KC, et al. Associations of Depression, Anxiety, Worry, Perceived Stress, and Loneliness Prior to Infection With Risk of Post-COVID-19 Conditions. *JAMA Psychiatry*. (2022) 79:1081–1091. doi: 10.1001/jamapsychiatry.2022.2640

29. Taylor, HO, Cudjoe, TK, Bu, F, Lim, MH. The state of loneliness and social isolation research: current knowledge and future directions. *BMC Public Health* (2023) 23:1049. doi: 10.1186/s12889-023-15967-3

30. Helliwell, JF., and Putnam, RD. The social context of well-being. *Philos Trans R Soc Lond B Biol Sci*. (2004) 359:1435–1446. doi: 10.1098/rstb.2004.1522

31. Maes, M, Nelemans, SA, Danneel, S, Fernández-Castilla, B, Van den Noortgate, W, Goossens, L, et al. Loneliness and social anxiety across childhood and adolescence: Multilevel meta-analyses of cross-sectional and longitudinal associations. *Dev. Psychol.* (2019) 55:1548–1565. doi: 10.1037/dev0000719

32. Helliwell, JF, and Wang, S. Trust and wellbeing. *International Journal of Wellbeing* (2011) 1:42–78. doi: 10.5502/ijw.v1i1.9

33. Sigurðardóttir ÁK, Kristófersson GK, Gústafsdóttir SS, Sigurdsson S, Arnadottir SA, Steingrimsson JA, et al. Self-rated health and socio-economic status among older adults in northern Iceland. *Int J Circumpolar Health*. (2019) 78. doi: 10.1080/22423982.2019.1697476

34. Kokorsch M, Gísladóttir J. "You talk of threat, but we think of comfort": the role of place attachment in small remote communities in Iceland that experience avalanche threat. *Reg Environ Chang*. (2023) 23:150. doi: 10.1007/s10113-023-02144-w

35. Börsch-Supan, A, Brandt, M, Hunkler, C, Kneip, T, Korbmacher, J, Malter, F, et al. Data Resource Profile: the Survey of Health, Ageing and Retirement in Europe (SHARE). *Int J Epidemiol*. (2013) 42:992–1001. doi: 10.1093/ije/dyt088

frontiers | Frontiers in Public Health

TYPE Study Protocol
PUBLISHED 07 May 2024
DOI 10.3389/fpubh.2024.1360037

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Ik-Whan Kwon,
Saint Louis University, United States
Juan Corral-Pérez,
University of Cádiz, Spain

*CORRESPONDENCE
Yanping Duan
✉ duanyp@hkbu.edu.hk

RECEIVED 22 December 2023
ACCEPTED 10 April 2024
PUBLISHED 07 May 2024

CITATION
Yang M, Duan Y, Lippke S, Liang W and Su N (2024) A blended face-to-face and eHealth lifestyle intervention on physical activity, diet, and health outcomes in Hong Kong community-dwelling older adults: a study protocol for a randomized controlled trial.
Front. Public Health 12:1360037.
doi: 10.3389/fpubh.2024.1360037

COPYRIGHT
© 2024 Yang, Duan, Lippke, Liang and Su. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

A blended face-to-face and eHealth lifestyle intervention on physical activity, diet, and health outcomes in Hong Kong community-dwelling older adults: a study protocol for a randomized controlled trial

Min Yang[1], Yanping Duan[1]*, Sonia Lippke[2], Wei Liang[3] and Ning Su[3]

[1]Department of Sport, Physical Education and Health, Faculty of Social Sciences, Hong Kong Baptist University, Kowloon, Hong Kong SAR, China, [2]School of Business, Social and Decision Sciences,Constructor University, Bremen, Germany, [3]College of Physical Education, Shenzhen University, Shenzhen, China

Background: Aging individuals are vulnerable to various Noncommunicable Diseases (NCDs). Different behaviors are closely related to a decreased risk of suffering from NCDs: sufficient Physical Activity (PA) (e.g., at least 150 mins Moderate-to-vigorous Physical Activity (MVPA) per week) and a healthy daily diet (e.g., at least five portions of Fruit and Vegetable Intake (FVI), 5–6 taels (189.0–226.8 g) Meat, Fish, Egg and Alternatives (MFEA)). Traditional face-to-face interventions were effective in behavior change. However, it was revealed to be resource-intensive and limited transfer due to poor self-regulation skills outside of face-to-face sessions. Thus, eHealth could be a supplement for older adults outside traditional face-to-face settings. The blended approach combining these two interventions might optimize the intervention effects on lifestyle behavior initiation and maintenance, but little research can be found among Hong Kong older adults. Therefore, the study aims to test a blended intervention to promote PA, diet, and health outcomes among Hong Kong community-dwelling older adults.

Methods: This study will adopt a 10-week three-arm randomized controlled trial. The blended group will receive weekly (1) two 60-min face-to-face sessions with one for PA and one for diet, and (2) two web-based sessions with one for PA and one for diet. The face-to-face group will receive the same intervention content as the face-to-face sessions in the blended group. The control condition will receive a biweekly telephone call. The outcomes will include MVPA (minutes/week), FVI (portions/day), MFEA consumption (taels/day), social-cognitive factors (self-efficacy, planning, social support, action control), physical health outcomes (clinical indicators, senior physical fitness), mental health outcomes (depression, loneliness) and health-related quality of life. Data collection will be implemented at the pre-test, post-test, and 3-month follow-up test.

Discussion: This is the first study evaluating a blended intervention promoting multiple health behaviors among Hong Kong community-dwelling older adults.

If the effect of the blended intervention is superior to the traditional face-to-face group and the control group, it will enrich lifestyle intervention approaches and can be applied to older adults, helping them obtain health benefits. Furthermore, a better understanding of mechanisms will also have implications for theory-building.

Clinical trial registration: https://www.isrctn.com/ISRCTN32329348, ISRCTN 32329348.

KEYWORDS

physical activity, diet, health outcomes, older adults, blended intervention

1 Introduction

Noncommunicable diseases (NCDs), such as cardiovascular diseases, cancer, diabetes, and obesity, are responsible for the mortality of approximately 41 million individuals annually, accounting for a staggering 74% of all global deaths (1). NCDs are of high prevalence due to a confluence of factors, including the globalization of unhealthy lifestyles and the demographic shift toward an aging population (2). Physical inactivity and unhealthy dietary patterns contribute to the manifestation of metabolic risk factors, such as elevated blood pressure, hyperglycemia, dyslipidemia, and obesity (3, 4). However, over one-quarter of adults were physically inactive, while over 3 million NCD-related deaths per year could be averted by increasing physical activity (PA) (5). The evidence indicates that 28% of adults were physically inactive and did not meet the World Health Organization (WHO) recommendation level of PA (5). The survey conducted in America suggested that the prevalence of physical inactivity significantly increases with age, with 26.9% among those aged 65–74 years and 35.3% among those aged ≥75 years (6). In Hong Kong, 24.8% of adults do not meet the WHO PA recommendation (at least 150 minutes Moderate-to-vigorous Physical Activity (MVPA) per week), while the percentage among older people is higher than that of other age groups (7).

Less than 50% of older adults adhere to the recommended five portions per day of fruit and vegetables (8, 9). An estimated 3.9 million deaths worldwide were attributable to inadequate fruit and vegetable consumption in 2017 (10). For Fruit and Vegetable Intake (FVI), most Hong Kong older adults consume less than five servings per day, in particular, 94.8% in the 65–74 age group, 96.6% in the 75–84 age group, and 99.3% in the 85 or above age group (7). As individual household incomes rise, global meat consumption and average *per capita* meat consumption are also increasing, driven by globalization and evolving food preferences, which heightened meat consumption is closely linked to the development of various diseases (11), particularly NCDs (12). It is essential to avoid excessive consumption of certain foods, such as meat consumption. In Hong Kong, the *per capita* meat consumption was 375 g, which ranked first in the world (13), while older people are recommended to have 5–6 taels Meat, Fish, Egg and Alternatives (MFEA) (189.0–226.8 g) per day (7). Engaging in multiple risk behaviors can lead to adverse health effects. Healthy lifestyle interventions among older adults are essential and meaningful to prevent harmful effects on individual health, medical systems, and medical costs (14).

Face-to-face workshops enable providers to deliver individualized interventions, facilitate interactive communication, and protect privacy (15). Empirical evidence supports the efficacy of face-to-face interventions in promoting health behaviors, such as PA and dietary choices (16, 17). Notwithstanding the practical support of face-to-face health interventions, this approach exhibits several limitations. Previous research also indicated significant barriers to older adults' attendance and adherence to health behavior change intervention, including lack of perceived social support, low motivation, and poor self-regulation skills (18). The adherence rate of stand-alone face-to-face intervention on health promotion among older adults decreased over time (19).

eHealth is an emerging channel for delivering healthcare services and information through the Internet and associated technologies and media (e.g., computers and smartphones). It can complement face-to-face interventions for older adults in their homes or beyond traditional care settings (20). eHealth efficiently provides personalized feedback and long-term monitoring related to healthy lifestyles, which can enhance the maintenance of a healthy lifestyle over an extended period (21).

This study used the Health Action Process Approach (HAPA) model as a theoretical backdrop for the eHealth intervention (22). The HAPA model posited two phases (motivational and volitional) in the process of behavior change (23). During this dynamic process, individuals move from forming a behavioral intention to executing and sustaining a specific health behavior. In the process of behavioral change, several psychosocial factors play a crucial role. The motivational stage focuses on developing a behavioral intention, with action self-efficacy, outcome expectancies, and risk perceptions identified as contributing factors (24, 25). After individuals have established a behavioral intention, volitional factors such as action planning, coping planning, maintenance and recovery self-efficacies, and external resources like social support become essential in overcoming the intention-behavior gap (26). These factors collectively facilitate the execution and maintenance of the desired behavior (27). The widespread approval of the HAPA model in promoting various health behaviors among adults underscores its applicability (28). The effect of the techniques can be explained by theory, mainly relating to Behavior Change Techniques (27, 29).

However, eHealth intervention may also have disadvantages compared to face-to-face interventions. It demands specific skills, including electronic device functionality and reading comprehension proficiency. Providing individualized attention from professional medical care may pose challenges for caregivers (30). Furthermore, adherence is a crucial challenge in any eHealth intervention program, as many participants drop out before completion (31, 32).

In recent years, the blended intervention combining face-to-face workshops and eHealth intervention anticipates that the strengths of one delivery mode would offset the weaknesses of the other (33–36). A recent meta-analysis reported that the blended intervention can significantly promote total PA levels and diet behavior among adults (37). However, whether a blended intervention is more effective than traditional face-to-face interventions is unclear. Also, only limited findings reported the effectiveness of blended interventions in promoting PA and diet among older adults.

The findings of this study aim to fill the research gap, and its research design will be outlined in the following sections. There are two research objectives in this study. The primary aim is to compare the intervention effects between blended, face-to-face, and control groups in primary outcomes, including PA, diet (FVI and MFEA), and adherence to the health recommendations of PA and diet (FVI and MFEA). The second objective is to compare the intervention effects between blended, face-to-face, and control groups in secondary outcomes, including social-cognitive variables of behavior change (i.e., self-efficacy, planning, social support, and action control), physical health outcomes (i.e., clinical indicators, senior physical fitness), mental health outcomes (i.e., depression, loneliness), and health-related quality of life (HRQoL).

2 Methods and design

2.1 Study design and procedure

This study is a single-blind randomized controlled trial (RCT) comprising three groups: a blended face-to-face and eHealth intervention group (IG-1), a stand-alone face-to-face intervention group (IG-2), and a control group (CG). Evaluation will be conducted at pre-intervention (T1), post-intervention (T2), and 3 months follow-up after intervention completion (T3). The target population will be Hong Kong community-dwelling older adults. Participants will be recruited and randomly assigned into one of three groups. The intervention givers (i.e., PA coach and nutritionist) will be blinded from the assignment results to the intervention. The study process is presented in Figure 1.

2.2 Target population

Participants will be recruited from two Senior Centers in Hong Kong. The e-poster and video will be advertised by the staff in the Senior Centers. There are over 3,000 members in these two centers. Therefore, recruiting participants by advocating for the Senior Centers is feasible and advantageous. Potential study participants will be informed that there will be a health promotion program in which they can obtain health-related programs and receive a $300HKD (about $39USD) supermarket gift card as an incentive if the participants complete the 10-week health project and finish three times data collection.

Once the older adults express their interests, they will be encouraged to register in the program. After finishing all the registration and eligible screening, they will receive the study consent forms. The eligible criteria include: (1) aged 65 years and above; (2) owning a smartphone and having access to the Internet; (3) passing the Physical Activity Readiness Questionnaire (PAR-Q); (4) having sufficient reading and listening skills in Cantonese; (5) at least one health behavior (PA, FVI, MFEA) fails to meet the recommended health guideline. Exclusion criteria will include: (1) under special situations that seriously affected their diet (e.g., oral allergy syndrome) and mobility (e.g., physical disability); (2) meet all the health guidelines of PA, FVI, and MFEA; (3) participate in other

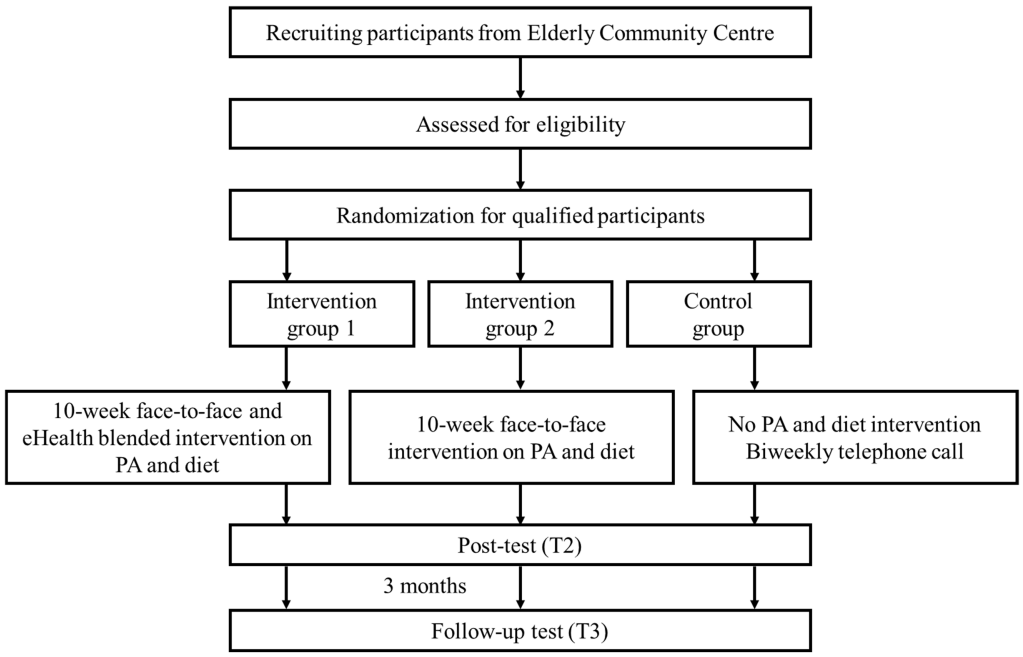


FIGURE 1
The flowchart of the study.

ongoing project related to PA and diet intervention. Then, all participants will be allocated to one of three groups with an equal ratio (in a 1:1:1 ratio). The group allocation will be blinded. The researchers will provide the individual web link for the blended intervention group participants.

The sample size was calculated using G*Power 3.1 software. For achieving a medium effect size (Cohen's f 0.26) on PA and diet based on a previous similar blended study among adults (35), with a statistical power (1-β) of 0.8 and an alpha of 0.05 (38), a total of 91 participants is required for the three groups (IG-1, IG-2, and CG). Considering the dropout rate of approximately 20% (35), a total of $N = 114$ participants is required to enable a robust evaluation.

2.3 Intervention content

2.3.1 Face-to-face intervention group

Previous findings indicated that the majority of the face-to-face sessions conducted exercise training and education among older adults without theory backdrop (39). The participants in the face-to-face intervention group will engage in two 60-min sessions per week, including one session for PA at the gym and one for diet at the neighborhood senior center (40) for 10 weeks. Each PA session will consist of two parts: health education on PA and health (10 minutes) and physical exercise (50 minutes). Each session will include a warm-up exercise (5 minutes), a main exercise (40 minutes), and a cool-down exercise (5 minutes). The main activity will consist of diverse components such as aerobic training, resistance training, balance training, and mindfulness meditation training. The feedback will be given during PA courses if the participants have questions. Each PA session will be delivered by a PA coach with the assistance of two to four research helpers to ensure safety and feasibility.

Each diet session will consist of two parts: health education on diet (30 minutes) and nutrition counseling (30 minutes). The education topics, such as dietary fiber, cholesterol, fruits and vegetables, and red and white meat, were developed based on suggestions from a nutritionist. The nutrition counseling will include a 15 minutes group discussion with 3–4 participants in one group to design daily dishes and 15 minutes of dish sharing. Personalized nutritional advice will be offered by the nutritionist accordingly. Each diet session will be delivered by a nutritionist with the assistance of one research helper.

2.3.2 Face-to-face and eHealth blended intervention group

In addition to attending all face-to-face sessions, participants in the blended intervention group will participate in a theory-based and web-based behavioral change promotion eHealth intervention, including one program for PA and one program for diet each week. A mobile-based website, namely Perfect Diet and Exercise (in Cantonese: "食" 全十美，行大 "運"), will be established to facilitate the intervention. The website's homepage will have the PA module and the diet (FVI and MFEA) module. Participants can access each module to take part in respective online learning activities. Each module will consist of two sections. Section 1 comprises a theory-based 10-week intervention program targeting social-cognitive predictors of PA/diet (FVI and MFEA). Participants will access this section once a week. Section 2 is a data repository platform collecting former exercises and incentive activities. Participants can access their files at any time throughout the 10-week intervention period, including behavior records of PA/diet, action planning of PA/diet, coping planning of PA/diet, and "my diary" about PA/diet behaviors. The weekly eHealth intervention component will be developed based on the Health Action Process Approach (HAPA) (41). Following the HAPA-based social-cognitive variables, the weekly intervention content will be designed accordingly (see Table 1).

In addition, the intervention will apply different behavior change techniques (BCTs) to facilitate behavior (42). The detailed strategies of BCTs are presented in Table 1. For example, the participants will receive two types of feedback in the weekly web-based health session. This will include individualized feedback on their behavior performance in the 1st week, 2nd week, 3rd week, 4th week, and 5th week, respectively. Furthermore, the normative feedback on the criterion-based behavior recommendations (e.g., accumulated at least 150 minutes with moderate intensity of PA per week, five portions of FVI per day, 5–6 taels of MFEA per day) (see Figure 2) will be contained.

Each weekly web-based section for PA and diet will last about 15 minutes. In the first week, once the participants complete the face-to-face intervention, the researcher will immediately organize a web-based intervention course for older adults at the PA gymnasium and the senior center for diet, respectively. The researcher will first introduce the website's content and then demonstrate the steps to use this web-based program. Afterward, research helpers will guide participants in accessing the website and finishing the online study. In the 2nd week, the web-based intervention course will be continuously offered at the gym and the senior center to ensure older adults are familiar with the website's usage. From the 3rd week, participants will be encouraged to finish the online courses at home to support transfer.

2.3.3 Control group

The participants in the control group will receive a biweekly telephone call. Each call will last about 5 minutes. The participants will be asked several health-related questions, such as "Has your physical activity changed in the last 2 weeks?" "If it changed, what are the reasons for the increase or decrease?" "Have you changed your diet in the last 2 weeks?" and "What has changed? What are the reasons for the increase or decrease if it changed?"

2.4 Outcome evaluation of the intervention

All the outcomes will be measured at T1 (baseline pre-test), T2 (post-test), and T3 (follow-up). Only demographics will be collected at T1. All measurement scales will be in Cantonese, which has been widely used in previous studies conducted in Hong Kong.

2.4.1 Primary outcomes: behavior indicators

2.4.1.1 Physical activity (PA)

The waist-worn accelerometer (wGT3XBT, ActiGraph Inc., Pensacola, FL, USA) will objectively assess moderate-to-vigorous intensity physical activity (MVPA) during the last 7 days. The participants will be guided to wear accelerometers attached to elastic belts around their waists during all waking hours for seven consecutive days. They must remove the waist-worn accelerometers only during sleeping or water-based activities (43). The Troiano wear time

10.3389/fpubh.2024.1360037

TABLE 1 Theory-based intervention variables and behavior change techniques (BCTs) in 10 weeks.

Time	Social-cognitive variables	Behavior change techniques (BCTs)	BCTs related strategies
Week1	Motivational self-efficacy Action planning Social support	1.4 Action planning 2.2 Feedback on behavior 3.2 Social support practical 3.3 Social support emotional 7.1 Prompts/cues 15.1 Verbal persuasion about capability	a) Asking participants about their MVPA/diet behavior and providing personally tailored feedback b) Prompting verbal persuasion about the capability of performing MVPA/diet (targeting motivational self-efficacy) c) Asking participants to keep their plan in mind can help them successfully perform the wanted behavior (targeting Action control) d) Giving examples of successful action plans for MVPA/diet adherence (targeting action planning) e) Asking participants to make specific action plans of when, where, and how to perform MVPA/diet (targeting action planning) f) Asking participants to review social support on MVPA/diet initiation they received and give examples of successful social support for MVPA/diet adherence (targeting perceived social support)
Week 2–4	Motivational self-efficacy Action planning Social support	1.4 Action planning 2.2 Feedback on behavior 3.2 Social support practical 3.3 Social support emotional 7.1 Prompts/cues 15.1 Verbal persuasion about capability	Some strategies used in Week 1 (a, b, c, d, f) will be further applied in Week 2–4 g) Giving examples of successful cases of MVPA/diet participation (further targeting motivational self-efficacy) h) Participants will be asked to access the execution of action plans and adjust the previous action plans if necessary (targeting revision of action planning)
Week 5	Volitional self-efficacy Coping planning Action control Social support	1.2 Problem solving (coping panning) 2.2 Feedback on behavior 2.3 Self-monitoring of behavior 3.2 Social support practical 3.3 Social support emotional 7.1 Prompts/cues 10.1. Material incentive behavior 15.1 Verbal persuasion about capability	Some strategies used in Week 1–4 (a, b, d, f) will be further applied in Week 5 i) Giving examples of successful cases of MVPA/diet maintenance and recovery (targeting VSE) j) Giving examples of successful coping plans for MVPA/diet maintenance and recovery (targeting coping planning) k) Providing guidance (e.g., If-then algorithm) on how to set coping plans to overcome potential barriers when performing MVPA/diet (targeting coping planning) l) Guiding how to write a reflective diary (MVPA/diet behavior performed and emotional experience) to record and self-monitor their daily MVPA/diet (targeting action control)
Week 6–10	Volitional self-efficacy Coping planning Action control Social support	1.2 Problem solving (coping panning) 2.2 Feedback on behavior 2.3 Self-monitoring of behavior 3.2 Social support practical 3.3 Social support emotional 7.1 Prompts/cues 10.1. Material incentive behavior 15.1 Verbal persuasion about capability	Some strategies used in Week 1–5 (a, b, d, f, l) will be further applied in Week 6–10 m) Participants will be asked to review the execution of coping plans and adjust the coping plans in Weeks 6–9 if necessary (targeting revision of coping planning)

validation algorithm will be applied to activity counts (44). With this algorithm, periods of 60+ consecutive minutes of continuous zero counts with a tolerance of up to 2 minutes of activity counts between 0 to 100 counts/min will be classified as non-wear time (44). Data of at least 10 hours per day for at least 3 days will be considered valid and included in data analysis according to a previous systematic review

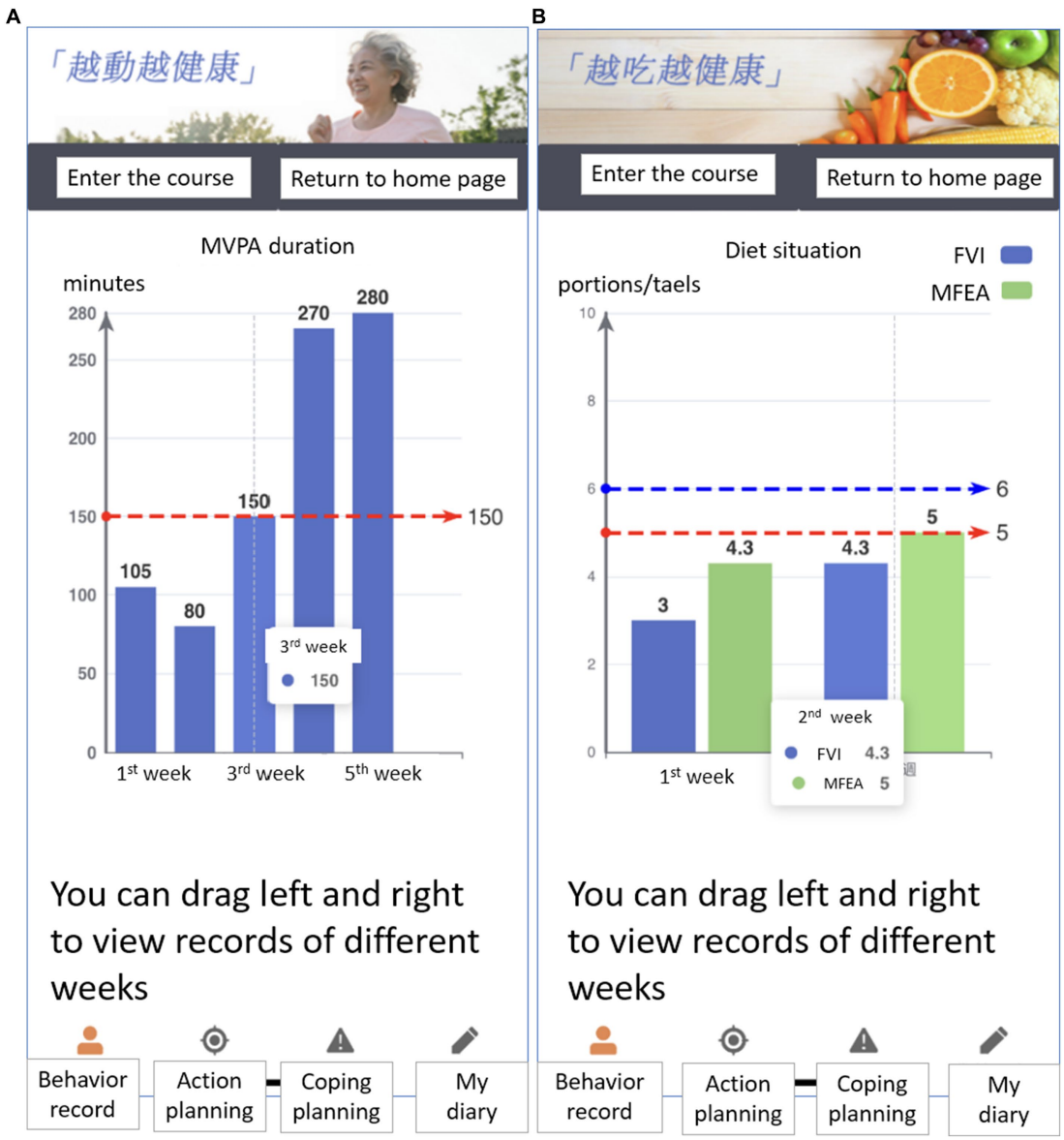


FIGURE 2
Individualized and normative feedback regarding PA per week during the past 5 weeks **(A)** as well as portions of fruit and vegetable, and taels of meat, fish, egg, and alternatives consumption in average per day during the past 2 weeks **(B)** for the blended intervention group.

(45). For the estimated PA intensity, the Sasaki et al. cut-point will be applied, 200–2,690 counts/min is for LPA, and ≥2,691 counts/min is for MVPA (46).

2.4.1.2 Fruit and vegetable intake (FVI) and meat, fish, egg & alternatives (MFEA)

To assess the FVI and MFEA during the past 7 days, participants will be asked to finish a diet record booklet and fill in how many portions of fruit, vegetable, and fruit and vegetable juice as well as how many taels of meat, fish, egg, and alternatives they have consumed within 1 day. The items will include "On the first day, I ate xxx portions of vegetables, I ate xxx portions of fruits, I drank xxx portions of vegetable and fruit juice. In total, xxx portions fruit and vegetables" and "On the first day, I ate xxx taels of meat (including fish), I ate xxx taels of eggs, I ate xxx taels of alternatives and a total of xxx taels meat, fish, egg, and alternatives." The average number of FVI and MFEA they ate daily will be calculated based on the records they filled out during the past 7 days. These items are developed based on the diet recommendations provided by the Center for Health Protection Department of Health in Hong Kong (47). One tael is equal to 37.799 grams. Each participant will receive an assessment guide booklet on the portion of fruit and vegetables and the tael of MFEA.

2.4.2 Secondary outcomes: health outcomes

2.4.2.1 Physical health outcomes

The Senior Fitness Test (SFT) Manual will be applied to assess the physical fitness of participants (48). The testing materials have been widely used in many countries and translated into many languages, including Chinese (49). The physical fitness testing includes the

measurements of the 30-Second Chair Stand Test (lower body strength), 30-Second Arm Curl Test (upper body strength), 2-Minute Step Test (aerobic endurance), Chair Sit-and-Reach Test (lower body flexibility), Back Scratch Test (upper body flexibility), 8-foot Up-and-Go Test (agility and dynamic balance), and body mass index (BMI). Detailed testing guidance will be provided during testing. For example, 30-Second Chair Stand Test will be used to test lower body strength. Required measuring tools include a straight back or folding chair without armrests (seat 17 inches/43 cm high) and a stopwatch. The participant will be asked to sit in the middle of the seat, with their feet shoulder-width apart, flat on the floor. The arms should be crossed at the wrists and held close to the chest. The participant will be required to keep their back straight and keep their arms against the chest. After listening to the "Go" instruction, the participant should rise to a full standing position, and then sit back down again. The participant should repeat this action for 30 s. If the participant has completed a full stand from the sitting position when the time has elapsed, the final stand is counted in the total. The reliability of SFT items ranged from 0.80 to 0.98 (49).

The blood pressure will be measured by an automated portable device (Omron HEM-7121 Standard, Japan) following the procedure guidelines (50). Participants will be asked to sit quietly for 5–10 minutes before their blood pressure is measured. The blood pressure will then be recorded on an electronic screen and written on paper for recording. The unit would be mmHg. Capillary blood samples will be collected by finger-prick (51). The glycosylated hemoglobin (HbA1c, mmol/mol) and lipid (Total Cholesterol, CHOL; triglycerides, TG; high-density lipoprotein, HDL; mg/dL) will be tested by Point of Care (POC) Cobas b 101 system (Roche Diagnostics, Mannheim, Germany). A 30 uL fingertip blood sample will be collected from participants and immediately tested using two test trips. The system can generate HbA1c and lipid assay results by using 2 uL for the HbA1c test and 19 uL for the lipid test by finger-prick blood samples within 15 minutes (52). Participants will be asked to stay in a fasted state for 12 hours before the blood test.

2.4.2.2 Mental health outcomes

The Geriatric Depression Scale 15-item (GDS-15) - Cantonese Version will be used to assess depression among participants. The validity and reliability of the GDS-15 were validated as satisfactory among Chinese older adults in previous studies and were regarded as a valuable method for measuring depression in older adults (Cronbach's $\alpha = 0.81–0.83$) (53, 54). Participants will be asked 15 items referring to the past week, such as "Are you satisfied with your life?" and "Have you dropped many of your activities and interests?." Answers are indicated as yes "1" or no "0." For items 1, 5, 7, 11, and 13, the answer is yes "0" or no "1."

The Chinese translation of the 6-item De Jong Gierveld Loneliness Scale will be applied to assessing loneliness. This scale was reliable and valid for measuring loneliness among Hong Kong older adults (Cronbach $\alpha = 0.76$) (55). The participants will be informed, "Please see if these statements describe your situations or feelings now. If you think that they are describing you, answer yes; if you disagree with the statements, answer more or less; if you do not think that they are describing you, answer no." Participants will be asked six items including two domains (emotional loneliness and social loneliness), such as "I experience a general sense of emptiness" and "There are plenty of people I can rely on when I have problems." For the first three items related to emotional loneliness, answers are indicated as yes "1," more or less "1," and no "0." For the last three items related to social loneliness, answers are indicated as yes "0," more or less "1," and no "1."

2.4.2.3 Social-cognitive factors

The validated questionnaires will be used to assess the four social-cognitive variables (56–58), including Questionnaires of Self-efficacy (five items for each behavior) (59), Questionnaires of Planning (six items for PA, four items for each diet behavior) (60, 61), Questionnaires of Social Support (3 items for each behavior) (62), and Questionnaires of Action Control (6 items for each behavior) (63).

2.4.2.4 Health-related quality of life (HRQoL)

A brief version of the World Health Organization's Quality of Life questionnaire (WHOQOL-BREF HK) will be used to evaluate the HRQoL (62) in Hong Kong. Participants will be first asked about their general quality of life using the question "How would you rate your quality of life?" on a two-item five-point scale (1 = very poor; 5 = very good). The physical health subdomain with seven items will also be used (Cronbach's $\alpha = 0.71$), such as "Are you satisfied with your ability to do everyday things?" and "Do you have enough energy to cope with daily life?" (1 = very dissatisfied; 5 = very satisfied). However, for item 3 and item 4, the participants will be asked, "Do you need medical help to cope with everyday life?" and "Do you feel pain and discomfort holding you back?" (1 = an extreme amount; 5 = not at all).

2.4.2.5 Demographics

Items will include name, mobile number, gender, age, marital status, number of children, educational level, professional status, household income, and history of chronic diseases.

2.5 Pilot study

A pilot study of blended intervention was run before the main study. The aim was to ensure that the recruitment procedure, data collection instruments, and intervention content were feasible and acceptable. The preparation study was conducted for 4 weeks. Four older adults were recruited through Purposive Sampling with two females and two males (Mean age = 69.3 years, SD = 3.30) (64).

The participants were asked to finish all the measurements once and to attend a 4-week blended intervention program. The intervention content was the same as the first 4-week out of the proposed 10-week intervention content in the main study. After finishing the pilot study, the participants were invited to give suggestions and feedback. Depending on the input from the participants (e.g., making web pages more accessible to operate, shortening the health talk), the intervention content was further adapted. The participants in the pilot study will not be involved in the main study.

2.6 Retention strategies

Different strategies will be applied to improve the adherence rate of the three assessments and the participation rate of all intervention sessions throughout the program. Such methods will include (1) a WhatsApp message will be sent to older adults in all groups 1 day

before the interventions start to remind participants to participate by then; (2) there will be a check-in before each face-to-face class to help participants and researchers keep track of the attendance rate of all study participants throughout the course; (3) the printed materials of the face-to-face health talk will be distributed to the older adults in each face-to-face session. Since older people tend to have declining memories, this will help them look it up at home after they finish the course; (4) starting from the fifth week, the participants who document a valid diary three times a week on the website for each behavior will receive a cash reward of $10HKD, which will be distributed once a week; (5) after the completion of each data collection (T1, T2, and T3), the individualized health report including physical and mental health outcomes will be provided to the older adults.

2.7 Data analysis

All data will be analyzed by using SPSS 29.0. The Expectation Maximization (EM) method will be applied for missing values. Intention-to-treat principles will be used for all analyses. Independent samples *t*-tests, *F*-tests, and Chi-square tests will be used to compare the baseline characteristics at T1. Statistical significance will be set at the 5% level (two-tailed).

A series of generalized linear mixed models (GLMM) will be applied to evaluate the intervention effects on behaviors (PA, FVI, and MFEA), social-cognitive variables of behaviors (i.e., self-efficacy, planning, social support, and action control), physical health outcomes (i.e., physical fitness test, clinical indicators), mental health outcomes (i.e., depression, loneliness), and health-related quality of life (HRQoL).

2.8 Time schedule of the study

The proposed study will be completed over 36 months, as shown in Figure 3.

3 Discussion

The high prevalence of inadequate PA and unhealthy dietary habits in the old population has garnered significant attention from health researchers and policymakers. Current research would investigate the effectiveness of a blended approach comprising face-to-face and eHealth interventions, specifically focusing on PA, dietary patterns, and health outcomes among older adults. It will be one of the first studies to apply blended intervention among older adults to promote healthy lifestyle behaviors theory- and evidence-based. Three unique aspects characterize the project.

The first unique aspect is the intervention channels, which include face-to-face workshops and eHealth sessions. The eHealth session will supplement traditional face-to-face treatment or seminars for older adults (65). Although the blended interventions are still under-explored, some potential benefits exist: The participants can review the intervention content anytime after the physical session. It is easier

Research activity	Months																										
	1	2	3	4	5	6	7-12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32-36
Intervention development																											
● Website construction																											
Initiation and design (Step 1)																											
Development content (Step 2)																											
Internal testing and fine-tuning (Step 3)																											
User testing and launch website (Step 4)																											
● Face-to-face session content development																											
Allocation of PA coach and nutritionist (Step 1)																											
Develop content and activities (Step 2)																											
Preparing PPT for health talk and equipment (Step 3)																											
● Implementation of the intervention (4-week)																											
Recruitment of participants																											
● Posters and videos																											
● Screening																											
Assignment of student helpers and briefing																											
Pilot study and promotion																											
Conducting the pre-test at (T1) *																											
Implementation for intervention																											
● IG-1: 10-week face-to-face and eHealth blended intervention																											
● IG-2: 10-week face-to-face intervention																											
● CG: 10-week biweekly telephone call																											
Conducting the post-test at T2 *																											
Conducting the follow-up test at T3*																											
Data analysis																											

FIGURE 3
Gantt chart of research activities. *: The lengths of outcome tests at each time point, interventions, and follow-ups will be 1 month, 2.5 months (10 weeks), and 3 months, respectively.

to get timely feedback from health care providers (e.g., doctors, health instructors, social workers), reducing the travel time, appointment process, and waiting time for feedback. It also helps increase the social interaction between healthcare providers (e.g., doctors, health instructors, social workers) and participants, reducing participants' isolation after face-to-face contact. Besides, the healthcare providers can track the process and enhance adherence to the intervention (66).

The second unique aspect is that this is the first study applying eHealth technology to promote PA and diet behavior among Hong Kong community-dwelling older adults. Driven by the development of technology, more than 73.0% of Hong Kong's older adults (≥ 65 years) have smartphones, and more than 70% use the Internet regularly in 2021 (67). Although many older adults have access to the Internet in Hong Kong, it is still difficult for them to use smartphones due to unfamiliarity with functions and unfriendly application design and operation (68). Hence, the stand-alone eHealth intervention might be complex for older people to adhere to. eHealth might be a complementary technology for the traditional face-to-face intervention project. It was found that 75% of people aged 65 years or above are suffering from one or more chronic diseases in Hong Kong. As these chronic diseases affect functionality and well-being, the old population accounts for more than 46% of patients' hospital days (69). With the aging population and high prevalence of suffering from chronic diseases, this should be addressed immediately and appropriately to cope with the financial burden of treatment, rehabilitation, and residential care services. This study can develop and prove a blended intervention strategy for promoting lifestyle behaviors. It will be expected to be applied for disease management after the physical clinical.

The third unique aspect lies in exploring the psychosocial factors of behavior change and comprehensive health outcomes (BMI, physical fitness, clinical indicators, depression, loneliness, and health-related quality of life). The findings of this study can provide evidence about whether sufficient PA and a healthy diet are proven to be a protective factor for NCDs and associated with improvement in physical health, mental health, social well-being, cognitive function, and different aspects of body functions, which were proved by previous studies among other populations (70, 71). Besides, exploring the relationship between behavior change and psychosocial factors can enrich understanding mechanisms and have implications for theory-building.

Suggestions for further research encompass various aspects, including comparisons of a blended intervention with stand-alone eHealth interventions among older adults exploring aging effects and examining health lifestyle intervention effects in diverse geographical regions or countries. New research approaches are needed to enhance lifestyle behaviors, which can alleviate the growing demand for healthcare systems due to the aging population across the global landscape and within all medical and public health domains. Yet, identifying the critical predictive variables that underlie specific behavioral changes remains of utmost importance, a facet requiring comprehensive investigation in future research.

Ethics statement

The studies involving humans were approved by the Research Ethics Committee at Hong Kong Baptist University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MY: Conceptualization, Methodology, Project administration, Writing – original draft. YD: Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. SL: Conceptualization, Supervision, Writing – review & editing, Methodology. WL: Investigation, Supervision, Writing – review & editing. NS: Investigation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. World Health Organization. Noncommunicable diseases. (2018). Available at: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

2. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. *Lancet*. (2011) 377:1438–47. doi: 10.1016/S0140-6736(11)60393-0

3. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. (2012) 380:219–29. doi: 10.1016/S0140-6736(12)61031-9

4. Popkin BM, Ng SW. The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. *Obes Rev*. (2022) 23:e13366. doi: 10.1111/obr.13366

5. World Health Organization. Global status report on physical activity 2022. (2022). 1–112. Available at: https://www.who.int/teams/health-promotion/physical-activity/global-status-report-on-physical-activity-2022

6. Watson KB, Carlson SA, Gunn JP, Galuska DA, O'Connor A, Greenlund KJ, et al. Physical inactivity among adults aged 50 years and older — United States, 2014. *Morb Mortal Wkly Rep*. (2016) 65:954–8. doi: 10.15585/mmwr.mm6536a3

7. Centre for Health Protection. Diet and nutrition. (2022). Available at: https://www.chp.gov.hk/en/resources/465/8800.html

8. Pascual RW, Phelan S, La Frano MR, Pilolla KD, Griffiths Z, Foster GD. Diet quality and micronutrient intake among long-term weight loss maintainers. *Nutrients*. (2019) 11:1–12. doi: 10.3390/nu11123046

9. Nicklett EJ, Kadell AR. Fruit and vegetable intake among older adults: A scoping review. *Maturitas*. (2013) 75:305–12. doi: 10.1016/j.maturitas.2013.05.005

10. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet*. (2019) 393:1958–72. doi: 10.1016/S0140-6736(19)30041-8

11. Stanaway JD, Afshin A, Gakidou E, Lim SS, Abate D, Abate KH, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet*. (2018) 392:1923–94. doi: 10.1016/S0140-6736(18)32225-6

12. Yip CSC, Lam W, Fielding R. A summary of meat intakes and health burdens. *Eur J Clin Nutr*. (2018) 72:18–29. doi: 10.1038/ejcn.2017.117

13. Food and Agriculture Organization of the United Nations. Daily meat consumption per person, 2021. (2020). Available at: https://ourworldindata.org/grapher/daily-meat-consumption-per-person

14. World Health Organization. Noncommunicable diseases. (2023). Available at: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

15. Carey KB, Scott-Sheldon LAJ, Elliott JC, Garey L, Carey MP. Face-to-face versus computer-delivered alcohol interventions for college drinkers: a meta-analytic review, 1998 to 2010. *Clin Psychol Rev*. (2012) 32:690–703. doi: 10.1016/j.cpr.2012.08.001

16. Kader M, Sundblom E, Elinder LS. Effectiveness of universal parental support interventions addressing children's dietary habits, physical activity and bodyweight: a systematic review. *Prev Med*. (2015) 77:52–67. doi: 10.1016/j.ypmed.2015.05.005

17. Haghighi MM, Mavros Y, Singh MAF. The effects of structured exercise or lifestyle behavior interventions on long-term physical activity level and health outcomes in individuals with type 2 diabetes: a systematic review, meta-analysis, and Meta-regression. *J Phys Act Health*. (2018) 15:697–707. doi: 10.1123/jpah.2017-0589

18. Moschny A, Platen P, Klaaßen-Mielke R, Trampisch U, Hinrichs T. Barriers to physical activity in older adults in Germany: a cross-sectional study. *Int J Behav Nutr Phys Act*. (2011) 8:121–10. doi: 10.1186/1479-5868-8-121

19. Denny KG, Chan ML, Gravano J, Harvey D, Meyer OL, Huss O, et al. A randomized control trial of a behavioral intervention for older adults with subjective cognitive complaints that combines cognitive rehabilitation strategies and lifestyle modifications. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn*. (2023) 30:78–93. doi: 10.1080/13825585.2021.1965530

20. Boogerd EA, Arts T, Engelen LJ, van de Belt TH. "What is eHealth": time for an update? *JMIR Res Protoc*. (2015) 4:e29. doi: 10.2196/resprot.4065

21. Asbjørnsen RA, Smedsrød ML, Nes LS, Wentzel J, Varsi C, Hjelmesæth J, et al. Persuasive system design principles and behavior change techniques to stimulate motivation and adherence in electronic health interventions to support weight loss maintenance: scoping review. *J Med Internet Res*. (2019) 21:e14265. doi: 10.2196/14265

22. Schwarzer R. Modeling health behavior change: how to predict and modify the adoption and maintenance of health behaviors. *Appl Psychol*. (2008) 57:1–29. doi: 10.1111/j.1464-0597.2007.00325.x

23. Schwarzer R, Lippke S, Luszczynska A. Mechanisms of health behavior change in persons with chronic illness or disability: the health action process approach (HAPA). *Rehabil Psychol*. (2011) 56:161–70. doi: 10.1037/a0024509

24. Duan Y, Li X, Guo L, Liang W, Shang B, Lippke S. A WeChat Mini program-based intervention for physical activity, fruit and vegetable consumption among Chinese cardiovascular patients in home-based rehabilitation: a study protocol. *Front Public Health*. (2022) 10:10. doi: 10.3389/fpubh.2022.739100

25. Liang W, Duan YP, Shang BR, Wang YP, Hu C, Lippke S. A web-based lifestyle intervention program for Chinese college students: study protocol and baseline characteristics of a randomized placebo-controlled trial. *BMC Public Health*. (2019) 19:1097. doi: 10.1186/s12889-019-7438-1

26. Sutton S. How does the health action process approach (HAPA) bridge the intention-behavior gap? An examination of the model's causal structure. *Appl Psychol*. (2008) 57:66–74. doi: 10.1111/j.1464-0597.2007.00326.x

27. Lippke S, Ziegelmann JP. Theory-based health behavior change: developing, testing, and applying theories for evidence-based interventions. *Appl Psychol*. (2008) 57:698–716. doi: 10.1111/j.1464-0597.2008.00339.x

28. Zhang CQ, Zhang R, Schwarzer R, Hagger MS. A Meta-analysis of the health action process approach. *Health Psychol*. (2019) 38:623–37. doi: 10.1037/hea0000728

29. Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *J Med Internet Res*. (2010) 12:1–18. doi: 10.2196/jmir.1376

30. Aref-Adib G, O'Hanlon P, Fullarton K, Morant N, Sommerlad A, Johnson S, et al. A qualitative study of online mental health information seeking behaviour by those with psychosis. *BMC Psychiatry*. (2016) 16:1–10. doi: 10.1186/s12888-016-0952-0

31. Pedersen DH, Mansourvar M, Sortsø C, Schmidt T. Predicting dropouts from an electronic health platform for lifestyle interventions: analysis of methods and predictors. *J Med Internet Res*. (2019) 21:1–12. doi: 10.2196/13617

32. Lippke S, Dahmen A, Gao L, Guza E, Nigg CR. To what extent is internet activity predictive of psychological well-being? *Psychol Res Behav Manag*. (2021) 14:207–19. doi: 10.2147/PRBM.S274502

33. van der Vaart R, Witting M, Riper H, Kooistra L, Bohlmeijer ET, van Gemert-Pijnen LJ. Blending online therapy into regular face-to-face therapy for depression: content, ratio and preconditions according to patients and therapists using a Delphi study. *BMC Psychiatry*. (2014) 14:1–10. doi: 10.1186/s12888-014-0355-z

34. Wentzel J, van der Vaart R, Bohlmeijer ET, van Gemert-Pijnen JEWC. Mixing online and face-to-face therapy: how to benefit from blended Care in Mental Health Care. *JMIR Ment Health*. (2016) 3:e4534:e9. doi: 10.2196/mental.4534

35. Hurkmans E, Matthys C, Bogaerts A, Scheys L, Devloo K, Seghers J. Face-to-face versus mobile versus blended weight loss program: randomized clinical trial. *JMIR Mhealth Uhealth*. (2018) 6:e14. doi: 10.2196/mhealth.7713

36. Erbe D, Psych D, Eichert HC, Riper H, Ebert DD. Blending face-to-face and internet-based interventions for the treatment of mental disorders in adults: systematic review. *J Med Internet Res*. (2017) 19:e306. doi: 10.2196/jmir.6588

37. Yang M, Duan Y, Liang W, Peiris DLIHK, Baker JS. Effects of face-to-face and eHealth blended interventions on physical activity, diet, and weight-related outcomes among adults: a systematic review and Meta-analysis. *Int J Environ Res Public Health*. (2023) 20:1560. doi: 10.3390/ijerph20021560

38. Weisburd D, Wilson DB, Wooditch A, Britt C. Statistical power. *Adv Stat Criminol Crim Justice*. (2022) 6:321–65. doi: 10.1007/978-3-030-67738-1_8

39. Moore M, Warburton J, O'Halloran PD, Shields N, Kingsley M. Effective community-based physical activity interventions for older adults living in rural and regional areas: A systematic review. *J Aging Phys Act*. (2016) 24:158–67. doi: 10.1123/japa.2014-0218

40. Zubala A, MacGillivray S, Frost H, Kroll T, Skelton DA, Gavine A, et al. Promotion of physical activity interventions for community dwelling older adults: a systematic review of reviews. *PLoS One*. (2017) 12:e0180902. doi: 10.1371/journal.pone.0180902

41. Schwarzer R. Health action process approach (HAPA) as a theoretical framework to understand behavior change. *Act Psic*. (2016) 30:119. doi: 10.15517/ap.v30i121.23458

42. Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. *Health Psychol*. (2008) 27:379–87. doi: 10.1037/0278-6133.27.3.379

43. Troiano RP, McClain JJ, Brychta RJ, Chen KY. Evolution of accelerometer methods for physical activity research. *Br J Sports Med*. (2014) 48:1019–23. doi: 10.1136/bjsports-2014-093546

44. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, Mcdowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. (2008) 40:181–8. doi: 10.1249/mss.0b013e31815a51b3

45. Migueles JH, Cadenas-Sanchez C, Ekelund U, Delisle Nyström C, Mora-Gonzalez J, Löf M, et al. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. *Sport Med*. (2017) 47:1821–45. doi: 10.1007/s40279-017-0716-0

46. Sasaki JE, Júnior JH, Meneguci J, Tribess S, Marocolo Júnior M, Stabelini Neto A, et al. Number of days required for reliably estimating physical activity and sedentary behaviour from accelerometer data in older adults. *J Sports Sci*. (2018) 36:1572–7. doi: 10.1080/02640414.2017.1403527

47. Disease Branch Centre for Health Protection Department of Health. Report of health behaviour survey 2018/19. (2020). Available at: http://www.chp.gov.hk

48. Rikli RE, Jones CJ. *Senior fitness test manual-second version*. Champaign, IL: Human Kinetics (2013).

49. Rikli RE, Jones CJ. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical Independence in later years. *Gerontologist*. (2013) 53:255–67. doi: 10.1093/geront/gns071

50. Goessler KF, Buys R, VanderTrappen D, Vanhumbeeck L, Cornelissen VA. A randomized controlled trial comparing home-based isometric handgrip exercise versus endurance training for blood pressure management. *J Am Soc Hypertens*. (2018) 12:285–93. doi: 10.1016/j.jash.2018.01.007

51. Kruijshoop M, Feskens EJM, Blaak EE, De Bruin TWA. Validation of capillary glucose measurements to detect glucose intolerance or type 2 diabetes mellitus in the general population. *Clin Chim Acta*. (2004) 341:33–40. doi: 10.1016/j.cccn.2003.10.033

52. Kenealy T, Herd G, Musaad S, Wells S. HbA 1c screening in the community: lessons for safety and quality management of a point of care programme. *Prim Care Diabetes*. (2019) 13:170–5. doi: 10.1016/j.pcd.2018.11.008

53. Zhao H, He J, Yi J, Yao S. Factor structure and measurement invariance across gender groups of the 15-item geriatric depression scale among Chinese elders. *Front Psychol*. (2019) 10:1360. doi: 10.3389/fpsyg.2019.01360

54. Cheng ST, Chan ACM. A brief version of the geriatric depression scale for the Chinese. *Psychol Assess*. (2004) 16:182–6. doi: 10.1037/1040-3590.16.2.182

55. Leung GTY, De Jong GJ, Lam LCW. Validation of the Chinese translation of the 6-item De Jong Gierveld loneliness scale in elderly Chinese. *Int Psychogeriatr*. (2008) 20:1262–72. doi: 10.1017/S1041610208007552

56. Duan Y, Shang B, Liang W, Yang M, Brehm W. Psychosocial profiles of physical activity fluctuation in office employees: A latent profile analysis. *PLoS One*. (2020) 15:1–15. doi: 10.1371/journal.pone.0227182

57. Duan YP, Julian W, Hu C, Gang M, Si Y, Lippke S. Web-based intervention for physical activity and fruit and vegetable intake among Chinese university students: a randomized controlled trial. *J Med Internet Res*. (2017) 19:e106. doi: 10.2196/jmir.7152

58. Duan YP, Liang W, Guo L, Wienert J, Si GY, Lippke S. Evaluation of a web-based intervention for multiple health behavior changes in patients with coronary heart disease in home-based rehabilitation: pilot randomized controlled trial. *J Med Internet Res*. (2018) 20:e12052. doi: 10.2196/12052

59. Luszczynska A, Sutton S. Physical activity after cardiac rehabilitation: evidence that different types of self-efficacy are important in maintainers and relapsers. *Rehabil Psychol*. (2006) 51:314–21. doi: 10.1037/0090-5550.51.4.314

60. Scholz U, Schüz B, Ziegelmann JR, Lippke S, Schwarzer R. Beyond behavioural intentions: planning mediates between intentions and physical activity. *Br J Health Psychol*. (2008) 13:479–94. doi: 10.1348/135910707X216062

61. Lippke S, Schwarzer R, Ziegelmann JP, Scholz U, Schüz B. Testing stage-specific effects of a stage-matched intervention: A randomized controlled trial targeting physical exercise and its predictors. *Health Educ Behav*. (2010) 37:533–46. doi: 10.1177/1090198109359386

62. Jackson J, Lippke S, Gray CD. Stage-specific prediction of physical activity in orthopedic patients after rehabilitation treatment. *Int J Sport Psychol*. (2011) 42:586–609.

63. Sniehotta FF, Scholz U, Schwarzer R. Bridging the intention-behaviour gap: planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychol Health*. (2005) 20:143–60. doi: 10.1080/08870440512331317670

64. Etikan I, RSAD SAM. Comparison of convenience sampling and purposive sampling. *Am J Theor Appl Stat*. (2016) 5:1. doi: 10.11648/j.ajtas.20160501.11

65. Fitzpatrick M, Nedeljkovic M, Abbott JA, Kyrios M, Moulding R. "Blended" therapy: the development and pilot evaluation of an internet-facilitated cognitive behavioral intervention to supplement face-to-face therapy for hoarding disorder. *Internet Interv*. (2017) 12:16–25. doi: 10.1016/j.invent.2018.02.006

66. Richards P, Simpson S. Beyond the therapeutic hour: an exploratory pilot study of using technology to enhance alliance and engagement within face-to-face psychotherapy. *Brit J Guid Couns*. (2015) 43:57–93. doi: 10.1080/03069885.2014.936824

67. Hong Kong Census and Statistics Department. "Thematic household survey report no. 69". (2020). Available at: https://www.censtatd.gov.hk/en/press_release_detail.html?id=4766

68. The Hong Kong Council of Social Service. The distance between digital technology and the elderly. (2021). Available at: https://www.hkcss.org.hk/數碼科技與長者的距離/?lang=en

69. Hong Kong Elderly Commission. Report on healthy ageing executive summary. (2021). Available at: https://www.elderlycommission.gov.hk/en/library/Ex-sum.htm

70. Langhammer B, Bergland A, Rydwik E. The importance of physical activity exercise among older people. *Biomed Res Int*. (2018) 2018:1–3. doi: 10.1155/2018/7856823

71. Głąbska D, Guzek D, Groele B, Gutkowska K. Fruit and vegetable intake and mental health in adults: a systematic review. *Nutrients*. (2020) 12:1–34. doi: 10.3390/nu12010115

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 17 May 2024
DOI 10.3389/fpubh.2024.1361572

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Lennon Tsang,
Hong Kong Baptist University,
Hong Kong SAR, China
Jesse W. C. Yip,
The Education University of Hong Kong,
Hong Kong SAR, China

*CORRESPONDENCE
Yan Zhang
✉ zhangyanmy@126.com

RECEIVED 26 December 2023
ACCEPTED 29 April 2024
PUBLISHED 17 May 2024

CITATION
Zhang H, Zhang Y, Yan Y, Li X and Tian Y (2024) Traditional Chinese medicine health literacy among rural older adults: a cross-sectional study.
Front. Public Health 12:1361572.
doi: 10.3389/fpubh.2024.1361572

COPYRIGHT
© 2024 Zhang, Zhang, Yan, Li and Tian. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Traditional Chinese medicine health literacy among rural older adults: a cross-sectional study

Huizhong Zhang, Yan Zhang*, Yuwen Yan, Xizheng Li and Yutong Tian

Nursing, School of Nursing and Health, Zhengzhou University, Zhengzhou, Henan, China

Background: The purpose of this study was to understand the current status of traditional Chinese medicine (TCM) health literacy among rural older adults people and its influencing factors.

Methods: This study used a random number table method to select one prefecture from Henan Province, China and used a convenience sampling method to select 200 rural older adults who met the inclusion criteria in a township in northern Henan from March to April 2023. A cross-sectional survey was conducted using a general information questionnaire and a traditional Chinese medicine health literacy questionnaire, and the influencing factors of rural older adults were analyzed using univariate analysis of variance (ANOVA) and multiple linear regression.

Results: The total TCM health literacy score of 200 rural older adults people was 84.14 ± 6.709. One-way ANOVA revealed that six factors, including education level, marital status, type of occupation, presence of family members engaged in medical-related work, main economic sources, and monthly income, influenced the TCM health literacy score of rural older adults people ($p < 0.05$). Multiple linear regression analysis revealed that education level, occupation type, and the presence of family members engaged in medical-related work were the factors influencing the TCM health literacy of rural older adults.

Conclusion: The TCM health literacy level of rural older adults people is at the lower to middle level, and health educators should strengthen the publicity and education of TCM healthcare knowledge for rural older adults people to improve their TCM health literacy level and thus enhance their quality of life.

KEYWORDS

active aging, rural, older adults, traditional Chinese medicine, health literacy

1 Introduction

Population aging is a major issue and an inevitable trend in international development, and countries around the world are entering the stage of population aging one after another. Since China's population ages, the number of older adults people has been increasing. Data from the Seventh National Population Census show that there are 264 million older adults people aged 60 and above in China (1). By the end of 2022, China will have 209.78 million people aged 65 and over, at a moderate stage of aging (2). China's aging population will continue to grow at a rapid rate, with some scholars estimating that there will be a net increase

of more than 12 million older adults people per year between 2021 and 2025, and the proportion of the population aged 65 and above will reach approximately 28.5% by 2050 (3).

In the process of aging, the level of aging in rural areas is greater than that in towns and cities, and the number of older adults people in rural areas exceeds 200 million (1). In 2021, this number accounted for 23.99% of the total rural population (4) and is expected to exceed 30% by 2033 (5). In addition, Henan Province in central China is a large population province, and its aging level ranks among the highest in China. At the same time, Henan Province is also a large agricultural province. Rural residents are an important part of all residents in the province. Paying attention to the problem of rural aging in Henan Province is a key measure for promoting the active aging of the province.

With increasing age and decreasing physical function, older adults people are more susceptible to chronic diseases. The poor health status of older adults people will lead to increased medical and nursing costs (6), which places the burden of continuous care on society and families. Studies have shown that (7) Chinese rural older adults people have worse self-rated health than do urban older adults people. In the countryside, 83.69% of rural older adults people suffer from at least one chronic disease. The risk of multiple chronic diseases is greater among the rural older adult population, and the burden of population aging is also exacerbated by multiple diseases.

To cope with the series of social problems brought about by aging, the State has elevated active aging to a strategic initiative (8), and how to achieve active aging is the focus of exploration. Most previous studies at home and abroad have shown that health literacy is an important determinant of health and that older adults with low health literacy have decreased medication adherence (9). At the same time, low health literacy is a risk factor for frailty in older adults (10), which ultimately leads to an increase in poor health outcomes and mortality (11), while older adults with higher levels of health literacy have higher levels of life satisfaction and active aging, and there is a strong correlation between health literacy and active aging in older adults (12). Therefore, the important strategy and key link in realizing active aging is to improve the health literacy of older adults people (13).

The Chinese government issued the Healthy China Action (2019–2030) in 2019, proposing to make every effort to improve the health literacy level of the population and fully implement the Healthy China Strategy (14). TCM health literacy is an important part of health literacy and distinctive health literacy with traditional Chinese characteristics; it refers to the ability of an individual to obtain and understand information and services on TCM healthcare knowledge and to utilize such information and services to make correct decisions to maintain and promote their own health (15). In recent years, proactive health has been proposed and promoted. In fact, the concept of preventing diseases before they occur originated from the Huangdi Neijing (16), which has a long history in Chinese medicine, and the idea of "treating the disease before it occurs" in Chinese medicine coincides with the connotation of active health. Since then, the state has gradually increased its inclination toward TCM in terms of policy. In 2022, the State Council issued the "14th Five-Year Plan for the Development of Traditional Chinese Medicine" (17), which will further broaden the coverage of TCM cultural dissemination and continue to improve the level of citizens' TCM health literacy, which has drawn increased academic attention to the study of health literacy in Chinese medicine.

Currently, research related to TCM health literacy in the Chinese context is gradually being conducted, and its target population is mainly residents of different provinces (18) and regions (19), older adult individuals (20), and university students (21). Moreover, this type of research has focused on investigating the current situation of Chinese medicine healthcare literacy and analyzing its influencing factors. Furthermore, some scholars have explored the correlation between TCM health literacy and residents' quality of life (22) and found that an increase in the level of knowledge of TCM health culture could enhance residents' self-assessed health status (23). However, the baseline TCM health literacy of Chinese citizens is relatively low (24). With the promotion and efforts of TCM in recent years, the level of TCM health literacy has slowly improved, but few studies have investigated the level of TCM health literacy in rural older adults people. Rural China is a special region that differs from urban areas in many ways, so this study focused on the level of TCM health literacy of older adults people in rural areas, with the aim of providing a reference for the development of TCM health literacy enhancement programs for rural older adults people.

2 Materials and methods

2.1 Study design and participants

We used a random number table method to select one prefecture from Henan Province, China and used a convenience sampling method to select older adults people in rural areas as the study population. The inclusion criteria were as follows: ① age ≥ 60 years (25), ② rural household registration, and ③ living in rural areas for at least 1 year. The exclusion criteria were as follows: ① cognitive impairment, visual and auditory impairment, and loss of expression and communication ability and ② other reasons for refusal to cooperate. The exclusion criteria were as follows: ① questionnaires were not completed, people quit the study in the middle, ② questionnaires filled in the content of the obvious regularity, and ③ questionnaires with missing values greater than 5% and abnormal values. All respondents provided informed consent and participated in this study voluntarily. The sample size is estimated to be 5 ~ 10 times the number of variables, and there are 15 variables in this study. Considering that 20% of the questionnaires were invalid, the number of questionnaires was calculated to be 94 ~ 188. The sample content of this questionnaire survey included 200 patients, which met the sample size requirements.

2.2 Measures

2.2.1 General information questionnaire

Based on the literature review, the researcher designed a general information questionnaire that considered the characteristics of rural older adults people, including gender, age, education level, marital status, type of occupation, presence of family members engaged in medicine-related work, main economic sources, monthly income, chronic conditions, monthly medical costs, and resident population. The permanent household population was defined as the number of people who had lived in the household for more than 6 months.

2.2.2 Questionnaire on TCM health literacy

The questionnaire was developed by Zhou Ping (26). The questionnaire was developed based on the questionnaire on healthcare literacy with TCM in 2014. The questionnaire consists of four parts, including basic knowledge and concepts, healthy lifestyle, healthcare content, and common healthcare methods, with a total of 37 entries. In terms of the scoring method, basic knowledge and concepts were scored 3 points for "correct," 2 points for "do not know," and 1 point for "incorrect"; for example, "Chinese medicine health care is to The natural properties of Chinese medicines are utilized to regulate the vitality of the body's qi, blood, yin and yang. Chinese medicine should pay attention to differences in age, constitution and season. Do you think this statement is correct?." The answers in the Common Health Practices section were 3 points for "often," 2 points for "occasionally," and 1 point for "never," for example, "Do you try to promote blood and chi flow and mental clarity by brushing your hair?." Healthy lifestyle and healthcare content was scored from "cannot" to "can" from 1 to 4. For example, "Do you maintain your health by way of practising traditional Chinese medicine health programs such as Taijiquan and Baduanjin?" The higher the score is, the greater the level of TCM health literacy. The questionnaire has good reliability and validity in the older adult population, with a Cronbach's α coefficient of 0.845 and validity of 0.793, which is suitable for surveying the healthcare level of older adults people. The level of Chinese medicine health culture literacy (TCM-QL) refers to the proportion of people with basic Chinese medicine health culture literacy in the total population, with a questionnaire score of 70% and above of the total score indicating Chinese medicine literacy, a questionnaire score of 128 points, a questionnaire score of ≥89.6 points indicating basic Chinese medicine health culture literacy, and a Chinese medicine literacy rate = the number of people who have literacy/the total number of people surveyed × 100% (27). The rate of Chinese medicine literacy = the number of people with literacy/the total number of people surveyed × 100%.

2.3 Data collection procedure

An on-site questionnaire survey was conducted among rural older adults people who met the inclusion criteria, and the paper version of the questionnaire was personally distributed by the researcher in the households. The purpose of the study, the content of the study, and the method of questionnaire completion were explained to the respondents before distributing the questionnaires. The researcher promised the respondents that the interview data would be used only for academic research and that personal privacy would be kept strictly confidential. The respondents agreed to sign a letter of informed consent. Older adults people who can read and write can complete the questionnaire by themselves, and the researcher also supervises the process of completing the questionnaire. For the older adults who could not understand the content of the entries due to their limited literacy, the researcher explained the entries in face-to-face format by converting the written words into easy-to-understand spoken language and asking questions one by one while avoiding leading questions, for example, interpreting the statement "The idea of treating the unhealthy disease in traditional Chinese medicine covers the whole process of health and disease, including preventing the occurrence of diseases before they occur, preventing the development of severe diseases and preventing the recurrence of diseases after millennium" into "Chinese medicine's idea of treating diseases before they occur includes preventing the occurrence of diseases, preventing the development of serious diseases and preventing the recurrence of diseases." For older adults with physical disabilities, the researcher explained the entries item by item and asked questions while completing the questionnaire by pen on behalf of the older adult and returning to determine if the answers were in line with their thoughts. At the end of each survey, the interviewer thanked the participants by giving them gifts (pill boxes and salt control spoons) and health education brochures.

The paper questionnaires were collected on the spot and checked for completeness by the researcher, and errors and invalid questionnaires were excluded. A total of 212 questionnaires were distributed, and 205 questionnaires were recovered, of which 200 were valid; the effective recovery rate of the questionnaires was 94.34%.

2.4 Statistical analysis

We used Epi Data 3.1 for data entry, and double-checking was performed to ensure data accuracy. SPSS 25.0 was used to analyze the data, and different descriptive statistical methods were used according to the type of data. Measurements that conform to a normal distribution are expressed as $\bar{x} \pm s$, and non-normal measures are expressed as the median and interquartile range. Count data are expressed as frequencies and percentages. Independent-sample *t*-tests were used for continuous variables, analysis of variance (ANOVA) was used for comparisons between multiple groups of measures, and chi-square tests were used for categorical variables. Multifactorial analysis was performed using multiple linear regression with a test level of $\alpha = 0.05$.

3 Results

3.1 The TCM health literacy scores of rural older adults people

The rate of TCM health literacy among the 200 rural older adult individuals was 17%, and the scores for each part were calculated using a percentage system. The order from highest to lowest was basic knowledge and concepts (88.37 ± 6.437 points), healthy lifestyle (74.73 ± 7.935 points), and healthcare content and common healthcare methods (52.96 ± 7.311 points and 42.97 ± 9.233 points, respectively), as shown in Table 1. The top five and bottom five rankings of scores for all entries are shown in Table 2.

TABLE 1 Total score and individual dimension scores of TCM health literacy among rural older adults ($n = 200$.$\bar{x} \pm s$).

Dimension	Score	Standardized Score
Basic knowledge and concepts	26.51 ± 1.931	88.37 ± 6.437
Healthy lifestyle	29.89 ± 3.174	74.73 ± 7.935
Healthcare contents	14.83 ± 2.047	52.96 ± 7.311
Common healthcare methods	12.89 ± 2.770	42.97 ± 9.233

TABLE 2 Entries with top and bottom five scores on health literacy in TCM.

Item	Average score	Arrange in order
Top five		
The idea of "treating the disease before it occurs" in Chinese medicine covers the whole process of health and disease, including "preventing illness before it occurs, preventing changes in existing illnesses, and preventing recurrence of disease after it occurs."	9.67 ± 0.080	1
Avoid using aluminum and iron decoction containers for decocting herbs.	9.50 ± 0.093	2
The following Chinese herbs are "dual-use of medicine and food": honey, yam, jujube, wolfberry, and mung bean.	9.23 ± 0.117	3
Taking herbal medicines should pay attention to the differences in age, constitution and seasons.	9.20 ± 0.100	4
Are you able to maintain peace of mind, adapt to social conditions, and live and work positively?	9.15 ± 0.140	5
Bottom five		
Have you tried using the Eye Movement Method to clear the toxins of your liver and improve eyesight?	3.60 ± 0.077	33
Are you able to take acupuncture, tuina, massage, and exercise to unblock meridians and harmonize yin and yang?	3.33 ± 0.110	34
Do you maintain your health by practicing traditional Chinese healthcare projects?	3.28 ± 0.103	35
Are you able to develop a daily regimen that suits your constitution?	3.15 ± 0.088	36
Are you able to recognize your constitution?	2.90 ± 0.083	37

3.2 Statistical characteristics of the rural older adult

A total of 200 rural older adults people participated in the survey on TCM health literacy. Among them, 84 were men, accounting for 42%, and 116 were women, accounting for 58%. The majority of the survey respondents were aged 70–80 years (86 people, accounting for 43% of the sample); the literacy level of the rural older adult population was mostly elementary school, accounting for 37.5%. The basic characteristics of the survey respondents are shown in Table 3.

3.3 Single-factor analysis of traditional Chinese medicine healthcare literacy among rural older adults people

According to the univariate analysis of TCM health literacy in the rural older adult population, the differences in TCM health literacy in the rural older adult population for a total of six factors, namely, education level, marital status, occupation category, presence of family members engaged in medicine-related work, main economic sources, and monthly income, were statistically significant ($p < 0.05$), and the results are shown in Table 3.

3.4 Multiple linear regression analysis of traditional Chinese medicine healthcare literacy in rural older adults

Using the total TCM health literacy score of rural older adults people as the dependent variable and the statistically significant variables in the univariate analysis as the independent variables, multiple linear regression analyses were performed, and the values assigned to the respective variables are shown in Table 4. Three variables, namely, education, occupation category, and whether any family members were practicing medical-related fields, were entered into the regression equation, and the results are shown in Table 5.

4 Discussion

The results of this study revealed that the total TCM literacy score of the rural older adult population was 84.14 ± 6.709%, and the rate of TCM literacy was 17%, which was much lower than that of the community older adult population surveyed by Zou (28). The reason for this may be that the older persons in this study were from rural areas, while the scholar Zou investigated mostly urban older persons. There are great differences in the economy, education and geography between urban and rural areas (29). The development of urban health resources is more complete (30). There are more TCM healthcare service organizations in urban areas, so the accessibility of TCM healthcare services for urban seniors is high. However, in rural areas, TCM healthcare resources are relatively insufficient, and the form and content of TCM-related health education are relatively homogeneous, resulting in fewer opportunities for rural seniors to receive TCM health education. Second, the income level of the survey respondents in this study was low, with 65.5% of the older adults earning less than 1,000 yuan per month. The older adults are limited by their economic conditions and have less initiative in acquiring knowledge of TCM (31), and they have insufficient access to information about TCM (32). As a result, rural older adults people have less overall knowledge of TCM healthcare and a lower level of TCM health literacy.

The scores of each part of the questionnaire were the highest (26.51 ± 1.931) for basic knowledge and concepts, which is consistent with the findings of other scholars (33, 34). The reason may be that TCM is a traditional Chinese culture with a history of thousands of years in China and has a close connection with people's lives. Residents learn some of the basic knowledge of TCM through word-of-mouth. In addition, the lowest score in this survey was for the content and methods of healthcare (12.89 ± 2.770), which may be attributed to the low level of mastery of appropriate Chinese medicine technology among grassroots healthcare workers who undertake rural health education (35). Primary healthcare institutions can learn from previous studies, such as the use of remote medical education

10.3389/fpubh.2024.1361572

TABLE 3 One-way analysis of TCM health literacy among rural older adults (n = 200.$\bar{x}\pm s$).

Characteristics	*n*(%)	Mean(*SD*)	*F*/*Z*	*p*-value
Total	200 (100)	84.14 ± 6.709		
Individual level TCM Health literacy				
Gender			0.173*	133.247
Men	84 (42.0)	84.24 ± 8.228		
Women	116 (58.0)	84.06 ± 5.386		
Age, years			2.937**	0.055
60 ~ 70	79 (39.5)	85.54 ± 7.684		
70 ~ 80	86 (43.0)	83.22 ± 6.215		
80~	35 (17.5)	83.20 ± 4.880		
Education level			18.035**	<0.01
Illiteracy	51 (25.5)	80.63 ± 4.626		
Primary school	75 (37.5)	83.28 ± 5.198		
Junior high school	54 (27.0)	85.91 ± 7.069		
Senior high school	14 (7.0)	88.29 ± 7.477		
College or above	6 (3.0)	99.00 ± 4.366		
Marital status			2.423*	0.016
Have a spouse	140 (70.0)	84.88 ± 7.010		
Without a spouse	60 (30.0)	82.40 ± 5.627		
Occupation category			22.020**	<0.01
Farmers	156 (78.0)	83.08 ± 5.716		
Educators	25 (12.5)	83.68 ± 6.362		
Government officials	16 (8.0)	95.50 ± 6.643		
Others	3 (1.5)	82.00 ± 1.000		
Whether any family members are practicing medical-related field?			6.530*	<0.01
None	174 (87.0)	83.05 ± 5.931		
Yes	26 (13.0)	91.42 ± 7.168		
Main economic sources			24.072**	<0.01
Children	52 (26)	82.52 ± 4.604		
Pension	23 (11.5)	93.17 ± 6.853		
Government subsidy	17 (8.5)	79.41 ± 3.954		
Job	108 (54)	83.73 ± 6.251		
Monthly income, RMB			14.714**	<0.01
<500	60 (30.0)	81.07 ± 4.345		
500 ~ 1,000	71 (35.5)	83.27 ± 5.806		
1,000 ~ 2000	41 (20.5)	86.46 ± 5.801		
≥2000	28 (14.0)	89.50 ± 9.605		
Chronic conditions			0.352*	0.725
None	94 (47.0)	83.96 ± 6.046		
≥1	106 (53.0)	84.29 ± 7.272		
Monthly medical costs, RMB			2.365**	0.072
<100	134 (67.0)	84.40 ± 6.249		
100 ~ 500	51 (25.5)	83.00 ± 7.632		
500 ~ 1,000	12 (6.0)	83.75 ± 5.802		
≥1,000	3 (1.5)	93.00 ± 9.165		
Resident population			0.674**	0.610
1	26 (13.0)	82.42 ± 6.555		
2	50 (25.0)	84.68 ± 6.847		
3	15 (7.5)	84.40 ± 8.551		
4	27 (13.5)	85.15 ± 5.776		
≥5	82 (41.0)	83.96 ± 6.642		

*Z-value; **F-value.

platforms to fully unite with higher-level hospitals (36), improving the training service guarantee system between tertiary hospitals and primary healthcare institutions, expanding the popularization of appropriate Chinese medicine technology, and improving the level of Chinese medicine technology used by primary healthcare personnel. In addition, the medical association within the organization can form a professional health education team (37), long-term stable rural Chinese medicine education "passes on" mode, etc., for the rural older adult to enhance Chinese medicine healthcare literacy to provide necessary organizational safeguards.

In this study, the literacy level of the rural older adult population showed a positive correlation with TCM health literacy; that is, the greater the literacy level was, the greater the TCM literacy level was. Many studies have shown (38) that as the education level of survey respondents increases, their health literacy level also shows an increasing trend, similar to the results of this study. This may be because the greater the education level of older adults people, the more adequate their knowledge reserve and the greater their motivation to acquire health knowledge and participate in healthcare behaviors on their own (39). In addition, older adults people with a high education level have high information acquisition ability and information understanding abilities (40), which can transform learned knowledge into healthy behaviors. Older adults people with low literacy levels have lower cognitive levels and a single way of acquiring TCM health knowledge, coupled with their relatively low ability to screen for health information (41). They are resulting in a low level of TCM health literacy. This suggests that we should pay attention to the low literacy level of older adults people and improve the availability of relevant health education materials to make them suitable for aging and agriculture, highlighting readability, the use of picture-based text as a supplement and other characteristics. In addition, improving learning ability should be carried out in a two-way process by reducing the difficulty of learning, with the help of the form of geriatric school (42) to provide basic general education for the rural older adults and to improve the literacy level of the rural older adults as well as the use of electronic equipment skills (43) to help them better adapt to professional knowledge of the learning process.

Our findings showed that the presence or absence of family members engaged in medicine-related work in the home was the main influencing factor of TCM health literacy among rural older adults, i.e., older adults with family members engaged in medicine-related work had higher scores on the dependent variable. Shaoyan et al. (44) reported that the levels of knowledge, beliefs, and behavior related to TCM healthcare were greater among those who had relatives working in TCM and related professions, which was similar to the results of this study. This is because family members who have experience studying medicine have medical knowledge and health habits and supervise and manage the health of other family members in their lives, thus promoting family members' emphasis on knowledge of Chinese medicine and healthcare (45). At the same time, older adults in this type of family receive TCM health knowledge more directly and conveniently, and the content is relatively accurate and reliable, which is also conducive to enhancing their TCM healthcare literacy. Therefore, in future health education, older adults whose family members practice medicine and have high health literacy will be selected as health models and combined with peer education (46) to motivate other older adults to learn health knowledge. Second, under the premise of considering the family environment and intergenerational support, TCM health education should not be limited to older adults people but should be centered on older adults people's families, increasing the interaction and participation of children and their parents; at the same time, TCM health education can be strengthened in the form

TABLE 4 The method of assigning values to the independent variables.

Independent variable	Assignment method
Education	Illiteracy = 1; Primary school = 2; Junior high school = 3; Senior high school = 4; College = 5
Marital status	Have a spouse = 1; Without a spouse = 0
Occupation category	Educators ($Z_1 = 1, Z_2 = 0, Z_3 = 0$); Government officials ($Z_1 = 0, Z_2 = 1, Z_3 = 0$); Others ($Z_1 = 0, Z_2 = 0, Z_3 = 1$)
Whether any family members are practicing medical-related field?	Yes = 1; No = 0
Main Economic Sources	Pension ($Z_1 = 1, Z_2 = 0, Z_3 = 0$); Government subsidy ($Z_1 = 0, Z_2 = 1, Z_3 = 0$); Job ($Z_1 = 0, Z_2 = 0, Z_3 = 1$)
Monthly Salary, yuan	<500 = 1; 500 ≤ X < 1,000 = 2; 1,000 ≤ X < 2000 = 3; ≥2000 = 4

TABLE 5 Multiple linear regression analysis of TCM health literacy among rural older adults.

Variable	Partial regression coefficient	Standard Error	Standardized regression coefficient	*t*	*P*
A constant (math.)	90.288	3.862		23.376	<0.01
Family members are practicing medical-related field	−5.275	1.202	−0.265	−4.388	<0.01
Farmers as a comparison					
Educators	0.957	1.259	0.029	0.474	0.636
Government officials	12.417	1.535	0.503	8.090	<0.01
Others	−1.083	3.408	−0.020	−0.318	0.751
Education	2.128	0.440	0.320	4.843	<0.01

of digital narratives (47) to strengthen the interest in learning and drive the improvement of TCM literacy among older adults people through the radiation of their children.

In our study, the TCM health literacy level of the group that used to work as farmers was lower than that of the respondents who used to work in township administration and other institutions. This may be because the nature of the farmers' work reduces their exposure to knowledge related to TCM, and the farmers' ability and means to learn TCM healthcare methods are insufficient (48). Older people who used to work in organizations have more chances of contacting Chinese medicine because of regular medical checkups or health exchanges with friends in the medical industry (49), thus promoting the enhancement of their TCM health literacy. This suggests that we can broaden the channels of health education and carry out all-around, multimodal TCM health education for farmers, such as using platforms like TikTok and WeChat to accurately push rich TCM knowledge and technology to the rural population. In addition, health education should be combined with the characteristics of the farmers themselves, adjusting the content of communication so that it is closely related to their daily lives. According to the 24 solar terms and traditional Chinese festivals, we can maintain traditional Chinese medicine-free clinical activities in accordance with farming culture. For example, doctors could give scented sachets to older adults at the Dragon Boat Festival and distribute "summer treatment of winter diseases" Sanfu medicinal patches in summer. At the same time, the routine rural older adults people can be trained to follow the regulations of the four seasons, teaching them simple and practical healthcare techniques and recipes, thereby increasing their interest in learning Chinese medicine.

From the perspective of inheriting and promoting traditional knowledge and techniques of Chinese medicine, this study focuses on the healthcare literacy of rural older adults people in Chinese medicine, and it suggests that a health education team of rural Chinese medicine knowledge should be formed as soon as possible to help them so that they can further achieve the cultural and spiritual level of "agrarianization and aging" on the basis of comprehensive improvement of the content and form of education. From the receiver's point of view, we should mobilize their motivation to learn Chinese medicine knowledge, guided by the idea of proactive health and Chinese medicine's "treating the disease before it occurs," and enhance the rural older adults quality of Chinese medicine and healthcare while making them realize the importance of actively seeking health so that their health-seeking behaviors can change from passive to active, and their knowledge of Chinese medicine can be applied to their healthcare throughout their entire lifecycle (50).

The limitations of this study are that only 200 rural older adults people in northern Henan Province were investigated, and the sample size was relatively limited. The sample size can be subsequently expanded to carry out multicenter and cross-provincial studies, and qualitative interviews can be used to explore in-depth rural older adults people's cognitive experiences and expectations of Chinese medicine and healthcare knowledge to improve the quality of life of rural older adults people.

Conclusion

The TCM health literacy of the 200 rural older adult individuals in this survey is at the lower middle level, and their literacy needs to be improved urgently, with literacy, type of occupation, and the presence or absence of family members engaged in medically related work as the main influencing factors.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Life Science Ethics Review Committee of Zhengzhou University (ZZUIRB 2021-105). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

HZ: Investigation, Writing – original draft. YZ: Supervision, Writing – review & editing. YY: Visualization, Writing – original draft. XL: Visualization, Writing – original draft. YT: Formal analysis, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Funding support was provided by the Henan Provincial Social Science Circles Federation (SKL-2023-569). The authors thank all participants of the fund application.

Acknowledgments

The authors thank the Henan Provincial Social Science Circles Federation for providing funding support (SKL-2023-569). The authors thank all participants of the fund application.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Statistics NBo. The seventh national population census 2021. Available at: http://www.stats.gov.cn/sj/pcsj/rkpc/7rp/indexch.htm.

2. Statistics NBo. Statistical bulletin of the People's Republic of China on National Economic and social development 2022. Available at: http://www.stats.gov.cn/sj/zxfb/202302/t20230228_1919011.html?eqid=f5c232a10002041400000005642ebc66.

3. Peng D, Long L. Long-term trends projection of China's population aging in the new era. *J Renmin Univ. China*. (2021) 35:96–109. doi: 10.3969/j.issn.1000-5420.2021.01.010

4. Houkai W, Peng Y, Shukun W. *China's comprehensive survey and research report on rural revitalization*. Beijing: China Social Sciences Press, (2022).

5. Hua L. Reconsideration on government behavior of rural elder security system in China under the concept of demand. *J Lanz Univ*. (2019) 47:163–73. doi: 10.13885/j.issn.1000-2804.2019.06.022

6. Hao S. Modeling hospitalization medical expenditure of the elderly in China. *Econ Anal Policy*. (2023) 79:450–61. doi: 10.1016/j.eap.2023.06.020

7. Jingshu M, Jianfang Z, Xingyu S. Status and influencing factors of health among rural elderly in eastern, central and western regions of China: a comparative study. *Chin J Public Health*. (2018) 34:342–5. doi: 10.11847/zgggws1115817

8. China SCo. Communiqué of the fifth plenary session of the 19th central Committee of the Communist Party of China. Available at: http://www.gov.cn/zhengce/2021-11/24/content_5653181.htm.

9. Sebastian MS, Stefanie P, Corinna B. Self-reported health literacy and medication adherence in older adults: a systematic review. *BMJ Open*. (2021) 11:e056307–7. doi: 10.1136/bmjopen-2021-056307

10. HyeRi S, EunYoung C, SuKyung K, HeeYun L, YoungSun K. Health literacy and frailty in community-dwelling older adults: evidence from a Nationwide cohort study in South Korea. *Int J Environ Res Public Health*. (2021) 18:7918–8. doi: 10.3390/ijerph18157918

11. Crane CC, Simko LC, Colbert AM, Bennett IM. Health literacy, health disparities, and sources of health information in U.S. older adults. *Orthop Nurs*. (2018) 37:54–65. doi: 10.1097/NOR.0000000000000418

12. Özkan O, Alp S, Özer O, Kambur ES. Healthy aging and life satisfaction. *Act Adapt Aging*. (2023):1–15. doi: 10.1080/01924788.2023.2291630

13. Eronen J, Paakkari L, Portegijs E, Saajanaho M, Rantanen T. Health literacy supports active aging. *Prev Med*. (2021) 143:106330. doi: 10.1016/j.ypmed.2020.106330

14. China SCo. Action for a healthy China (2019–2030). Available at: https://www.gov.cn/xinwen/2019-07/15/content_5409694.htm.

15. Xiaoyue Y, Qi J, Hui W, Ying G, Wei T. Comparative analysis of TCM science popularization and health care status between different gender. *China J Tradit Chin Med Phar*. (2017) 32:5309–13.

16. Tianfang W, Tao S. Exploration on the concept and category of subhealth and Chinese medicine "treating pre-disease" doctrine and the relationship between them. *Chin J Intergr Med*. (2009) 29:929–33. doi: 10.3321/j.issn:1003-5370.2009.10.017

17. China SCo. The fourteenth five-year plan for the development of Chinese medicine. Available at: https://www.ndrc.gov.cn/fggz/fzzlgh/gjjzxgh/202206/t20220601_1326724_ext.html.

18. Haoyuan M. *Analysis on the present situation and influencing factors of TCM health care literacy level of residents in Liaoning Province* China Medical University (2023).

19. Hao L. *Study on the level and influencing factors of traditional Chinese medicine health culture literacy of residents in Gansu Province* Gansu University of Chinese Medicine (2023).

20. Bingchan Z, Yonghong W, Ye X, Hui L, Xiangquan S, Shushen Z. Survey on Chinese medicine health care literacy and influencing factors of the elderly in Hebei under the perspective of healthy China strategy. *Hebei Beifang Xueyuan Xuebao*. (2023) 39:43–7.

21. Jing L. *Investigation and countermeasure research on college Students' TCM health care literacy in Changchun City* Changchun University of Chinese Medicine (2023).

22. Xueyan Z. *Study on the correlation between TCM health literacy and HRQoL of residents in Jiangxi Province* Jiangxi University of Traditional Chinese Medicine (2020).

23. Yiqing H, Yani W, YuHua L, Zhenshi X, Xiaorong J, Rui W, et al. Influence of health culture knowledge popularization of traditional Chinese medicine on the self-rated health status among residents in Qingdao. *Chin J Health Educ*. (2022) 38:599–603. doi: 10.16168/j.cnki.issn.1002-9982.2022.07.005

24. Wei T, Qi J, Yuyang Z, Tiantian L, Siyan Q, Yirong D, et al. Analysis of Chinese citizens' traditional Chinese medicine health culture literacy level and its influence factors in 2017. *Chin J Trad Chin Med*. (2019) 44:2865–70. doi: 10.19540/j.cnki.cjcmm.20190606.504

25. Mengke G, Yan Z, Yutong T, Yue G, Xiaohua L, Yixin L. A qualitative exploration of Chinese rural older adults' adaptation experience to disability in Henan Province. *BMC Public Health*. (2023) 23:512. doi: 10.1186/s12889-023-15425-0

26. Ping Z. *Survey research on Chinese medicine health care literacy and health status of retired elderly in Jinan universities* Shandong University of Traditional Chinese Medicine (2017).

27. Shuming J, Yiming L, Guorong K, Yuanyuan Y, Jianqiang W, Guohong Q, et al. Study on health literacy level on traditional Chinese medicine and its influencing factors among residents aged 15-69 years in Gansu Province in 2017. *China Health Educ*. (2019) 35:119–23. doi: 10.16168/j.cnki.issn.1002-9982.2019.02.005

28. Lixue Z. *A study on the correlation between traditional Chinese medicine health care literacy and health inputs and health behaviors among community-dwelling older adults* Yanbian University (2021).

29. Xuewei C, Orom H, Hay JL, Waters EA, Schofield E, Yuelin L, et al. Differences in rural and urban health information access and use. *J Rural Health*. (2019) 35:405–17. doi: 10.1111/jrh.12335

30. Lei Y, Boyang Y, Lei G, Maolin D, Yipeng L, Xu L, et al. Decomposition analysis of health inequalities between the urban and rural oldest-old populations in China: evidence from a national survey. *SSM Popul Health*. (2023) 21:101325. doi: 10.1016/j.ssmph.2022.101325

31. Ruolin L, Xinwen F, Wenling L, Zheng R, Hong S, Xiumin Z, et al. Popularization of Chinese medicine health culture knowledge and literacy level among middle-aged and elderly people in Jilin Province. *Chin J Gerontol*. (2021) 41:1977–80. doi: 10.3969/j.issn.1005-9202.2021.09.053

32. Xuqiang L, Xinru S, Lihui W, Siyuan L, Hongying Z. Investigation Report of Chinese Rural Residents' Traditional Chinese Medicine Health Literacy. *China Primary Health Care*. (2021) 35:53–5. doi: 10.3969/j.issn.1001-568X.2021.10.0016

33. Wei T, Ying G, Xiaoyue Y, Limin G, Hui W, Qi J. Evaluation on the questionnaire of healthcare literacy with TCM among Chinese residents in 2014. *China Health Educ*. (2018) 34:848–51. doi: 10.16168/j.cnki.issn.1002-9982.2018.09.021

34. Jinxing X. *Survey research on traditional Chinese medicine health care literacy and health status of community elderly* Yanbian University (2020).

35. Baihui L, Jie Z, Zhiyong L, Shuhui Y, Jingkun Q, Jiawen Y, et al. Investigation and Analysis on the Promotion of Appropriate Technology for Primary Nurses in Changsha, Hu'nan. *Guiding J Trad Chin Med Phar*. (2019) 25:58–62.

36. Jing F, Hongyi L, Jiong Z, Zhaoyu L, Mengyuan T, Mingwei Q. Telemedicine platform promotes the extension of hospital function: analysis of tele-clinical cooperation model. *China Hospital*. (2021) 25:83–4. doi: 10.19660/j.issn.1671-0592.2021.3.27

37. Xiaolin S, Weiwei H. Highlights and suggestions on the promotion of appropriate technology of TCM in Hongkou District of Shanghai. *China Prim Health Care*. (2022) 36:108–10. doi: 10.3969/j.issn.1001-568X.2022.02.0033

38. Lima ACP, Maximiano-Barreto MA, Martins TCR, Luchesi BM. Factors associated with poor health literacy in older adults: a systematic review. *Geriatr Nurs*. (2023) 55:242–54. doi: 10.1016/j.gerinurse.2023.11.016

39. Yongbing L, Hui L, Yufeng Z, Yanli C, Qingquan C, Hua Y, et al. Relationship between health literacy and physical and psychological health status in senior citizens of nursing homes. *Chin J Prevent Cont Chron Dis*. (2014) 22:148–51. doi: 10.16386/j.cjpccd.issn.1004-6194.2014.02.037

40. Bowen Z, Yiwan Y. Gender disparities in the education gradient in self-reported health across birth cohorts in China. *BMC Public Health*. (2020) 20:375. doi: 10.1186/s12889-020-08520-z

41. Dan W, Yizhe L. Online health information seeking behaviors among Chinese elderly. *Libr Inf Sci Res*. (2016) 38:272–9. doi: 10.1016/j.lisr.2016.08.011

42. Jixian Z. Research on the application scenes construction of inclusive senior education under the background of common prosperity. *J Vocat Educ*. (2022) 38:82–9.

43. Vivien Xi W, Yanhong D, Poh Choo T, Peiying G, Di Z, Yuchen C, et al. Development of a community-based e-health program for older adults with chronic diseases: pilot pre-post study. *JMIR Aging*. (2022) 5:e33118. doi: 10.2196/33118

44. Shaoyan Z, Shujie S, Xiaojing W, Chao Z, Jing X. Knowledge, belief, and practice of traditional Chinese medicine health preservation and influencing factors among residents in Henan Province. *Modern Prevent Med*. (2021) 48:701–5.

45. Ang L. Research progress on the influencing factors of Chinese residents' health literacy. *Chin Gen Pract Nurs*. (2019) 17:1043–5. doi: 10.12104/j.issn.1674-4748.2019.09.007

46. Ling I, Zambrana RE, Echeverria S, Lopez L. Peer support to enhance type 2 diabetes prevention among African American and Latino adults. *Endocrinol Metab Clin N Am*. (2023) 52:573–83. doi: 10.1016/j.ecl.2023.05.012

47. Hausknecht S, Vanchu-Orosco M, Kaufman D. Digitizing the wisdom of our elders: connectedness through digital storytelling. *Ageing Soc*. (2019) 39:2714–34. doi: 10.1017/S0144686X18000739

48. Yanbo S. *Research on the current status of Chinese medicine health culture literacy of Liaoning residents and its influencing factors* Jilin University (2020).

49. Morimoto A, Koh C, Yasumoto R, Furuki H, Watanabe K, Tsuzuki C, et al. Relationship between communicative and critical health literacy, health information sources, and participation in health checkups among middle-aged Japanese community residents. *Prev Med*. (2022) 161:107112. doi: 10.1016/j.ypmed.2022.107112

50. Jue L, Weidong L, Hongyan Y, Jianjun L. Proactive health: an imperative to achieve the goal of healthy China. *China CDC Wkly*. (2022) 4:799–801. doi: 10.46234/ccdcw2022.156

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 27 May 2024
DOI 10.3389/fpubh.2024.1348214

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Sup Amornpinyo,
Khon Kaen University, Thailand
Daisy Volmer,
University of Tartu, Estonia

*CORRESPONDENCE
Hongyu Li
✉ reda4673@sina.com
Yuan Chi
✉ 78136309@qq.com

RECEIVED 02 December 2023
ACCEPTED 14 May 2024
PUBLISHED 27 May 2024

CITATION
Wang L, Li Y, Zhao R, Li J, Gong X, Li H and Chi Y (2024) Influencing factors of home hospice care needs of the older adults with chronic diseases at the end of life in China: a cross-sectional study.
Front. Public Health 12:1348214.
doi: 10.3389/fpubh.2024.1348214

COPYRIGHT
© 2024 Wang, Li, Zhao, Li, Gong, Li and Chi. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Influencing factors of home hospice care needs of the older adults with chronic diseases at the end of life in China: a cross-sectional study

Lei Wang[1], Yaru Li[1], Rui Zhao[1], Jiangxu Li[1], Xiangru Gong[1], Hongyu Li[1]* and Yuan Chi[2]*

[1]College of Nursing, Jinzhou Medical University, Jinzhou, China, [2]Department of Science and Technology, Jinzhou Medical University, Jinzhou, China

Introduction: Chronic diseases are becoming a serious threat to the physical and mental health of older people in China as their aging process picks up speed. Home hospice care addresses diverse needs and enhances the quality of life for older adult individuals nearing the end of life. To ensure the well-being of chronically ill older adults at the end of life, it is vital to explore and assess the multidimensional hospice needs of terminally ill older individuals in their homes. The aim of this study was to investigate the current situation of home hospice care needs of Chinese older adults with chronic diseases at the end of life, and to analyze the influencing factors (sociodemographic and disease-related factors).

Methods: In this cross-sectional study, 247 older adult people with chronic diseases at the end of life were selected from the communities of 4 community health service centers in Jinzhou City, Liaoning Province from June to October 2023 by random sampling method. A general information questionnaire and the home hospice care needs questionnaire developed by our research group were used to investigate. Independent samples t-test or one-way ANOVA was used to compare the differences in the scores of different characteristics, and the factors with significant differences were selected for multivariate linear regression analysis to determine the final influencing factors.

Results: The total score of home hospice needs of the dying older adult was 115.70 ± 12, with the mean scores for each dimension in descending order being Information Needs (3.96 ± 0.61), Social Support Needs (3.96 ± 0.44), Spiritual Needs (3.92 ± 0.43), Physical Needs (3.60 ± 0.59), Psychological Needs (3.37 ± 0.65). Status of residence, duration of illness (year), the type of disease, and self-care ability were influential factors in the total score of home hospice needs.

Discussion: The need for hospice care for the terminally ill older adult is high, and healthcare professionals should implement services according to the influencing factors of need to meet their multidimensional needs and improve their quality of life.

KEYWORDS

home hospice, influencing factors, older adults, chronic diseases, need

1 Introduction

Chronic diseases are non-communicable diseases with a long duration and slow progression, characterized by widespread prevalence, high costs, disability and mortality (1). Since the 1990s, the most common non-communicable diseases, including stroke, ischemic heart disease, cancer and chronic obstructive pulmonary disease, have become the leading causes of death in China (2). Increasing age is the primary risk factor for the increased morbidity and mortality of most chronic diseases (3). China currently has the largest older adult population in the world, with 264 million individuals over 60 making up 18.7% of the overall population (4). It is projected that by 2050, the number of older people in China will reach 400 million, with an aging level of more than 30% (5). With the further intensification of the aging process in China, the issue of end-of-life care for the older adult with chronic diseases is imminent.

In China, most end-of-life patients prefer to spend their final stages of life at home due to limited medical resources and the traditional cultural concept of returning to one's roots (6, 7). Since 2017, China has explicitly referred to hospice care, end-of-life care and palliative care collectively as hospice care (8). As a type of hospice service, home hospice provides palliative and supportive care to end-of-life patients and their families in their own homes by a team of community medical professionals and social volunteers (9, 10), aiming to meet the multifaceted needs of end-of-life patients and their families and optimize the quality of life of end-of-life patients. Bužgová and Sikorová confirmed that a patient's overall quality of life can be impacted by unmet hospice needs (11). Therefore, it's critical to evaluate the multifaceted hospice needs of terminally ill older persons in their homes in order to ensure the well-being of these individuals with chronic illnesses in their latter years. Furthermore, identifying the hospice needs of older adults with complex chronic illnesses is becoming an important concern for health systems (12).

Currently, there are many research investigations on the end-of-life needs of older adult people with cancer at home, such as the physiological need for pain control (13), the psychological need for worry and terror relief (14), the spiritual need for peace of mind (15), and other economic support (16). The complexity and intractability of the needs of senior non-cancer terminally ill patients contribute to the relative paucity of research addressing the needs of these individuals with complicated chronic multimorbidity. Most of the reported needs were related to emotional and/or psychological dimensions (social isolation, depression) (17, 18). Bajwah et al. (19) and Ryan et al. (20) both emphasize the supportive need to address clinical symptoms and maintain their activities of daily living. Older adult people with non-cancer chronic disease at the end of life are likely to experience a heavier symptom burden than those with advanced cancer, meaning that more care needs will be presented.

Western studies have reported sociodemographic and disease-related factors that primarily influence the need for home hospice care for the chronically ill older adult. The majority of research indicates women have a higher need for hospice care than men (21, 22). As older adults age, their physiologic functioning and health levels decline, which may increase the need for hospice care. Relevant research also suggests that economic level, education level, and health insurance are also influential factors in the need for hospice care (21, 23). Disease-related factors indicate that older adults with serious illnesses, such as malignant tumors, or multiple coexisting illnesses, face significant physical, psychological, and spiritual challenges, resulting in more urgent needs in all areas (23). The need for hospice care is often closely related to cultural traditions and social systems, and cultural differences between China and the West have led to differences in the factors influencing the need for home hospice care. Nevertheless, home hospice care has paid relatively little attention in China, and there has not been much research done on the variables that affect it.

This study aims to investigate the multi-dimensional hospice care needs of older adults with end-stage chronic diseases in China's home environment, taking into account the country's unique aging conditions. Additionally, it analyzes the sociodemographic and disease-related characteristics influencing factors to provide a basis for the provision of high-quality home hospice services.

2 Materials and method

2.1 Design and samples

This study was a cross-sectional study. A random sampling method was used to include the older adult with chronic diseases at the end of life in the communities belonging to four community health centers (providing home hospice services) in Jinzhou City, Liaoning Province, from June to October 2023, as study subjects. Inclusion criteria for end-of-life older adult: (1) age $\geq$ 60 years; (2) chronic non-tumor diseases, with 1 or more organs severely impaired in function, no effective means of cure into the terminal stage or patients with malignant tumors into the terminal stage (expected survival $\leq$6 months); (3) choose to die at home (hospice); (4) clear consciousness, with normal language communication, understanding ability. Exclusion Criteria for end-of-life older adult: (1) hospitalized or living in nursing homes; (2) dying in the middle or withdrawing for reasons. The Jinzhou Medical University College of Nursing Ethics Committee gave its approval to the study (No. JZMULL2023062). Every older adult person who was recruited for the study was required to give written informed consent before taking part. G*Power 3.1 was used to calculate the sample size. The effect size was 0.15 (medium size), the significance level α was set at 0.05, and the statistical power (1-β) was 0.90. The minimum sample size was 183 cases. A total of 260 questionnaires were finally distributed.

2.2 Measurement

2.2.1 General information questionnaire

The general information questionnaire was developed by searching the relevant literature and the clinical experience of the investigators. It covers data on disease-related as well as sociodemographic characteristics. Sociodemographic characteristics included gender, age, marital status, education level, medical insurance payment method, religion, status of residence, and household incomes *per capita* (yuan). Disease-related information comprised the duration of illness (year), number of comorbidities (kind), the type of disease, and self-care ability. Socio-demographic characteristics were collected by self-reporting, and part of the disease-related data (duration of illness, the type of disease) were filled in by the researcher through medical records.

2.2.2 Home hospice care needs questionnaire for the dying older adult

The home hospice care needs questionnaire for the dying older adult (HHCNQ-DE) was an assessment tool developed by our research group to assess the home hospice care needs of the dying older adult in China. From April to September 2023, a total of 5 hospice pilot community health service centers were selected from 7 administrative districts in Jinzhou City, Liaoning Province by stratified sampling method. Secondly, a simple random sampling method was used to select a total of 199 terminally older adult people from the communities of pilot community service centers for psychological verification. The questionnaire had been psychologically validated and the instrument was found to have good reliability and validity. The Cronbach's alpha coefficient of the total questionnaire was 0.832, the Cronbach's alpha coefficients of the dimensions were 0.845–0.942, and the re-test reliability was 0.806. The content validity index of the questionnaire was 0.982, and the content validity index of the items was 0.83–1.00. The exploratory factors were extracted from the five common factors, and the cumulative variance contribution was 68.811%. The questionnaire included physiological needs (9 items), spiritual needs (7 items), psychological needs (6 items), social support needs (5 items) and information needs (4 items) 5 dimensions, a total of 31 items. Likert 5-point scale was used for each item, ranging from 1 to 5 points from "not needed" to "very needed." The total questionnaire scores ranged from 31 to 155, with higher scores indicating higher levels of need. Among them, < 104 was defined as low need, 104–115 was defined as medium need, and > 115 was defined as high need.

2.3 Data collection

The household survey was carried out by the researcher as the investigator, and the community nurses in charge of home follow-up in each community health center assisted in the survey implementation. Before the survey, the purpose and significance of the study were explained to the respondents, and an informed consent form was signed. Then, we explained the requirements for filling out the questionnaire and asked the older adult to fill out the questionnaire on their own after they fully understood it. For those who were illiterate or physically weak, the researchers would read and explain the questionnaire item by item to the respondents, and finally record the survey results truthfully. The time limit for answering the questionnaire was 20 min. The survey was conducted at a time when the older adult had enough sleep and were not undergoing nursing care or treatment. Incomplete or single-option questionnaires were considered invalid.

2.4 Statistical analysis

Epidata 3.1 software was used for double entry of raw values and SPSS22.0 (IBM Corp, Armonk, NY) software was used for statistical analysis of data. The two-sided test level was $\alpha = 0.05$, and the difference was statistically significant at $p < 0.05$.

General information about the study participants was described using frequency and component ratio, and the HHCNQ-DE total and dimension need scores were described using mean and standard deviation. To analyze differences, first, independent samples t-tests (variables grouped into two groups) and one-way ANOVA (variables grouped into three or more groups) were used to initially explore the relationship between the home hospice need dimension scores and general information about study participants. Second, using the HHCNQ-DE total score and the scores of the five dimensions as dependent variables, the statistically significant independent variables in the one-way analysis of variance were selected for multiple linear regression analyses ($\alpha_{in} = 0.05$, $\alpha_{out} = 0.10$) to find out the influencing factors of the total needs and the needs of the dimensions.

3 Results

3.1 Participant characteristics

A total of 260 questionnaires were distributed in this study, and 247 meeting the requirements were recovered, with a response rate of 95%. 13 invalid questionnaires were excluded, among which 9 refused to answer part of the questions in the questionnaire due to personal reasons, resulting in incomplete questionnaires. Four were excluded because the subjects filled in their errors.

More than half (53.80%) of the older adult dying of chronic diseases were women. The majority were 60–69 years old (40.50%), married or cohabiting (78.10%), with a primary school education or below (55.10%), using medical insurance for urban workers (53.40%), not practicing any religion (85.00%), and living with their spouses (63.20%). The most common type of disease was cancer (54.70%), of which lung cancer was more prevalent (40.00%). Among non-cancer chronic diseases, Cardiovascular diseases were more prevalent (40.18%). Table 1 displayed more general study population data.

3.2 Home hospice care needs score

The older adult with chronic diseases had a total score of 115.70 ± 12.79 for home hospice needs, with a mean score of 3.73 ± 0.41 for all items. The mean scores of the items of the dimensions of the needs in descending order were Information Needs (3.96 ± 0.61), Social Support Needs (3.96 ± 0.44), Spiritual Needs (3.92 ± 0.43), Physical Needs (3.60 ± 0.59), Psychological Needs (3.37 ± 0.65). More specific details are displayed in Table 2.

The top and bottom five scoring items for each dimension are displayed in Table 3. The top 5 items were related to the dimensions of Information Needs and Social Support Needs, of which the top 2 need items were "Hope to get the care, concern and support of relatives and friends" (4.73 ± 0.48) and "I hope I can leave peacefully with my family by my side" (4.69 ± 0.51). The last 5 items in the ranking were primarily related to the Psychological Needs dimension, of which the last 2 need items were "Hope to resolve the contradictions and grievances between friends and relatives" (2.23 ± 1.06) and "I hope to help me regulate negative emotions such as anxiety and panic (such as fear of death)" (2.61 ± 1.16).

3.3 Univariate analyses of the home hospice care needs

In Table 4, there were significant differences in the home care needs of older adults with end-stage chronic disease based on

10.3389/fpubh.2024.1348214

TABLE 1 General information of survey participants (*N* = 247).

Characteristics		N	Percentage (%)
Gender	Male	133	53.80
	Female	114	46.20
Age (year)	60–69	100	40.50
	70–79	96	38.90
	≥80	51	20.60
Marital status	Unmarried	3	1.20
	Married/ Cohabitation	193	78.10
	Divorce	7	2.80
	Widowed	44	17.80
Education level	Primary school and below	136	55.10
	Middle school education	76	30.80
	High school education or technical secondary school	15	6.10
	Junior college and above	20	8.10
Medical insurance payment method	Insurance for urban workers	132	53.40
	New Rural Co-operative Medical System	94	38.10
	Commercial health insurance	6	2.40
	Self-paying	15	6.10
Religion	No	210	85.00
	Yes	37	15.00
Status of residence	Live with children	31	12.60
	Live with spouse	156	63.20
	Live alone	40	16.20
	Live with children and spouse	20	8.10
Duration of illness (year)	<1	81	32.80
	1–3	94	38.10
	>3	72	29.10
Household incomes *per capita* (yuan)	<1,500	93	37.70
	1,500–2,999	93	37.70
	3,000–4,999	46	18.60
	≥5,000	15	6.10
Number of Comorbidities (kind)	1	129	52.20
	2	81	32.80
	≥3	37	15.00
The type of disease	Non-cancer chronic diseases	112	45.30
	Cardiovascular diseases Chronic	45	18.23
	Respiratory diseases	32	12.94
	Nervous system diseases	15	6.07
	Cerebrovascular diseases	12	4.85
	Other	8	3.24
	Cancer	135	54.70
	Lung cancer	54	21.69
	Liver cancer	30	12.16
	Colorectal cancer	22	8.91
	Leukemia	12	4.86
	Esophageal cancer	10	4.05
	Other	7	2.84

(Continued)

TABLE 1 (Continued)

Characteristics		N	Percentage (%)
Self-care ability	Completely capable of	67	27.10
	Most able to	96	38.90
	A part of	54	21.90
	Completely unable	30	12.10

TABLE 2 Scores for items on dimensions of need for home hospice care for older adult with end-stage chronic disease ($N = 247$).

Dimension	Number of items	Range of score	Total score ($\bar{X} \pm SD$)	Items score ($\bar{X} \pm SD$)	Order
Physical Needs	9	9–45	32.40 ± 5.29	3.60 ± 0.59	4
Psychological Needs	6	6–30	20.19 ± 3.93	3.37 ± 0.65	5
Social Support Needs	5	5–25	19.82 ± 2.21	3.96 ± 0.44	2
Information Needs	4	4–20	15.83 ± 2.42	3.96 ± 0.61	1
Spiritual Needs	7	7–35	27.46 ± 3.03	3.92 ± 0.43	3
Total score	31	31–155	115.70 ± 12.79	3.73 ± 0.41	

TABLE 3 Score for the first 5 and last 5 items of the need (N = 247).

	Item	Dimension	Score ($\bar{X} \pm SD$)
Top 5 items	Hope to get the care, concern and support of relatives and friends	Social support needs	4.73 ± 0.48
	I hope I can leave peacefully with my family by my side	Spiritual needs	4.69 ± 0.51
	It is hoped that medical staff provide long-term disease health guidance, empowerment education (such as pain assessment and mindfulness therapy), and assist family members to complete care	Social support needs	4.48 ± 0.77
	It is hoped that the community will carry out pair assistance (such as social workers and volunteers to provide care services) and mutual assistance activities (such as peer support for the older adult)	Social support needs	4.33 ± 0.79
	Hope to respect my end-of-life medical decisions (such as refuse invasive treatment)	Spiritual needs	4.30 ± 0.78
Last 5 items	Hope to resolve the contradictions and grievances between friends and relatives	Social support needs	2.23 ± 1.06
	I hope to help me regulate negative emotions such as anxiety and panic (such as fear of death)	Psychological needs	2.61 ± 1.16
	Hope to help me regulate the negative emotions of depression and pessimism (e.g., due to weakness, illness and pain)	Psychological needs	2.72 ± 1.21
	Hope to respect my privacy and dignity	Spiritual needs	3.29 ± 0.99
	Hope you can help me with daily care (such as skin care, oral care)	Physical needs	3.32 ± 0.94

several sociodemographic and disease-related factors. Regarding the overall needs score, the dying older adult with older age, lower education, commercial health insurance, religious beliefs, living with children and spouse, long illness duration, monthly household income of 3,000–4,999 yuan, many chronic illnesses, non-cancer chronic disease, and partial able to care had higher HHCNQ-DE scores.

3.4 Multiple linear regression analysis of factors influencing the need for home hospice care

The independent variables medical insurance payment method (based on Insurance for urban workers) and status of residence (based on living with children) were set as dummy variables. Other independent variables were assigned values, like age, which was coded as 1 for 69–69 years, 2 for 70–79 years, and 3 for ≥80 years. The independent variable assignments and dummy variable settings are shown in Table 5.

Six multivariate linear regression analyses were performed to identify significant correlates of overall home hospice needs and five dimensions of needs (see Table 6). The diagnostic test independent variables had all variance inflation factor (VIF) values less than 10, indicating no multicollinearity issue existed before the analysis was conducted. Furthermore, residual analysis provided support for the equation models' linearity, normality, and homogeneity of variance. The terminal older adult lived with children and spouse ($\beta = 16.385$, $p = 0.000$), had a disease duration ≥3 years ($\beta = 2.721$, $p = 0.007$), had a non-cancer chronic disease ($\beta = -5.874$, $p = 0.002$), and were completely unable to care for themselves ($\beta = 1.919$, $p = 0.031$) may have a higher total need for home hospice care, with 30% of the variance explained. The terminal older adult who used commercial health insurance to pay for health care ($\beta = 3.808$, $p = 0.031$), lived

TABLE 4 Univariate analysis of home hospice care needs (independent samples t-test or one-way analysis of variance, $\bar{x} \pm s$).

Variable		Physical needs	Psychological needs	Social support needs	Information needs	Spiritual needs	Total score
Gender	Female	32.51 ± 5.13	20.20 ± 3.85	19.96 ± 2.19	16.00 ± 2.28	27.76 ± 2.81	116.43 ± 11.85
	Male	32.26 ± 5.50	20.19 ± 4.03	19.96 ± 2.24	15.54 ± 2.57	27.11 ± 3.25	114.85 ± 13.81
Age (year)	60–69	**30.91 ± 5.02**	20.01 ± 4.02	**19.28 ± 2.27**	15.91 ± 2.08	27.02 ± 2.73	**113.13 ± 12.53**
	70–79	**32.35 ± 5.18**	20.50 ± 4.04	**20.19 ± 2.16**	15.75 ± 2.61	27.85 ± 3.14	**116.65 ± 12.88**
	≥80	**35.39 ± 4.84**	19.98 ± 3.54	**19.98 ± 3.54**	15.84 ± 2.69	27.57 ± 3.32	**118.96 ± 12.37**
Marital status	Unmarried	**37.33 ± 1.53**	21.33 ± 1.16	22.00 ± 0.00	16.67 ± 3.22	27.00 ± 0.00	124.33 ± 2.31
	Married/Cohabitation	**31.92 ± 5.27**	20.29 ± 4.21	19.68 ± 2.22	15.89 ± 2.39	27.56 ± 3.14	115.35 ± 13.32
	Divorced	**30.43 ± 5.47**	17.43 ± 2.44	19.71 ± 1.70	15.57 ± 2.76	26.14 ± 2.73	109.29 ± 11.74
	Widowed	**34.45 ± 4.96**	20.14 ± 2.57	20.27 ± 2.22	15.59 ± 2.51	27.23 ± 2.68	117.68 ± 10.87
Education level	Primary school and below	**33.7 ± 5.15**	**20.63 ± 3.60**	**20.37 ± 2.05**	**16.07 ± 2.33**	**27.94 ± 3.03**	**118.7 ± 11.75**
	Middle school education	**29.82 ± 4.87**	**19.13 ± 4.40**	**18.78 ± 2.38**	**15.09 ± 2.71**	**26.3 ± 3.00**	**109.12 ± 13.52**
	High school education or technical secondary school	**31.87 ± 5.25**	**19.8 ± 3.53**	**19.87 ± 1.46**	**16.4 ± 1.24**	**27.33 ± 2.06**	**115.27 ± 8.84**
	Junior college and above	**33.75 ± 4.45**	**21.6 ± 3.69**	**20 ± 1.72**	**16.65 ± 1.87**	**28.65 ± 2.54**	**120.65 ± 9.72**
Medical insurance payment method	Insurance for urban workers	**32.86 ± 5.06**	19.97 ± 3.89	19.96 ± 2.30	**16.17 ± 2.32**	**27.76 ± 3.09**	**116.72 ± 12.37**
	New Rural Co-operative Medical System	**31.00 ± 5.49**	20.24 ± 4.15	19.47 ± 2.08	**15.36 ± 2.51**	**26.71 ± 2.95**	**112.79 ± 13.39**
	Commercial health insurance	**35.33 ± 3.33**	24.00 ± 3.69	21.67 ± 1.63	**14.17 ± 1.84**	**29.33 ± 2.58**	**124.5 ± 9.33**
	Self-paying	**35.87 ± 4.19**	20.33 ± 1.72	20.00 ± 2.10	**16.53 ± 2.36**	**28.73 ± 1.98**	**121.47 ± 9.13**
Religion	No	**31.90 ± 5.21**	20.18 ± 3.87	19.71 ± 2.20	**15.70 ± 2.41**	27.28 ± 2.82	**114.77 ± 12.28**
	Yes	**35.22 ± 4.92**	20.27 ± 4.30	20.43 ± 2.24	**16.57 ± 2.36**	28.49 ± 3.93	**120.97 ± 14.43**
Status of residence	Live with children	**32.84 ± 5.69**	**19.9 ± 3.02**	**19.71 ± 2.15**	**19.71 ± 2.53**	**26.71 ± 3.04**	**113.74 ± 13.02**
	Live with spouse	**31.08 ± 5.06**	**19.74 ± 3.89**	**19.40 ± 2.27**	**19.40 ± 2.46**	**27.01 ± 2.82**	**112.97 ± 12.12**
	Live alone	**34.93 ± 3.63**	**21.05 ± 3.01**	**20.93 ± 1.73**	**20.93 ± 1.88**	**28.18 ± 2.22**	**121.5 ± 7.00**
	Live with children and spouse	**36.9 ± 5.14**	**22.45 ± 5.89**	**21.00 ± 1.52**	**21.00 ± 1.87**	**30.70 ± 3.83**	**128.4 ± 15.60**
Duration of illness (year)	<1	**29.94 ± 5.32**	**19.30 ± 4.49**	**19.09 ± 2.36**	**15.49 ± 2.44**	26.85 ± 3.03	**110.67 ± 14.40**
	1–3	**32.4 ± 4.73**	**20.96 ± 3.84**	**20.04 ± 2.14**	**15.70 ± 2.76**	27.69 ± 3.19	**116.80 ± 11.95**
	>3	**35.15 ± 4.62**	**20.21 ± 3.12**	**20.35 ± 1.94**	**16.39 ± 1.77**	27.83 ± 2.75	**119.93 ± 9.87**
Household incomes *per capita* (yuan)	<1,500	31.69 ± 5.64	**20.52 ± 3.93**	**19.44 ± 2.09**	15.52 ± 2.69	**27.11 ± 2.99**	**114.27 ± 13.66**
	1,500–2,999	32.30 ± 4.88	**18.97 ± 3.28**	**19.71 ± 2.28**	15.74 ± 2.31	**26.89 ± 2.73**	**113.61 ± 10.75**
	3,000–4,999	33.76 ± 5.61	**22.00 ± 4.55**	**20.54 ± 2.12**	16.35 ± 2.18	**29.15 ± 3.32**	**121.80 ± 14.26**
	≥5,000	33.20 ± 3.99	**20.27 ± 3.31**	**20.60 ± 2.29**	16.8 ± 1.57	**27.93 ± 2.40**	**118.80 ± 7.70**

(Continued)

10.3389/fpubh.2024.1348214

TABLE 4 (Continued)

Variable		Physical needs	Psychological needs	Social support needs	Information needs	Spiritual needs	Total score
Number of Comorbidities (kind)	1	**30.71 ± 5.26**	19.94 ± 4.18	19.57 ± 2.17	15.78 ± 2.47	27.35 ± 2.96	**113.68 ± 13.32**
	2	**33.49 ± 4.88**	20.52 ± 3.64	19.79 ± 2.15	15.94 ± 2.46	27.74 ± 3.25	**117.48 ± 12.64**
	≥3	**35.86 ± 3.90**	20.38 ± 3.64	19.91 ± 2.28	15.81 ± 2.18	27.22 ± 2.80	**118.84 ± 10.01**
The type of disease	Non-cancer chronic diseases	**35.30 ± 4.00**	20.37 ± 3.23	**20.81 ± 1.81**	**16.25 ± 2.30**	**28.23 ± 2.95**	**120.96 ± 9.97**
	Cancer	**29.99 ± 3.00**	20.05 ± 4.43	**18.99 ± 2.18**	**15.49 ± 2.47**	**26.81 ± 2.96**	**111.33 ± 13.25**
Self-care ability	Completely capable of	**29.39 ± 5.40**	19.04 ± 4.50	**19.30 ± 1.88**	15.94 ± 2.19	27.28 ± 3.38	**110.96 ± 13.94**
	Most able to	**32.26 ± 5.09**	20.6 ± 3.91	**19.85 ± 2.37**	15.99 ± 2.46	27.86 ± 2.83	**116.57 ± 12.61**
	A part of	**34.52 ± 4.06**	20.8 ± 3.10	**20.65 ± 1.99**	15.98 ± 2.37	27.41 ± 2.86	**119.35 ± 10.00**
	Completely unable	**35.73 ± 3.95**	20.37 ± 3.56	**19.37 ± 2.39**	14.83 ± 2.74	26.63 ± 3.09	**116.93 ± 12.68**

The bold and italics indicated the $p < 0.05$.

with children and spouse ($\beta = 5.566$, $p = 0.000$), had a disease duration ≥3 years ($\beta = 1.154$, $p = 0.001$), had a comorbid combination of ≥3 chronic diseases ($\beta = 1.302$, $p = 0.001$), with non-cancer chronic diseases ($\beta = -5.874$, $p = 0.000$), and completely unable to care for themselves ($\beta = 1.463$, $p = 0.031$) were more likely to have Physical Needs, explaining 49.6% of the variance. The terminal older adult used commercial medical insurance to pay medical expenses ($\beta = 4.384$, $p = 0.031$), lived with children and spouse ($\beta = 3.925$, $p = 0.000$) and were completely unable to take care of themselves ($\beta = 0.814$, $p = 0.008$) were significantly correlated with Psychological Needs, which explained 11.4% of the variance. Duration of illness ≥3 years ($\beta = 0.421$, $p = 0.019$), comorbidity of ≥3 chronic disease ($\beta = -0.561$, $p = 0.003$), and suffering from non-cancer chronic disease ($\beta = -1.537$, $p = 0.000$) were higher in the terminally ill older adult Social Support Needs, explaining 25.5% of the variance. The use of urban workers' insurance to pay for medical expenses ($\beta = -2.925$, $p = 0.005$) and living with children and spouse ($\beta = 2.145$, $p = 0.003$) among the terminally ill older adult were significantly associated with Information Needs, explaining 17.2% of the variance. Terminally ill older adult were more likely to express Spiritual Needs by paying for healthcare out-of-pocket ($\beta = 1.689$, $p = 0.043$), living with children and spouse ($\beta = -3.551$, $p = 0.000$), and having a non-cancer chronic disease ($\beta = -1.001$, $p = 0.037$), explaining 19.5% of the variance.

4 Discussion

The results of this study showed that the total score for home hospice needs was 115.70 ± 12.79, indicating that there is a high level of hospice needs for the older adult at the end of life with chronic diseases in the home setting. The highest scoring items were Information Needs, Social Support Needs, and Spiritual Needs in that order, indicating that these three dimensions are of particular concern to the older adult dying at home in China, and that there are still many unmet needs in these three dimensions with the existing medical resources. The three items with higher scores in Social Support Needs implied that the dying older adult longed for assistance from family members, medical staff, social workers, and senior peers, which was similar to the results of Hu et al. (24). The item that received the lowest score in terms of Social Support Needs was "Hope to resolve the contradictions and grievances between friends and relatives," which suggests that the dying older adult in this study had harmonious relationships with their friends and relatives. Dunham et al. believed that harmonious interpersonal relationships could help older adult cancer patients enhance their sense of self-worth and reduce psychological anxiety (25). Two Spiritual Needs items with higher scores expressed the dying older adult's need for increased autonomy. Since the older adult are respected in their right to die at home and have essentially had their wish to pass away with dignity fulfilled, the low score for "Hope to respect my privacy and dignity" can be explained.

The dimensions of physical and psychological needs had the lowest mean scores among the items. Ghesquiere demonstrated that older people who had multiple chronic illnesses experienced more depressive feelings along with a greater number of physical symptoms (e.g., pain, and fatigue) (26). Therefore, it is not implied that these two dimensions were met by the study's low results. The low scores may

TABLE 5 Dummy variable setting and independent variable assignment situation.

Variable	Assignment mode			
Age (year)	60–69 = 1	70–79 = 2	≥80 = 3	
Education level	Primary school and below = 1	Middle school education = 2	High school education or technical secondary school = 3	Junior college and above = 4
Medical insurance payment method	Insurance for urban workers = 0	New Rural Co-operative Medical System = 1	Commercial health insurance = 0	Self-paying = 1
	Insurance for urban workers = 0	New Rural Co-operative Medical System = 0	Commercial health insurance = 1	Self-paying = 0
	Insurance for urban workers = 0	New Rural Co-operative Medical System = 0	Commercial health insurance = 0	Self-paying = 1
Religion	No = 1	Yes = 2		
Status of residence	Live with children = 0	Live with spouse = 1	Live alone = 0	Live with children and spouse = 1
	Live with children = 0	Live with spouse = 0	Live alone = 1	Live with children and spouse = 0
	Live with children = 0	Live with spouse = 0	Live alone = 0	Live with children and spouse = 1
Duration of illness (year)	<1 = 1	1–3 = 2	>3 = 3	
Household incomes *per capita* (yuan)	<1,500 = 1	1,500–2,999 = 2	3,000–4,999 = 3	≥5,000 = 4
Number of Comorbidities (kind)	1 = 1	2 = 2	≥3 = 3	
The type of disease	Non-cancer chronic diseases = 1	Cancer = 2		
Self-care ability	Completely capable of = 1	Most able to = 2	A part of = 3	Completely unable = 4

be because China is deeply influenced by Confucian culture, which is family-centered, and not being a burden to the family is the greatest expectation of the dying older adult (27), which is reflected in the item "Hope to help me with daily care (such as skin care, oral care)." Family members are responsible for personal care, symptom management, and emotional support for the dying older adult, and the responsibility of caring for them makes the caregiver's burden of care heavy. In order to minimize the burden and indebtedness to the family, the dying older adult conceal their actual feelings and tolerate their physical discomfort.

Next, we determined a number of variables pertaining to the need for home hospice care for the older adult dying of chronic illness. The study's findings demonstrated that the status of residence was an influential factor of needs, with those who live with their spouse and children reporting higher levels of physical, psychological, informational, and spiritual needs. Contrary to the results of several scholars (28, 29). One potential explanation could be the low monthly household income of the study's population, of which 75.4% earn less than ≤3,000 yuan per month. This amount of money is far less than the monthly *per capita* income of Liaoning Province's urban residents in 2022 (3,667 yuan) (30). Higher costs are associated with more people living together, and older people's access to high-quality healthcare is restricted by the state of the economy. At present, home hospice care is not covered in its whole by medical insurance in China (31). Due to financial constraints, older patients who are terminally ill only accept a portion of the home hospice care service program, so the fact cannot meet their basic physiological needs. According to Maslow's Hierarchy of Needs Theory, unmet physiological needs make it difficult to meet other needs at a higher level (32). Furthermore, this study discovered that due to differences in reimbursement rates, different types of insurance are linked to various needs. In order to relieve financial strain, it is advised that healthcare professionals help family members apply for grants and benefits, as well as applications for donations from individuals and social organizations for the older adult with terminal illnesses. China needs to reform its health insurance system in the future, intending to break down the barriers of the home hospice medical system and provide institutional safeguards for the development of the home hospice care business.

In this study, end-of-life older adult with longer illness duration and more comorbidities had higher physical and social support needs, which was consistent with the findings of Wyld et al. (33). The reason for this analysis is the progressive aggravation of symptoms brought about by the disease as the duration of the disease increases. Studies have shown that cancer patients with longer disease duration experience more symptoms than patients with shorter disease duration (28), which suggests that the duration of the disease is closely related to the patient's quality of life. Relevant studies have found that heart failure is often complicated by diabetes mellitus, arrhythmia, hypertension and other diseases (34). The combination of chronic diseases in older adult patients can cause multi-system damage, leading to a decline in physiologic function, increasing the burden of medication (increased adverse drug reactions, decreased medication adherence), and severely reducing the quality of life. Wang et al. have found that a higher level of social support can positively affect patients (35). Support from healthcare professionals in relation to physical symptoms and moral support from family and friends ultimately improved their quality of life. Consequently, healthcare professionals should provide early home hospice care for

TABLE 6 Multiple linear regression analysis of total home hospice need and factors influencing need by dimension.

Dependent variable	Independent variable	Unstandardized coefficients		Standardized coefficients	R^2	Adjusted R^2	t	p-value
		β	SE	β				
Total score	(Constant)	107.167	6.894		0.3	0.258	15.545	0
	Status of residence							
	Live alone	5.594	2.817	0.161			1.985	0.048
	Live with children and spouse	16.385	3.464	0.35			4.73	0
	Duration of illness (year)	2.721	0.994	0.168			2.739	0.007
	The type of disease	−5.874	1.878	−0.229			−3.128	0.002
	Self-care ability	1.919	0.883	0.146			2.174	0.031
Physical needs	(Constant)	27.262	2.423		0.496	0.465	11.253	0.000
	Medical insurance payment method							
	Commercial health insurance	3.808	1.758	0.111			2.166	0.031
	Self-paying	2.514	1.144	0.114			2.197	0.029
	Status of residence							
	Live with children and spouse	5.566	1.217	0.287			4.573	0.000
	Duration of illness (year)	1.154	0.349	0.172			3.306	0.001
	Number of Comorbidities (kind)	1.302	0.373	0.18			3.488	0.001
	The type of disease	−3.028	0.66	−0.285			−4.589	0.000
	Self-care ability	1.463	0.31	0.268			4.716	0.000
Psychological needs	(Constant)	15.897	2.381		0.114	0.061	6.715	0.000
	Medical insurance payment method							
	Commercial health insurance	4.348	1.727	0.171			2.518	0.012
	Status of residence							
	Live with children and spouse	3.925	1.196	0.273			3.282	0.001
	Self-care ability	0.814	0.305	0.201			2.671	0.008
Social support needs	(Constant)	21.397	1.231		0.255	0.21	17.384	0
	Duration of illness (year)	0.42	0.177	0.149			2.366	0.019
	Number of Comorbidities (kind)	0.561	0.19	0.186			2.959	0.003
	The type of disease	−1.537	0.335	−0.346			−4.584	0.000

(Continued)

10.3389/fpubh.2024.1348214

10.3389/fpubh.2024.1348214

TABLE 6 (Continued)

Dependent variable	Independent variable	Unstandardized coefficients		Standardized coefficients	R^2	Adjusted R^2	t	p-value
		β	SE	β				
Information needs	(Constant)	15.281	1.419		0.172	0.122	10.716	0.000
	Medical insurance payment method							
	Commercial health insurance	−2.925	1.03	−0.186			−2.84	0.005
	Status of residence							
	Live with spouse	1.057	0.475	0.211			2.224	0.027
	Live alone	1.777	0.58	0.271			3.063	0.002
	Live with children and spouse	2.145	0.713	0.242			3.008	0.003
Spiritual needs	(Constant)	27.315	1.735		0.195	0.146	15.578	0
	Medical insurance payment method							
	Self-paying	1.689	0.828	0.133			2.04	0.043
	Status of residence							
	Live with children and spouse	3.551	0.881	0.32			4.03	0.000
	The type of disease	−1.001	0.487	−0.165			−2.096	0.037

the older adult chronic population can effectively reduce disease distress. Simultaneously, we should highlight the function and influence of social support on older persons with chronic illnesses and their families, as well as develop practical strategies to offer social interventions to patients.

According to the study's findings, older adult with non-cancer chronic diseases had higher home hospice care needs than those with cancer, particularly in terms of their physical, social, and spiritual needs. This agrees with Llop-Medina et al.'s (36) findings. Theoretical trajectories of dying of patients with advanced cancer, proposed by Glaser and Strauss, can predict changes in the condition of cancer patients in advance (37). Healthcare professionals can make appropriate end-of-life care decisions based on changes in symptoms. In contrast, non-cancer-diagnosed patients are characterized by long-term, progressive and rapid deterioration (38), and the difficulty in grasping the course of the disease makes it more difficult to carry out nursing care. Burt believes that it is difficult to meet the physiological needs of the patient without effective symptom management or adequate nursing care (39). Repeated changes in disease not only increase physical pain but also mental suffering and a diminished sense of confidence and meaning in life. Roughly half of patients with severe heart failure will pass away suddenly from sudden cardiac death (40); this suggests that a professional hospice team is necessary due to the disease's rapid deterioration. Therefore, community healthcare professionals should encourage seniors and their families to develop advanced care planning as early as possible to cope with the unpredictability of chronic disease at the end of life. It is also possible to establish a hospice care multidisciplinary chronic disease specialist team, according to different types of chronic diseases, through division of labor and cooperation, to improve the sense of meaning in life based on relieving physical pain, and provide timely professional help when the disease deteriorates rapidly.

This study's findings, which are in line with those of Kun Zhang and Chaoying Wang's (28, 29) study, show that the poorer the self-care ability of the terminal older adult, the higher the need for home hospice care, especially physical needs and psychological needs. With the increase of age, the self-care ability of the older adult gradually decreases. According to the current survey, 72.9% of older persons have defective self-care ability, which means that they greatly depend on the assistance of others. Influenced by the traditional Chinese concept of "raising children to prevent old age," most of the dying older adult tend to choose family members to provide care for them (41). Due to the lack of caregiving knowledge, it is difficult for family members to manage their symptoms effectively while providing basic care such as daily living. For instance, Tarter's research revealed that informal caregivers were inefficient in managing dementia patients' pain (42). In addition, dying older adult have restricted activities due to their illness (dyspnea, heart failure), which often keeps them indoors and isolates them from the outside world. This creates psychological needs like loneliness. As a result, community medical staff use both online and offline techniques to instruct caregivers on caregiving skills. If the condition permits, assist family members in transferring the patient to the outdoor area to talk with others and participate in social activities together, to reduce the sense of social alienation; When the illness does not allow outdoor activities, assist family members in arranging home activities, such as having dinner together or accompanying the patient to catch up with old times.

5 Limitations

The following are the limitations of this study. First, the classification of chronic illness categories and comorbidities was overly simple and rough due to the small sample size. To determine the differences in need, the classification of chronic diseases can be further differentiated in the future using a sizable sample size. Second, this study was conducted in Jinzhou City, Liaoning Province, which is useful for studies under the same economic and cultural conditions, but whether the conclusions are representative of the chronic terminal older adult population in other regions needs to be further explored. Future studies can collect data in different regions to make the findings more generalizable. Finally, this study was a cross-sectional survey that investigated the need for and factors influencing home hospice care for this population at a certain point in time. In the future, a longitudinal study could be conducted to investigate trends in home hospice needs and influencing factors as their condition changes. Based on this study, we need to continue to explore cultural differences in hospice needs at home or evaluate the effectiveness of different hospice interventions in the future.

6 Conclusion

In summary, the need for home hospice care in China is high for the older adult with end-stage chronic disease, who need care in physical, psychological, spiritual, and social support. Among them, status of residence, duration of illness (year), the type of disease, and self-care ability were the main factors influencing the need for home hospice care. In the process of providing hospice care services for the dying older adult and their families, healthcare professionals should assess their needs and fully consider the influencing factors of needs, so as to promote the improvement of the level of hospice care services. Moreover, the provision of personalized and comprehensive care and nursing care centered on the dying older adult can improve their quality of life within a limited period of time. It is also necessary for government departments to standardize and formulate a comprehensive hospice policy so that older adult patients can finish their final journey in a home environment, quietly and comfortably.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Jinzhou Medical University College of Nursing Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LW: Writing – original draft. YL: Writing – original draft. RZ: Writing – review & editing. JL: Writing – review & editing. XG: Writing – original draft. HL: Writing – review & editing. YC: Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This project has received funding from the Chinese Association of Gerontology and Geriatrics, Action for Health Promotion in the Elderly (2021–2025), First Action Program Fund (No. CAGG-2021-04-01).

Acknowledgments

We are very grateful to the terminally ill seniors and their families who participated in this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Namisango E, Powell RA, Taylor S, Radbruch L, Freeman R, Haufiku D, et al. Depressive symptoms and palliative care concerns among patients with non-communicable diseases in two southern African countries. *J Pain Symptom Manag*. (2023) 65:26–37. doi: 10.1016/j.jpainsymman.2022.09.008

2. Zhou M, Wang H, Zeng X, Yin P, Zhu J, Chen W, et al. Mortality, morbidity, and risk factors in China and its provinces, 1990-2017: a systematic analysis for the global burden of disease study 2017. *Lancet*. (2019) 394:1145–58. doi: 10.1016/s0140-6736(19)30427-1

3. Kennedy BK, Berger SL, Brunet A, Campisi J, Cuervo AM, Epel ES, et al. Geroscience: linking aging to chronic disease. *Cell*. (2014) 159:709–13. doi: 10.1016/j.cell.2014.10.039

4. Chen X, Giles J, Yao Y, Yip W, Meng Q, Berkman L, et al. The path to healthy ageing in China: a Peking University-lancet commission. *Lancet*. (2022) 400:1967–2006. doi: 10.1016/s0140-6736(22)01546-x

5. Pot AM, Oliveira D, Hoffman J. Towards healthy ageing in China: shaping person-centred long-term care. *Lancet*. (2022) 400:1905–6. doi: 10.1016/s0140-6736(22)02361-3

6. Gu X, Cheng W, Cheng M, Liu M, Zhang Z. The preference of place of death and its predictors among terminally ill patients with cancer and their caregivers in China. *Am J Hosp Palliat Care*. (2015) 32:835–40. doi: 10.1177/1049909114542647

7. Xu T. Survey of feasibility on foundation of home hospice center in Chenngdu city. *Chin Nurs Res*. (2014) 28:3113–5. doi: 10.3969/j.issn.10096493.2014.25.016

8. Xia CF, Chen WQ. Fractions and trends of cancer burden attributable to population ageing in China. *Zhonghua Zhong Liu Za Zhi*. (2022) 44:79–85. doi: 10.3760/cma.j.cn112152-20211012-00756

9. Hui D, Nooruddin Z, Didwaniya N, Dev R, de la Cruz M, Kim SH, et al. Concepts and definitions for "actively dying," "end of life," "terminally ill," "terminal care," and "transition of care": a systematic review. *J Pain Symptom Manag*. (2014) 47:77–89. doi: 10.1016/j.jpainsymman.2013.02.021

10. Agarwal A, Alshakhs S, Luth E, Dignam R, Reid MC, Adelman RD, et al. Caregiver challenges seen from the perspective of certified home hospice medical directors. *Am J Hosp Palliat Care*. (2022) 39:1023–8. doi: 10.1177/10499091211056323

11. Bužgová R, Sikorová L. Association between quality of life, demographic characteristics, physical symptoms, and unmet needs in inpatients receiving end-of-life care: a cross-sectional study. *J Hosp Palli Nur*. (2015) 17:325–32. doi: 10.1097/njh.0000000000000170

12. Kingston A, Robinson L, Booth H, Knapp M, Jagger C. Projections of multi-morbidity in the older population in England to 2035: estimates from the population ageing and care simulation (PACSim) model. *Age Ageing*. (2018) 47:374–80. doi: 10.1093/ageing/afx201

13. Hazelwood DM, Koeck S, Wallner M, Anderson KH, Mayer H. Patients with cancer and family caregivers: management of symptoms caused by cancer or cancer therapy at home. *HeilberufeSCIENCE*. (2012) 3:149–58. doi: 10.1007/s16024-012-0118-z

14. Moghaddam N, Coxon H, Nabarro S, Hardy B, Cox K. Unmet care needs in people living with advanced cancer: a systematic review. *Support Care Cancer*. (2016) 24:3609–22. doi: 10.1007/s00520-016-3221-3

15. Höcker A, Krüll A, Koch U, Mehnert A. Exploring spiritual needs and their associated factors in an urban sample of early and advanced cancer patients. *Eur J Cancer Care (Engl)*. (2014) 23:786–94. doi: 10.1111/ecc.12200

16. Gott M, Allen R, Moeke-Maxwell T, Gardiner C, Robinson J. 'No matter what the cost': a qualitative study of the financial costs faced by family and whānau caregivers within a palliative care context. *Palliat Med*. (2015) 29:518–28. doi: 10.1177/0269216315569337

17. Higginson IJ, Daveson BA, Morrison RS, Yi D, Meier D, Smith M, et al. Social and clinical determinants of preferences and their achievement at the end of life: prospective cohort study of older adults receiving palliative care in three countries. *BMC Geriatr*. (2017) 17:271. doi: 10.1186/s12877-017-0648-4

18. Low J, Pattenden J, Candy B, Beattie JM, Jones L. Palliative care in advanced heart failure: an international review of the perspectives of recipients and health professionals on care provision. *J Card Fail*. (2011) 17:231–52. doi: 10.1016/j.cardfail.2010.10.003

19. Bajwah S, Higginson IJ, Ross JR, Wells AU, Birring SS, Riley J, et al. The palliative care needs for fibrotic interstitial lung disease: a qualitative study of patients, informal caregivers and health professionals. *Palliat Med*. (2013) 27:869–76. doi: 10.1177/0269216313497226

20. Ryan T, Ingleton C, Gardiner C, Parker C, Gott M, Noble B. Symptom burden, palliative care need and predictors of physical and psychological discomfort in two UK hospitals. *BMC Palliat Care*. (2013) 12:11. doi: 10.1186/1472-684x-12-11

21. Daya AP, Sarkar S, Kar SS. Estimation of palliative care need in the Urban Community of Puducherry. *Indian J Palliat Care*. (2017) 23:81–7. doi: 10.4103/0973-1075.197959

22. Elayaperumal S, Venugopal V, Dongre AR. Identifying people in need of palliative Care Services in Rural Tamil Nadu: a survey. *Indian J Palliat Care*. (2018) 24:393–6. doi: 10.4103/ijpc.Ijpc_92_18

23. Kozlov E, Cai A, Sirey JA, Ghesquiere A, Reid MC. Identifying palliative care needs among older adults in nonclinical settings. *Am J Hosp Palliat Care*. (2018) 35:1477–82. doi: 10.1177/1049909118777235

24. Hu T, Xiao J, Peng J, Kuang X, He B. Relationship between resilience, social support as well as anxiety/depression of lung cancer patients: a cross-sectional observation study. *J Cancer Res Ther*. (2018) 14:72–7. doi: 10.4103/jcrt.JCRT_849_17

25. Dunham M, Ingleton C, Ryan T, Gott M. A narrative literature review of older people's cancer pain experience. *J Clin Nurs*. (2013) 22:2100–13. doi: 10.1111/jocn.12106

26. Ghesquiere A, Gardner DS, McAfee C, Kenien C, Capezuti E, Kozlov E, et al. Development of a community-based palliative care screening tool for underserved older adults with chronic illnesses. *Am J Hosp Palliat Care*. (2018) 35:929–37. doi: 10.1177/1049909117749467

27. Kastbom L, Milberg A, Karlsson M. A good death from the perspective of palliative cancer patients. *Support Care Cancer*. (2017) 25:933–9. doi: 10.1007/s00520-016-3483-9

28. Kun Z, Yunyun P, Li L, Can G. The status quo and influencing factors of palliative care needs of the community elderly with chronic diseases Chinese. *Nurs Manag*. (2023) 23:1306–11. doi: 10.3969/j.issn.1672-1756.2023.09.005

29. Chaoying W, Wei Z, Yanju J, Fuying Z, Cuizhen S. Study on the demand for hospice care and its influencing factors in elderly patients. *Shang Med Pharm J*. (2017) 38:15–9.

30. Minxin (2022) *Liaoning provincial government work report*. (2022) 2:24–30. doi: 10.3969/j.issn.1674-201X.2022.02.015

31. Ying Y, Chen D, Zhang P, Tang Y, Zhu Q, Jiang S. Status quo of hospice care service in community health service centers in Shanghai. *Chin J General Pract*. (2023) 22:367–72. doi: 10.3760/cma.j.cn114798-20220729-00808

32. Maslow AH. *Motivation and personality*. New York City: Harper & Row,Publishers, Inc. (1987).

33. Wyld MLR, Morton RL, Clayton P, Wong MG, Jardine M, Polkinghorne K, et al. The impact of progressive chronic kidney disease on health-related quality-of-life: a 12-year community cohort study. *Qual Life Res*. (2019) 28:2081–90. doi: 10.1007/s11136-019-02173-1

34. Conrad N, Judge A, Tran J, Mohseni H, Hedgecott D, Crespillo AP, et al. Temporal trends and patterns in heart failure incidence: a population-based study of 4 million individuals. *Lancet*. (2018) 391:572–80. doi: 10.1016/s0140-6736(17)32520-5

35. Wang T, Molassiotis A, Tan JY, Chung BPM, Huang HQ. Prevalence and correlates of unmet palliative care needs in dyads of Chinese patients with advanced cancer and their informal caregivers: a cross-sectional survey. *Support Care Cancer*. (2021) 29:1683–98. doi: 10.1007/s00520-020-05657-w

36. Llop-Medina L, Fu Y, Garcés-Ferrer J, Doñate-Martínez A. Palliative Care in Older People with multimorbidities: a scoping review on the palliative care needs of patients, Carers, and health professionals. *Int J Environ Res Public Health*. (2022) 19:19. doi: 10.3390/ijerph19063195

37. Glaser BG, Strauss A. *Time for Dying*. Chicago, IL: Aldine Publishing (1968).

38. Romem A, Tom SE, Beauchene M, Babington L, Scharf SM, Romem A. Pain management at the end of life: a comparative study of cancer, dementia, and chronic obstructive pulmonary disease patients. *Palliat Med*. (2015) 29:464–9. doi: 10.1177/0269216315570411

39. Burt J, Shipman C, Richardson A, Ream E, Addington-Hall J. The experiences of older adults in the community dying from cancer and non-cancer causes: a national survey of bereaved relatives. *Age Ageing*. (2010) 39:86–91. doi: 10.1093/ageing/afp212

40. Jackevicius CA, de Leon NK, Lu L, Chang DS, Warner AL, Mody FV. Impact of a multidisciplinary heart failure post-hospitalization program on heart failure readmission rates. *Ann Pharmacother*. (2015) 49:1189–96. doi: 10.1177/1060028015599637

41. van den Berg B, Brouwer WB, Koopmanschap MA. Economic valuation of informal care. An overview of methods and applications. *Eur J Health Econ*. (2004) 5:36–45. doi: 10.1007/s10198-003-0189-y

42. Tarter R, Demiris G, Pike K, Washington K, Parker OD. Pain in hospice patients with dementia: the informal caregiver experience. *Am J Alzheimers Dis Other Dement*. (2016) 31:524–9. doi: 10.1177/1533317516653825

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 27 May 2024
DOI 10.3389/fpubh.2024.1358106

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Vicente Paulo Alves,
Catholic University of Brasilia (UCB), Brazil
Theingi Maung Maung,
AIMST University, Malaysia

*CORRESPONDENCE
Yahui Meng
✉ yhlf_meng@sina.com

RECEIVED 19 December 2023
ACCEPTED 08 May 2024
PUBLISHED 27 May 2024

CITATION
Li F, Gao X and Meng Y (2024) Analysis of the life course effects of the disability dilemma among rural older adults in China.
Front. Public Health 12:1358106.
doi: 10.3389/fpubh.2024.1358106

COPYRIGHT
© 2024 Li, Gao and Meng. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Analysis of the life course effects of the disability dilemma among rural older adults in China

Fen Li[1], Xiangdong Gao[2] and Yahui Meng[3]*

[1]School of Management, Xuzhou Medical University, Xuzhou, Jiangsu, China, [2]School of Public Administration, East China Normal University, Shanghai, China, [3]Xuzhou Cancer Hospital, Xuzhou, Jiangsu, China

Objective: To analyse whether the accumulation of early adverse experiences among individuals of different generations has an impact on disabilities and evaluate the cumulative effects of disadvantages in rural older adults in China.

Methods: A Binary Logit Model was used to analyse the life course effects of the disability dilemma among rural older adults.

Results: Regarding Activities of Daily Life (ADLs), there was no significant difference between older adults that experienced 1 adverse events and the control group. The probability of older adults experiencing difficulties in 2, 3, 4, or more types of ADLs was 1.486 times, 2.173 times, and 3.048 times higher than that of the control group, respectively. Regarding Instrumental Activities of Daily Life (IADLs), there was no significant difference between the population that experienced 1 or 2 adverse events and the control group. The probability of experiencing difficulties in 3, 4, or more types of IADLs was 1.527 times and 1.937 times higher than that of the control group, respectively. Early adverse events had a cumulative disadvantageous effect on disability in older adults. The longer the duration of adverse experiences, the higher the risk of disability in old age. Education had a significant mitigating effect on health risks.

Conclusion: Pay attention to early factors in the life course, strengthen the promotion of health prevention concepts, and pay attention to the moderating and relieving effects of education on health. We should also gradually improve the rural disability care system and family health security capabilities in China's rural areas.

KEYWORDS

healthy aging, rural older adults in China, disability dilemma, life course, prevention

1 Introduction

Exploring the cumulative effects of disability and disadvantages among rural older adults in China from a life course perspective to achieve healthy aging is inherently necessary and an important way to shift the prevention threshold forwards and intervene in the influencing factors of health (1–5). Promoting healthy aging and ensuring the health rights of older adults are important parts of helping China Modernization. According to the Seventh Population Census Data of China, in rural areas, the population is shrinking, and the proportion of the rural population to the total population is 36.11%. Compared with the Sixth Population Census of China, the rural population has decreased by 164.4 million, while the proportion of older adults aged 60 and above living in rural areas is 7.99 percentage points higher than

that living in urban areas (6–8). With the gradual increase in population migration and mobility in rural areas of China, the transformation of the family structure, and the continuous advancement of the aging process, the demand for healthy aging of the older adult population has also increased. Health is an important cornerstone of individual survival and development, and disability has become one of the important factors affecting the healthy aging of rural older adults (9, 10). Over time, do the early experiences of individuals born in different eras have an impact on disability in old age? Do these experiences have a cumulative disadvantageous effect on disabilities in older adults? This is the key issue discussed in this article.

2 Materials and methods

2.1 Data sources

The data used in this article came from the China Health and Retirement Longitudinal Survey (CHARLS) from 2014 and 2018. CHARLS 2014 is the "Life Course Special Survey," and CHARLS 2018 is the fourth follow-up survey. This article used the individual's ID as the identification condition to merge data from the 2014 and 2018 surveys. Based on research needs, we performed logical matching, merging, filtering, and cleaning of the data to obtain the required variables. With both registered residence and residence in rural areas as the criteria, 5,017 older adults were selected as the research objects.

2.2 Variable selection and feature description

2.2.1 Disability indicators and descriptions

This study used self-care ability to measure the disability status of older adults, including whether they had difficulties in ADLs, IADLs, and their subitems. In the CHARLS questionnaire, ADL and IADL scales were used to measure the disability status of rural older adults (11, 12). In the questionnaire, the independently completed ADL and IADL scales are divided into four levels: 1 = no difficulty, 2 = difficulty but still achievable, 3 = difficulty requiring help, and 4 = inability to complete. For the purpose of this research, the disability status of older adults was divided into binary variables (13). If there were no difficulties in any of the subitems in the ADL scale for rural older adults, then ADL = 0 was defined; if there were difficulties in at least one ADL, ADL = 1 was defined. Similarly, when rural older adults had no difficulties in any IADLs, then IADL was defined as 0; when they had difficulties in at least one IADL, IADL = 1.

From ADLs, such as bathing (10.91%), getting into/out of bed (10.79%), and Getting up from/off the toilet (19.15%), had a higher proportion of difficulties. However, the proportion of activities such as dressing (8.80%), eating (3.77%), and controlling urination and defecation (6.45%) that were small in scope and intensity and essential for maintaining a regular life had a smaller proportion of difficulties. The proportion of people who had difficulties in IADLs, especially the ability to perform household chores (18.40%), cooking (13.50%), shopping (12.28%), making phone calls (27.78%), Taking medications (6.38%) and managing finances (14.32%) were greater than that of people who had difficulties in ADLs. In addition, the proportion of difficulties in at least one ADL was 28.21%, and the proportion of difficulties in at least one IADL was 43.84%. Therefore, for rural older adult individuals, the proportion of IADL difficulties was higher than that of ADL difficulties.

2.2.2 Main characteristics and descriptions

When exploring the reasons for the disability dilemma of older adults in rural China, based on life course theory, the individual characteristics selected were gender, age, and education. The early variables in the life course were health status before age 15, duration of early adverse experiences, number of early adverse events, adult health status, and occupation in adulthood. The characteristics of older adult individuals were body mass index, self-assessment of memory, measurement of mental health, self-assessment of mental health, medical insurance, pension insurance, duration of sleep at night, and whether they nap, smoke, and drank alcohol in the past year.

This study selected 10 types of adverse events from childhood and adolescence, as well as youth and adulthood, for early life experiences. Among them, adverse experiences of children and adolescents included biological parents divorced before the age of 17, a bedridden father or mother, a father or mother with mental impairments, a father or mother with serious disabilities, a father or mother who passed away before the individuals was aged 17, being bullied by neighboring children when young, being detained before the age of 17, and family experience of hunger before the age of 17. Adverse experiences in youth and adulthood included whether the individual experienced serious physical injuries after the age of 16 and whether they ever left work for more than a month due to physical health reasons. First, the 10 selected adverse events or experience indicators were summed to obtain the "number of adverse events" indicator. The value range of the indicators was 0–10, and the larger the value, the more adverse events experienced. Second, we examined the duration of adverse events: for the 10 adverse events selected in this article, the duration of the experience of hunger was a convenient indicator for calculating the duration of adverse events. Therefore, we used the period and duration of hunger as proxy variables to represent the duration of adverse events. The assignment and characteristics of the variables are shown in Table 1.

2.3 Method and model construction

To evaluate the disability dilemma among older adults in rural China, it was first necessary to construct a basic equation for the impact of early life process factors on older adult disability status as shown in equation (1):

$$H_i = \alpha_0 + \alpha_1 X_i + \alpha_2 X_j + \varepsilon \quad (1)$$

Where H_i is the health status of individual i in the older adult stage, X_i is a certain life process variable, X_j is other variables controlled for when analysing the impact of X_i on the current health status, and μ is a random perturbation term. When performing analyses based on this basic equation, the indicators of ADLs and IADLs were treated as binary variables, with 0 indicating no difficulties and 1 indicating difficulties. A binary logit model was used to analyse the causes of the disability dilemma among rural older adults.

The Logit Model and form were as follows: $f(p) = \alpha + \beta X + \varepsilon$. To analyse the factors contributing to the disability dilemma of rural

TABLE 1 Assignment and description of variables.

Variables	Assignment	Observations	Mean	Standard deviation
ADLs	0 = No difficulty, 1 = Difficulty	5,002	0.282	0.450
IADLs	0 = No difficulty, 1 = Difficulty	4,952	0.438	0.496
Gender	0 = male, 1 = female	5,017	0.52	0.50
Age	1 = 60–64,2 = 65–69,3 = 70–74,4 = 75–79,5 = 80 years old and above	5,015	67.55	6.57
Education	1 = Uneducated, 2 = Primary school and below, 3 = Junior high school and above	4,761	1.74	0.69
Health status before 15 years of age	0 = poor, 1 = good	4,976	0.14	0.34
Duration of early adverse experiences	0 = none, 1 = 1 stage, 2 = 2 stages, 3 = 3 stages	4,884	1.46	1.08
Number of early adverse experiences	0–10	5,017	1.85	1.19
Health status during adulthood	1 = poor, 0 = good	4,994	0.18	0.38
Occupation type during adulthood	1 = Agriculture, 2 = Non-agriculture, 3 = Agriculture+non-agriculture, 4 = None	4,967	–	–
BMI	0 = normal, 1 = abnormal	5,017	0.537	0.499
Memory self-assessment	0 = good, 1 = poor	4,973	4.267	0.794
Measurement of mental health	0 = good, 1 = poor	5,017	0.414	0.493
Self-evaluation of mental health	0 = good, 1 = poor	4,908	0.083	0.275
Medical insurance	0 = not participating, 1 = participating	4,767	0.933	0.250
Pension insurance	0 = not participating, 1 = participating	5,017	0.815	0.388
Duration of sleep at night	1 = less than 4 h, 2 = greater than 4 but less than 6 h, 3 = greater than 6 but less than 8 h, 4 = greater than 8 h	4,847	2.383	0.959
Napping	0 = no, 1 = yes	4,948	0.572	0.495
Smoking	0 = no, 1 = yes	4,854	0.473	0.499
Alcohol consumption	0 = no, 1 = yes	5,013	0.317	0.465

Due to varying degrees of missing variables, the number of observations varies. The occupation type during adulthood was a non-hierarchical variable, so the mean and standard deviation were not calculated.

older adults, p represents the probability of difficulty in older adults' ability to take care of themselves, $p/(1-p)$ represents the "probability ratio," and the "probability ratio" represents the probability of difficulty being $p/(1-p)$ times higher than the probability of difficulty not being present. Here, X represents the explanatory and control variables included in the logit model, and μ represents the error term in the dependent variable that cannot be explained by the dependent variable. Based on equation (1), we constructed a set of logit models as shown in equations (2), (3):

$$y_{ADL} = \beta_0^{ADL} + \beta_1^{ADL} x_1 + \beta_2^{ADL} x_2 + \cdots + \beta_k^{ADL} x_k + \varepsilon^{ADL} \quad (2)$$

$$y_{IADL} = \beta_0^{IADL} + \beta_1^{IADL} x_1 + \beta_2^{IADL} x_2 + \cdots + \beta_k^{IADL} x_k + \varepsilon^{IADL} \quad (3)$$

The Biomedical Ethics Review Committee of Peking University approved CHARLS, and all participants were required to provide written informed consent. The ethical approval number was IRB00001052-11015.

3 Results

3.1 The impact of the number of adverse experiences on the disability dilemma of rural older adults

Based on the model constructed in this article, we analysed the impact of the number of early adverse events on the disability status of older adults in rural China. The results are shown in Table 2. The constant terms were significant, and the fitting degree of the model

10.3389/fpubh.2024.1358106

TABLE 2 Estimated results of the impact of the number of early adverse experiences on the disability status of older adults in rural China.

Variables	ADLs	IADLs
Number of early adverse events (none)		
1 type	1.132 (0.131)	1.014 (0.104)
2 types	1.486*** (0.174)	1.163 (0.123)
3 types	2.173*** (0.274)	1.527*** (0.178)
4 types or more	3.048*** (0.432)	1.937*** (0.262)
Gender (male)	1.259** (0.128)	1.511** (0.143)
Age (60–64 years old)		
65–69 years old	1.416*** (0.114)	1.324*** (0.098)
70–74 years old	1.767*** (0.160)	2.025*** (0.172)
75–79 years old	2.197*** (0.258)	2.815*** (0.321)
80 years old and above	2.812*** (0.414)	3.762*** (0.568)
Education (uneducated)		
Primary school and below	1.038 (0.077)	0.570*** (0.039)
Junior high school and above	0.966 (0.113)	0.480*** (0.051)
Health before 15 years of age (poor)	0.821** (0.073)	0.775*** (0.062)
Health status during adulthood (good)	1.365*** (0.111)	1.549*** (0.116)
Occupation type during adulthood (agriculture)		
Non-agriculture	0.916 (0.215)	0.494*** (0.103)
Agriculture + non-agriculture	0.916 (0.069)	0.679*** (0.044)
None	2.048 (1.031)	1.937 (0.262)
BMI (normal)	1.365*** (0.112)	1.161** (0.070)
Memory self-assessment (good)	1.943*** (0.127)	1.986*** (0.121)
Measurement of mental health (good)	1.848*** (0.124)	1.764*** (0.111)
Self-evaluation of mental health (good)	1.800*** (0.193)	2.177*** (0.249)
medical insurance (not participating)	0.777** (0.096)	0.883 (0.108)
pension insurance (not participating)	0.956 (0.081)	0.939 (0.075)
Duration of sleep at night (<4 h)		
4–6 h	0.667*** (0.057)	0.689*** (0.058)
6.1–8 h	0.537*** (0.046)	0.694*** (0.058)
>8 h	0.569*** (0.066)	0.940 (0.101)
Napping (no)	1.233*** (0.081)	1.075 (0.065)
smoking (no)	1.083 (0.100)	1.126 (0.098)
Alcohol consumption (no)	0.810** (0.062)	0.819** (0.058)
Constant	0.172*** (0.042)	0.525** (0.120)
samples	4,136	4,094
Prob > chi2	0.000	0.000
R^2	0.125	0.152

The parentheses after the independent variable indicate the control group. The coefficients in the table represent the odds ratio. **$p < 0.05$, ***$p < 0.01$.

was good. For ADLs, there was no significant difference in ADLs between the 1 type group and the group who had not experienced any adverse events in the early stage. From the early experiences of groups with difficulties in 2, 3, 4, and more ADLs, the probability of difficulty in ADLs was 1.486 times, 2.173 times, and 3.048 times higher than that of the control group, respectively. For IADLs, there was no significant difference between the population who experienced one or two adverse events in the early stage and the control group. The probability of experiencing difficulties in the early stages in 3, 4, or more ADLs was 1.527 times and 1.937 times higher than that of the control group, respectively. The number of early adverse experiences significantly affected the disability status of older adults. The more early adverse experiences there were, the higher the probability of disability in older age.

10.3389/fpubh.2024.1358106

Health status before the age of 15 significantly affected the disability status of rural older adults. People with good health status before the age of 15 were 0.821 times and 0.775 times more likely to have difficulties with ADLs and IADLs in older age compared to those with a poor early health status, respectively. That is, older adults with good health status before the age of 15 had a relatively low probability of disability. Health status in adulthood significantly affected the ability to take care of oneself in old age. Older adults with poor health status in adulthood were 1.365 times and 1.549 times more likely to have difficulties with ADLs and IADLs compared to those with poor health status in adulthood. Poor health in adulthood led to a relatively high probability of disability in old age. From the perspective of occupation type in adulthood, the impact of occupation type in adulthood on ADLs in older adults was not significant, but it had a significant impact on IADLs. Older adults engaged in non-agricultural or agricultural+ non-agricultural activities also had relatively good IADL abilities.

From the perspective of control variables, as age increased, the likelihood of difficulties in older adults' ability to take care of themselves increased, and the likelihood of difficulties in IADLs increased with age. There was a significant gender difference in the disability status of older adults, with male older adults having better self-care abilities on average than female older adults. Older adults with poor BMI, poor memory self-evaluation, poor measured mental health, or poor self-evaluated mental health had a higher probability of disability. Participating in medical insurance protected against disability. A sufficient sleep duration and afternoon naps had a positive effect on older adult individuals' ability to take care of themselves. The impact of pension insurance and smoking on their ADLs was not significant. Older adults who consumed alcohol in the past year had relatively good self-care abilities, which may be due to reverse selection; that is, older adults with poor self-care abilities tend to avoid drinking behavior to a certain extent.

TABLE 3 Estimated results of the impact of early adverse event duration on the disability status of rural older adults.

Variables	ADLs		IADLs	
	1	2	1	2
Early adverse experience duration (none)	1.083*** (0.030)		1.087*** (0.029)	
1 stage		1.123 (0.095)		1.061 (0.083)
2 stages		1.341*** (0.134)		1.167* (0.110)
3 stages		1.257*** (0.112)		1.273*** (0.108)
control variables	Yes	Yes	Yes	Yes
Constant	0.270*** (0.039)	0.204*** (0.046)	0.640*** (0.084)	0.557** (0.120)
samples	4,071		4,030	
Prob>chi2	0.000		0.000	
R^2	0.116		0.149	

The parentheses after the independent variable indicate the control group. The coefficients in the table represent the odds ratio. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

The level of education had a significant impact on the IADLs of older adults in rural China. The results are shown in Table 2, the probability of difficulty in IADLs in primary school and below was 0.570 times higher than that of the control group (uneducated), and the probability of difficulty in IADLs in junior high school and above was 0.480 times that of the control group (uneducated). That is, older adults with high levels of education were relatively less likely to have difficulties with IADLs. Studies have shown that education level, as one of the important indicators of socioeconomic status, presents a significant mediating effect between early adverse experiences and IADLs disability in older adults, the more early adverse experiences there are, the lower the level of education, and the lower the ability to acquire health capital (14). Education level was a factor that was present throughout the entire life course from the early stages. The education level of rural older adults was closely related to their early life background and experiences. The different early life backgrounds and experiences to some extent led to different opportunities and degrees of early education, which affected career choices throughout the life course, further directly or indirectly affecting the opportunities to obtain health resources during the life course, thus causing differences in the disability status of rural older adults to a certain extent.

3.2 The impact of duration on the disability dilemma of rural older adults

The estimation results in Table 3 show that with the addition of control variables (the significance and impact effects of the control variables are not listed separately), the constant terms are significant, and the model fits well. The duration of early adverse events had a significant impact on the disability status of rural older adults. The longer the duration of early adverse events, the higher the probability of disability in old age. Taking no adverse events as the control group, the duration of early adverse events for one stage had no significant impact on the disability status of older adults. For ADLs, the probability of experiencing 2 or 3 stages of early adverse events regarding self-rated health was 1.341 times and 1.257 times higher than that of the control group, respectively. For IADLs, the probability of difficulty in early adverse events lasting for 2 and 3 stages was 1.167 and 1.273 times higher than that of the control group, respectively. As early adverse events continued, the growth rate of health capital slowed or the depreciation rate of health capital gradually increased. The continuous impact of adverse events on health accumulate with age, affecting the ability to take care of oneself in old age.

The impact of early adverse events on the disability status of rural older adults varied with the number and duration of adverse events, and early disadvantages accumulated in the older adult population. One of the earliest descriptions of risk/disadvantage accumulation was proposed by Riley JC in 1989, who stated that early adverse experiences can cause long-term damage to physical health through gradual accumulation (15, 16). The accumulation of early adverse factors can have an impact on individual health trajectories, allowing people to experience different lifestyles and obtain different health resources, thereby leading to varying levels of self-care ability among older adults to a certain extent. These adverse factors can be referred to as disadvantages in the life course, and their impact on disability in older adults can be independent or interactive, thereby having a cumulative effect on disability in older adults (17, 18). From the life course perspective, individual early experiences and health

endowments are transmitted through the accumulation of life course, and to a certain extent, they constrain and affect the self-care ability of older adult individuals, causing them to fall into the disability dilemma (19, 20). However, when older adults reach a certain age, the importance of early adverse factors on their ability to take care of themselves decreases, and the role of intrinsic biological functions gradually becomes prominent. Rural older adults who did not experience adverse events in early life had a longer life expectancy and a lower risk of disability compared to those who experienced more adverse events in early life.

4 Conclusion

Based on the above analysis, the following conclusions can be drawn: (1) the disability dilemma of older adults in rural China is a result of the interaction and transmission of factors in old age and early life, and early adverse events increase the risk of disability in older adults through the cumulative effect of disadvantages. (2) The number and duration of early adverse experiences significantly affect the disability status of older adults in rural China. The more and longer the number and duration of early adverse experiences, the higher the probability of disability in old age, and older adults without adverse experiences tend to live longer. Lifestyle and security conditions in old age significantly affect the health status of older adults in rural China. (3) Individuals with higher levels of education have more opportunities to access health resources and the ability to resist health risks during their growth process. To a certain extent, education can regulate and alleviate the cumulative disadvantageous effect of early adverse experiences on disability in old age.

To further improve the health status of older adults in rural China, first, actively the population must be actively encouraged to adopt the concept of "not getting old" to prevent "getting old." The occurrence of health risks in the early stages of the life course must be prevented, the cumulative effects of health risks must be reduced, and the health status of older adults must be improved. Second, the prevention of "advanced age" will enhance the health awareness of older adults in rural China. The prevention perspective is not only based on the health of the underage population to preserve their health in old age but also actively encourages the improvement of the health status of young people to prevent a poor health status. The concept of prevention promotes the transformation from passively seeking health services after disability to proactively seeking health care without disability and improves people's awareness of prevention and health care. This transformation can not only effectively improve the overall health status of rural older adults but also save many medical resources. The prevention threshold must be moved forwards, prevention first health policies must be implemented, and healthy aging must be promoted.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Biomedical Ethics Review Committee of Peking University approved CHARLS, and all participants were required to provide written informed consent. The ethical approval number was IRB00001052-11015. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

FL: Writing – original draft. XG: Writing – review & editing. YM: Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by Medical research project of Jiangsu Provincial Health Commission: "Study on Health Management Services and Health Risk Prevention and Control Strategies for Disabled Population in Jiangsu Province" (Z2021020).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Han RL, Han XJ, Zhang LL, Lu XL. Trends in the size and structure of disabled older adults in rural China—research based on CLHLS data and the seventh national population census data. *Population Res.* (2023) 47:63–77.

2. Latorre-Román PA, Laredo-Aguilera JA, García-Pinillos F, Soto-Hermoso VM, Carmona-Torres JM. Physical activity, weight and functional limitations in elderly Spanish people: the National Health Survey (2009–2014). *Eur J Public Health*. (2018) 1:1–6. doi: 10.1093/eurpub/ckx219

3. Botes R, Vermeulen KM, Ranchor AV, Buskens E. Functional health state description and valuation by people aged 65 and over: a pilot study. *BMC Geriatr*. (2018) 18:11. doi: 10.1186/s12877-018-0711-9

4. Hale K, Stbye T, Perera B, Bradley R, Maselko J. A novel adaptation of the HOME inventory for elders: the importance of the Home environment across the life course. *Int J Environ Res Public Health*. (2019) 16:2826. doi: 10.3390/ijerph16162826

5. Zhang X, Li W, Dai J, Zhang X. An analysis of urban-rural difference of self-care ability of seniors-an empirical analysis based on CHARLS (2018) data. *Population Dev*. (2022) 28:129–42. doi: 10.12088/j.issn.1674-1668.2022.4.scyrkfx202204011

6. Hu HW, Li YY. A study on the demand and cost of Care for the Disabled Elderly inRural China. *Chin J Popoul Sci*. (2021) 3:98.

7. Li LM, Yang MY, Li ZY. The influence and mediating effect between education and health from the life course perspective. *J Xi'an Jiao-tong University*. (2020) 40:69–79. doi: 10.15896/j.xjtuskxb.202006007

8. Li J. The family Care of the Disabled Elderly: care-giving willingness and its influencing factors. *J Yunnan Minzu University*. (2023) 40:72–81. doi: 10.13727/j.cnki.53-1191/c.20230306.002

9. He WJ, Zhang X. The optimization of policies of health poverty alleviation based on common prosperity. *J Hebei University*. (2022) 47:1–9. doi: 10.3969/j.issn.1005-6378.2022.01.001

10. Research group. The research group of the National Development Strategy Research Institute of Wuhan University. To achieve modernization in a populous country, to actively respond to aging. *Population Dev*. (2023) 29:99–100.

11. Vergara I, Bilbao A, Orive M, Garcia-Gutierrez S, Navarro G, Quintana J.Validation of the Spanish version of the Lawton IADL scale for its application in elderly people.*Health Qual Life Outcomes*, (2012), 10:130. doi: 10.1186/1477-7525-10-130

12. Mattos IE, do Carmo CN, Santiago LM, Luz LL. Factors associated with functional incapacity in elders living in long stay institutions in Brazil: a cross-sectional study. *BMC Geriatr*. (2014) 14:47. doi: 10.1186/1471-2318-14-47

13. Li F, Gao XD. A study of gender differences of self-care ability of rural elderly people-an empirical analysis based on CHARLS (2015) data. *Population Dev*. (2019) 25:39–49.

14. Liu RP, Li JX. The effects of adverse childhood experiences on disability trajectory among Middle-aged and older adults. *Population J*. (2023) 45:68–80. doi: 10.16405/j.cnki.1004-129X.2023.01.008

15. WHO. *Primary health care. International conference on primary health care Alma-Ata USSR*. New York: WHO (1978).

16. Riley JC. *Sickness and death in the twenty-first century: a transformation toward health?* UK: Palgrave Macmillan (1989).

17. WHO. Universal Health Coverage across the Life Course. (2019), Available at: https://www.who.int/life-course/en/

18. Kuh D, Ben-Shlomo Y, Lynch J, Hallqvist J, Power C. Life course epidemiology. *J Epidemiol Community Health*. (2003) 57:778–83. doi: 10.1136/jech.57.10.778

19. Li F, Gao XD. Retrospective analysis of health risk generation mechanism of rural elderly under the background of common prosperity. *Lanzhou Academic J*. (2022) 9:135–47. doi: 10.3969/j.issn.1005-3492.2022.09.011

20. Liang XJ, Hu D. Institutional logic of relative poverty governance under the goal of common prosperity. *Stud Prac*. (2022) 7:87–95. doi: 10.19624/j.cnki.cn42-1005/c.2022.07.006

frontiers | Frontiers in Public Health

TYPE Systematic Review
PUBLISHED 10 July 2024
DOI 10.3389/fpubh.2024.1369066

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Paul I. Kadetz,
Queen Margaret University, United Kingdom
Jefferson Todd Frazier,
Houston Methodist Hospital, United States

*CORRESPONDENCE
Erica Viola
✉ erica.viola@uniupo.it

RECEIVED 11 January 2024
ACCEPTED 28 June 2024
PUBLISHED 10 July 2024

CITATION
Viola E, Martorana M, Ceriotti D, De Vito M, De Ambrosi D and Faggiano F (2024) The effects of cultural engagement on health and well-being: a systematic review.
Front. Public Health 12:1369066.
doi: 10.3389/fpubh.2024.1369066

COPYRIGHT
© 2024 Viola, Martorana, Ceriotti, De Vito, De Ambrosi and Faggiano. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

The effects of cultural engagement on health and well-being: a systematic review

Erica Viola[1]*, Marco Martorana[1,2], Daniele Ceriotti[3], Marta De Vito[3], Damiano De Ambrosi[3] and Fabrizio Faggiano[1]

[1]Department of Sustainable Development and Ecological Transition, University of Eastern Piedmont, Vercelli, Italy, [2]Department of Statistics, Computer Science, and Applications "Giuseppe Parenti" (DiSIA), University of Florence, Florence, Tuscany, Italy, [3]Department of Translational Medicine, University of Eastern Piedmont, Novara, Piedmont, Italy

Purpose: This paper examines the effectiveness of culture-based activities in improving health-related outcomes among middle-aged and older adults. Based on the biopsychosocial model, this review aims to explore the impact of cultural engagement on health and well-being.

Methods: We conducted a systematic literature review based on peer-reviewed articles retrieved from various electronic databases. In total, 11 studies were included in this review. Our study population consisted of healthy adults aged over 40 years.

Results: The results provide evidence of positive association between cultural participation and better mental health (e.g., cognitive decline, depression, anxiety), frailty, resilience, well-being and social relations.

Conclusion: This review suggests that cultural engagement serves as an effective means for individuals to maintain and enhance their health and well-being. The field is mostly limited by the heterogeneity of the studies and poor conceptualization of cultural activities. Thus, it is recommended that future research consider the effects of different cultural interventions in developing effective strategies for promoting healthy lifestyles and enhancing quality of life in later stages of life.

KEYWORDS

cultural engagement, leisure activities, health, well - being, quality of life

1 Introduction

For many years, the concept of health has evolved from a mere absence of disease to a more comprehensive evaluation. In 1948, the World Health Organization (WHO) defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (1). This marked the beginning of a process that shifted the concept of health from an individual perspective to a more social one (2). This evolution has culminated in the current vision of health, described as "the ability to adapt and self-manage" (3) (p. 2), emphasizing the development of personal capabilities.

Therefore, despite significant progress in disease treatment, in recent decades, many researchers have shifted their focus to exploring methods for enhancing and maintaining health and well-being, leveraging cognitive, emotional, and social resources to confront challenges and meet daily requirements effectively. In particular, artistic activities have

received significant attention as a potential means to enhance the quality of life, especially among the older population (4, 5). This association is now widely recognized (6), emphasizing the significant role of culture as a determinant of individual psychological well-being (7–9), psychological flexibility and health (10). Evidence from a recent comprehensive scoping review highlights the beneficial outcomes of engaging in diverse cultural and arts events (4), relevant to both health promotion and prevention efforts by fostering health-promoting behaviors and aiding in illness prevention.

In light of the complex challenges of the aging population, understanding the role of culture in promoting health and well-being becomes increasingly important. By expanding and intensifying research in these areas, we can identify strategies to enhance quality of life in an economically advantageous, accessible, and enjoyable manner.

The aim of the present paper is to review current literature addressing the relationship between different forms of cultural engagement and health and well-being in people aged over 40 years. We chose to follow the biopsychosocial model as a comprehensive framework that considers the interconnected influence of biological, psychological, and social factors on human behavior and experiences. This approach allows for a nuanced analysis, fostering a deeper understanding of human functioning. Additionally, aligning with this model enhances the relevance and applicability of our research findings across various fields. In the context of this systematic review, we will distinguish between "receptive culture," which encompasses visits to museums, galleries, art exhibitions, theaters, concerts, cultural festivals, and community events, and "cultural participation," which refers to active engagement in one or more of these activities (4). Both types of activities involve aspects of artistic and cultural experience, ranging from creativity, cognitive and sensory stimulation, to social interaction (e.g., esthetic pleasure, and emotional evocation), which promote health (11, 12). However, differences emerge in the impact of receptive and participatory culture; moreover, studies show contrasting results. Although active cultural engagement interventions have shown greater benefits in terms of psychophysical outcomes (13, 14), other authors have found only the efficacy of receptive activities in supporting healthy aging, perhaps because they more consistently involve social interactions and movement, which are positively associated with healthy aging (11, 12). Further research is needed for a better understand the underlying reasons for such differences. There is still a lack of research that evaluates the overall impact of arts engagement on healthy aging in a comprehensive and integrated manner (11, 12).

Based on these observations, we address the following key questions:

- How might different forms of cultural engagement relate to health and well-being?
- What gaps exist in the current literature examining the effects of cultural engagement on health and well-being outcomes? Consequently, what further research is needed?
- What are the implications of the present literature for healthcare and cultural systems and policies?

2 Methods

2.1 Study design

This study can be classified as a systematic review.

2.2 Search strategy

A comprehensive search of published studies was conducted using the following databases: Cochrane, EBSCO and PubMed. Concerning the keywords, we considered very inclusive terms that refer to cultural engagement; regarding the effects, we have considered words related to health and well-being. The key terms for searches included: ("Cultural participation" OR "Cultural attendance" OR "cultural engagement" OR "cultural event*" OR "Art* activit*" OR "Art* participation" OR "Art* attendance") AND ("Healthy lifestyle" OR "Health*" OR "health promotion" OR "Health behavior*" OR "well-being" OR "Well-being" OR "quality of life"). No publication date restriction was applied. Figure 1 presents the flowchart of the process of identifying and selecting literature. The selected articles were required to have undergone peer review processes prior to publication and to present a clear and consistent methodology. However, given the diverse methods and outcomes considered in the selected studies, this review will provide a qualitative synthesis of the results reported by the researchers.

2.3 Inclusion and exclusion criteria

Our criteria for inclusion were as follows: (1) quantitative methodology; (2) randomized controlled trial (RCT), longitudinal and cross-sectional studies with controls; (3) receptive arts engagement in terms of attendance of arts-based events such as museums, art exhibitions and galleries, concerts, the theater, and the cinema (15) as well as the active production of art (16); (4) according to the biopsychosocial approach, the consideration of physical, psychological and social variables associated to health and well-being as outcomes; (5) samples of healthy people aged over 40 years. The specific effects of music and/or making music on health were excluded in this study; instead, a separate study was dedicated to examining them (5). Systematic reviews and meta-analyses were also excluded.

2.4 Study selection

Our selection was conducted by screening articles titles, abstracts and considering full-text articles of potentially eligible papers. Three independent reviewers (EV, MM, DC) executed these procedures, resolving disagreements through discussion. The systematic review was undertaken according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (17).

2.5 Quality criteria

The methodological quality of the considered studies was analyzed using Checklist for Analytical Cross Sectional Studies (18). Two

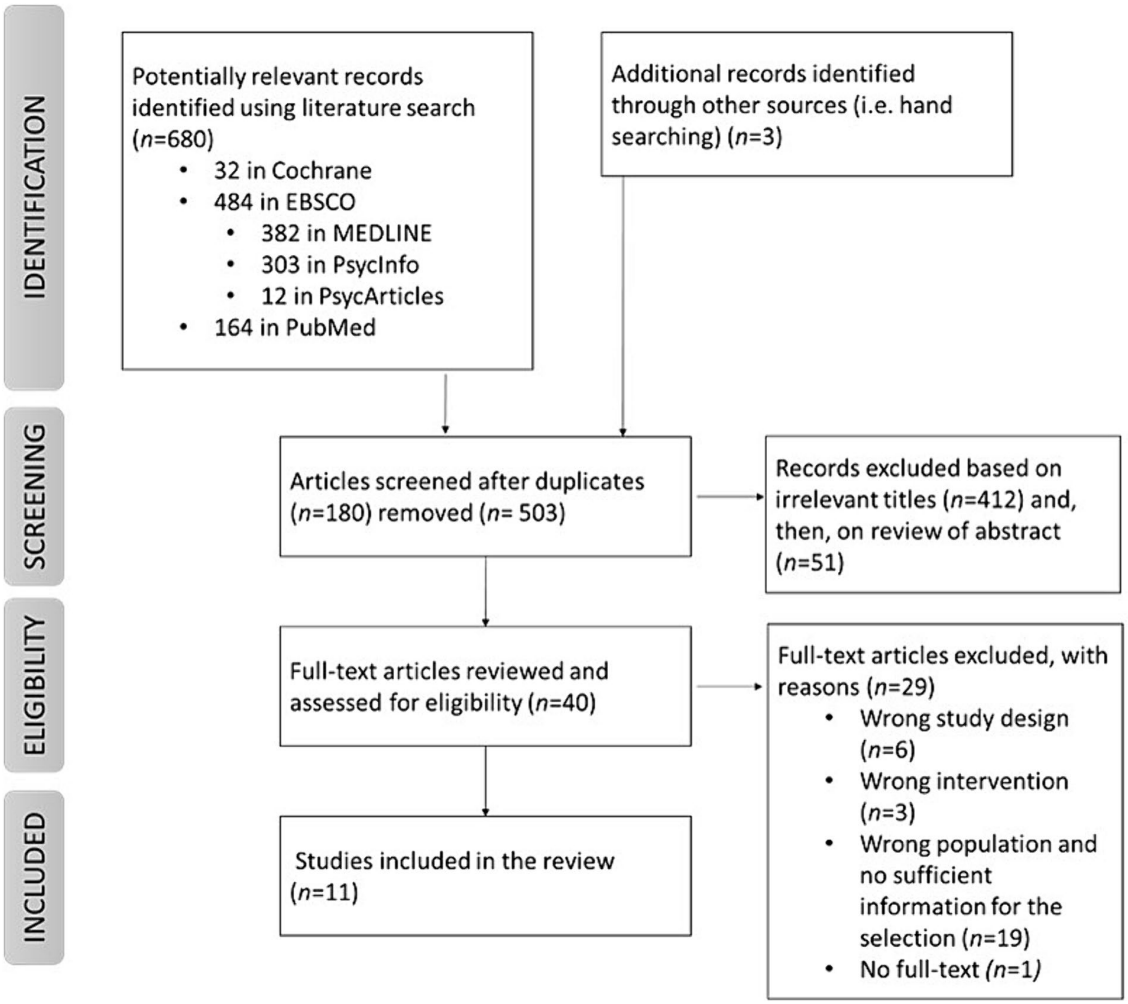


FIGURE 1
Flowchart of the literature identification and selection process.

reviewers (EV and MM) assessed the methodological quality of included studies based on 8 criteria (see Supplementary Table A1). Each paper was assigned to be low (<5), moderate (between 5 and 7) or high quality (7 or 8) depending on the number of criteria they met; possible discrepancies were resolved by consensus. The results of the quality assessment process are listed in Supplementary Table A1.

3 Results

3.1 Search results

We identified 683 articles through the literature search process. After the exclusion of duplicates and following the inclusion/exclusion criteria, 11 studies were selected (see Figure 1). Summaries of the studies included in this review are presented in Table 1. All these studies examined the effects of cultural engagement on particular dimensions of health and well-being: mental health status, frailty, loneliness, and so forth. We present the results according to the specific outcome (Table 2 for effects and significance). In general, out of 95 overall effects, 42 statistically significant positive effects emerge (44%), whereas the remaining effects, although not statistically significant, are not negative and therefore do not worsen health and well-being. The most significant effects are derived from regular and sustained forms of cultural participation, whereas going to the cinema is found to be the least beneficial for health promotion.

Several studies used data from national databases ($n = 6$). All studies used a quantitative methodology. Concerning the research designs, most of the studies were longitudinal ($n = 7$, one of which is retrospective), since cross-sectional ($n = 2$), a follow-up survey and an RCT. The time elapsed between the initial data collection and subsequent data collection in longitudinal studies typically ranged from 6 to 10 years. Sample sizes varied considerably, from 28 participants (RCTs) to large national surveys with 16,642 participants. The majority of the studies were conducted in the United Kingdom ($n = 6$), with Japan ($n = 2$), Italy ($n = 1$), Israel ($n = 1$), and Germany ($n = 1$) also represented. The age range of participants spanned from 50 to 99 years, with a balanced gender distribution.

The psychological and social health outcomes varied significantly. The most prominent variables examined were resilience ($n = 2$), well-being ($n = 2$) and frailty ($n = 2$), followed by depression ($n = 1$), anxiety ($n = 1$), mental health ($n = 1$), dementia ($n = 1$), cognitive functions

TABLE 1 Detailed summary of the considered studies (alphabetical order).

First author, year	Country	N participants (% women)	Age (min-max)	Samples	Intervention / Data collection	Cultural variable classification	Outcome
Bolwerk, 2014 (16)	Germany	28 (53.5%)	62–70 ($M = 63.7$)	2 groups: art production group ($n = 14$) art evaluation group ($n = 14$)	RCT; weekly participation in two different 10-week-long art interventions (art production: active production of art in an art class; cognitive art evaluation: cognitive evaluation of artwork at a museum)	Production (active creation) or Evaluation (cognitive evaluation of artistic creations) of art in group interventions, 2 h and once a week for 10 weeks	Resilience
Fancourt, 2018 (19)	UK	3,911 (55%)	>50 ($M = 63.8$)	1 group (data from ELSA)	Longitudinal (data for a decade: 2004/2005-2014/2015) (Wave 2 – Wave 7)	Frequency of engagement in visiting museums, art galleries, and exhibitions on a six-point Likert scale ('never', 'less than once a year', 'about once or twice a year', 'every few months', 'about once a month', 'twice a month or more') merging the last 3 categories ('every few months or more') for a four-point scale	Diagnosis of Dementia
Fancourt, 2018 (20)	UK	3,445 (55.2%)	52–90 ($M = 62.9$)	1 group (data from ELSA)	Longitudinal (data for a decade: 2004/2005-2014/2015) (Wave 2 – Wave 7)	Frequency of engagement in visiting: (i) art gallery, museum or exhibition, (ii) theater, concert or opera (iii)cinema on a six-point Likert scale (from 'never' to 'twice a month or more') merging the last 2 categories for a five-point scale	Cognitive functions
Fancourt, 2019 (21)	UK	8,780	≥50	2 groups (data from ELSA): Infrequent cultural engagement; Frequent cultural engagement	Longitudinal (data for a decade: 2004/2005-2016/2017) (Wave 2 – Wave 8)	Frequency of engagement in visiting: (i) theater, concert or opera, (ii) cinema, (iii) art gallery, exhibition or museum, considering infrequent participation ('never', 'less than once a year', 'once or twice a year') *vs* frequent participation ('every few months', 'about once a month', 'twice a month or more')	Depression
Fushiki, 2012 (22)	Japan	3,583 (1,955 participants completed the questionnaires 3 times during the study period)	65–84	4 groups: Solitary physical activities; Group physical activities; Solitary cultural activities; Group cultural activities	Longitudinal (collected annually from 2007 to 2010 and completion of the questionnaire three times during this period)	Number of cultural activities (in solitary [music appreciation, ceramics, handicrafts, etc.] and in group [cultural club, tea klatch, Japanese chess, etc.]). Yes/no responses. The author also considered the participation in physical activities, this aspect is not taken into account in this review.	Frailty
Keisari, 2021 (15)	Israel	205 (67.3%)	65–92 ($M = 72.3$)	1 group	Cross-sectional	Receptive arts engagement (visiting theater, concerts, dance performance, art galleries, museums, and the cinema) on a single-item scale ranging from 1 (not at all) to 6 (at least once a week) during the year preceding the COVID-19 outbreak	Anxiety for COVID-19
Rapacciuolo, 2016 (23)	Italy	571 (50.6%)	>60 ($M = 70.1$)	1 group	Cross-sectional	Participation and Nonparticipation in Cultural and Social Activities	Perceived psychological well-being; Resilience

(Continued)

10.3389/fpubh.2024.1369066

TABLE 1 (Continued)

First author, year	Country	N participants (% women)	Age (min-max)	Samples	Intervention / Data collection	Cultural variable classification	Outcome
Rogers, 2020 (24)	UK	4,575 (52.7%)	52–99 ($M = 64.7$)	1 group (data from ELSA)	Longitudinal (data for a decade: 2004/2005–2014/2015) (Wave 2 –Wave 7)	Frequency of engagement in visiting: (i) theater, concert, or opera, (ii) cinema, (iii) art gallery, exhibition or museum on a six-point Likert scale (from 'never' to 'twice a month or more') generating an overall frequency of cultural engagement with 4 intensity levels ("never," "less than once a year," "once or twice a year," "every few months or more")	Frailty
Takeda, 2015 (25)	Japan	16,642 (50.8%)	50–59 ($M_M = 54.7$; $M_F = 54.7$)	1 group (data from the population-based survey LSMEP)	Longitudinal (six-year panel survey: 2005/2010)	Hobbies or cultural activities in the last year, classifying those who answered affirmatively as "active" and the others as "inactive"	Mental health status
Tymoszuk, 2020 (26)	UK	Cross- sectional: 6,222 (53.5%). Longitudinal (7 years): 3,127 (55.1%).	Cross-sectional: $M = 65.6$ Longitudinal: $M = 62.5$	2 groups (data from ELSA)	Longitudinal (data for a decade: 2004/2005–2014/2015) (Wave 2 –Wave 7)	Frequency of engagement in visiting: (i) the cinema, (ii) art galleries, exhibitions or museums, (iii) the theater, concerts, or the opera on a four-point Likert scale ('never', 'less than once a year', 'once or twice a year', 'every few months or more') creating a binary variable (if every few months or more often = frequent engagement, otherwise less frequent)	Loneliness
Tymoszuk, 2020 (27)	UK	2,767 (54%)	$M = 62.3$	1 group (data from ELSA)	Longitudinal (data for a decade: 2004/2005–2014/2015) (Wave 2 - Wave 7)	Frequency of engagement in visiting: (i) the cinema, (ii) art galleries, exhibitions or museums, (iii) the theater, concerts, or the opera ('never', 'less than once a year', 'once or twice a year', 'every few months', 'once a month or more'); subsequently coded as a binary variable 'non-frequently engaged' ['never', 'less than once a year', 'once or twice a year'] and 'frequently engaged' ['every few months or more']. Concerning the six waves (scores ranging from 0 to 6): 0 = 'no or infrequent arts engagement at all waves', 1 = 'short-term engagement' (frequent engagement at one wave only), 2 = 'repeated engagement' (frequent engagement at 2–3 waves), 'sustained engagement' (frequent engagement at 4–6 waves).	Experienced well-being, Evaluative well-being and Eudaimonic well-being

ELSA, English Longitudinal Study of Aging; LSMEP, Longitudinal Survey of Middle-aged and older Persons.

10.3389/fpubh.2024.1369066

10.3389/fpubh.2024.1369066

TABLE 2 Effects and significance of the impact of various cultural activities on the considered variables.

Author, year	Outcome measure	Cultural variable	*n*	Statistical Indicators ± SE / (SE) (95% IC)	Effect and significance
Fancourt, 2018 (20)[a]	Verbal memory (participants had to remember as many words as possible immediately and after a short delay during which they completed other cognitive tests)	Visiting galleries/museums			
		less than once a year	954	0.19 ± 0.14 (−0.08–0.47)	*ns*
		once or twice a year	767	0.52 ± 0.15 (0.22–0.82)	+***
		every few months	491	0.67 ± 0.18 (0.32–1.02)	+***
		monthly or more	178	0.74 ± 0.26 (0.23–1.25)	+**
		Theater/concert/opera			
		less than once a year	742	0.41 ± 0.16 (0.10–0.72)	+**
		once or twice a year	873	0.24 ± 0.16 (−0.07–0.55)	*ns*
		every few months	662	0.63 ± 0.17 (0.29–0.97)	+***
		monthly or more	270	0.80 ± 0.24 (0.33–1.27)	+***
		Cinema			
		less than once a year	845	0.16 ± 0.14 (−0.12–0.44)	*ns*
		once or twice a year	643	0.17 ± 0.15 (−0.13–0.48)	*ns*
		every few months	585	0.56 ± 0.17 (0.23–0.89)	+***
		monthly or more	284	0.25 ± 0.22 (−0.18–0.67)	*ns*
	Semantic fluency (by asking participants to think of as many words of a particular category as possible in less than 1 min)	Visiting galleries/museums			
		less than once a year	954	0.26 ± 0.29 (−0.31–0.82)	*ns*
		once or twice a year	767	1.02 ± 0.31 (0.41–1.62)	+***
		every few months	491	1.75 ± 0.36 (1.04–2.46)	+***
		monthly or more	178	1.20 ± 0.50 (0.22–2.19)	+*
		Theater/concert/opera			
		less than once a year	742	0.58 ± 0.32 (−0.05–1.20)	*ns*
		once or twice a year	873	0.74 ± 0.32 (0.12–1.37)	+*
		every few months	662	1.23 ± 0.34 (0.56–1.91)	+***
		monthly or more	270	1.41 ± 0.47 (0.50–2.32)	+**
		Cinema			
		less than once a year	845	0.66 ± 0.30 (0.07–1.25)	+*
		once or twice a year	643	0.65 ± 0.31 (0.04–1.25)	+*
		every few months	585	0.76 ± 0.35 (0.06–1.45)	+*
		monthly or more	284	0.14 ± 0.39 (−0.63–0.91)	*ns*
Fancourt, 2018 (19)[b]	Dementia (Informant Questionnaire on Cognitive Decline in the older adults - IQCODE)	Visiting art galleries and museums			
		Never	1,279	1	
		Less than once a year	1,048	0.92 (0.15) (0.67–1.26)	*ns*
		Once or twice a year	845	0.76 (0.14) (0.53–1.09)	*ns*
		Every few months	739	0.51 (0.13) (0.32–0.83)	+**
Takeda, 2015 (25)[c]	Mental health status (Kessler 6 (K6) scale - Japanese version)	Hobbies or cultural activities			
		Women			
		Inactive	2,934	1	
		By oneself	1,107	0.74 (0.62–0.90)	+**
		With others	4,291	0.76 (0.67–0.87)	+***
		Both solo and in group	135	0.55 (0.33–0.93)	+*
		Men			
		Inactive	3,392	1	
		By oneself	1,350	0.96 (0.81–1.15)	*ns*
		With others	3,317	0.83 (0.71–0.97)	+*
		Both solo and in group	116	0.85 (0.39–1.86)	*ns*

(Continued)

10.3389/fpubh.2024.1369066

TABLE 2 (Continued)

Author, year	Outcome measure	Cultural variable	*n*	Statistical Indicators ± SE / (SE) (95% IC)	Effect and significance
Keisari, 2021 (15)[d,e]	COVID-19 Anxiety (Generalized Anxiety Disorder - GAD-7)	Receptive arts engagement	205	−5.10 (0.24) (−0.99–0.03) (art) 0.64 (0.24) (0.16–1.12) (moderation effect)	+* +**
Fancourt, 2019 (21)[f]	Depression experienced over 12 years (8-item Center for Epidemiologic Studies Depression Scale - CES-D)	Cultural engagement			
		Never	89	1	
		Less than once a year	104	0.80 (0.54–1.19)	*ns*
		Once or twice a year	174	0.74 (0.51–1.06)	*ns*
		Every few months	167	0.68 (0.47–0.99)	+*
		Once a month or more	82	0.52 (0.34–0.80)	+**
Fushiki, 2012 (22)[g]	Incident frailty (3-items questionnaire). Incident frailty was defined as being newly institutionalized or bedridden at home because of physical disability or severe cognitive impairment	Solitary cultural activities			
		No	39	1	
		Yes	15	0.74 (0.40–1.35)	*ns*
		Group cultural activities			
		No	46	1	
		Yes	8	0.40 (0.19–0.85)	+*
Rogers, 2020 (24)[h]	Frailty incidence (56-items Frailty Index – FI) and frailty trajectory (measured biennially for 10 years - waves 2–7)	Incidence			
		Cultural engagement			
		Never	718	1	
		Less than once a year	750	1.09 (0.87–1.38)	*ns*
		Once or twice a year	1,212	0.92 (0.74–1.14)	*ns*
		Every few months or more	1889	0.47(0.63–0.996)	+*
		Trajectory			
		Cultural engagement			
		Never	718	1	
		Less than once a year	750	−0.0031 (−0.0053 – −0.0010)	+**
		Once or twice a year	1,212	−0.0035 (−0.005 - -0.0015)	+**
		Every few months or more	1889	−0.0039 (−0.0059 - -0.0019)	+***
Bolwerk, 2014 (16)[i]	Resilience (brief German version of the Resilience Scale - RS-11)	Visual art production	14	Pre-intervention: 60.64 (± 1.71) Post-intervention: 63.50 (± 1.47)	+*
		Cognitive art evaluation	14	Pre-intervention: 62.57 (± 2.32) Post-intervention: 64.79 (± 1.80)	*ns*
Rapacciuolo, 2016 (23)[j]	Perceived psychological well-being (Psychological General Well Being Schedule - PGWB-S); Resilience (Connor-Davidson Resilience Scale CD-RISC2)	Resilience			
		Participating in cultural and social activities	448	6.07 ± 1.58	+***
		Non participating in cultural and social activities	123	5.14 ± 1.83	
		Psychological General Well-Being			
		Participating in cultural and social activities	448	70.53 ± 17.89	+***
		Non participating in cultural and social activities	123	58.95 ± 23.2	

(Continued)

10.3389/fpubh.2024.1369066

TABLE 2 (Continued)

Author, year	Outcome measure	Cultural variable	*n*	Statistical Indicators ± SE / (SE) (95% IC)	Effect and significance
Tymoszuk, 2020 (27)[k]	Experienced well-being – Positive affect (CASP-19); Evaluative well-being – Life satisfaction (Diener's life satisfaction scale); Eudaimonic well-being - Control and Autonomy (CASP-19); Eudaimonic well-being - Self-realization (CASP-19)	Positive affect			
		Engagement with cinema			
		No or infrequent	1,572	1	
		Short-term	316	0.80 (0.61–1.03)	*ns*
		Repeated	371	0.99 (0.78–1.26)	*ns*
		Sustained	508	1.14 (0.91–1.43)	*ns*
		Engagement with galleries/exhibitions/museums			
		No or infrequent	1,695	1	
		Short-term	317	0.98 (0.76–1.28)	*ns*
		Repeated	327	1.05 (0.82–1.35)	*ns*
		Sustained	428	1.25 (0.98–1.61)	*ns*
		Engagement with theater/concerts/opera			
		No or infrequent	1,409	1	
		Short-term	486	1.17 (0.91–1.51)	*ns*
		Repeated	364	1.10 (0.86–1.41)	*ns*
		Sustained	608	1.42 (1.14–1.77)	+**
		Life satisfaction			
		Engagement with cinema			
		Short-term	316	0.001 (−0.56–0.56)	*ns*
		Repeated	371	−0.01 (−0.56–0.54)	*ns*
		Sustained	508	−0.24 (−0.74–0.25)	*ns*
		Engagement with galleries/exhibitions/museums			
		Short-term	317	0.32 (−0.25–0.90)	*ns*
		Repeated	327	0.46 (−0.08–1.00)	*ns*
		Sustained	428	0.76 (0.28–1.25)	+**
		Engagement with theater/concerts/opera			
		Short-term	486	0.11 (−0.45 – 0.66)	*ns*
		Repeated	364	0.13 (−0.42–0.67)	*ns*
		Sustained	608	0.43 (0.02–0.89)	*ns*
		Control autonomy			
		Engagement with cinema			
		Short-term	316	−0.18 (−0.44–0.08)	*ns*
		Repeated	371	0.16 (−0.10–0.43)	*ns*
		Sustained	508	0.06 (−0.17–0.29)	*ns*
		Engagement with galleries/exhibitions/museums			
		Short-term	317	−0.001 (−0.28–0.27)	*ns*
		Repeated	327	0.28 (0.02–0.54)	+*
		Sustained	428	0.20 (−0.04–0.44)	*ns*
		Engagement with theater/concerts/opera			
		Short-term	486	0.08 (−0.17–0.33)	*ns*
		Repeated	364	0.33 (0.08–0.58)	+*
		Sustained	608	0.28 (0.05–0.51)	+*
		Self-realization			
		Engagement with cinema			
		Short-term	316	0.09 (−0.20–0.39)	*ns*

(Continued)

10.3389/fpubh.2024.1369066

TABLE 2 (Continued)

Author, year	Outcome measure	Cultural variable	*n*	Statistical Indicators ± SE / (SE) (95% IC)	Effect and significance
		Repeated	371	0.09 (−0.17–0.36)	*ns*
		Sustained	508	0.13 (−0.10–0.37)	*ns*
		Engagement with galleries/exhibitions/museums			
		Short-term	317	0.16 (−0.12–0.44)	*ns*
		Repeated	327	0.31 (0.04–0.58)	+*
		Sustained	428	0.51 (0.27–0.76)	+***
		Engagement with theater/concerts/opera			
		Short-term	486	0.17 (−0.10 – 0.45)	*ns*
		Repeated	364	0.27 (−0.01–0.54)	*ns*
		Sustained	608	0.30 (0.08–0.53)	+**
Tymoszuk, 2020 (26)[l]	Loneliness (three-item short-form of the Revised UCLA Loneliness Scale)	Engagement with cinema			
		Never	937	1	
		Less than once a year	776	1.15 (0.87–1.54)	*ns*
		Once or twice a year	603	0.91 (0.66–1.27)	*ns*
		Every few months or more	811	0.96 (0.78–1.41)	*ns*
		Engagement with art galleries and museums			
		Never	908	1	
		Less than once a year	883	0.86 (0.65–1.13)	*ns*
		Once or twice a year	716	0.74 (0.54–1.01)	*ns*
		Every few months or more	620	0.68 (0.48–0.95)	+*
		Engagement with theater/concert/opera			
		Never	776	1	
		Less than once a year	699	0.75 (0.55–1.02)	*ns*
		Once or twice a year	807	0.69 (0.50–0.95)	+*
		Every few months or more	855	0.84 (0.61–1.15)	*ns*

***$p \leq 0.001$; **$p \leq 0.01$; *$p \leq 0.05$. [a]Pre- Post- Model 4 (Ordinary Least Square Regression - β): adjusted for baseline cognition, sex, age, marital status, ethnicity, educational attainment, employment status, occupational classification, wealth, self-reported health, eyesight, hearing, depression, social network, civic engagement, whether participants had a hobby, whether participants used the internet and whether participants read a daily newspaper. [b]Model 4 (Poisson regression - Incidence Rate Ratio (IRR) of dementia incidence and 95% Cis): adjusted for gender, age, marital status, educational attainment, employment, wealth and occupational classification, eyesight, hearing, depression and existing cardiovascular health conditions, community engagement. [c]Model (Multiple logistic regression models - AOR): adjusted for demographic and socioeconomic status, physical health condition, chronic diseases and mental health status at the baseline. [d]Cross-sectional - Multiple hierarchical regression analysis (moderation effect of culture between resilience and anxiety) (B); [e]Multiple hierarchical regression model (step 2: Resilience $p < 0.00$ and Art $p < 0.04$; step 3: Resilience × Art $p = 0.01$). [f]Model 3 (Logistic regression analyses - OR): adjusted for age, gender, SES & baseline depression. [g]Cox Proportional Hazard Models (Hazard ratios - HRs and 95% Cis) for frailty associated with participation in hobby activities. HRs adjusted for sex, age, self-perceived health status, cerebrovascular disease, smoking and drinking habits and body mass index. [h]Incidence and trajectory: Model 2 (Competing risk regression model Sub-hazard ration – SHR and 95% CI), adjusted for covariates and baseline frailty (non-frail vs pre-frail). [i]Wilcoxon signed-rank test (Median and standard error of the mean – SEM). [j]Cross-sectional - Student's t-test between "Participant" and "Non-Participant" groups; mean and ± standard deviation was reported. [k]Positive affect: Logistic regression model was reported Odds Ratio (OR), 95%; for Life satisfaction, Control autonomy, Self-realization: Linear Regression Model was reported B and 95% CI. All model was adjusted for: Wave 2 well-being score, gender, age, ethnicity, coupled relation status, highest educational attainment, employment status, and net non-pension wealth, eyesight and hearing problem, experiences of pain and chronic illness, social isolation index, and civic activities. [l]Model 5 (Logistic regression analyses – OR): univariate + demographic factors (gender, age, ethnicity, highest educational attainment, employment status, and net non-pension wealth + health factors) (eyesight and hearing problems, experiences of pain and long-standing illness status) + social factors (social contact, romantic relationship status, and engagement with community activities) + baseline loneliness score.

(memory and semantic fluency; $n = 1$) and loneliness ($n = 1$). Except for the RCT, which introduced specific cultural activities, the remaining studies focused on regular, ongoing cultural participation.

3.2 Quality assessment

9 studies displayed a high methodological quality, whereas 2 studies received moderate quality ratings due to (a) a non-clear description of the criteria for inclusion in the sample as well as for the study subjects and the setting ($n = 1$), and (b) the non-identification of confounding factors ($n = 1$). The authors of 7 studies utilized data from national databases, which did not permit a clear *a priori* specification of inclusion criteria beyond age. Nevertheless, they expanded the survey to encompass large samples and provided adequate descriptions.

3.3 Health and well-being outcome

The order of the discussed outcome aligns with the principles of the biopsychosocial model: first, "Cognitive Functioning" addresses the fundamental aspects of brain biology; then, "Dementia" is

explored due to its involvement in cognitive processes; "Mental Health" encompasses a spectrum of psychological aspects; "Frailty" acts as a crucial connector, spanning individual and societal domains; "Resilience" acknowledged as both personal and social resource; "Well-being" is examined for its multifaceted determinants, including social influences; finally, "Social Relationships" for their direct involvement in social interaction. The decision to separate the discussion by theme stems from the diverse methods and variables considered in the selected studies.

3.3.1 Cognitive functioning

Fancourt and Steptoe (20) found that cultural participation in general has a positive impact in terms of cognitive conservation, verbal memory and semantic fluency, especially if adequately sustained (at least a couple of times a year), regardless of baseline cognitive status and other variables (e.g., demographics, health, etc.). Particularly, a dose–response relationship emerges, indicating that a higher frequency of visits to galleries or museums, as well as theaters, concerts, or opera, had a greater effect on cognition with a protective effect. The results regarding the association between going to the cinema and cognitive function become less clear and consistent when other control factors are considered and corrected for multiple comparisons. On the whole, the reported results show that the activities were protective regardless of the median level of baseline cognition.

3.3.2 Dementia

Visiting museums could be a promising psychosocial activity to support dementia prevention, especially if sustained over time (19) The reported results show that such activity is associated with a lower incidence rate of dementia over a 10-year follow-up period in individuals aged over 50. The incidence rate of dementia is lower among individuals who regularly attend museums compared to those who do not attend museums. Particularly, the overall incidence rate was 5.42 (95% CI 4.78–6.17) per 1,000 person-years; the incidence rate resulted higher than average for non-participants ($\Delta = 4.05$), slightly lower than average for sporadic participants (less than once a year: $\Delta = -1.46$; once or twice a year: $\Delta = -1.69$), and even lower for those who visited galleries and museums frequently ($\Delta = -3.27$) (19). Taken into account the demographic differences, the association between cultural participation and a dementia remained significant only for those who visited museums every few months or more.

3.3.3 Mental and psychological health

Participation in recreational activities (hobbies/cultural activities) showed a positive association with mental health after a five-year follow-up (25). Participating in activities with others has a positive impact on mental health, and this effect is particularly marked when compared to those who do not engage in any social activities. These differences are also notable between genders. Whereas this association was observed among men in a larger sample, women showed a positive relationship with mental health regardless of the mode of participation in group activities (25). Keisari et al. (15) found that receptive artistic engagement moderated the relationship between resilience, conceptualized as an individual's ability to effectively cope with and adapt to the challenges and difficulties brought about by the coronavirus pandemic and COVID-19 anxiety. Specifically, the significant interaction between resilience and receptive arts engagement accounted for an additional 3% of the variance in anxiety symptoms. Furthermore, the authors found that pre-pandemic cultural participation had a buffering effect against COVID-19 anxiety; conversely, individuals with low artistic involvement reported higher levels of anxiety. Fancourt and Tymoszuk (21) confirmed that a regular and sustained cultural engagement (at least every few months) represents an important risk reducing factor for the development of depression in older age. A clear dose–response relationship emerges, indicating that higher frequency of participation is associated with a reduced risk. Those who rarely or never participate (once or twice a year) showed an incidence rate of depression above the average, whereas higher participation frequencies were linked to rates below the average.

3.3.4 Frailty

Rogers and Fancourt (24) found a dose–response relationship between cultural participation and both the incidence and progression of frailty. Regarding the incidence, the authors found a subhazard ratio of 0.92 CI [0.85–0.98] between frequency of cultural engagement and incidence frailty. Moreover, the risk of frailty at the age of 80 is 1.3 times higher for those who do not engage in cultural activities, independent of confounding factors such as demographics, socioeconomic status, and social factors. These findings corroborate those of a prior study by Fushiki and colleagues (22), which indicated that individuals who participated - in their life - in at least one or more cultural or physical group activities after adjustment exhibited a lower incidence of frailty compared to those who engaged in such activities alone. Furthermore, when comparing cultural and physical activities (solo or in groups), individuals participating in one or more cultural activities demonstrated a lower incidence of frailty.

3.3.5 Resilience

Bolwerk and coll (16) showed that the cultural engagement can increase resilience, conceptualized as a protective personality trait enabling individuals to mitigate the negative impacts of stress and facilitating successful and healthy functioning even amidst challenging life circumstances. Although the effects were greater and statistically significant only in the "Visual art production" group (the resilience level increased by 2.86 points between pre- and post-intervention), a non-significant improvement also emerged in the "Cognitive art evaluation" group (+2.22). These results are also confirmed at the biological level: using fMRI, they observed that participants engaged in visual art production, compared to the assessment of art, showed greater spatial improvement in functional connectivity in different brain areas (mostly between the parietal and frontal cortices) over time, and that this was related to psychological resilience. Rapacciuolo and coll (23) showed that those who participate in cultural and social activities (both women and men) have higher levels of resilience, define as successful stress-coping ability, compared to non-participants (+ 0.93).

3.3.6 Well-being

As previously mentioned, Rapacciuolo and coll (23) showed an association between participation in cultural activities (mostly for women) and psychological well-being: who participate in cultural and social activities have higher levels of well-being compared to non-participants (+ 11.58). Participation in social and cultural activities, along with interventions aimed at fostering positive

emotions, could be crucial in combating social isolation and its adverse effects on health. Additionally, as suggested by the authors, these activities may contribute to promoting healthier lifestyles, such as improving nutrition. Tymoszuk and coll (27) showed that sustained (once a month or more) cultural participation has a positive impact on various forms of well-being. Considering experienced well-being, sustained engagement with the theater/concert/opera compared with no or infrequent engagement showed a positive effect (OR = 1.4, 95% CI 1.14–1.77, $p = 0.02$). Moreover, about evaluative well-being, sustained engagement with gallery/museum compared with no or infrequent engagement was associated with higher life satisfaction (B = 0.76, 95% CI: 0.28, 1.25, $p = 0.002$). In addition, regarding eudaimonic well-being, sustained engagement with galleries/exhibitions/museums was associated with higher self-realization if compared to no or infrequent engagement (B = 0.51, 95% CI: 0.27, 0.76, $p < 0.001$). Finally, considering again eudaimonic dimension, sustained engagement with the theater/concerts/opera respect to no or infrequent engagement was related with higher control/autonomy (B = 0.28, 95% CI: 0.05, 0.51, $p = 0.018$) and self-realization (B = 0.30, 95% CI: 0.08, 0.53, $p = 0.008$). No associations were found for engagement with screen-based performances (cinema attendance), in contrast to studies that have demonstrated its beneficial effects but in line with other studies that have identified positive associations between time spent in front of screens (TV) and depressive symptoms, sedentary behavior, and other factors.

3.3.7 Social relationships

Tymoszuk and coll (26) used the second wave of ELSA for the cross-sectional analyses and data from the seventh wave (a decade later) for the longitudinal analyses. The cross-sectional results showed that: engaging with cinema every few months or more often, compared with never, was associated with 26% lower odds of loneliness, visiting galleries/exhibitions/museums every few months or more often and once or twice a year had, respectively, 26 and 22% lower odds of loneliness compared with those who reported no engagement. Participants who reported attending theater, concerts, or opera every few months or more frequently, as well as those attending once or twice a year, exhibited 33 and 23% lower odds of experiencing loneliness, respectively, compared to those who reported no engagement in such activities. However, longitudinal analysis revealed no association between the frequency of cinema attendance and the likelihood of experiencing loneliness, even after adjusting for covariates. Engaging with galleries, exhibitions, and museums every few months or more often, compared to never, was associated with a 32% reduction in the odds of experiencing loneliness at wave 7. Similarly, engaging once or twice a year was linked to a 26% decrease in the likelihood of reporting loneliness at wave 7 after adjusting for covariates. In the fully adjusted model, participating in theater, concerts, or opera once or twice a year, compared to never, was associated with a 31% decrease in the odds of experiencing loneliness at wave 7. The longitudinal analytical sample exhibited skewness toward participants who were female, younger, employed, more educated, in good health, in coupled relationships, reported higher levels of social, community, and arts engagement, and were less likely to be lonely at wave 2. In general, the participation in receptive artistic activities is negatively associated with the risk of loneliness especially for attending museums/galleries/exhibitions compared to theater/concerts/opera and visits to the cinema. This effect emerged regardless of the baseline loneliness level and different confounding variables (i.e., demographic, socioeconomic, health and social factors).

4 Discussion

The results of this systematic review suggest that cultural engagement may be effective in maintaining and enhancing health and well-being of middle-aged and older populations. Regarding our first research question, the evidence suggests that cultural activities have a positive impact on various dimensions of well-being. Visiting museums, galleries, and exhibitions provides positive cognitive stimulation, reducing the risk of cognitive decline or the development of dementia (19). Indeed, there is a relationship between the frequency of museum visits and the incidence rate of dementia, with a lower rate among those who participate more in this activity, and these results remain significant even after accounting for demographic and health variables (19). Moreover, art exhibitions as well as live performances have a positive impact on memory and semantic fluency, reducing decline in cognitive function compared to non-participation (20). Longitudinal associations spanning a decade were observed independent of initial indications of cognitive decline, indicating that cultural engagement may yield benefits also for individuals experiencing cognitive impairment (20). Overall, the results concerning cognitive dimension support the assumption that «cultural engagement […] contributes to cognitive reserve: the resilience of our brains as we age» (4) (p. 24). According to Stern (28), the cognitive reserve against brain damage allows people to deal with cognitive decline; this hypothesis supports the idea that the reserve factors derive from different cognitive dimensions, including education level and intelligence (*cf.* (29)), and participation in specific activities (e.g., cultural activities), which act as protective factors against brain disease (28). The studies reveal intriguing benefits of cultural engagement on psychological resilience at the cerebral level as well: engaging in visual arts has been found to enhance the interaction between various brain regions, thereby improving the ability to endure or cope with challenging situations (16). Furthermore, a high degree of involvement in the arts can potentially act as a protective barrier against specific emotional responses, effectively serving as a moderator between resilience and COVID-19-related anxiety, demonstrating its efficacy as a coping strategy (15). Especially for individuals with low involvement in receptive arts, increased resilience significantly reduced anxiety symptoms; therefore, both context and personal resources influence how resilience and engagement in the arts combine to affect anxiety. Receptive arts engagement has been shown to enhance psychological resources in older age, thereby reducing the risk of developing mental health problems (25). The results suggest that sailing in shared experiences can yield significant benefits for mental health. Overall, socialization and interaction with others represent an added value. Notably, compelling associations have emerged between consistent participation in cultural activities and subjective dimensions of well-being, encompassing both subjective and psychological aspects (23). Additionally, it serves as a protective factor for older individuals, mitigating the risk of mental illnesses such as depression (21). In the realm of cultural engagement, older adults find a sovereign refuge against depression, woven with threads of social interaction, mental creativity, and cognitive stimulation. The advantages of arts engagement in older age extend to frailty

trajectories, effectively reducing the incidence and progression of physiological decline and providing protection against vulnerability to adverse health outcomes (24). Notably, this study represents the initial evidence supporting the potential significance of cultural engagement in older age in reducing both the risk of developing frailty and the trajectory of its progression (24). Finally, at a social level, sustained engagement with museums, galleries, and exhibitions protects against loneliness. Several studies have shown that life events which tend to occur in older age can increase the risk of social isolation and feelings of loneliness (30). This is a very important effect since loneliness negatively affects psychophysical well-being, exacerbating cognitive decline and progression of dementia, increasing the risk of premature mortality (31). Whereas some studies tend to attribute the benefits of cultural engagement, for example, to reducing social isolation, further analysis reveals the relevance of other aspects, such as pleasure experiences and emotional expression (24). Therefore, social benefit is not the sole important factor contributing to the positive health effects. A more critical analysis of this literature might shed further light on this. In a kind of melody of interconnection, the presence of others during recreational activities could play a pivotal role in promoting health, suggesting an interconnectedness between social engagement and positive health outcomes in the realm of cultural activities (25).

In summary, according to the recent scoping review of Fancourt and Finn (4), this systematic review highlights the potential of cultural participation in promoting healthy aging. In accordance with the WHO Global Strategy and Action Plan on Aging and Health, healthy aging is "the process of developing and maintaining the functional ability that enables well-being in older age" (32). These findings emphasize that a regular and sustained cultural engagement, especially in group, can enhance or maintain the well-being while also serving as a preventive measure against potential psychophysical and social disorders and challenges. However, some limitations were observed. In certain studies, various leisure activities and cultural activities were grouped together as a single variable, making it difficult to isolate the impact of specific cultural participation forms. An issue also arises due to the self-reported and retrospective measurement of cultural involvement. Consequently, the data may not always be accurate and may not fully capture the true value of participation in such activities. Numerous studies, especially those utilizing ELSA data, did not thoroughly explore active participation by separating the different activities. In some cases, the assessment of this multifaceted activity was simplified to a single item, despite the diverse effects demonstrated in the reviewed literature across various forms of participation. Furthermore, due to the observational nature of the data (with only one randomized controlled trial included in this review), caution is required when inferring causal relationships between cultural engagement and the various outcomes. The primary findings suggest bidirectional associations, indicating susceptibility to reverse causality bias. Indeed, it is possible that mostly healthy people tend to participate in such activities.

To the best of our knowledge, this is the first systematic review that specifically focuses on the healthy population aged over 40, exclusively considering the psychophysical and social effects of cultural participation. Moreover, our study did not limit the selection of research to randomized controlled trials (RCTs), but also included longitudinal studies based on national databases and cross-sectional studies. We conducted the review by searching various electronic databases with no restrictions on publication dates. The independent analysis conducted by two team members, focusing of both study quality and results, further strengthens the credibility of our review. The studies considered in our analysis were conducted in various geographic regions, not limited to Western countries, thereby providing cross-cultural validation of the value of cultural participation.

Obviously, conducting a meta-analysis could provide empirical evidence regarding the value of cultural participation. However, the variations in methods used to measure this type of activity, along with the diverse range of outcomes considered, hinder the feasibility of such an approach. Additionally, our selection was limited to studies with samples aged over 40, but it could be of interest to explore broader age groups in future research to uncover potential differences that may arise at various stages of life.

In light of the limitations observed in the current literature, there are some future topics to investigate. First, efforts should be made to reduce heterogeneity. This can be achieved by developing a more standardized measure and the definition of culture and cultural participation. Additionally, it is crucial to distinguish between different forms of cultural engagement, as this review has shown that some activities are less effective than others (e.g., cinema attendance). Furthermore, future studies should aim to minimize reliance on self-reported measures of participation and instead utilize standardized measures. Lastly, researchers should consider the aspect of active cultural participation, which involves individuals in the creation of artistic works. This transformation shifts the passive viewer into an active participant or artist, potentially yielding unique insights into the relationship between culture and well-being. A fundamental distinction arises between active participation, where individuals directly engage in the creative process, and receptive engagement (i.e., attending arts events or listening to music). These distinctions result in significant variability that need for consideration in future studies aimed at advancing our understanding of the complex relationship between culture and health (11, 12). To address the problem of revers causality, future studies should consider adopting experimental design, RCTs and consistently include a control group or condition.

5 Conclusion

Our results are encouraging. The primary finding from this systematic review suggests that sustained cultural participation appear to have a positive impact on various dimensions—biopsychosocial—of health and well-being, highlighting the importance of culture for middle-aged and older populations. Those who engage in cultural activities show an improvement in terms of well-being, or at the very least, a maintenance of their health status. Further research, particularly RCTs with control conditions, is needed to gain a deeper understanding of the mechanisms by which cultural participation influences health and well-being outcomes and to develop effective intervention strategies. These studies should employ robust multidimensional measures and also explore potential moderators and mediators, ultimately enhancing the development of future interventions. These findings present a valuable opportunity for multidisciplinary collaboration between healthcare, sociocultural sectors, and arts-related systems and policies.

Author contributions

EV: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. MM: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. DC: Conceptualization, Data curation, Investigation, Writing – review & editing. MV: Conceptualization, Data curation, Investigation, Writing – review & editing. DA: Investigation, Writing – review & editing. FF: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The study was partially funded by a grant from Compagnia di Sanpaolo (three-year Cultural Wellbeing Lab project of Compagnia di Sanpaolo, date of resolution 14/12/2020, No. 2020.2218). This publication is part of the project AGE-IT which has received funding from the MUR–M4C2 1.3 of PNRR with grant agreement no. PE0000015.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1369066/full#supplementary-material

References

1. World Health Organization. Constitution of the World Health Organization. New York: United Nations (1948).

2. Keyes CLM. Social well-being. *Soc Psychol Q*. (1998) 61:121–40. doi: 10.2307/2787065

3. Huber M, Knottnerus JA, Green L, Van Der Horst H, Jadad AR, Kromhout D, et al. How should we define health? *BMJ*. (2011) 343:d4163. doi: 10.1136/bmj.d4163

4. Fancourt D, Finn S. What is the evidence on the role of the arts in improving health and well-being? A scoping review. Health evidence network synthesis report 67. WHO Europe: Copenhagen (2019).

5. Viola E, Martorana M, Airoldi C, Meini C, Ceriotti D, De Vito M, et al. The role of music in promoting health and well-being: a systematic review and meta-analysis. *Eur J Pub Health*. (2023) 33:738–45. doi: 10.1093/eurpub/ckad063

6. Goulding A. How can contemporary art contribute toward the development of social and cultural capital for people aged 64 and older. *The Gerontologist*. (2013) 53:1009–19. doi: 10.1093/geront/gns144

7. Grossi E, Sacco PL, Blessi GT, Cerutti R. The impact of culture on the individual subjective well-being of the Italian population: an exploratory study. *Appl Res Qual Life*. (2011) 6:387–410. doi: 10.1007/s11482-010-9135-1

8. Grossi E, Tavano Blessi G, Sacco PL, Buscema M. The interaction between culture, health and psychological well-being: data mining from the Italian culture and well-being project. *J Happiness Stud*. (2012) 13:129–48. doi: 10.1007/s10902-011-9254-x

9. Wheatley D, Bickerton C. Subjective well-being and engagement in arts, culture and sport. *J Cult Econ*. (2017) 41:23–45. doi: 10.1007/s10824-016-9270-0

10. Bennington R, Backos A, Harrison J, Reader AE, Carolan R. Art therapy in art museums: promoting social connectedness and psychological well-being of older adults. *Arts Psychother*. (2016) 49:34–43. doi: 10.1016/j.aip.2016.05.013

11. Rena M, Fancourt D, Bu F, Paul E, Sonke J, Bone J. Receptive and participatory arts engagement and healthy aging: longitudinal evidence from the health and retirement study. (2022). Available at: https://osf.io/preprints/psyarxiv/q4h6y [10/05/2024]

12. Rena M, Fancourt D, Bu F, Paul E, Sonke JK, Bone JK. Receptive and participatory arts engagement and subsequent healthy aging: evidence from the health and retirement study. *Soc Sci Med*. (2023) 334:116198. doi: 10.1016/j.socscimed.2023.116198

13. Bone JK, Fancourt D, Sonke JK, Bu F. Participatory and receptive arts engagement in older adults: associations with cognition over a seven-year period. *Creat Res J*. (2023):1–15. doi: 10.1080/10400419.2023.2247241

14. Pesata V, Colverson A, Sonke J, Morgan-Daniel J, Schaefer N, Sams K, et al. Engaging the arts for wellbeing in the United States of America: a scoping review. *Front Psychol*. (2022) 12:791773. doi: 10.3389/fpsyg.2021.791773

15. Keisari S, Hoffman Y, Ring L, Palgi Y. The moderating effect of older adults' receptive arts engagement on the association between resilience and anxiety symptoms during coronavirus breakout. *J Nerv Ment Dis*. (2021) 209:443–8. doi: 10.1097/NMD.0000000000001326

16. Bolwerk A, Mack-Andrick J, Lang FR, Dörfler A, Maihöfner C. How art changes your brain: differential effects of visual art production and cognitive art evaluation on functional brain connectivity. *PLoS One*. (2014) 9:e101035. doi: 10.1371/journal.pone.0101035

17. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Int J Surg*. (2021) 88:105906. doi: 10.1016/j.ijsu.2021.105906

18. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, et al. Systematic reviews of etiology and risk In: E Aromataris and Z Munn, editors. JBI manual for evidence synthesis (2020)

19. Fancourt D, Steptoe A, Cadar D. Cultural engagement and cognitive reserve: museum attendance and dementia incidence over a 10-year period. *Br J Psychiatry*. (2018) 213:661–3. doi: 10.1192/bjp.2018.129

20. Fancourt D, Steptoe A. Cultural engagement predicts changes in cognitive function in older adults over a 10 year period: findings from the English longitudinal study of ageing. *Sci Rep*. (2018) 8:10226–8. doi: 10.1038/s41598-018-28591-8

21. Fancourt D, Tymoszuk U. Cultural engagement and incident depression in older adults: evidence from the English longitudinal study of ageing. *Br J Psychiatry*. (2019) 214:225–9. doi: 10.1192/bjp.2018.267

22. Fushiki Y, Ohnishi H, Sakauchi F, Oura A, Mori M. Relationship of hobby activities with mortality and frailty among community-dwelling elderly adults: results of a follow-up study in Japan. *J Epidemiol*. (2012) 22:340–7. doi: 10.2188/jea.JE20110057

23. Rapacciuolo A, Perrone Filardi P, Cuomo R, Mauriello V, Quarto M, Kisslinger A, et al. The impact of social and cultural engagement and dieting on well-being and resilience in a group of residents in the metropolitan area of Naples. *J Aging Res*. (2016) 2016:1–11. doi: 10.1155/2016/4768420

24. Rogers NT, Fancourt D. Cultural engagement is a risk-reducing factor for frailty incidence and progression. *J Gerontol: Series B*. (2020) 75:571–6. doi: 10.1093/geronb/gbz004

25. Takeda F, Noguchi H, Monma T, Tamiya N. How possibly do leisure and social activities impact mental health of middle-aged adults in Japan?: an evidence from a national longitudinal survey. *PLoS One*. (2015) 10:e0139777. doi: 10.1371/journal.pone.0139777

26. Tymoszuk U, Perkins R, Fancourt D, Williamon A. Cross-sectional and longitudinal associations between receptive arts engagement and loneliness among older adults. *Soc Psychiatry Psychiatr Epidemiol*. (2020) 55:891–900. doi: 10.1007/s00127-019-01764-0

27. Tymoszuk U, Perkins R, Spiro N, Williamon A, Fancourt D. Longitudinal associations between short-term, repeated, and sustained arts engagement and well-

being outcomes in older adults. *J Gerontol: Series B.* (2020) 75:1609–19. doi: 10.1093/geronb/gbz085

28. Stern Y. What is cognitive reserve? Theory and research application of the reserve concept. *J Int Neuropsychol Soc*. (2002) 8:448–60. doi: 10.1017/S1355617702813248

29. Buckner RL. Memory and executive function in aging and AD: multiple factors that cause decline and reserve factors that compensate. *Neuron*. (2004) 44:195–208. doi: 10.1016/j.neuron.2004.09.006

30. Somes J. The loneliness of aging. *J Emerg Nurs*. (2021) 47:469–75. doi: 10.1016/j.jen.2020.12.009

31. Rokach A. The effect of gender and culture on loneliness: a Mini review. *Emerg Sci Jl*. (2018) 2:59–64. doi: 10.28991/esj-2018-01128

32. World Health Organization (WHO). Decade of healthy ageing 2021–2030. (2021). Available at: https://www.who.int/initiatives/decade-of-healthy-ageing.

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 30 September 2024
DOI 10.3389/fpubh.2024.1352937

Check for updates

OPEN ACCESS

EDITED BY
Elena Carrillo-Alvarez,
Blanquerna Ramon Llull University, Spain

REVIEWED BY
Wei Chen,
Renmin University of China, China
Oscar A. Martínez-Martínez,
Universidad Iberoamericana, Mexico

*CORRESPONDENCE
Yuanyan Chen
✉ chenyuanyan@cueb.edu.cn

RECEIVED 09 December 2023
ACCEPTED 13 September 2024
PUBLISHED 30 September 2024

CITATION
Chen Y (2024) Childhood and adult socioeconomic status influence on late-life healthy longevity: evidence from the Chinese longitudinal healthy longevity survey.
Front. Public Health 12:1352937.
doi: 10.3389/fpubh.2024.1352937

COPYRIGHT
© 2024 Chen. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Childhood and adult socioeconomic status influence on late-life healthy longevity: evidence from the Chinese longitudinal healthy longevity survey

Yuanyan Chen*

School of Public Finance and Taxation, Capital University of Economics and Business, Beijing, China

Background: Older people in low- and middle-income countries are more susceptible to the impact of childhood experiences. This study comprehensively examines how childhood socioeconomic status (SES) and adult SES collectively influence late-life healthy longevity from a life course perspective, providing insights for shaping health-related policies.

Methods: This study analyzed data from the Chinese Longitudinal Healthy Longevity Survey (1998–2018) with 37,264 individuals aged 65 and above. Using R software, we applied continuous-time multi-state models incorporating the Rockwood frailty index with 38 indicators to assess participants' health. Childhood SES or life course SES trajectories were core explanatory variables, while age and gender were controlled. Multinomial regression estimated annual transition probabilities between different states, and the multi-state life table method calculated total and frailty-specific life expectancy (LE).

Results: (1) Social mobility among older people in China showed an upward trend from childhood to adulthood. (2) Transition probabilities for robust-frailty, robust-dead, and frailty-dead increased with age, while frailty-robust decreased. Transition probabilities and LE varied across different childhood SES (low, medium, high) or life-course SES trajectory categories (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high), with probabilities of robust-frailty, robust-dead, and frailty-dead decreasing sequentially across different categories, and frailty-robust increasing sequentially across different categories. Total LE, robust LE, and robust LE proportion increased sequentially across different categories, while frailty LE decreased sequentially across different categories. (3) Women had higher total LE and frailty incidence, but lower recovery rate, mortality risk, robust LE, and robust LE proportion compared to men.

Conclusion: Favorable childhood SES and lifelong accumulation of SES advantages protect against frailty morbidity, improve recovery rate, reduce mortality risk, and increase total LE, robust LE, and robust LE proportion. High childhood SES has a stronger protective effect than high adult SES, indicating the lasting impact of childhood conditions on healthy longevity. Systematic interventions in education, food supply, and medical accessibility for children from impoverished families are crucial.

KEYWORDS

healthy longevity, childhood socioeconomic status, adult socioeconomic status, life course perspective, multi-state models, frailty index

1 Introduction

According to the findings of the China Seventh National Population Census, the population aged 65 and over accounted for 13.50 percent of the total national population, totaling 190 million individuals (1). Furthermore, it is noteworthy that China accounted for 25% of the global population aged 65 and over during the same period (2). In terms of life expectancy (LE), there has been a notable increase in both male and female LE at birth in China. From 1978 to 2021, male LE at birth rose from 61.1 years to 75.5 years, while female LE at birth increased from 65.5 years to 81.2 years (2). In contemporary China, a significant proportion of the older population has lived through challenging circumstances during their formative years, including war and social instability (3). Nevertheless, the majority of older people in China have experienced substantial enhancements in their living conditions throughout their adult and senior years (4). The contrast between the circumstances of their youth and the quality of life in their later years could exert a significant influence on their well-being (4–6). Therefore, applying a life course perspective to investigate health concerns among older people in China holds distinctive significance. Furthermore, China's substantial population, accelerated aging, and rapid social and economic progress during the last 45 years have established the nation as a unique and globally influential research environment.

The life course approach suggests that the development of age-related illnesses, physical impairments, and mortality is influenced by a range of factors across different life phases, with socioeconomic status (SES) assuming a central role (7). The life course perspective encompasses the critical period model, the pathway model, the social trajectory model, the accumulation model, and the social mobility model (8, 9). The critical period model posits that adverse childhood experiences, once embedded in biological systems, may exert long-lasting influences on adult health, irrespective of later life exposures (10). Multiple studies in the United States, Sweden, and Finland have corroborated the critical period model (11–15). The pathway model underscores the impact of early socioeconomic conditions on adult SES and their influence on life course trajectories (16), as confirmed by several studies in the United States and Europe (14, 17, 18). The social trajectory model delineates the interconnected pathways of risk, wherein one adverse exposure amplifies the likelihood of subsequent negative exposures (9, 19). The accumulation model emphasizes the impact of progressively accumulating risk factors over the course of one's life on shaping health outcomes (20, 21), as evidenced by several studies in Sweden, Finland, the UK, France, and the USA (9, 11, 13, 15, 22–27). The model of social mobility argues that SES attained in adulthood has the potential to ameliorate or counteract the impacts of early-life circumstances (8, 28), as confirmed by several studies in France, Sweden, Finland, and the United States (11–15, 22, 23, 25).

Research on health in old age from a life course perspective has primarily focused on high-income countries (HICs), with limited attention to low- and middle-income countries (LMICs), although some evidence exists from China. An investigation conducted through the Chinese Longitudinal Healthy Longevity Survey (CLHLS) in 2002 and 2005 revealed a potential direct correlation between childhood SES and cognitive, physical, and self-rated health, as well as mortality risk, while indicating a limited influence of adult SES on these associations. Examination of social mobility patterns demonstrated that maintaining a high SES consistently offered the greatest protection against cognitive decline and mortality risk, whereas a sustained low SES had the most detrimental impact. In terms of self-rated health, it was observed that only a sustained high SES provided substantial protection, with upward mobility failing to counteract the negative effects of lower childhood SES on self-rated health in later life (29). A separate investigation, utilizing data from the CLHLS spanning 1998, 2000, 2002, and 2005, revealed that women with non-agricultural working fathers exhibited more advantageous developmental paths (30). Study showed a correlation between SES during childhood and adulthood and the development of functional disability in older age. Specifically, lower paternal education was associated with limitations in instrumental activities of daily living (IADL). Conversely, higher educational attainment and improved economic circumstances in adulthood were identified as protective factors against both activities of daily living (ADL) and IADL disabilities (31). Another study found that childhood SES directly affects type 2 diabetes and indirectly influences it through adult SES (32). Additionally, a study revealed that low childhood SES has an unfavorable indirect effect on oral health mediated through adult SES (33).

The literature on health among older people from a life course perspective typically uses indicators such as self-rated health, ADL, IADL, and functional limitations (FL) to assess health status (13, 22, 29, 31). However, these indicators may not be comprehensive enough. Frailty, a common geriatric syndrome associated with disability, mortality, and hospitalization, is receiving increasing attention (34). Frailty is typically assessed using the frailty index (FI) (35). Research in Europe has shown that immigrants born in LMICs exhibit higher levels of frailty in Nordic/Western Europe (36). Multiple UK studies have explored frailty. One study revealed that lower childhood SES was associated with higher FI (37). Additionally, a study on twins showed a negative correlation between father's occupational class and the participants' Rockwood FI (38), while participants' educational levels mediated the relationship between early life factors and FI (38, 39). A study in Germany found that women and those living below the poverty line have higher levels of FI in their later years (40). Furthermore, there is limited evidence from LMICs. A cross-border survey of older people from five major cities in Latin America revealed that

Abbreviations: LE, life expectancy; SES, socioeconomic status; HICs, high-income countries; LMICs, low- and middle-income countries; CLHLS, the Chinese Longitudinal Healthy Longevity Survey; IADL, instrumental activities of daily living; ADL, activities of daily living; FL, functional limitations; FI, frailty index; MSLT, multi-state life table.

childhood and adulthood adversity are associated with higher rates of frailty in later years, with women exhibiting a higher prevalence of frailty than men (41). There are only two pieces of evidence from China. A recent investigation revealed that the FI experienced an average increase of 0.10 within the most disadvantaged subpopulation compared to the most advantaged subpopulation (42). A comparative study between China and Europe found that experiencing three or more childhood adversities is associated with an increase in FI levels (43).

The life course theory, while widely supported, presents conflicting perspectives. An investigation into the health outcomes of U.S. men unveiled that the association between childhood SES and adult health exhibited a reduced strength among men from racial and ethnic minority groups in comparison to White men. Furthermore, the impact of childhood SES on health appeared to diminish with age specifically for African American and Mexican American men (44). In Sweden, a study found that gap in self-rated health increases from early to middle adulthood, but remains unchanged after the age of 55 (45). Research in China indicated that health inequalities induced by childhood SES gradually widen before 60 years of age, but then gradually converge after 60 years of age (46), aligning with the age-neutral effect theory (47, 48).

Older people in LMICs are more influenced by childhood experiences compared to HICs (32, 49). However, research on LMICs is limited and the conclusions are inconsistent. Only a small number of studies on healthy aging in China from a life course perspective use the FI to measure health diversity among older people (42, 43). Several studies have used various models such as linear regression (38, 42, 43), linear mixed effects (26, 46), structural equation (17, 18, 32, 33, 40), logistic regression (9, 13, 23–25, 29, 31, 41), and growth curve models (14, 44). Nevertheless, the dynamics of disability incidence, recovery, and mortality interaction might be neglected by these models. Continuous-time multi-state models offer a comprehensive insight into the life experiences of disability and mitigate the risk of biased disability level estimates at the population scale (4, 50). There is scarce literature utilizing continuous time multi-state models to study healthy longevity in later years from a life course perspective. Only two exceptions exist, with one study using relatively short-term data and a limited sample size (4). Another study explored the impact of childhood starvation on healthy longevity in later years, using relatively limited indicators for childhood and adult SES, and a single measure for late health status (51).

This study aims to contribute to the existing body of research by employing the Rockwood FI, which includes 38 indicators, to thoroughly examine the combined impact of childhood and adult SES on healthy longevity in later life. Utilizing data from eight waves of CLHLS spanning from 1998 to 2018, and encompassing a substantial sample size, this research seeks to answer the primary question: How do childhood and adult SES jointly influence healthy longevity among the older population in China? The objective is to provide a nuanced understanding of the long-term effects of SES across the life course on health outcomes in old age. This is achieved through the application of continuous-time multi-state models, which effectively capture the dynamics of disability incidence, recovery, and mortality. The findings aim to inform health-related policies and interventions by highlighting the critical role of childhood SES and the lifelong accumulation of SES advantages in shaping health trajectories in later years, with a particular emphasis on the greater impact of childhood SES.

2 Methods

2.1 Data

The study utilized information obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which involved conducting eight repeated cross-sectional surveys spanning from 1998 to 2018. The survey interviewed individuals aged 65 and above in randomly selected counties and cities across 23 provinces/municipalities/autonomous regions in China. The initial and follow-up surveys, which included replacements for deceased participants, were conducted in a randomly selected half of the counties and cities within 22 of mainland China's 31 provinces during the years 1998, 2000, 2002, and 2005. The provinces surveyed were Liaoning, Jilin, Heilongjiang, Hebei, Beijing, Tianjin, Shanxi, Shaanxi, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan, and Chongqing. Hainan was added as the 23rd province in the 5th, 6th, and 7th waves. The regions covered by these surveys represent approximately 85 percent of China's total population (52). The surveys included 631 counties and cities in 1998, 777 in 2000, and 866 in 2002, with all subsequent surveys from 2002 onwards consistently including over 860 counties and cities (53). The CLHLS survey stands out for its unparalleled breadth of older adult participants in longitudinal studies on a global scale (54), earning acclaim from scholars both domestically and abroad (55). The study received ethical approval from the Biomedical Ethics Committee of Peking University under the reference number IRB00001052-13,074, and written informed consent was obtained from all participants or their authorized representatives.

During the period from 1998 to 2014, a cohort of 44,298 participants was individually recruited and longitudinally monitored until 2018. After applying the criteria for the multi-state model to investigate frailty status transitions, the final analysis encompassed 37,264 participants, following the exclusion of individuals below 65 years of age, respondents to a single survey wave, or those lacking age or frailty index (FI) data. The achieved response rate stood at 84.12%. Comprehensive findings are delineated in Supplementary Figure S1.

2.2 Variables

2.2.1 The frailty index (FI) and death

The Rockwood Frailty Index (FI) provides a dependable assessment of frailty in the CLHLS (54, 56, 57), employing standardized protocols (58) and incorporating 38 self-reported health deficits (59–61). These deficits, including ADL, bodily function, cognitive function, psychological status, sensory abilities, self-reported health, chronic illness, and other factors, were used to construct the FI, the detailed results are available in Supplementary Table S1, S2. Deficits with missing information were excluded from both the denominator and the numerator. In cases where over 30% of the deficits had missing data, the FI was classified as incomplete (61). The frailty index, graded on a scale from 0.00 to 1.00, reflects the individual's health status, with higher scores signifying increased frailty. In line with prior study (62), the frailty index is stratified into two tiers: robust (frailty index score ≤ 0.10) and frailty (frailty index score > 0.10). Data regarding mortality is

acquired from close relatives or primary caregivers, and the accuracy of the date and cause of death is confirmed through the examination of death certificates (63), thereby ensuring the high quality of the data. The follow-up duration is determined by measuring the time elapsed between the initial interview date and the date of death. During each survey wave, participants are categorized as either deceased or into one of two frailty states (robust and frailty), as depicted in Supplementary Figure S2. The health status of the respondents is represented by the variable state, with a value of 1 indicating robust, 2 indicating frailty, and 3 indicating deceased.

2.2.2 Estimating childhood and adulthood SES

2.2.2.1 Childhood SES

Drawing from existing literature, the key indicators for assessing childhood SES encompass parental education level (6, 14, 18, 32, 33, 44, 46, 64), father's occupation (6, 14, 17, 18, 32, 33, 44, 46, 64), the presence of food scarcity or the economic status of childhood families (6, 14, 25, 33, 44, 64), whether the birthplace or primary childhood residence was in an urban setting (6, 33), and the availability of medical care (6, 33).

Childhood SES was assessed using four indicators: (1) birth type, indicating urban (1) or rural (0) birth; (2) hunger-free, denoting absence of frequent childhood hunger (1) or presence of hunger (0); (3) father's occupation, categorized as non-agricultural (1) or agricultural/housework (0) based on specific job types (6, 31, 32); and (4) medical care, indicating adequate childhood medical service (1) or lack thereof (0). The four variables are well validated and commonly used in the literature on childhood SES for Chinese older people (6, 29, 31, 33). In the early 20th century, China was predominantly an agricultural society with low education levels (32, 65), resulting in approximately 95% of respondents having mothers without formal education. The CLHLS only started collecting data on the education level of respondents' parents in 2005, hence parental education level indicators were not included in the selection of childhood SES indicators.

The missing values for the four indicators are as follows: birth type missing value accounts for only 0.238%, hunger-free missing value accounts for 2.938%, father's occupation missing value accounts for only 0.606%, and the missing value for medical care accounts for 6.635%. Multiple imputation by chained equations was used to impute values for missing data (4). The imputation model for the childhood SES index included all other variables comprising the childhood SES index, and 100 imputed datasets were generated. Values for missing data were estimated as the mean of these 100 imputed values, rounded to the nearest whole number, and then converted to either 0 or 1. The scores of the four indicators for each respondent were summed, the total scores of the childhood SES index for all respondents were sorted, and the total scores were divided into 4 equal-width bins, categorizing childhood SES into three categories: low, medium, and high, denoted by 0, 1, 2, respectively (29).

2.2.2.2 Adulthood SES

Drawing from existing literature, the key indicators for assessing adult SES encompass educational attainment (18, 25, 33, 44, 46, 66), household income and wealth (14, 17, 44, 46, 66), and occupation (17, 18). Furthermore, current urban–rural residence, pension status, and access to health care are endorsed by existing literature as effective proxies of SES in modern-day China (29, 67–69).

The assessment of adult SES encompasses six key indicators: (1) residence, reflecting the interviewee's urban or rural dwelling, with urban areas assigned a value of 1 and rural areas a value of 0; (2) education, representing the years of schooling, with a value of 0 for no schooling and 1 for any years of schooling; (3) occupation, indicating the interviewee's primary occupation before age 60, with non-agricultural jobs assigned a value of 1 and agricultural jobs or housework assigned a value of 0; (4) pension, denoting the presence of a pension, with a value of 1 for "yes" and 0 for "no"; (5) financial sufficiency, signifying whether the interviewee's financial resources are adequate, with a value of 1 for "yes" and 0 for "no" or "so so"; (6) medical care at age 60, indicating whether the interviewee received adequate medical service, with a value of 1 for "yes" or "not sick" and 0 for "no." Our analysis assumes the stability of adult SES over time due to the limitations of the multi-state life table model in accommodating time-varying covariates. Consequently, income was not included as a measure of adult SES, given its time-varying nature.

Regarding missing data, the residence indicator exhibited no missing values, while the missing value rates for education, occupation, pension, financial sufficiency, and medical care at age 60 were 0.429, 0.379, 0.106, 1.655, and 4.728%, respectively. To address missing data, multiple imputation by chained equations was employed, generating 100 imputed datasets (4). The imputation model for the adulthood SES index encompassed all other variables comprising the index. The imputed values were estimated as the mean of the 100 imputed values, rounded to the nearest whole number, and then converted to either 0 or 1. Subsequently, the scores for the six indicators for each interviewee were summed, and the summed scores for all interviewees' adulthood SES index were categorized into three classes: low, medium, and high, represented by 0, 1, and 2, respectively (29).

2.2.2.3 Life course SES trajectories

Life course SES trajectories are constructed based on a combination of childhood and adult SES indicators, resulting in nine distinct trajectories (3 childhood SES groups × 3 adulthood SES groups): low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high, denoted by 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively (4). The age of the participants is represented by the variable "age." Previous research in the field has extensively explored gender disparities in health among older people (15, 22, 40, 41, 66, 70). Gender is represented by the variable "gender," with male coded as 1 and female as 0. In the covariate selection process, this study deliberately excluded variables that could be influenced by frailty, such as indicators of present health behaviors or living conditions. Factors like changes in health behaviors (e.g., smoking or physical activity) may be a response to changes in frailty status (30), and these variables are also prone to change over time. Time-varying covariates were not included.

2.3 Modeling stochastic health processes and life expectancy computation

Continuous-time multi-state models, based on the principles of continuous-time Markov chains, excel at illustrating random

health-related developments over time, enabling the portrayal of different health phases or mortality. At a specific age, residual life expectancy (LE) can be divided into two categories: robust LE and frailty LE, with their collective sum representing the total LE. The multi-state life table (MSLT) method, widely endorsed in global literature, relies on cohort data to precisely depict the health status of the research population, resulting in more reliable research findings (4, 51, 61, 71, 72).

Initially, a comprehensive multi-state Markov model incorporating covariates was implemented utilizing the msm package within the R programming language (73). Following this, we utilized continuous-time multi-state models to calculate total and frailty-specific LE in a two-stage procedure. Initially, a multinomial regression was applied to estimate the annual probability of transitioning between different health states, producing transition probability matrices for each gender and SES (either childhood SES or life course SES trajectory) combination. Subsequently, the annual transition probabilities derived from the initial stage were fed into the MSLT method to compute total and frailty-specific LE (robust LE and frailty LE) using the elect package in the R programming language (74). For detailed explanations, please refer to Supplementary material [Section 3 Estimation methods of life expectancy (LE)].

In this study, the maximum age of the participants is 125 years old, and it was assumed that the maximum human age was 130 years old. When performing the calculation using the default "step" method for numerical approximation, the integral was approximated on a 0.1-year grid. A standard error was computed for each estimate using a bootstrapping method that involved 500 repeated estimates through random draws.

2.4 Statistical analysis

The analysis commenced with a descriptive statistical examination of the data, focusing on the distribution of participants' age, gender, childhood SES, adulthood SES, and life course SES (child–adult). Subsequently, we present the annual transition probabilities based on childhood SES or life course SES trajectory, illustrating the transition probabilities from robust to frailty, frailty to robust, robust to dead, and frailty to dead by childhood SES or by life course SES trajectory. Finally, an analysis of life expectancy based on childhood SES or life course SES trajectory is presented, providing estimated robust, frailty, and total life expectancy (LE) at ages 65 and 75 by childhood SES or by life course SES trajectory.

3 Results

3.1 Descriptive analysis

In Table 1, the final analysis included 37,264 participants, with a mean age of 88.44 years (SD: 11.18). The proportion of males (41.2%) was slightly lower than that of females. Regarding childhood SES, 67.7% were classified as low, 20.7% as medium, and 11.6% as high. Notably, 98% of the participants were born between 1895 and 1945, a period marked by challenging living circumstances, societal upheaval, prolonged food scarcity, and childhood exposure to infectious diseases (3), leading to a relatively high proportion of participants with disadvantaged childhood SES. In terms of adulthood SES, 52.1% were classified as low, 33.5% as medium, and 14.4% as high, reflecting an overall upward social mobility trend from childhood to adulthood among older people in China. Specifically, based on social mobility classification (29, 64, 75), 41.6% of participants consistently remained in a low position (low–low) in terms of Life Course SES (child–adult), 8.2% consistently remained in a medium position (medium–medium), and 5.2% consistently remained in a high position (high–high). The proportion of participants experiencing upward mobility (low–medium, low–high, medium–high) was 29.7%, while the proportion experiencing downward mobility (medium–low, high–low, high–medium) was only 15.2%, significantly lower than the proportion experiencing upward mobility. This study categorized participants' childhood SES and adulthood SES into three classes (low, medium, and high), represented by 0, 1, and 2, respectively. Therefore, according to the accumulation model (13, 20, 21), the proportion of participants with an accumulated advantage of 0 (low–low) was 41.6%, an accumulated advantage of 1 (low–medium, medium–low) was 29.3%, an accumulated advantage of 2 (low–high, medium–medium, high–low) was 15.4%, an accumulated advantage of 3 (medium–high, high–medium) was 8.4%, and an accumulated advantage of 4 (high–high) was 5.2%, showing a decreasing trend.

The differences in childhood SES (low, medium, high) were examined, revealing statistically significant differences among the three groups in terms of gender, age, and state ($p < 0.001$). Similarly, the analysis of adulthood SES (low, medium, high) and life course SES (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) demonstrated statistically significant differences in gender, age, and state ($p < 0.001$). Detailed results of the hypothesis tests are provided in Supplementary Table S3.

3.2 Annual transition probability

3.2.1 Annual transition probability by childhood SES

Figure 1 depicts the annual transition probabilities from robust to frailty based on childhood SES, with separate analyses for males and females. The data indicates that, as individuals age, the annual transition probabilities from robust to frailty increase across all three categories of childhood SES (low, medium, high), regardless of gender. Specifically, male participants with low, medium, and high childhood SES show annual transition probabilities from robust to frailty ranging from 23 to 51%, 21 to 48%, and 19 to 44%, respectively, between the ages of 65 and 95. These results suggest that the annual transition probabilities from robust to frailty for male participants in the three categories of childhood SES (low, medium, high) have decreased sequentially, with the lowest transition probability for the most favorable childhood SES category, the highest for the least favorable, and the medium category falling in between, with female participants showing the same characteristics. Moreover, across all ages, female participants in all three childhood SES categories (low, medium, high) had higher annual transition probabilities from robust to frailty than their male counterparts in the same categories. These findings align with prior research in Latin American cities (41) and a study in Germany (40), which concluded that the frailty rate is higher in women than in men. Furthermore, this preliminary evidence supports

TABLE 1 Participant demographics at baseline, *n* (%).

		Enrolled in 1998	Enrolled in 2000	Enrolled in 2002	Enrolled in 2005	Enrolled in 2008	Enrolled in 2011	Enrolled in 2014	Total
N		8,090	5,383	8,362	5,941	7,547	1,071	870	37,264
Age (mean (SD))		92.33 (7.70)	90.37 (7.51)	83.06 (12.76)	88.02 (12.20)	89.26 (11.45)	87.94 (12.47)	88.48 (9.88)	88.44 (11.18)
Gender	Male	3,215 (39.7)	2,293 (42.6)	3,585 (42.9)	2,406 (40.5)	3,049 (40.4)	448 (41.8)	373 (42.9)	15,369 (41.2)
	Female	4,875 (60.3)	3,090 (57.4)	4,777 (57.1)	3,535 (59.5)	4,498 (59.6)	623 (58.2)	497 (57.1)	21,895 (58.8)
Childhood SES	Low	3,895 (48.2)	2,988 (55.5)	6,093 (72.9)	4,403 (74.1)	6,205 (82.2)	925 (86.4)	724 (83.2)	25,233 (67.7)
	Medium	2,713 (33.5)	1,522 (28.3)	1,412 (16.9)	928 (15.6)	898 (11.9)	119 (11.1)	113 (13.0)	7,705 (20.7)
	High	1,482 (18.3)	873 (16.2)	857 (10.3)	610 (10.3)	444 (5.9)	27 (2.5)	33 (3.8)	4,326 (11.6)
Adulthood SES	Low	4,555 (56.3)	2031 (37.7)	4,214 (50.4)	3,035 (51.1)	4,422 (58.6)	655 (61.2)	505 (58.1)	19,417 (52.1)
	Medium	2,666 (33.0)	2,343 (43.5)	2,697 (32.3)	1870 (31.5)	2,238 (29.7)	373 (34.8)	298 (34.3)	12,485 (33.5)
	High	869 (10.7)	1,009 (18.7)	1,451 (17.4)	1,036 (17.4)	887 (11.8)	43 (4.0)	67 (7.7)	5,362 (14.4)
Life course SES (child–adult)	Low-low	2,692 (33.3)	1,462 (27.2)	3,612 (43.2)	2,666 (44.9)	4,044 (53.6)	602 (56.2)	440 (50.6)	15,518 (41.6)
	Low-medium	994 (12.3)	1,214 (22.6)	1878 (22.5)	1,286 (21.7)	1731 (22.9)	292 (27.3)	250 (28.7)	7,645 (20.5)
	Low-high	209 (2.6)	312 (5.8)	603 (7.2)	451 (7.6)	430 (5.7)	31 (2.9)	34 (3.9)	2070 (5.6)
	Medium-low	1,538 (19.0)	484 (9.0)	513 (6.1)	306 (5.2)	337 (4.5)	48 (4.5)	63 (7.2)	3,289 (8.8)
	Medium-medium	940 (11.6)	750 (13.9)	559 (6.7)	368 (6.2)	351 (4.7)	63 (5.9)	38 (4.4)	3,069 (8.2)
	Medium-high	235 (2.9)	288 (5.4)	340 (4.1)	254 (4.3)	210 (2.8)	8 (0.8)	12 (1.4)	1,347 (3.6)
	High-low	325 (4.0)	85 (1.6)	89 (1.1)	63 (1.1)	41 (0.5)	5 (0.5)	2 (0.2)	610 (1.6)
	High-medium	732 (9.1)	379 (7.0)	260 (3.1)	216 (3.6)	156 (2.1)	18 (1.7)	10 (1.2)	1771 (4.8)
	High-high	425 (5.3)	409 (7.6)	508 (6.1)	331 (5.6)	247 (3.3)	4 (0.4)	21 (2.4)	1945 (5.2)

10.3389/fpubh.2024.1352937

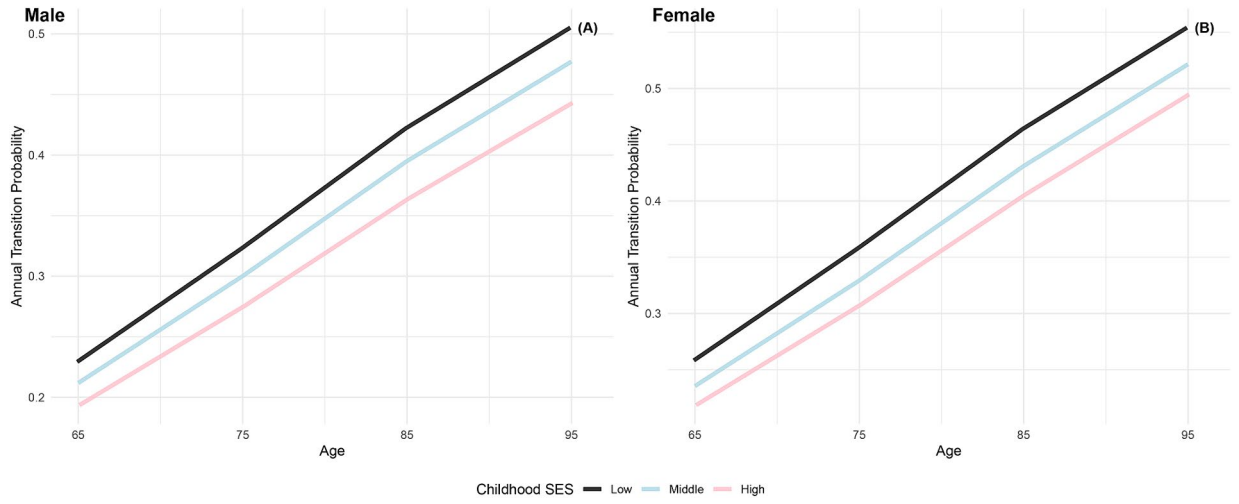


FIGURE 1
Annual transition probabilities from robust to frailty based on childhood SES, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

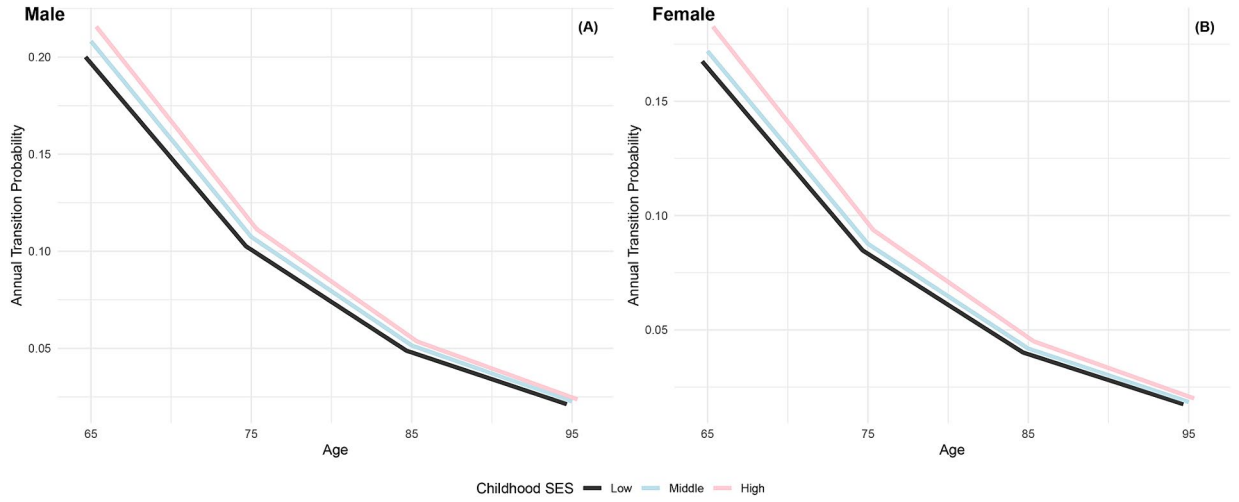


FIGURE 2
Annual transition probabilities from frailty to robust based on childhood SES, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

the critical period model (10), suggesting that advantageous childhood SES exerts a protective influence on frailty rates, regardless of gender.

The annual transition probabilities from frailty to robust by childhood SES for men and women are depicted in Figure 2. It is apparent that as individuals age, the transition probabilities from frailty to robust decrease, regardless of gender. When examining male participants, those with low childhood SES experience a decrease from 20% at age 65 to 2.13% at age 95, while those with medium childhood SES decrease from 21% at age 65 to 2.27% at age 95, and those with high childhood SES decrease from 22% at age 65 to 2.37% at age 95. Notably, the transition probabilities for male participants tend to converge at age 95. Similarly, female participants exhibit a similar trend, with lower transition probabilities compared to their male counterparts in the same categories. It is evident that advantageous childhood SES has a protective effect on the recovery rate from frailty to robust, with the recovery rate for females being lower than that for males. However, with increasing age, the recovery rates tend to converge, regardless of gender.

Figure 3 illustrates the increasing annual transition probabilities from robust to dead by childhood SES for both genders as individuals age. Male participants with low, medium, and high childhood SES experience incremental increases in annual transition probabilities from robust to dead, with the lowest probability for the most favorable childhood SES category and the highest for the least favorable, mirroring the trend observed in female participants. Additionally, female participants across all age groups demonstrate lower annual transition probabilities from robust to dead than their male counterparts in the same categories, aligning with previous research conclusions that females have poorer health conditions but generally live longer than males (66, 76). Furthermore, the differences in transition probabilities from robust to dead among participants in the three childhood SES categories show an increasing trend as individuals

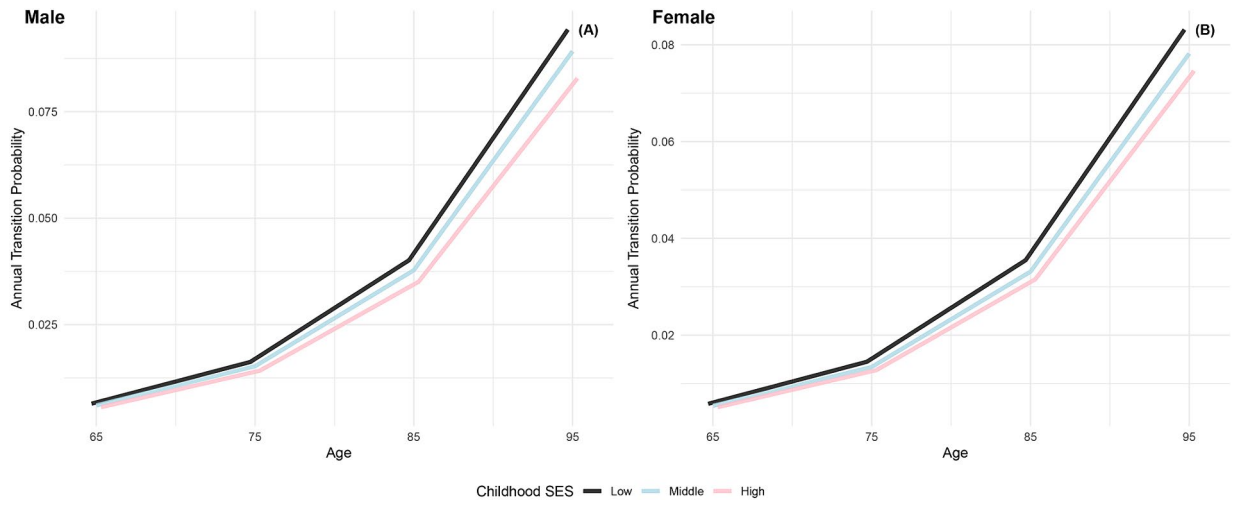


FIGURE 3
Annual transition probabilities from robust to mortality based on childhood SES, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

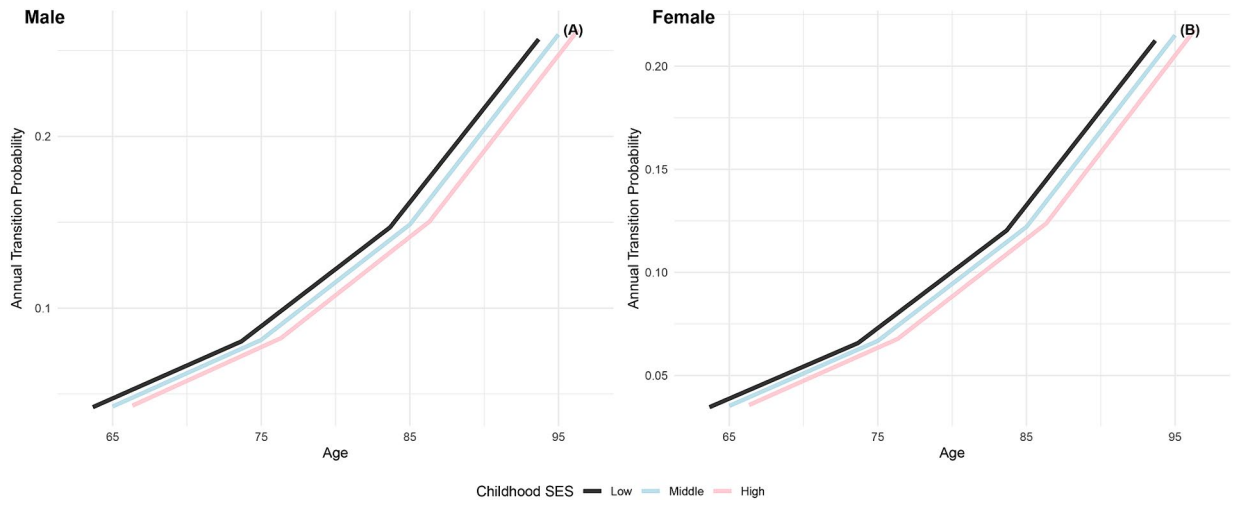


FIGURE 4
Annual transition probabilities from frailty to mortality based on childhood SES, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

age, providing preliminary evidence of the protective effect of advantageous childhood SES on the risk of death (29).

The annual transition probabilities from frailty to death by childhood SES for men and women are depicted in Figure 4. As age increases, the transition probabilities show an upward trend across all childhood SES categories. When considering gender, the annual transition probabilities from frailty to death for male participants in the three childhood SES categories (low, medium, high) decreased sequentially, while female participants exhibited a similar pattern. Notably, female participants in all age groups showed lower transition probabilities compared to their male counterparts in the same categories, indicating a potential longevity advantage for females (66, 76). Moreover, the differences in transition probabilities from frailty to death among participants in the three childhood SES categories show a slight widening trend with increasing age, suggesting a potential protective effect of favorable childhood SES on the risk of death (29).

3.2.2 Annual transition probability by life course SES

The findings presented in Figure 5 depict the annual transition probabilities from robust to frailty based on life-course SES trajectory for both men and women. As participants age, there is a discernible increasing trend in transition probabilities from robust to frailty across the nine SES trajectory categories. Irrespective of gender, participants in the nine categories of life-course SES trajectory (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) demonstrate a sequential decrease in transition probabilities, with the most favorable category (high-high) exhibiting the lowest transition probability and

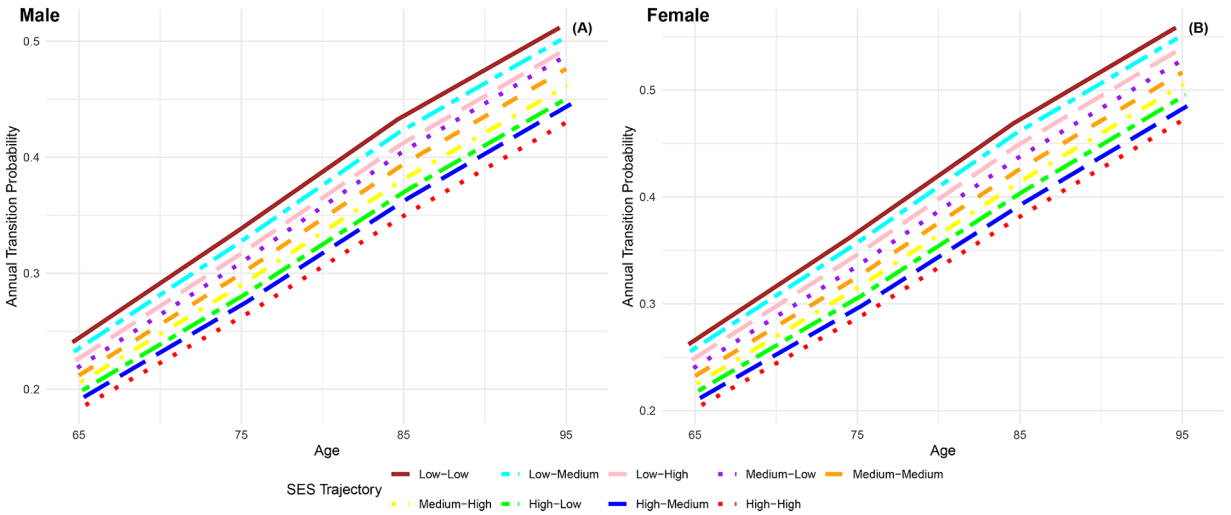


FIGURE 5
Annual transition probabilities from robust to frailty based on life-course SES trajectory, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

the least favorable category (low-low) showing the highest. Notably, female participants consistently exhibit higher transition probabilities than their male counterparts in the same categories, indicating a higher frailty rate for females. The substantial differences in annual transition probabilities from robust to frailty between the most and least favorable SES trajectory categories underscore the close connection between lifelong SES disadvantage and frailty rates.

When comparing male participants with low-high and high-high life-course SES trajectory, the transition probability is 3.83% higher at age 65 and 5.83% higher at age 95 for those with low-high trajectory, indicating a significantly higher frailty rate for individuals with low childhood SES compared to high childhood SES, with the gap widening with age. Similarly, when comparing male participants with low-low and high-low life-course SES trajectory, the transition probability is 4.15% higher at age 65 and 5.98% higher at age 95 for those with low-low trajectory, indicating a protective effect of high childhood SES on frailty rates among individuals with low adulthood SES. Lastly, when comparing male participants with low-low and low-high life-course SES trajectories, the transition probability was found to be 1.58% higher at age 65 and 2.03% higher at age 95 for those with the low-low trajectory. This, combined with the results of comparing male participants with life-course SES trajectories of low-low and high-low, indicates a stronger protective effect of high childhood SES compared to high adulthood SES on frailty rates. This suggests that the transition probability from robust to frailty is more influenced by childhood SES rather than adulthood SES. Similar conclusions can be drawn from female participants. These findings further validate the critical period model (10) and the accumulation model (13, 20, 21).

The analysis depicted in Figure 6 demonstrates a consistent decline in annual transition probabilities from frailty to robust as individuals age across the nine life-course SES trajectory categories, regardless of gender. Irrespective of gender, the annual transition probabilities from frailty to robust increase sequentially across the nine life-course SES trajectory categories (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high), with the most favorable category (high-high) exhibiting the highest transition probability, and the least favorable category (low-low) showing the lowest transition probability. Additionally, it is evident that across all age groups, the annual transition probabilities from frailty to robust for female participants in the nine life-course SES trajectory categories are lower than those for male participants in the same category, indicating a lower recovery rate for females compared to males. Regardless of gender, the difference in annual transition probabilities from frailty to robust between the most favorable (high-high) and the least favorable (low-low) categories of life-course SES trajectory underscores the protective effect of a favorable life-course SES trajectory on the recovery rate from frailty to robust. However, as age increases and physical function declines, the recovery rate diminishes, and the differences in recovery rates among the nine life-course SES trajectory categories tend to converge.

Figure 7 presents the annual transition probabilities from robust to dead across different life-course SES trajectories for both men and women. The analysis reveals that, irrespective of gender, the annual transition probabilities from robust to dead increase with age for participants in the nine categories of life-course SES trajectory. Irrespective of gender, the annual transition probabilities from robust to dead for participants in the nine categories of life-course SES trajectory (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) decrease sequentially, with the most favorable category (high-high) exhibiting the lowest transition probability, and the least favorable category (low-low) showing the highest transition probability. Moreover, it is evident that across all age groups, the annual transition probabilities from robust to dead for female participants in the nine categories of life-course SES trajectory are lower than those for male participants in the corresponding categories, indicating a longer life expectancy for females (66, 76). Additionally, the analysis highlights that regardless of gender, the differences in transition probabilities from robust to dead among the nine categories of participants show an expanding trend with increasing age, emphasizing the protective effect of accumulated lifelong SES advantages on the risk of death (29). Furthermore, it is observed that

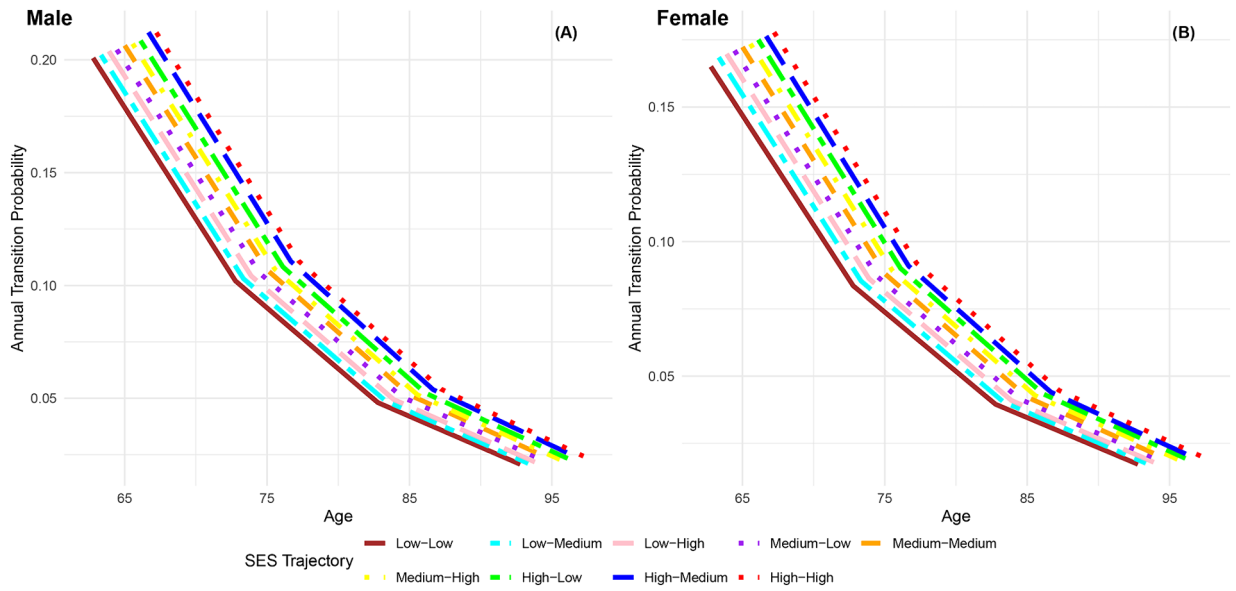


FIGURE 6
Annual transition probabilities from frailty to robust based on life-course SES trajectory, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

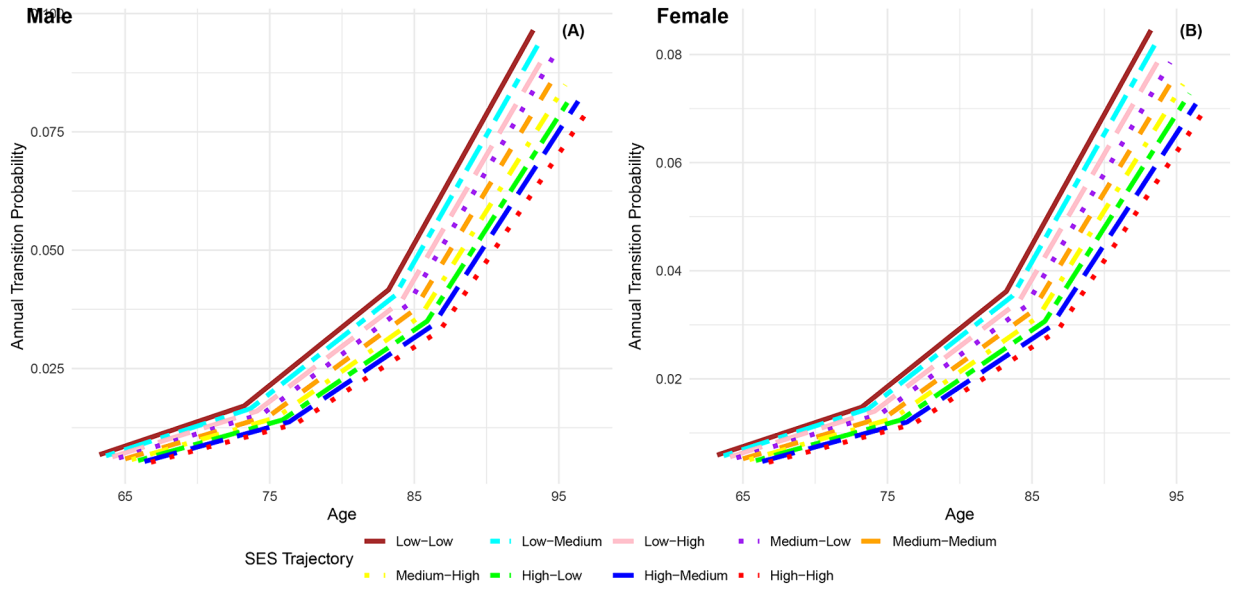


FIGURE 7
Annual transition probabilities from robust to mortality based on life-course SES trajectory, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

a higher childhood SES provides stronger protection against the risk of death compared to a higher adult SES, suggesting that the transition probability from robust to dead is more influenced by childhood SES than adult SES.

Figure 8 displays the annual transition probabilities from frailty to death by life-course SES trajectory for men and women. It is observed that regardless of gender, as age increases, the annual transition probabilities from frailty to death for participants in the nine categories of life-course SES trajectory show an increasing trend. Irrespective of gender, the annual transition probabilities from frailty to death for participants in the nine categories of life-course SES trajectory (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) decrease sequentially, with the most favorable category (high-high) exhibiting the lowest transition probability from frailty to death, and the least favorable category (low-low) showing the highest transition probability. Notably, at all age groups, the annual transition probabilities from frailty to death for female participants in the nine categories of life-course SES trajectory are lower than those for male participants in the corresponding categories, indicating that females

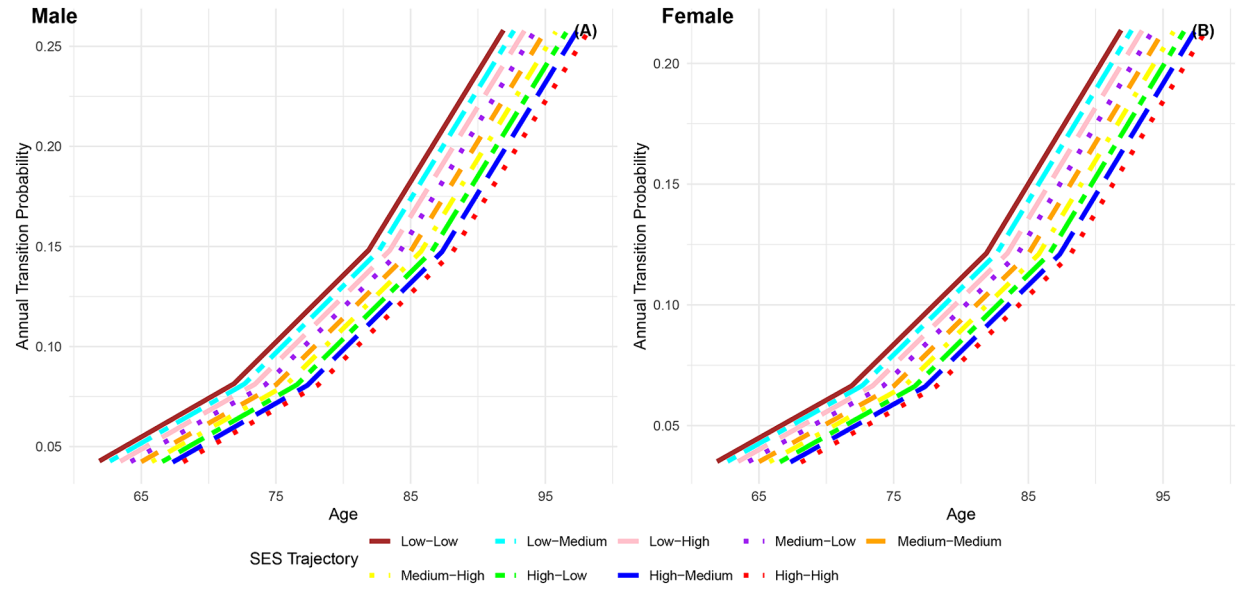


FIGURE 8
Annual transition probabilities from frailty to mortality based on life-course SES trajectory, CLHLS 1998–2018. **(A)** Male. **(B)** Female.

TABLE 2 Childhood SES-stratified estimated robust, frailty, and total life expectancy (LE) at ages 65 and 75, including 95% confidence intervals (CLHLS 1998–2018).

Childhood SES	Total LE	Robust LE	Frailty LE	Proportion robust	Proportion frailty
Men					
Age 65					
Low childhood SES	14.34 [12.59, 14.52]	4.74 [4.10, 4.89]	9.59 [8.49, 9.74]	33.05%	66.95%
Medium childhood SES	14.47 [7.36, 14.67]	5.07 [2.29, 5.22]	9.40 [5.07, 9.56]	35.04%	64.96%
High childhood SES	14.62 [3.49, 14.93]	5.44 [0.71, 5.70]	9.19 [2.75, 9.38]	37.21%	62.79%
Age 75					
Low childhood SES	9.62 [9.11, 9.74]	3.03 [2.88, 3.13]	6.59 [6.22, 6.70]	31.50%	68.50%
Medium childhood SES	9.74 [7.33, 9.87]	3.29 [2.49, 3.39]	6.45 [4.83, 6.56]	33.78%	66.22%
High childhood SES	9.91 [5.17, 10.11]	3.61 [1.95, 3.79]	6.30 [3.22, 6.46]	36.43%	63.57%
Women					
Age 65					
Low childhood SES	15.50 [15.03, 15.73]	4.15 [3.96, 4.32]	11.35 [11.01, 11.56]	26.77%	73.23%
Medium childhood SES	15.56 [13.59, 15.79]	4.45 [3.74, 4.59]	11.11 [9.85, 11.32]	28.60%	71.40%
High childhood SES	15.65 [6.30, 15.93]	4.79 [1.55, 5.03]	10.86 [4.75, 11.11]	30.61%	69.39%
Age 75					
Low childhood SES	10.55 [10.33, 10.70]	2.69 [2.61, 2.79]	7.86 [7.66, 7.98]	25.50%	74.50%
Medium childhood SES	10.65 [10.26, 10.80]	2.96 [2.83, 3.05]	7.69 [7.40, 7.83]	27.79%	72.21%
High childhood SES	10.73 [9.44, 10.95]	3.21 [2.85, 3.37]	7.52 [6.56, 7.70]	29.92%	70.08%

① SES, socioeconomic status; ② LE, life expectancy; ③ Proportion robust, robust life expectancy accounted for total life expectancy; ④ Proportion frailty, frailty life expectancy accounted for total life expectancy.

generally live longer than males (66, 76). Additionally, the analysis highlights that regardless of gender, with increasing age, the differences in transition probabilities from frailty to death among the nine categories of participants show an expanding trend, emphasizing the protective effect of accumulated lifelong SES advantages on the risk of death (29).

3.3 Analysis of life expectancy

3.3.1 Analysis of life expectancy by childhood SES

Table 2 presents a comparison of total, robust, and frailty life expectancy (LE) among Chinese men and women at ages 65 and 75, based on their childhood SES. Irrespective of gender, participants

with low childhood SES exhibit the lowest total LE, followed by those with medium childhood SES, while the highest total LE is observed in participants with high childhood SES. At age 65, male participants in the three childhood SES categories demonstrate residual total LE of 14.34 years, 14.47 years, and 14.62 years, while female participants exhibit residual total LE of 15.50 years, 15.56 years, and 15.65 years. At age 75, male participants display residual total LE of 9.62 years, 9.74 years, and 9.91 years, while female participants show residual total LE of 10.55 years, 10.65 years, and 10.73 years. The robust LE exhibits a sequential increase, with the lowest observed in participants with low childhood SES, followed by those with medium childhood SES, and the highest in participants with high childhood SES. The robust LE proportion increases sequentially across the three childhood SES categories for both male and female participants. At age 65, the robust LE proportion for male participants in the low, medium, and high childhood SES categories is 33.05, 35.04, and 37.21% respectively, while for female participants, it is 26.77, 28.60, and 30.61%, respectively. At age 75, the estimated robust LE proportion for male participants in the three childhood SES categories is 31.50, 33.78, and 36.43% respectively, and for female participants, it is 25.50, 27.79, and 29.92%, respectively. Conversely, the frailty LE proportion demonstrates a sequential decrease, with the highest observed in participants with low childhood SES, followed by those with medium childhood SES, and the lowest in participants with high childhood SES.

Females exhibit a higher total LE than males, but their robust LE and robust LE proportion lag behind, reaffirming the notion that despite females generally outliving males, their health status tends to be poorer, marked by a higher frailty rate (66, 76). At age 65, male participants with low childhood SES have a robust LE proportion 4.15% lower than those with high childhood SES, and at age 75, this difference increases to 4.93%. Similarly, for females at age 65, the robust LE proportion for those with low childhood SES is 3.84% lower than those with high childhood SES, and at age 75, this difference grows to 4.42%. As individuals age, the disparity in robust LE proportion due to childhood SES disadvantage widens, once again affirming the critical period model (10).

3.3.2 Analysis of life expectancy by life course SES

Table 3 presents the comparison of total, robust, and frailty LE among Chinese men and women at ages 65 and 75, across nine SES trajectories. Total LE increases sequentially across life-course SES trajectories, with the least favorable category (low-low) having the lowest total LE, and the most favorable category (high-high) having the highest. Male participants estimate residual total LE at 65 to be 14.097–14.575 years, and at 75 to be 9.49–10.13 years. Female participants estimate residual total LE at 65 to be 15.313–15.694 years, and at 75 to be 10.47–11.02 years. Irrespective of gender, participants' robust LE in the nine life-course SES trajectory categories shows a sequential increase, with the least favorable category (low-low) exhibiting the lowest robust LE and the most favorable category (high-high) showing the highest robust LE.

The robust LE proportion among male and female participants in the nine categories of life-course SES trajectory (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) has exhibited a sequential increase. At the age of 65, the robust LE proportion for male participants in the nine categories of life-course SES trajectory was 31.67, 32.06, 32.46, 32.72, 33.12, 33.43, 33.89, 34.42, and 34.85%, respectively. Similarly, for female participants in the same categories, the robust LE proportion at the age of 65 was 25.80, 26.16, 26.46, 26.77, 27.08, 27.41, 27.75, 28.11, and 28.49%, respectively. Upon reaching the age of 75, the estimated robust LE proportion for male participants in the nine categories of life-course SES trajectory is 30.66, 31.45, 32.23, 32.92, 33.71, 34.55, 35.34, 36.16, and 37.02%, respectively. Correspondingly, for female participants in the same categories, the estimated robust LE proportion at the age of 75 is 25.21, 25.86, 26.63, 27.30, 27.96, 28.70, 29.47, 30.16, and 30.94%, respectively. In contrast, the frailty LE proportion of male and female participants in these categories decreases sequentially, with the least favorable category (low-low) having the highest frailty LE proportion and the most favorable category (high-high) having the lowest frailty LE proportion. The data reveals that across all nine categories, women exhibit a higher total LE compared to men, while their robust LE and robust LE proportion are lower than those of men. This reaffirms the notion that despite women generally outliving men, they experience poorer health conditions, with a heightened prevalence of frailty and illness (66, 76).

At the age of 65, the robust LE proportion of male participants following a low-low life-course socioeconomic status (SES) trajectory was found to be 3.18% lower than that of male participants with a high-high life-course SES trajectory. By the age of 75, the robust LE proportion of male participants with a low-low life-course SES trajectory had further decreased to 6.36% below that of their counterparts with a high-high life-course SES trajectory. Similarly, at the age of 65, the robust LE proportion of female participants with a low-low life-course SES trajectory was 2.69% lower than that of female participants with a high-high life-course SES trajectory, and by the age of 75, this proportion had decreased to 5.73% below that of female participants with a high-high life-course SES trajectory. These findings underscore the widening gap in robust LE proportion with age, emphasizing the cumulative impact of lifelong SES disadvantage, thus affirming the accumulation model (13, 20, 21).

At 65, male participants with a low-high life-course SES trajectory had a 2.39% lower robust LE proportion than those with a high-high trajectory. At 75, the difference increased to 4.79%. This suggests that men achieving high SES in adulthood, but with low childhood SES, had a significantly lower robust LE proportion, a difference that widened with age. Similar conclusions were drawn from female participants. For men with a low-low SES trajectory, the robust LE proportion was 2.22% lower at 65 and 4.68% lower at 75 compared to those with a high-low trajectory. This demonstrates the protective effect of high childhood SES on late-life robust LE proportion among men with low adult SES. Similar conclusions were drawn from female participants. At 65, male participants with a low-low SES trajectory had a 0.79% lower robust LE proportion than those with a low-high trajectory, increasing to 1.57% at 75. Comparing the robust LE proportion of male participants with a low-low life-course SES trajectory to that of male participants with a high-low life-course SES trajectory, this highlights the stronger protective effect of childhood SES on late-life robust LE proportion compared to adult SES. Similar conclusions were drawn from female participants, further validating the critical period model (10).

TABLE 3 Estimated robust, frailty, and total life expectancy (LE) at ages 65 and 75 by life course SES trajectory, including 95% confidence intervals (CLHLS 1998–2018).

Life course SES trajectory (child–adult)	Total LE	Robust LE	Frailty LE	Proportion robust	Proportion frailty
Men					
Age 65					
Low–low	14.097 [12.913, 14.295]	4.465 [4.031, 4.634]	9.633 [8.857, 9.808]	31.67%	68.33%
Low–medium	14.155 [13.229, 14.361]	4.538 [4.212, 4.697]	9.617 [9.010, 9.773]	32.06%	67.94%
Low–high	14.216 [12.748, 14.392]	4.615 [4.050, 4.741]	9.601 [8.715, 9.754]	32.46%	67.54%
Medium–low	14.274 [10.616, 14.461]	4.671 [3.234, 4.815]	9.602 [7.382, 9.748]	32.72%	67.28%
Medium–medium	14.332 [7.053, 14.517]	4.747 [1.948, 4.897]	9.585 [5.091, 9.733]	33.12%	66.88%
Medium–high	14.368 [11.588, 14.584]	4.803 [3.723, 4.982]	9.565 [7.752, 9.739]	33.43%	66.57%
High–low	14.434 [7.206, 14.691]	4.892 [1.950, 5.094]	9.542 [5.179, 9.723]	33.89%	66.11%
High–medium	14.525 [2.886,14.799]	5.000 [0.155, 5.205]	9.524 [2.784, 9.772]	34.42%	65.58%
High–high	14.575 [4.125, 14.957]	5.080 [0.690, 5.396]	9.495 [3.437, 9.741]	34.85%	65.15%
Age 75					
Low–low	9.49 [8.92, 9.63]	2.91 [2.76, 3.01]	6.58 [6.14, 6.69]	30.66%	69.34%
Low–medium	9.57 [9.24, 9.69]	3.01 [2.89, 3.10]	6.56 [6.35, 6.66]	31.45%	68.55%
Low–high	9.65 [9.22, 9.77]	3.11 [2.97, 3.20]	6.53 [6.23, 6.63]	32.23%	67.77%
Medium–low	9.72 [8.17, 9.84]	3.20 [2.74, 3.28]	6.52 [5.43, 6.61]	32.92%	67.08%
Medium–medium	9.79 [6.59, 9.93]	3.30 [2.26, 3.39]	6.49 [4.33, 6.59]	33.71%	66.29%
Medium–high	9.87 [8.71, 10.02]	3.41 [3.01, 3.51]	6.46 [5.73, 6.59]	34.55%	65.45%
High–low	9.96 [7.99, 10.12]	3.52 [2.86, 3.65]	6.44 [5.17, 6.57]	35.34%	64.66%
High–medium	10.04 [1.09, 10.23]	3.63 [0.39, 3.75]	6.41 [0.70, 6.55]	36.16%	63.84%
High–high	10.13 [4.61, 10.34]	3.75 [1.72, 3.92]	6.38 [2.89, 6.55]	37.02%	62.98%
Women					
Age 65					
Low–low	15.313 [11.941, 15.521]	3.950 [3.003, 4.078]	11.363 [9.009, 11.559]	25.80%	74.20%
Low–medium	15.341 [14.486, 15.561]	4.013 [3.733, 4.149]	11.328 [10.695, 11.508]	26.16%	73.84%
Low–high	15.387 [14.718, 15.592]	4.072 [3.823, 4.226]	11.315 [10.847, 11.505]	26.46%	73.54%
Medium–low	15.434 [14.754, 15.680]	4.131 [3.912, 4.272]	11.303 [10.827, 11.505]	26.77%	73.23%
Medium–medium	15.485 [14.328, 15.729]	4.193 [3.795, 4.348]	11.292 [10.572, 11.530]	27.08%	72.92%
Medium–high	15.533 [12.917, 15.782]	4.257 [3.423, 4.452]	11.276 [9.470, 11.494]	27.41%	72.59%
High–low	15.579 [10.767, 15.850]	4.323 [2.724, 4.541]	11.256 [8.007, 11.489]	27.75%	72.25%
High–medium	15.635 [7.184, 15.969]	4.395 [1.427, 4.626]	11.241 [5.740, 11.513]	28.11%	71.89%
High–high	15.694 [6.085, 16.067]	4.471 [0.954,4.755]	11.223 [5.099, 11.514]	28.49%	71.51%
Age 75					
Low–low	10.47 [9.05, 10.61]	2.64 [2.31, 2.73]	7.83 [6.77, 7.94]	25.21%	74.79%
Low–medium	10.52 [10.21, 10.65]	2.72 [2.62, 2.81]	7.80 [7.58, 7.92]	25.86%	74.14%
Low–high	10.59 [10.38, 10.72]	2.82 [2.72, 2.91]	7.77 [7.61, 7.89]	26.63%	73.37%
Medium–low	10.66 [10.43, 10.80]	2.91 [2.79, 3.00]	7.75 [7.59, 7.88]	27.30%	72.70%
Medium–medium	10.73 [10.35, 10.88]	3.00 [2.85, 3.10]	7.72 [7.45, 7.85]	27.96%	72.04%
Medium–high	10.80 [10.43, 10.96]	3.10 [2.95, 3.22]	7.69 [7.41, 7.82]	28.70%	71.30%
High–low	10.86 [9.82, 11.02]	3.20 [2.88, 3.32]	7.66 [6.91, 7.82]	29.47%	70.53%
High–medium	10.94 [8.61, 11.11]	3.30 [2.72, 3.45]	7.64 [5.86, 7.79]	30.16%	69.84%
High–high	11.02 [4.79, 11.22]	3.41 [1.52, 3.57]	7.61 [3.27, 7.80]	30.94%	69.06%

① SES, socioeconomic status; ② LE, life expectancy; ③ Proportion Robust, robust life expectancy accounted for total life expectancy; ④ Proportion Frailty, frailty life expectancy accounted for total life expectancy.

3.4 Enhancing result robustness through comparative analysis

3.4.1 Validating the reliability of life expectancy calculations

There is a paucity of literature utilizing continuous time multi-state models to explore healthy longevity in later years from a life course perspective, with only two exceptions (4, 51). However, these two studies both rely on a single ADL to assess health status in later years, whereas this study employs Rockwood FI, comprising 38 indicators, to evaluate health status in later life. Consequently, the LE estimations from these two studies are not directly comparable to those of this study.

Given the scarcity of literature employing Rockwood FI and continuous time multi-state models to investigate healthy longevity in later years from a life course perspective, the sole exception applies Rockwood FI and continuous time multi-state models to study healthy longevity in later life, utilizing CLHLS data (61). Nonetheless, that study did not adopt a life course perspective. Nevertheless, as the indicators used to characterize health status in later years, models, and data sources in that study align with this study, the LE calculated in that study is compared with the results of this study to validate the reliability of the LE calculations presented here. That study computed LE by gender at age 65, resulting in a residual total LE of 14.16 years for males (Robust LE: 4.71 years, Frailty LE: 9.45 years) and 15.60 years for females (Robust LE: 3.58 years, Frailty LE: 12.02 years).

The above calculations are largely in line with those in this study. At age 65, the average residual total LE for male participants in the three childhood SES categories is 14.47 years, with Robust LE at 5.08 years and Frailty LE at 9.39 years. For female participants in the three childhood SES categories, the average residual total LE is 15.57 years, Robust LE is 4.46 years, and Frailty LE is 11.11 years. Similarly, at age 65, male participants in the nine life-course SES trajectory categories demonstrate an average residual total LE of 14.33 years, with Robust LE at 4.75 years and Frailty LE at 9.57 years. Female participants in the nine trajectory categories exhibit an average residual total LE of 15.49 years, Robust LE at 4.2 years, and Frailty LE at 11.29 years. This affirms the reliability of the LE calculations in this study.

3.4.2 Enhancing result robustness through missing values removal

To enhance the response rate, this study employs multiple imputation by chained equations to impute missing data in childhood SES and adulthood SES indicators (4). Given the relatively limited number of missing values in each indicator, data points with missing values in childhood SES and adulthood SES are removed to assess result robustness. After the removal of missing values, the analytical sample comprises 32,432 participants, resulting in a response rate of 73.21%, with an average age of 88.18 years (SD: 11.14) and a male representation of 42%. The distribution of participants across low, medium, and high childhood SES categories is 66.89, 21.23, and 11.89%, respectively. Correspondingly, the distribution across low, medium, and high adulthood SES categories is 51.70, 33.26, and 15.04%, respectively. The distribution of participants among the nine categories of life-course SES trajectory (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) is 41.14, 20.03, 5.72, 8.91, 8.44, 3.87, 1.65, 4.79, and 5.45%, respectively. Notably, the age and gender distributions, along with the distributions in childhood SES, adulthood SES, and life course SES, exhibit consistency with the distributions before the deletion of missing values.

Following the removal of missing data, annual transition probabilities by childhood SES are illustrated in Supplementary Figures S3–S6, while annual transition probabilities by life course SES are delineated in Supplementary Figures S7–S10. The analysis of life expectancy by childhood SES is featured in Supplementary Table S4, and the analysis of life expectancy by life course SES is detailed in Supplementary Table S5. The study findings have demonstrated consistency with the outcomes prior to the deletion of missing values, affirming the robustness of the results. Given the potential widening of confidence intervals with a reduced estimation sample, precedence is given to utilizing the dataset without removed missing values as the principal outcomes.

4 Discussion

Studying the healthy longevity of older people in China from a life course perspective holds exceptional significance. This article, grounded in the life course approach, employs multi-state models to assess late-life health status using the Rockwood Frailty Index (FI), comprising 38 indicators. Leveraging the extensive CLHLS survey data spanning from 1998 to 2018, this research comprehensively examines how childhood SES and adult SES collectively shape late-life healthy longevity. By addressing the constraints of prior studies with limited sample sizes or brief durations (4), reliance on singular indicators for gauging late-life health status (4, 51), and models neglecting the interplay between disability incidence, recovery rate, and mortality rate (29, 30), this study makes a contribution to the field.

In China, older people demonstrate an upward social mobility trend from childhood to adulthood, with 29.7% experiencing upward mobility, while only 15.2% experience downward mobility, a proportion significantly lower than that of upwardly mobile participants. The multi-state transition probability forms the basis for estimating life expectancy. This study reveals that, irrespective of gender and the categorization of older people by childhood SES into three groups or by life-course SES trajectory into nine groups, the transition probabilities show an upward trend for robust–frailty, robust–dead, and frailty–dead with age, while the probability of frailty–robust exhibits a downward trend. Regardless of gender and the division of older people into three categories (low, medium, high) based on childhood SES or into nine categories (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) based on life-course SES trajectory, the transition probabilities of robust–frailty, robust–dead, and frailty–dead all decrease sequentially across different categories, while the probability of frailty–robust increases sequentially across different categories. Favorable childhood SES and the accumulation of lifelong SES advantages have a protective effect on frailty incidence, recovery rate, and mortality risk, with high childhood SES exerting a stronger influence than high adult SES.

Regardless of gender, whether older people are classified into three groups (low, medium, high) based on childhood SES or into nine groups (low-low, low-medium, low-high, medium-low, medium-medium, medium-high, high-low, high-medium, high-high) based on life-course SES trajectory, total LE, robust LE, and robust LE proportion exhibit sequential increases across different categories, while frailty LE shows sequential decreases across different categories.

Favorable childhood SES and the accumulation of lifelong SES advantages exert a significant protective effect on late-life robust LE proportion, with high childhood SES demonstrating a stronger protective influence than high adult SES. The frailty incidence rate and total LE are higher in women than in men (40, 41), but the recovery rate, mortality risk, robust LE, and robust LE proportion are lower in women, indicating that despite women generally living longer than men, their health status is poorer (66, 76).

This study substantiates the critical period model (10) and accumulation model (13, 20, 21). Unlike prior research (4), our findings reveal that a higher childhood SES exerts a more potent protective influence on late-life healthy longevity than a higher adult SES. The policy implications of our study suggest that despite substantial enhancements in the living standards of most older Chinese people during adulthood and old age (4), these improvements do not counterbalance the adverse impact of childhood SES disadvantage on late-life healthy longevity (29). This underscores the crucial need for early intervention in late-life healthy longevity, as exposure to adverse conditions in early life is irreversible (12, 29, 43), and significantly contributes to late-life health inequality.

Our study's findings align with various previous studies, highlighting the critical role of childhood SES in determining long-term health outcomes. Data from the Survey of Health, Aging, and Retirement in Europe (SHARE) indicated higher frailty levels among immigrants from LMICs in Nordic and Western Europe (36). Similarly, the 1958 British birth cohort linked lower childhood SES to higher FI scores (37), and a study on UK twins found an inverse relationship between father's occupational class and participants' FI (38). Research using SHARE and the China Health and Retirement Longitudinal Study (CHARLS) data showed that three or more childhood adversities increased FI levels (43), emphasizing the global nature of these effects. Our results support the critical period model (10), consistent with various studies. The Health and Retirement Study (HRS) in the U.S. linked childhood financial hardship to multimorbidity (12) and lower cognitive function (14). Research from the Utah Population Database found that higher childhood SES is associated with better morbidity trajectories and survival rates (15). These studies reinforce our conclusion that early-life socioeconomic conditions profoundly impact health trajectories. Additionally, our research indicates that high childhood SES has a greater impact than high adult SES. A British birth cohort study supports this, linking early-life SES to frailty, with adult SES only partially explaining this relationship (37). This underscores the need for early-life interventions to break the cycle of disadvantage.

The accumulation model validated in our study is also supported by several prior studies. For instance, a public health survey in Sweden linked lifelong economic stress to poor self-rated health (13). The HRS indicated that higher cumulative SES correlates with better cognitive function (14). A Life History survey in France associated lifelong socioeconomic disadvantage with increased morbidity ratios (22). Similarly, evidence from Sweden highlighted the impact of lifelong SES on health trajectories in older adult (26). These findings demonstrate that cumulative socioeconomic conditions throughout life significantly influence health outcomes, emphasizing the need for sustained socioeconomic support. Furthermore, while women tend to live longer than men, their overall health is worse. This aligns with findings from a cohort study in Germany (40), research in five major Latin American cities (41), and the HRS cohort in the U.S. (66). These studies, along with our findings, highlight the need for gender-specific health interventions to address unique health challenges faced by women. Despite extensive research from HICs, evidence from LMICs is limited, and these studies have not used continuous-time multi-state models. Thus, our study provides a valuable addition to the existing literature.

Given these findings, it is imperative for governmental authorities to strengthen nutritional and health initiatives aimed at disadvantaged children, improve the nutritional and health status of children in impoverished communities and households by executing early childhood nutrition enhancement initiatives (51), and further narrow the urban–rural gap. It is imperative to emphasize the implementation of comprehensive intervention strategies at multiple levels, including education, healthcare accessibility, and food provision, in order to develop effective strategies for promoting child health. Our research highlights the significance of approaching the topic of healthy aging from a life course perspective. We recommend that policymakers embrace a proactive strategy to enhance early-life nutrition and promote health among at-risk populations.

This study has several potential limitations. Firstly, due to the inability of the multi-state life table model to accommodate time-varying covariates, and our deliberate exclusion of variables susceptible to frailty, we did not incorporate indicators of current health behaviors or living arrangements as covariates. This decision was made because changes in health behaviors, such as smoking or physical activity, may be responses to changes in frailty (30), and these variables are also subject to change over time. Our study focuses on exploring the observable social differentiation in healthy longevity. We do not draw conclusions regarding the causal relationship between SES at various life stages and health outcomes in later life (4). Secondly, while the retrospective information was deemed reasonably reliable (64), the assessment of childhood SES relied on retrospective self-reports, inevitably introducing recall bias. However, the approach to mitigate recall bias involves enlarging the sample size, and the substantial sample size of the cohort data used in this study, 37,264 participants, can significantly mitigate the impact of recall bias on the research findings. Thirdly, individuals with extremely disadvantaged childhood SES may be absent from our study sample due to premature death. Although our study's model incorporates age variable, the estimates derived from our sample may still be subject to survivor bias, potentially underestimating the influence of childhood SES on late-life healthy longevity (77).

5 Conclusion

Favorable childhood SES and lifelong accumulation of SES advantages protect against frailty morbidity, improve recovery rate, reduce mortality risk, and increase total LE, robust LE, and robust LE proportion. Moreover, high childhood SES exerts a stronger protective effect than high adult SES, signifying that enhancements in adult living conditions are inadequate to offset the detrimental impact of childhood SES disadvantage on late-life healthy longevity. This study substantiates the critical period model and accumulation model. Therefore, in order to promote healthy aging, it is imperative for policymakers to adopt a proactive strategy and implement targeted interventions addressing diverse health determinants in early life, encompassing aspects such as education, healthcare accessibility, and food supply.

The implications of this study extend to social, health, and public policy levels. Socially, addressing childhood SES disparities can lead

to more equitable health outcomes across the lifespan. From a health perspective, early interventions can alleviate frailty and improve overall population health. At the public policy level, our findings advocate for policies that prioritize early-life health determinants, ensuring that resources are allocated to support disadvantaged populations from a young age, ultimately fostering a healthier, more equitable society.

However, this study has several potential limitations. Firstly, the multi-state life table model used does not accommodate time-varying covariates, and we excluded variables susceptible to frailty, such as current health behaviors and living arrangements. Secondly, the reliance on retrospective self-reports for childhood SES introduces recall bias, although the large sample size helps mitigate this issue. Lastly, the study may be subject to survivor bias, potentially underestimating the influence of childhood SES on late-life health outcomes.

Despite these limitations, this study offers valuable insights into how childhood SES and adult SES jointly shape late-life healthy longevity from a life course perspective, significantly contributing to a comprehensive understanding of the mechanisms that impact the healthy longevity of older people.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

The studies involving humans were approved by the Biomedical Ethics Committee of Peking University under the reference number IRB00001052-13,074, and written informed consent was obtained from all CLHLS survey participants or their authorized representatives. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

YC: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. The study was funded by Beijing Social Science Foundation Planning Project (Grant No. 20GLC047). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgments

I would like to thank the Center for Healthy Aging and Development, Peking University, for providing CLHLS data.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1352937/full#supplementary-material

SUPPLEMENTARY FIGURE S1
Flowchart depicting participant involvement in the CLHLS from 1998 to 2018.

SUPPLEMENTARY FIGURE S2
Multi-State Model Illustrating Transitions in Frailty States.

SUPPLEMENTARY FIGURE S3
Annual Transition Probabilities from Robust to Frailty Based on Childhood SES After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S4
Annual Transition Probabilities from Frailty to Robust Based on Childhood SES After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S5
Annual Transition Probabilities from Robust to Mortality Based on Childhood SES After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S6
Annual Transition Probabilities from Frailty to Mortality Based on Childhood SES After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S7
Annual Transition Probabilities from Robust to Frailty Based on Life-Course SES Trajectory After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S8
Annual Transition Probabilities from Frailty to Robust Based on Life-Course SES Trajectory After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S9
Annual Transition Probabilities from Robust to Mortality Based on Life-Course SES Trajectory After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY FIGURE S10
Annual Transition Probabilities from Frailty to Mortality Based on Life-Course SES Trajectory After Removing Missing Values, CLHLS 1998-2018. **(A)** Male. **(B)** Female.

SUPPLEMENTARY TABLE S1
Inventory of Components comprising the Frailty Index.

SUPPLEMENTARY TABLE S2
Inventory of Components Comprising the Mini-Mental State Examination (MMSE).

SUPPLEMENTARY TABLE S3
Results of Hypothesis Tests.

SUPPLEMENTARY TABLE S4
Childhood SES-Stratified Estimated Robust, Frailty, and Total Life Expectancy (LE) at Ages 65 and 75, Including 95% Confidence Intervals (CLHLS 1998-2018) After Removing Missing Values.

SUPPLEMENTARY TABLE S5
Estimated Robust, Frailty, and Total Life Expectancy (LE) at Ages 65 and 75 by Life Course SES Trajectory, Including 95% Confidence Intervals (CLHLS 1998-2018) After Removing Missing Values.

References

1. National Bureau of Statistics of China. Communiqué of the seventh National Population Census (no. 5). (2021). Available at: https://www.stats.gov.cn/english/PressRelease/202105/t20210510_1817190.html (Accessed December 6, 2023).

2. United Nations. World population prospects (2022). Available at: https://population.un.org/wpp/ (Accessed December 6, 2023)

3. Yang L, Wang Z. Early-life conditions and cognitive function in middle-and old-aged Chinese adults: a longitudinal study. *Int J Environ Res Public Health*. (2020) 17:3451. doi: 10.3390/ijerph17103451

4. Payne CF, Xu KQ. Life course socioeconomic status and healthy longevity in China. *Demography*. (2022) 59:629–52. doi: 10.1215/00703370-9830687

5. McEniry M, McDermott J. Early-life conditions, rapid demographic changes, and older adult health in the developing world. *Biodemography Soc Biol*. (2015) 61:147–66. doi: 10.1080/19485565.2015.1047488

6. Peele ME. Domains of childhood disadvantage and functional limitation trajectories among midlife men and women in China. *J Aging Health*. (2020) 32:501–12. doi: 10.1177/0898264319834813

7. Heikkinen E. A life course approach: research orientations and future challenges. *Eur Rev Aging Phys Act*. (2011) 8:7–12. doi: 10.1007/s11556-010-0069-2

8. Pudrovska T, Anikputa B. Early-life socioeconomic status and mortality in later life: an integration of four life-course mechanisms. *J Gerontol Ser B*. (2014) 69:451–60. doi: 10.1093/geronb/gbt122

9. Delgado-Angulo EK, Bernabé E. Comparing lifecourse models of social class and adult oral health using the 1958 National Child Development Study. *Community Dent Health*. (2015) 32:20–5. doi: 10.1922/CDH_3412Angulo06

10. Barker DJ. Maternal nutrition, fetal nutrition, and disease in later life. *Nutr Burbank Los Angel Cty Calif*. (1997) 13:807–13. doi: 10.1016/s0899-9007(97)00193-7

11. Bernabé E, Suominen AL, Nordblad A, Vehkalahti MM, Hausen H, Knuuttila M, et al. Education level and oral health in Finnish adults: evidence from different lifecourse models. *J Clin Periodontol*. (2011) 38:25–32. doi: 10.1111/j.1600-051X.2010.01647.x

12. Tucker-Seeley RD, Li Y, Sorensen G, Subramanian SV. Lifecourse socioeconomic circumstances and multimorbidity among older adults. *BMC Public Health*. (2011) 11:313. doi: 10.1186/1471-2458-11-313

13. Lindström M, Hansen K, Rosvall M. Economic stress in childhood and adulthood, and self-rated health: a population based study concerning risk accumulation, critical period and social mobility. *BMC Public Health*. (2012) 12:761. doi: 10.1186/1471-2458-12-761

14. Lyu J, Burr JA. Socioeconomic status across the life course and cognitive function among older adults: an examination of the latency, pathways, and accumulation hypotheses. *J Aging Health*. (2016) 28:40–67. doi: 10.1177/0898264315585504

15. Zimmer Z, Hanson HA, Smith K. Childhood socioeconomic status, adult socioeconomic status, and old-age health trajectories: connecting early, middle, and late life. *Demogr Res*. (2016) 34:285–320. doi: 10.4054/DemRes.2016.34.10

16. Hayward MD, Gorman BK. The long arm of childhood: the influence of early-life social conditions on men's mortality. *Demography*. (2004) 41:87–107. doi: 10.1353/dem.2004.0005

17. Pakpahan E, Hoffmann R, Kröger H. The long arm of childhood circumstances on health in old age: evidence from SHARELIFE. *Adv Life Course Res*. (2017) 31:1–10. doi: 10.1016/j.alcr.2016.10.003

18. Boylan JM, Cundiff JM, Jakubowski KP, Pardini DA, Matthews KA. Pathways linking childhood SES and adult health behaviors and psychological resources in black and white men. *Ann Behav Med Publ Soc Behav Med*. (2018) 52:1023–35. doi: 10.1093/abm/kay006

19. Ben-Shlomo Y, Kuh D. A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. *Int J Epidemiol*. (2002) 31:285–93. doi: 10.1093/ije/31.2.285

20. O'Rand AM, Hamil-Luker J. Processes of cumulative adversity: childhood disadvantage and increased risk of heart attack across the life course. *J Gerontol B Psychol Sci Soc Sci*. (2005) 60:117–24. doi: 10.1093/geronb/60.special_issue_2.s117

21. Willson AE, Shuey KM, Glen E. Cumulative advantage processes as mechanisms of inequality in life course health. *Am J Sociol*. (2007) 112:1886–924. doi: 10.1086/512712

22. Melchior M, Lert F, Martin M, Ville I. Socioeconomic position in childhood and in adulthood and functional limitations in midlife: data from a nationally-representative survey of French men and women. *Soc Sci Med*. (2006) 63:2813–24. doi: 10.1016/j.socscimed.2006.07.029

23. Lindström M, Fridh M, Rosvall M. Economic stress in childhood and adulthood, and poor psychological health: three life course hypotheses. *Psychiatry Res*. (2014) 215:386–93. doi: 10.1016/j.psychres.2013.11.018

24. Ramsay SE, Papachristou E, Watt RG, Lennon LT, Papacosta AO, Whincup PH, et al. Socioeconomic disadvantage across the life-course and oral health in older age: findings from a longitudinal study of older British men. *J Public Health Oxf Engl*. (2018) 40:e423–30. doi: 10.1093/pubmed/fdy068

25. Lee H. A life course approach to total tooth loss: testing the sensitive period, accumulation, and social mobility models in the health and retirement study. *Community Dent Oral Epidemiol*. (2019) 47:333–9. doi: 10.1111/cdoe.12463

26. Harber-Aschan L, Calderón-Larrañaga A, Darin-Mattson A, Hu X, Fratiglioni L, Dekhtyar S. Beyond the social gradient: the role of lifelong socioeconomic status in older adults' health trajectories. *Aging*. (2020) 12:24693–708. doi: 10.18632/aging.202342

27. Lunyera J, Stanifer JW, Davenport CA, Mohottige D, Bhavsar NA, Scialla JJ, et al. Life course socioeconomic status, allostatic load, and kidney health in black Americans. *Clin J Am Soc Nephrol CJASN*. (2020) 15:341–8. doi: 10.2215/CJN.08430719

28. Hallqvist J, Lynch J, Bartley M, Lang T, Blane D. Can we disentangle life course processes of accumulation, critical period and social mobility? An analysis of disadvantaged socio-economic positions and myocardial infarction in the Stockholm heart epidemiology program. *Soc Sci Med*. (2004) 58:1555–62. doi: 10.1016/S0277-9536(03)00344-7

29. Wen M, Gu D. The effects of childhood, adult, and community socioeconomic conditions on health and mortality among older adults in China. *Demography*. (2011) 48:153–81. doi: 10.1007/s13524-010-0003-2

30. Zimmer Z, Martin LG, Nagin DS, Jones BL. Modeling disability trajectories and mortality of the oldest-old in China. *Demography*. (2012) 49:291–314. doi: 10.1007/s13524-011-0075-7

31. Zhong Y, Wang J, Nicholas S. Gender, childhood and adult socioeconomic inequalities in functional disability among Chinese older adults. *Int J Equity Health*. (2017) 16:165. doi: 10.1186/s12939-017-0662-3

32. Zhang X, Jiang X, Sha M, Zhou Q, Li W, Guo Y, et al. Life-course pathways from childhood socioeconomic status to type 2 diabetes in mid-late Chinese adulthood. *Sci Rep*. (2021) 11:13051. doi: 10.1038/s41598-021-91768-1

33. Zhang X, Dai S, Jiang X, Huang W, Zhou Q, Wang S. The pathways from disadvantaged socioeconomic status in childhood to edentulism in mid-to-late adulthood over the life-course. *Int J Equity Health*. (2023) 22:150. doi: 10.1186/s12939-023-01865-y

34. Kojima G, Liljas AEM, Iliffe S. Frailty syndrome: implications and challenges for health care policy. *Risk Manag Healthc Policy*. (2019) 12:23–30. doi: 10.2147/RMHP.S168750

35. Mitnitski A, Song X, Rockwood K. Trajectories of changes over twelve years in the health status of Canadians from late middle age. *Exp Gerontol*. (2012) 47:893–9. doi: 10.1016/j.exger.2012.06.015

36. Brothers TD, Theou O, Rockwood K. Frailty and migration in middle-aged and older Europeans. *Arch Gerontol Geriatr*. (2014) 58:63–8. doi: 10.1016/j.archger.2013.07.008

37. Rogers NT, Blodgett JM, Searle SD, Cooper R, Davis DHJ, Pinto Pereira SM. Early-life socioeconomic position and the accumulation of health-related deficits by midlife in the 1958 British birth cohort study. *Am J Epidemiol*. (2021) 190:1550–60. doi: 10.1093/aje/kwab038

38. Young ACM, Glaser K, Spector TD, Steves CJ. The identification of hereditary and environmental determinants of frailty in a cohort of UK twins. *Twin Res Hum Genet Off J Int Soc Twin Stud*. (2016) 19:600–9. doi: 10.1017/thg.2016.72

39. Maharani A, Didikoglu A, O'Neill TW, Pendleton N, Canal MM, Payton A. Education mediating the associations between early life factors and frailty: a cross-sectional study of the UK biobank. *BMJ Open*. (2023) 13:e057511. doi: 10.1136/bmjopen-2021-057511

40. Stephan A-J, Strobl R, Schwettmann L, Meisinger C, Ladwig K-H, Linkohr B, et al. The times we are born into and our lifestyle choices determine our health trajectories in older age - results from the KORA-age study. *Prev Med*. (2020) 133:106025. doi: 10.1016/j.ypmed.2020.106025

41. Alvarado BE, Zunzunegui M-V, Béland F, Bamvita J-M. Life course social and health conditions linked to frailty in Latin American older men and women. *J Gerontol A Biol Sci Med Sci*. (2008) 63:1399–406. doi: 10.1093/gerona/63.12.1399

42. Cao X, Ma C, Zheng Z, He L, Hao M, Chen X, et al. Contribution of life course circumstances to the acceleration of phenotypic and functional aging: a retrospective study. *EClinicalMedicine*. (2022) 51:101548. doi: 10.1016/j.eclinm.2022.101548

43. Wang Q. Social contexts and cross-national differences in association between adverse childhood experiences and frailty index. *SSM - Popul Health*. (2023) 22:101408. doi: 10.1016/j.ssmph.2023.101408

44. Hargrove TW, Brown TH. A life course approach to inequality: examining racial/ethnic differences in the relationship between early life socioeconomic conditions and adult health among men. *Ethn Dis*. (2015) 25:313–20. doi: 10.18865/ed.25.3.313

45. Leopold L. Cumulative advantage in an egalitarian country? Socioeconomic health disparities over the life course in Sweden. *J Health Soc Behav*. (2016) 57:257–73. doi: 10.1177/0022146516645926

46. Chen Y, Zhao Y. Widening or convergence, the trajectories of health inequalities induced by childhood SES across the life course: evidence from China. *SSM - Popul Health*. (2023) 21:101324. doi: 10.1016/j.ssmph.2022.101324

47. House JS, Lepkowski JM, Kinney AM, Mero RP, Kessler RC, Herzog AR. The social stratification of aging and health. *J Health Soc Behav*. (1994) 35:213–34.

48. House JS, Lantz PM, Herd P. Continuity and change in the social stratification of aging and health over the life course: evidence from a nationally representative longitudinal study from 1986 to 2001/2002 (Americans' changing lives study). *J Gerontol B Psychol Sci Soc Sci*. (2005) 60 Spec No) 60 Spec No 2:15–26. doi: 10.1093/geronb/60.special_issue_2.s15

49. McEniry M. Early-life conditions and older adult health in low- and middle-income countries: a review. *J Dev Orig Health Dis*. (2013) 4:10–29. doi: 10.1017/S2040174412000499

50. Cai L, Schenker N, Lubitz J. Analysis of functional status transitions by using a semi-Markov process model in the presence of left-censored spells. *J R Stat Soc Ser C Appl Stat*. (2006) 55:477–91. doi: 10.1111/j.1467-9876.2006.00548.x

51. Dong H, Du C, Wu B, Wu Q. Multi-state analysis of the impact of childhood starvation on the healthy life expectancy of the elderly in China. *Front Public Health*. (2021) 9:690645. doi: 10.3389/fpubh.2021.690645

52. Yi Z. Introduction to the Chinese longitudinal healthy longevity survey (CLHLS) In: Z Yi, DL Poston, DA Vlosky and D Gu, editors. Healthy longevity in China: Demographic, socioeconomic, and psychological dimensions. Dordrecht: springer Netherlands (2008). 23–38.

53. Gu D. General data quality assessment of the CLHLS In: Z Yi, DL Poston, DA Vlosky and D Gu, editors. Healthy longevity in China: Demographic, socioeconomic, and psychological dimensions. Dordrecht: springer Netherlands (2008). 39–60.

54. Dupre ME, Gu D, Warner DF, Yi Z. Frailty and type of death among older adults in China: prospective cohort study. *BMJ*. (2009) 338:b1175. doi: 10.1136/bmj.b1175

55. Zeng Y, Feng Q, Gu D, Vaupel JW. Demographics, phenotypic health characteristics and genetic analysis of centenarians in China. *Mech Ageing Dev*. (2017) 165:86–97. doi: 10.1016/j.mad.2016.12.010

56. Gu D, Dupre ME, Sautter J, Zhu H, Liu Y, Yi Z. Frailty and mortality among Chinese at advanced ages. *J Gerontol B Psychol Sci Soc Sci*. (2009) 64:279–89. doi: 10.1093/geronb/gbn009

57. Gu Y, Wu W, Bai J, Chen X, Chen X, Yu L, et al. Association between the number of teeth and frailty among Chinese older adults: a nationwide cross-sectional study. *BMJ Open*. (2019) 9:e029929. doi: 10.1136/bmjopen-2019-029929

58. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. *BMC Geriatr*. (2008) 8:24. doi: 10.1186/1471-2318-8-24

59. Bennett S, Song X, Mitnitski A, Rockwood K. A limit to frailty in very old, community-dwelling people: a secondary analysis of the Chinese longitudinal health and longevity study. *Age Ageing*. (2013) 42:372–7. doi: 10.1093/ageing/afs180

60. Li S, Fan W, Zhu B, Ma C, Tan X, Gu Y. Effects of age, period, and cohort on the prevalence of frailty in Chinese older adults from 2002 to 2014. *Front Public Health*. (2022) 10:935163. doi: 10.3389/fpubh.2022.935163

61. Gao J, Wang Y, Xu J, Jiang J, Yang S, Xiao Q. Life expectancy among older adults with or without frailty in China: multistate modelling of a national longitudinal cohort study. *BMC Med*. (2023) 21:101. doi: 10.1186/s12916-023-02825-7

62. Shi G-P, Ma T, Zhu Y-S, Wang Z-D, Chu X-F, Wang Y, et al. Frailty phenotype, frailty index and risk of mortality in Chinese elderly population- Rugao longevity and ageing study. *Arch Gerontol Geriatr*. (2019) 80:115–9. doi: 10.1016/j.archger.2018.11.001

63. Gu D, Feng Q, Chen H, Zeng Y. Chinese longitudinal healthy longevity survey (CLHLS) In: D Gu and ME Dupre, editors. Encyclopedia of gerontology and population aging. Cham: Springer International Publishing (2021). 957–70.

64. Luo Y, Waite LJ. The impact of childhood and adult SES on physical, mental, and cognitive well-being in later life. *J Gerontol B Psychol Sci Soc Sci*. (2005) 60:S93–S101. doi: 10.1093/geronb/60.2.s93

65. Zhang Z, Liu J, Li L, Xu H. The long arm of childhood in China: early-life conditions and cognitive function among middle-aged and older adults. *J Aging Health*. (2018) 30:1319–44. doi: 10.1177/0898264317715975

66. Morton PM, Ferraro KF. Early social origins of biological risks for men and women in later life. *J Health Soc Behav*. (2020) 61:503–22. doi: 10.1177/0022146520966364

67. Luo Y, Wen M. Can we afford better health? A study of the health differentials in China. *Health (N Y)*. (2002) 6:471–500. doi: 10.1177/136345930200600404

68. Zimmer Z, Kwong J. Socioeconomic status and health among older adults in rural and urban China. *J Aging Health*. (2004) 16:44–70. doi: 10.1177/0898264303260440

69. Zhu H, Xie Y. Socioeconomic differentials in mortality among the oldest old in China. *Res Aging*. (2007) 29:125–43. doi: 10.1177/0164027506296758

70. Huang X, Deng J, Liu W. Sex differences in cognitive function among Chinese older adults using data from the Chinese longitudinal healthy longevity survey: a cross-sectional study. *Front Public Health*. (2023) 11:1182268. doi: 10.3389/fpubh.2023.1182268

71. Pedersen J, Bjorner JB. Worklife expectancy in a cohort of Danish employees aged 55-65 years - comparing a multi-state cox proportional hazard approach with conventional multi-state life tables. *BMC Public Health*. (2017) 17:879. doi: 10.1186/s12889-017-4890-7

72. Zaninotto P, Head J, Steptoe A. Behavioural risk factors and healthy life expectancy: evidence from two longitudinal studies of ageing in England and the US. *Sci Rep*. (2020) 10:6955. doi: 10.1038/s41598-020-63843-6

73. Jackson C. Multi-state models for panel data: the msm package for R. *J Stat Softw*. (2011) 38:1–28. doi: 10.18637/jss.v038.i08

74. van den Hout A, Sum Chan M, Matthews F. Estimation of life expectancies using continuous-time multi-state models. *Comput Methods Prog Biomed*. (2019) 178:11–8. doi: 10.1016/j.cmpb.2019.06.004

75. Turrell G, Lynch JW, Kaplan GA, Everson SA, Helkala E-L, Kauhanen J, et al. Socioeconomic position across the lifecourse and cognitive function in late middle age. *J Gerontol B Psychol Sci Soc Sci*. (2002) 57:S43–51. doi: 10.1093/geronb/57.1.s43

76. Read JG, Gorman BK. Gender and health inequality. *Annu Rev Sociol*. (2010) 36:371–86. doi: 10.1146/annurev.soc.012809.102535

77. Tian F, Meng SS, Qiu P. Childhood adversities and mid-late depressive symptoms over the life course: evidence from the China health and retirement longitudinal study. *J Affect Disord*. (2019) 245:668–78. doi: 10.1016/j.jad.2018.11.028

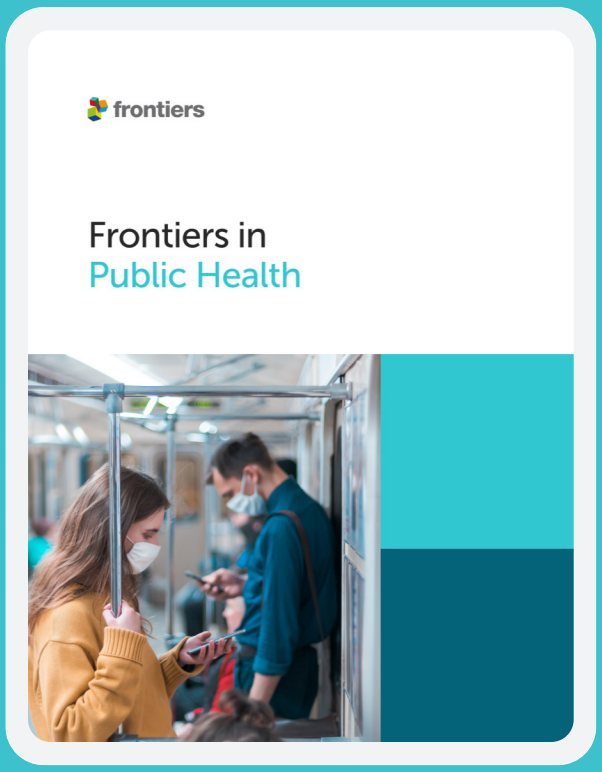
Frontiers in Public Health

Explores and addresses today's fast-moving healthcare challenges

One of the most cited journals in its field, which promotes discussion around inter-sectoral public health challenges spanning health promotion to climate change, transportation, environmental change and even species diversity.

Discover the latest Research Topics

See more →



Frontiers

Avenue du Tribunal-Fédéral 34
1005 Lausanne, Switzerland
frontiersin.org

Contact us

+41 (0)21 510 17 00
frontiersin.org/about/contact