Aging: challenges and opportunities for inclusion and active participation

Edited by
Ramona Bongelli, Gonzalo Del Moral, Alessandra Fermani and Paola Nicolini

Coordinated by
Chiara Aleffi and Veronica Guardabassi

Published in
Frontiers in Psychology

Generative AI statement
Any alternative text (Alt text) provided alongside figures in the articles in this ebook has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

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

Aging: challenges and opportunities for inclusion and active participation

Topic editors

Ramona Bongelli — University of Macerata, Italy
Gonzalo Del Moral — Universidad Pablo de Olavide, Spain
Alessandra Fermani — University of Macerata, Italy
Paola Nicolini — University of Macerata, Italy

Topic coordinators

Chiara Aleffi — University of Macerata, Italy
Veronica Guardabassi — University of Macerata, Italy

Table of
contents

Check for updates

Editorial: Aging: challenges and opportunities for inclusion and active participation

Ramona Bongelli[1]*, Chiara Aleffi[2], Alessandra Fermani[2], Veronica Guardabassi[3], Gonzalo del Moral Arroyo[4] and Paola Nicolini[3]

[1]Department of Political Science, Communication and International Relations, University of Macerata, Macerata, Italy, [2]Department of Education, Cultural Heritage and Tourism, University of Macerata, Macerata, Italy, [3]Department of Humanities, University of Macerata, Macerata, Italy, [4]Department of Education and Social Psychology, University of Pablo de Olavide, Seville, Spain

Editorial on the Research Topic
Aging: challenges and opportunities for inclusion and active participation

1 Introduction

In recent decades, the proportion of the population over the age of 65 has increased and, according to United Nations projections, it will reach 16% of the global population by 2050. While this trend reflects improved living conditions in many parts of the world, it also entails a growing prevalence of frailty and, consequently, a greater demand for care, thereby placing significant pressure on social and healthcare systems. Though aging is a heterogeneous process with significant variations between individuals, it is often associated with an increased risk of developing chronic conditions such as diabetes, respiratory diseases, neurological disorders, cardiovascular diseases, as well as cognitive impairments and decline. This frequently results in a growing need for long-term care, often provided by family members and professional caregivers. In other words, population aging increases the demand for, and the cost of, social and healthcare services, making it even more urgent to ensure that older adults receive timely, targeted care that preserves—as long as possible—their autonomy and wellbeing, while fostering genuine social inclusion and enabling full participation in society. Defining *social inclusion* is challenging, because it is a complex concept, that includes numerous components. Some definitions focus on the sense of belonging and recognition within a group, while others place greater emphasis on the procedural, relational, and action-related dimensions. Thus, *social inclusion* has been defined as "belonging to, identifying with, and feeling included in important and valued social groups (e.g., friendship groups, support groups, work groups, recreation groups)" (Hutchison and Ewens, 2022, p. 2162), as well as "a process that enhances opportunities for

social participation, strengthens social bonds, and ensures equitable access to opportunities and decision-making" (Tan et al., 2025, p. 1). *Social participation* can, instead, be conceived as the concrete opportunity to act, to take part in a social and relational context. It indeed refers to individuals' engagement in activities that foster interaction with other people, taking place within community settings and shared social spaces. Obviously, this involvement evolves over time depending on available personal resources and individuals' perceptions of what is valuable and meaningful. It is also shaped by the opportunities offered by the broader social context (Levasseur et al., 2022).

2 The Research Topic

In December 2024, the Research Topic entitled "*Aging: challenges and opportunities for inclusion and active participation*" was launched, inspired by the VITALITY project (Innovation, Digitalisation and Sustainability Ecosystem for the Widespread Economy in Central Italy), funded by the PNRR (National Recovery and Resilience Plan). One of the overarching aims of VITALITY was to improve sustainability and quality of life in both urban and rural areas. Within this framework, the University of Macerata focused specifically on Smart solutions and educational programmes for antifragility and inclusivity (SAFINA). "Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better" (Taleb, 2014, p. 3). It enables individuals to benefit and develop not despite, but rather, because of radical uncertainty and adversity (Klisanin, 2022). This capacity is based on interdependence, since "our psyche can withstand shocks and get stronger because we are not isolated" (Klisanin, 2022, p. 338). For older adults, this means overcoming uncertainty, limitations and challenging (e.g., psychical, psychological) that often characterize later life, through active engagement with their social environment. Crucially, antifragility in later life can only be fully developed within inclusive contexts that provide opportunities for participation, recognition, and meaningful social interactions, enabling older individuals to strengthen their adaptive and transformative capacities.

Thus, the main aim of this Research Topic was to identify, in different contexts, challenges and opportunities to address the needs of this population, as well as that of those who care for them in situations of frailty. More specifically, the goal was to gather contributions that would pay attention to the impact of aging (primarily in psychological, social, relational, and communicative terms, but not only) on older adults, caregivers and the wider community (e.g., Bongelli et al., 2024; Guardabassi, 2025; Santini et al., 2025).

For this Research Topic—the first volume of a two-volume collection—we received many highly interesting papers. Ten of them (nine original papers and one study protocol), authored by 42 researchers from different countries, with a particularly strong representation from China, were successfully published. Specifically, six papers were published in Frontiers in Public Health (sections Aging and Public Health, Life-Course Epidemiology and Social Inequalities Health, Digital and Public Health) and four in Frontiers in Psychology (sections Health Psychology and Psychology and Aging).

Although the articles address diverse topics, they can be grouped into three main thematic areas:

1. *Digital technologies and active aging;*
2. *Social participation, wellbeing, and mental health;*
3. *Cognitive stimulation and leisure activities for healthy aging.*

2.1 Digital technologies and active aging

The first thematic area includes papers exploring how internet use, social media engagement, smart products, and digital cultural adaptation can promote social participation, psychological wellbeing, and health among older adults. While some of them demonstrate physical and psychological benefits of internet, digital, smart, and social media use among older adults, others reveal persistent barriers, highlighting the need for targeted strategies in support, design, and services to maximize their participation and digital inclusion.

Kong and Zhu, analyzing data from the Chinese Longitudinal Aging Social Survey (CLASS) 2020, found that comprehensive use of internet (i.e., extending beyond simply entertainment) significantly reduced older adults' subjective age, which, in turn, positively affected perceived health, self-efficacy, and social capital.

Similarly, Liu et al. showed that active social media use foster physical activity among older adults in Shandon province (China), despite age-related physical decline. Taking together, these findings suggest that *active* engagement with internet and social media can help mitigate age-related decline, supporting healthier and more active aging.

Yun et al. focused instead on the emotional needs of older people living alone in urban China, and on their complex relations with smart technology, conducting, and analyzing 20 interviews. Their thematic analysis highlighted that many older persons resorted to physical, social, and spiritual activities to cope with anxiety, loneliness, and diminished autonomy, but they reported a limited use of smart products due to low motivation, usability barriers, and a lack of age-sensitive design.

In line with the previous study, also Li et al. examines the obstacles faced by people over 60 in fully participating in the digital world. Although participants reported satisfaction with digital life, personal adaptation, and content diversity, they also expressed dissatisfaction with family guidance, age-friendly digital services, and the role of digital content in improving quality of life.

2.2 Social participation, wellbeing, and mental health

The second thematic area includes papers on how social capital, recreational activities (including the use of the internet and social media), and social relationships influence depression, happiness, and life satisfaction among older adults, with particular attention to mediating mechanisms such as self-perceived aging and life-course experiences.

Cheng et al., through the lens of life course theory, conducted a qualitative study with 16 older adults in China, showing how past experiences of war, famine and political reform have shaped

the participants' current wellbeing and life perspectives. The findings highlight that the life wisdom and happiness of Chinese seniors unfold across three main dimensions: *personal* (rooted in education, family bonds and active social participation); *social* (characterized by an ambivalent perception, combing gratitude for social welfare with concerns about contemporary issues, especially corruption); *temporal* (linked to expectations for younger generations, with a strong sense of responsibility for guiding them, and an emphasis on resilience and the transmission of accumulated wisdom). Overall, the study reveals that older adults transform early-life experiences of suffering into a form of life wisdom, which not only contributes to their own wellbeing, but is also transmitted to younger generations, thereby reinforcing cultural continuity.

Ye et al. focused instead on the role of social capital in psychological wellbeing. They conducted a cross-sectional study of 1,809 community-dwelling older adults in Chengdu and found that levels of depression not only varied according to certain socio-demographic variables (age, marital status, chronic illness, insurance coverage, and income), but that social capital was negatively associated with both self-perceived aging and depression. These results suggest that strengthening social capital—through initiatives such as senior universities, dance and chorus groups, or community sports—and fostering positive perceptions of aging may help to prevent depression.

Also Tao et al.—analyzing data from three periods of the China Health and Aged Care Tracking Survey (CHRLS), collected between 2015 and 2020 on 3,762 adults aged 60 and above—found that both leisure-oriented social activities, as well as internet use have significant protective effect against depression in older adults.

Similarly, Xia et al., analyzing data from the China Health and Retirement Longitudinal Study (CHARLS), which covered 36,934 adults aged 45 and over, found that playing Mahjong or Bridge was linked to higher subjective levels of wellbeing, specifically among those subjects (retired individuals, women, and participants from rural areas and eastern regions of the country) who engaged in these activities more frequently. Promoting diverse cultural and sporting activities within older adult communities could foster socialization, prevent cognitive decline, and ultimately enhance wellbeing.

These studies all emphasize the importance of fostering social relationships and community involvement among older adults. Participating in cultural, recreational, and digital activities, as well as feeling like an active part of a community, is essential for reducing the risk of depression and promoting an active and fulfilling life, even in later years.

2.3 Cognitive stimulation and leisure activities for healthy aging

The third thematic area encompasses studies on training programme and leisure activities designed to enhance cognitive and emotional wellbeing in older populations, including those with intellectual disabilities.

Cavaggioni et al. present a detailed protocol for studying the effects of a visual training programme on cognitive performance and physical fitness in individuals with intellectual disabilities

(ID), hypothesizing greater improvements in cognitive and motor performance compared to usual care. They also expect the protocol to serve as a basis for developing exercise prescription guidelines for individuals with ID, offering therapists a practical and innovative approach, with the main aim of counteracting age-related physical and cognitive decline while promoting healthy aging and social participation.

Guardabassi et al. examined the role of board games in facilitating successful aging. They tested the hypothesis that wellbeing experienced during gameplay is higher than overall daily-life wellbeing, particularly when the games are of low difficulty. To this end, they conducted gaming sessions of varying difficulty with a sample of 132 older adults, divided into groups of four or five, and administered two questionnaires: the first, before each session, assessed general wellbeing; the second, after the session, assessed wellbeing during gameplay. The findings, which confirmed their hypothesis, showed that board games can be considered as a low-cost and easily adoptable intervention to enhance the wellbeing of older adults and to promote intergenerational activities in diverse settings (e.g., families, community centers).

Both studies emphasize the importance of structured, accessible activities, such as visual training or recreational gaming, as a way of sustaining cognitive, physical and emotional wellbeing in aging populations. They demonstrate that tailored, low-cost interventions can mitigate age-related decline and foster an active, meaningful aging process.

3 Conclusion

Although the articles in Volume I of this Research Topic cover diverse topics, a common theme emerges: active aging is closely linked to a sense of belonging to a community (social inclusion) and to social participation, through involvement in recreational, educational, sporting and cultural activities, both in person and online via the internet and digital technologies. Perceiving oneself as an integral part of and taking an active role in a community, both offline and online, appears to be a key factor in enhancing psychological wellbeing, reducing depression and counteracting negative perceptions of the aging process, promoting simultaneously antifragility.

While the contributions collected in this Research Topic highlight a series of conditions that can promote active aging, they also emphasize the persistence of significant obstacles to its achievement, including *ageism* (i.e., "the tendency to be prejudiced against older adults, to negatively stereotype them— e.g., as unhealthy, helpless, or incompetent-, and to discriminate against them, especially in employment and health care," APA Dictionary), *socio-economic inequalities*, the *intergenerational gap* and the *digital divide*. Addressing these challenges requires integrated strategies, that combine educational, social and cultural interventions.

Author contributions

RB: Writing – original draft, Writing – review & editing. CA: Writing – original draft, Writing – review & editing. AF: Writing –

original draft, Writing – review & editing. VG: Writing – original draft, Writing – review & editing. GM: Writing – original draft, Writing – review & editing. PN: Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

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.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

References

Bongelli, R., Busilacchi, G., Pacifico, A., Fabiani, M., Guarascio, C., Sofritti, F., et al. (2024). Caregiving burden, social support, and psychological well-being among family caregivers of older Italians: a cross-sectional study. *Front. Public Health* 12:1474967. doi: 10.3389/fpubh.2024.1474967

Guardabassi, V. (2025). Improving children's attitudes towards older people's competences: a weekly intergenerational summer camp. *BMC Psychol.* 13:542. doi: 10.1186/s40359-025-02806-w

Hutchison, P., and Ewens, E. (2022). "Social inclusion and the role of psychologists," in *Handbook of Social Inclusion: Research and Practices in Health and Social Sciences*, ed. P. Liamputtong (Cham: Springer Nature Switzerland AG), 2157–2173. doi: 10.1007/978-3-030-89594-5_128

Klisanin, D. (2022). "Psychological futures: antifragility and the imperative of interdependence," in *Routledge Handbook for Creative Futures*, eds. G. Donnelly, and A. Montuori (London: Routledge), 336–342. doi: 10.4324/9781003020714-42

Levasseur, M., Lussier-Therrien, M., Biron, M. L., Raymond, É., Castonguay, J., Naud, D., et al. (2022). Scoping study of definitions of social participation: update and co-construction of an interdisciplinary consensual definition. *Age Ageing* 51, 1–13. doi: 10.1093/ageing/afab215

Santini, S., Busilacchi, G., Lamura, G., Sofritti, F., Pacifico, A., Bongelli, R., et al. (2025). Reforming Italy's long-term care system: the role of barriers to and drivers of the use of services at the local level. *Front. Public Health* 13:1575330. doi: 10.3389/fpubh.2025.1575330

Taleb, N. (2014). *Antifragility: Things that Gain from Disorder*. New York, NY: Random House Trade Paperback Edition.

Tan, Y., Bayoumi, I., Knox, B., Cole, M., Jackson, L., Autumn, W., et al. (2025). Understanding social inclusion: a directed content analysis. *PLoS ONE* 20:e0333666. doi: 10.1371/journal.pone.0333666

Aging with board games: fostering well-being in the older population

Veronica Guardabassi ⓘ*, Evelyn Manoni ⓘ, Marta Di Massimo ⓘ, Elisa Cirilli ⓘ, Alessandro Maranesi ⓘ and Paola Nicolini ⓘ

Department of Humanities, University of Macerata, Macerata, Italy

Introduction: The increase in the average age of the population has resulted in a greater focus on interventions designed to facilitate successful Ageing. Notwithstanding its potential, the strategy of the board game remains relatively underexplored. This study aims to ascertain its role in fostering older people's well-being. Specifically, it was hypothesized that the level of well-being associated with the gaming experience is greater than overall well-being, particularly when the level of difficulty is low.

Methods: From an initial number of 164 participants, a total of 132 older people made up the final sample (M_{age} = 74.05; SD = 5.62). They were divided into groups of four or five individuals and engaged in a gaming session of varying levels of difficulty: low (N = 44), medium (N = 49) and high (N = 36). Prior to each game session, participants completed a questionnaire regarding their general well-being. After the game session, they filled out a similar questionnaire regarding their well-being while gaming.

Results: The results showed that the level of well-being experienced while playing was significantly higher than that observed in daily life, $F_{(1,131)}$ = 14.604, p = 0.000, η^2 = 0.100, particularly with board games with a low or medium level of difficulty, [$F_{(2,126)}$ = = 10.982, p = .001, η^2 = 0.148].

Discussion: Board games with an appropriate level of difficulty can be useful tools for promoting wellbeing in the older population. Future studies and possible interventions for people in the third and fourth ages will be discussed.

KEYWORDS

older people, active aging, positive aging, board games, well-being

1 Introduction

Aging is a natural, complex, and heterogeneous phenomenon that involves many aspects of human beings (WHO, 2020) and affects an increasing number of people. WHO estimates that by 2050, one in five people in the world will be over 60 years old, and the number of people over 80 will double (WHO, 2022). Life expectancy is increasing worldwide, making it necessary to manage and promote health among the older population.

1.1 Aging

Globally, aging is one of the most relevant current challenges from both health (e.g., cognitive decline, medical diseases, Dogra et al., 2022) and socioeconomic perspectives (Belachew et al., 2024). Health complications in older people make it imperative to find adequate and sustainable responses to ensure the well-being and quality of life of older people (Marquez et al., 2020). Aging is associated not only with physical decline but also

with social and emotional challenges (Gates et al., 2020). For example, as older people experience reduced physical mobility, they may be at increasing risk of having lower autonomy levels and perceived low control over their lives (Nyende et al., 2023; Ylönen et al., 2024). In addition, they may have lost friends and relatives, be isolated, and have a reduction or lack of positive social relationships, leading to negative feelings and loneliness. These situations can negatively impact perceptions of well-being and quality of life (Abu Elheja et al., 2021). Thus, older people can be at risk of a decline in psychological well-being (Buecker et al., 2023), and interventions to support them and their health are strongly recommended (Luke et al., 2024).

1.2 Active aging

In line with these considerations, the active aging perspective recognizes the aging process not only as a physical and cognitive decline but also as an opportunity to optimize individuals' health and improve quality of life (WHO, 2020) through promoting enjoyment, satisfaction, social fulfillment, and well-being (Goodwin et al., 2023). Indeed, according to the WHO (1948), health is not only the absence of disease but the result of a positive interaction between physical, mental, and social dimensions (Engel, 1977). In other words, health concerns the positive perception of one's general state of physical, psychological, and relational well-being. Interventions to promote successful aging aim to foster psychophysical well-being by promoting healthy lifestyles, such as good nutrition, physical activity, cognitive stimulation, and social participation (Belachew et al., 2024). Several studies found that living in one's own home for as long as possible (Ylönen et al., 2024), having autonomy in making life choices, and being able to use urban and extra-urban green spaces contribute to a sense of security, opportunities for social interaction, and well-being in older people (Fowler Davis et al., 2024; Hodgson et al., 2023; Sixsmith et al., 2023). Other research has found that expressive and creative activities such as art, dance, and yoga have positive effects on both cognitive and socio-affective dimensions (Chiang et al., 2024; Crealey et al., 2023; McQuade and O'Sullivan, 2023; Wang et al., 2021; Yang et al., 2021; Azman et al., 2017). The literature highlights that active aging interventions have multiple beneficial outcomes, including improved physical function, cognitive function, mental health, social health, and sleep (Dogra et al., 2022). Active aging interventions are associated with life satisfaction (Marsillas et al., 2017), positive quality of life (Cunningham et al., 2020), good social relationships, and well-being (Bruine de Bruin et al., 2020; Cresswell-Smith et al., 2019). Therefore, research into new strategies to foster well-being for older people is strongly encouraged and recommended, and board games can be used for this purpose.

1.3 Game-based activities and well-being

Play has always been an integral part of human culture, so much so that it can be considered one of the most important human experiences, extending well beyond childhood. Engaging in play is vital for physical, mental, and emotional well-being, serving as a powerful stimulus from cognitive, social, emotional, and ethical perspectives (Bruner et al., 1976; Piaget, 1945; Vygotskij, 1934; Winnicott, 1971). In addition, playing is considered a powerful tool to increase individuals' intrinsic motivation (Caillois, 1958) and achieve a mental state of flow (Csikszentmihalyi, 1975), especially when games are designed with an appropriate level of difficulty (Hattie et al., 2020; Ryan and Deci, 2020; Ryan et al., 2006; Csikszentmihalyi, 1990).

For example, Gerling et al. (2012) suggested that games for older people should be easy to understand to facilitate interaction without adding to cognitive load. In line with this, Skjæret-Maroni et al. (2016) found a slight decrease in performance when participants transitioned from the first to the second difficulty level of an exergame, indicating a potential decline in motivation and an increase in mind wandering (Thomson et al., 2015), which contrasts with the flow state. Furthermore, Chen and Janicki (2020) found that older participants felt proud and satisfied after engaging in a challenging game, emphasizing that personal experiences with board games significantly influence outcomes: mastering a game is positively associated with achieving a state of flow (Hodent, 2017).

For these reasons, adequate game-based activities may be a useful strategy to promote active aging (Aguirre-Cardona and Mendoza-Espinel, 2022).

Most interventions implemented through games are based on digital games (Afridi et al., 2021; Alhasan et al., 2017; Ayed et al., 2019; Campo-Prieto et al., 2021). Literature has shown that digital games have a positive impact on cognitive functioning (Anguera et al., 2021; Bonnechère et al., 2021; Torres, 2011; Hou and Li, 2022) and contribute to reducing feelings of social isolation and symptoms of depression (Cicek et al., 2020; de Morais et al., 2020; Antunes et al., 2017; Khosravi et al., 2016), as well as increasing individuals' self-efficacy (Czaja et al., 2018) and well-being (Kaufman et al., 2018; Lee et al., 2021; Mclaughlin et al., 2018; Seah et al., 2018).

However, the majority of older people spend their time with non-digital forms of gaming (Mortenson et al., 2017). Studies have shown that non-digital forms of gaming lead to benefits in terms of socialization, quality of life, depression symptoms, and feelings of loneliness (Hallgren et al., 2020; Mortenson et al., 2017; Yu et al., 2023). Within this group of games are the board games. Although they are used more as an extended strategy to counteract cognitive decline and train cognitive functions (Ching-Teng, 2019; Estrada-Plana et al., 2021; Chen and Tsai, 2022) or to reduce negative psychopathological symptoms (e.g., depression, Lee et al., 2020), some studies have investigated the role of board games in promoting physical and psychological health.

Indeed, board games are considered useful tools to improve people's health (e.g., Nakao, 2019; Gauthier et al., 2019), and positive results have been obtained in older people. Diniz et al. (2022) obtained positive results using a board game to prevent falls in older people, which are very common and dangerous in this population, while Tsai et al. (2024) designed a board game that was effective in increasing knowledge, attitudes and preventive behaviors regarding osteoporosis. Board games are also seen as a way of socializing; older people consider playing an opportunity to spend time and create new social relations (Cousins and Witcher, 2007) or to strengthen social relations (Outley and McKenzie, 2007). Consistent results have also been found by Chen and Tsai (2022); they conducted research aimed at investigating the effectiveness of board games in improving interpersonal communication, interpersonal relationships, and self-efficacy, as well as reducing loneliness. The board game involved four life themes (thank you, sorry, love, and goodbye) and took place in a center for older people for 4 weeks. The results showed significant improvements in interpersonal communication, self-efficacy, and

perceived loneliness at the end of the intervention, suggesting that board games should be used in projects aimed at promoting the well-being of older people.

In contrast, Estrada-Plana et al. (2021) found a different result in their study; they conducted a pilot study that included 35 participants who played modern board and card games (experimental group) or performed paper-pencil cognitive tasks (control group) to investigate the effects of board games on executive functions, depressive symptoms and quality of life in healthy older people aged 65 years and over. The intervention sessions took place twice a week for 5 weeks. They showed that board and card games can effectively stimulate cognitive functions but not satisfaction with the health or quality of family relationships. However, according to the authors, the type of game played and different sample compositions may explain the results. More recently, Bodner et al. (2024) investigated the effect of a make-believe game on the well-being and loneliness of older people; they used this board game for 3 months (once a week) in small groups of 4 or 5 people and found that, unlike participants in the control group, older people who played the Kioku board game showed increased well-being and reduced feelings of loneliness.

To conclude, board games may contribute significantly to promoting health, stimulating cognitive functions, and strengthening social relationships among older people. They appear to serve as a valuable coping strategy that can help older individuals manage the challenges associated with aging, such as physical illnesses, cognitive decline, and social isolation, ultimately fostering their overall well-being.

1.4 The present study

The older population is constantly increasing, resulting in demographic, epidemiological, and anthropological changes (WHO, 2022). This demographic shift underscores the importance of adopting positive aging experiences. Several programs have been implemented to achieve this goal (Belachew et al., 2024), but few studies have investigated the role of play activities despite their positive effects from a cognitive, social, and emotional point of view (Chen and Tsai, 2022; Mortenson et al., 2017). This study fills this gap in the literature by exploring the role of board games in promoting well-being in older people, a psychological dimension related to positive aging (Bruine de Bruin et al., 2020; Cresswell-Smith et al., 2019).

Evidence from the literature shows that board games promote well-being in children (Dell'Angela et al., 2020; Gashaj et al., 2021; Zaharia et al., 2022) and young adults (Gonzalo-Iglesia et al., 2018; Kloep et al., 2023), and have a positive impact on physical health, cognitive function and socialisation in older people (e.g., Bodner et al., 2024; Chen and Tsai, 2022; Diniz et al., 2022; Lee et al., 2020). Therefore, it was hypothesized that participation in board games would increase well-being in older people, i.e., gaming well-being is significantly higher than general well-being (H1). Furthermore, previous studies have found that a positive game experience is associated with an appropriate level of difficulty (Csikszentmihalyi, 1990; Hattie et al., 2020; Ryan and Deci, 2020; Ryan et al., 2006), especially for games with a low level of difficulty and low cognitive effort (Gerling et al., 2012; Skjæret-Maroni et al., 2016) or with a challenging game (Chen and Janicki, 2020). Thus, it was expected that older people, novice players with

low board game skills (Hodent, 2017), would experience high levels of well-being when playing a board game with an easy or medium level of difficulty (H2).

2 Methods

2.1 Participants and procedure

Data were collected as part of a larger investigation into the psychological and cognitive dimensions of play across the lifespan. The study was approved by the Ethical Commitment of the University of Macerata, and participants consented to take part in the study.

Based on *a priori* sample computation (repeated measure ANOVA: 3×2; power test: 0.8; effect size: 0.25; significant level: 0.005; type of effect: interaction effect), a sample of 157 people was planned. Thus, a total of 164 older people and members of Community Centres for the Third Age were invited to participate. Specifically, they were aged 65 years or over, according to the definition of older people by ISS (2014), and they were regular and active participants in the Community Centre's activities, with no experience with board games (people with a diagnosis of dementia were not included in this study). Two team researchers went to the Community Centre ($N=12$) to implement the study. They first introduced the research to inform older adults, obtained their consent to participate, and explained the data handling process. Then, the researchers invited the participants to form small groups of 4–5 people and sit around small tables to start the research session (1.5 h).

At the beginning, the participants filled out a questionnaire about their personal information and general well-being. Then, each group was given a board game to play. Three board games with different levels of complexity were used. Participants in the low-complexity condition played a game of chance, i.e., a game with simple rules and dependent on luck ($N=51$). The medium complexity level had skill or learning games with rules that required participants to memorize new words, pay attention to symbols, or guess a name using deductions ($N=57$). Participants who played the high-complexity game ($N=52$) had a strategy game with rules such as working together to solve logical-mathematical puzzles, choosing the better way to play according to the situation, or acquiring clues to continue the game. At the end, participants answered a questionnaire about their well-being during the game and expressed their satisfaction with the experience. All older adults participated in the entire study session, but some participants did not answer all questions of the well-being questionnaire. Thus, the final sample consisted of 132 older people ($M_{age}=74.05$ years old, $SD=5.62$; $Min_{age}=65$; $Max_{age}=89$) who played the board game of low ($N=44$), medium ($N=49$), and high ($N=36$) difficulty.

2.2 Measures

2.2.1 Information about participants

To obtain general information about the participants, data were collected on gender, year of birth, nationality, retirement status (not retired; <1 year; <5 years; for 5 years; more than 5 years), marital status (single, married, divorced, widow/widower), number of sons/daughters and grandchildren. The level of education was also examined (primary school, middle school, high school, bachelor's, master's, postgraduate specialization). This variable was categorized as "educational level" with

primary school equating to 5 years of education. Secondary school corresponded to 8 years of education and so on.

2.2.2 General well-being

The WHO-5 questionnaire (WHO, 1998) is a unidimensional measure of psychological well-being that refers to participants' experiences over the last 2 weeks. It consists of five items: (1) I have felt cheerful and in good spirits; (2) I have felt calm and relaxed; (3) I have felt active and vigorous; (4) I woke up feeling fresh and rested; (5) My daily life has been filled with things that interest me. Participants indicate their level of agreement using a 6-point Likert scale, ranging from 0 (never) to 5 (always). The final score corresponds to the mean of each response, and a higher score corresponds to a better assessment of one's well-being. Cronbach's alpha was 0.857.

2.2.3 Gaming well-being

Game-related well-being results from an adaptation of the WHO-5 questionnaire (WHO, 1998). It proposes the same five questions about the participants' feelings during the game: (1) I have felt cheerful and in good spirits; (2) I have felt calm and relaxed; (3) I have felt active and vigorous; (4) I have felt fresh and relaxed; (5) The game has been filled with things that interest me. Participants answered by using the 6-point Likert scale of WHO-5 (WHO, 1998), and the same scoring method was adopted. The reliability of the questionnaire was equal to 0.872.

2.2.4 Satisfaction questionnaire

The Satisfaction Questionnaire was an *ad hoc* instrument designed to explore participants' level of satisfaction with their gaming experience. Using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), participants expressed their level of agreement with seven statements about feeling competent, having fun, enjoying spending time with friends, age appropriateness of the activity, interest, gratitude, and wanting to repeat the experience. The score on the satisfaction questionnaire is the mean score on the scale, which has a reliability of 0.592.

2.3 Data analyses

Statistical analyses were performed using SPSS 25. Descriptive and correlational analyses were performed between the main variables, and an ANOVA was conducted to know about group differences. Repeated-measures ANOVA was used to identify differences between participants' general well-being and gaming well-being. ANOVA analysis was also used to investigate differences in satisfaction according to the game's complexity level.

3 Results

3.1 Descriptive and correlational data

Among the 132 participants (88 women, 44 men), 129 were Italian, while 2.3% had not provided the information. Regarding retirement status, 9.8% had been retired for 1 year, 7.6% for <5 years, 2.3% for 5 years, while 58.3% had been retired for more than 5 years (9.1% were not retired and 12.2% were missing). Responses regarding

marital status indicated that 6.1% of participants were single, 53.8% were married, 7.6% were divorced, and 21.2% were widows/widowers. Table 1 summarizes the means and bivariate correlations between the main variables.

Concerning group composition (see Table 2), ANOVA analyses showed no differences among groups, except for participants' age [$F_{(2, 126)} = 3.987$, $p = 0.021$]. Specifically, participants who played with a low level of difficulty were older ($M = 75.81$; $SD = 5.78$) than participants who were in the highly difficult board game ($M = 72.66$; $SD = 5.33$; $p = 0.031$).

3.2 Well-being and gaming well-being

Repeated-measures ANOVA showed that general well-being ($M = 2.82$; $SD = 1.15$) was significantly lower than gaming well-being ($M = 3.37$; $SD = 1.41$) [$F_{(1, 131)} = 14.604$, $p = 0.000$, $\eta^2 = 0.100$].

An effect of board-game level of complexity was also found [$F_{(1, 126)} = 10.982$, $p = 0.000$, $\eta^2 = 0.148$]. Indeed, post-hoc analyses suggest that participants who played board games of easy, $F_{(1, 126)} = 13.967$, $p = 0.000$, $\eta^2 = 0.098$, or medium, $F_{(1, 126)} = 22.208$, $p = 0.000$, $\eta^2 = 0.150$, level of difficulty presented a gaming well-being significantly higher than general well-being. This difference was not significant in participants with highly difficult board games [$F_{(1, 126)} = 3.128$, $p = 0.079$, $\eta^2 = 0.024$]. Table 3 describes these results.

In addition, post-hoc analyses revealed that the general well-being of participants in easy ($M = 2.81$; $SD = 1.27$), medium ($M = 2.75$; $SD = 1.16$), and high ($M = 2.90$; $SD = 1.06$) levels of difficulty was not significantly different [$F_{(2, 126)} = 0.148$, $p = 0.862$, $\eta^2 = 0.002$]. Instead, participants' gaming well-being changes according to the level of game difficulty [$F_{(2, 126)} = 13.459$, $p = 0.000$, $\eta^2 = 0.176$]. Results showed that participants who played a game of high level of difficulty had a level of gaming well-being ($M = 2.43$; $SD = 1.48$) lower than that of older people who played with medium ($M = 3.81$; $SD = 1.85$; $p = 0.000$) or easy levels of game difficulty ($M = 3.69$; $SD = 1.18$; $p = 0.000$). No differences in gaming well-being were found between participants who played with easy and medium levels of difficulty ($p = 0.653$).

Repeated analysis of ANOVA, controlling for age and educational level, revealed that well-being level did not significantly change from general to gaming experience: $F_{well-being}$ $(1,119) = 0.012$, $p = 0.915$, $\eta^2 = 0.000$; $F_{ageXwell-being}$ $(1,119) = 0.09$, $p = 0.925$, $p^2 = 0.000$; $F_{educationalLevelXwell-being}$ $(1,119) = 1.22$, $p = 0.270$, $\eta^2 = 0.010$. However, the effect of board game level of difficulty was significant, $F_{(2,119)} = 11.740$, $p = 0.000$, $\eta^2 = 0.165$, and post-hoc analyses showed significant effects (see Table 4).

Gaming well-being was higher than general well-being when the board game had an easy, $F_{(1,119)} = 12.647$, $p = 0.001$, $\eta^2 = 0.096$, or medium level of difficulty, $F_{(1,119)} = 21.375$, $p = 0.000$, $\eta^2 = 0.152$, whereas it was significantly lower with a high level of difficulty [$F_{(1, 119)} = 4.669$, $p = 0.033$, $\eta^2 = 0.038$]. Furthermore, gaming well-being significantly changed with board game difficulty level, $F_{(2, 119)} = 17.294$, $p = 0.000$, $\eta^2 = 0.225$: gaming well-being reported by participants who played with high difficult games was significantly lower compared to the other two groups ($p_{low level} = 0.000$; $p_{medium level} = 0.000$).

3.3 Satisfaction and board game type

ANOVA analyses showed that participants who played high-difficulty games reported the highest satisfaction with the experience

TABLE 1 Descriptive data and correlational analyses.

	M (SD)	Bivariate correlations					
		2	3	4	5	6	7
1. Age	74.05 (5.62)	−0.289**	0.198*	0.163	−0.143	−0.137	−0.146
2. Educational level	10.42 (4.37)	–	−0.027	−0.001	0.036	0.071	0.040
3. Son/Daughter	1.50 (0.98)	–	–	0.177	0.058	−0.040	−0.056
4. Grandchildren	1.32 (1.43)	–	–	-	−0.010	−0.173	−0.379**
5. General well-being	2.82 (1.15)	–	–	–	–	0.164	0.125
6. Gaming well-being	3.37 (1.41)	–	–	–	–	–	0.370**
7. Satisfaction	3.90 (0.47)	–	–	–	–	–	–

*Significant at the level of 0.05 (2-tails) **Significant at the level of 0.01 (2-tails).

$[F_{(2, 86)} = 3.178, p = 0.047]$. Their satisfaction ($M = 4.08$; $SD = 0.47$) was higher than participants in medium ($M = 3.84$; $SD = 0.38$) and low ($M = 3.78$; $SD = 0.43$) game level conditions. In addition, post-hoc analyses showed no variance between medium and low levels of difficulty ($p = 0.600$) but significant differences between participants who played with the high levels of difficulty compared to the medium ($p = 0.021$) or low levels ($p = 0.044$).

4 Discussion

This study investigated the role of board games as a viable tool to promote the well-being of older people and, consequently, to promote positive aging. Confirming the hypotheses of this study, the results showed that well-being during a single game was higher than general well-being, especially when board games had a low or medium level of difficulty.

The literature on play activities has provided evidence of the impact of board games on psychological well-being. Indeed, several studies have investigated the role of gaming experiences on children's emotional development (Zaharia et al., 2022; Dell'Angela et al., 2020), university students' well-being (Guardabassi et al., 2024) or adults' flow state (Khan and Pearce, 2015; Kloep et al., 2023). However, there is very little research on older people. Furthermore, the majority of studies on older people and play activities have mainly focused on cognitive performance (Ching-Teng, 2019; Estrada-Plana et al., 2021; Chen and Tsai, 2022), and the few investigations on the effects of board games on psychological health have shown contrasting results. For example, Estrada-Plana et al. (2021) found no significant differences in depressive symptoms and quality of life after weeks of board game sessions, whereas results from Chen and Tsai (2022), Bodner et al. (2024), or Lee et al. (2020) suggested that board games improved interpersonal communication, self-efficacy, and well-being and reduced depression symptoms in older people. This study integrates these contradictions by showing that the positive effects of board games depend on the level of complexity of the board game.

Moreover, in line with previous studies that emphasized the importance of game complexity level to motivate participants (Hattie et al., 2020; Ryan and Deci, 2020; Ryan et al., 2006), to have an optimal game experience (Csikszentmihalyi, 1990), board games are only effective when the level of complexity is not high. Just as simple digital games are more effective in older participants (Gerling et al., 2012; Skjæret-Maroni et al., 2016), older people who played the low-difficulty board game showed a higher gaming well-being than general well-being. Indeed, people who played a board game for the first time could mostly benefit from an easy and comfortable game (Hodent, 2017). However, older people also enjoyed playing a board game with a medium level of difficulty. Similar to the digital puzzle in Chen and Janicki's (2020) study, it probably represents a good mix of difficulty and the opportunity to gradually grasp the game's goals. The most difficult board game, with complex problem-solving activities, was perceived to be beyond the participants' possibility [i.e. beyond the zone of proximal development (Vygotskij, 1934)], and less enjoyable to play.

The results of this study have also enriched the literature on positive aging (e.g., Belachew et al., 2024), especially the area dealing with active sedentary activities (e.g., Hallgren et al., 2020; Kikuchi et al., 2014). In addition to physical or recreational activities (Dogra et al., 2022), board games with an appropriate level of difficulty can be included in positive aging programs for the well-being of older people. The results also suggest that participants were satisfied with their gaming experience, particularly older people who played the most difficult board game and reported lower levels of gaming well-being. This difference could be explained by cognitive dissonance theory (Festinger, 1962), but it should also be understood by considering gaming well-being and participant satisfaction as two different dimensions.

Although this study filled a gap in the literature and offered a new perspective on positive aging, its limitations should be considered. Firstly, no group tested a condition without any game-based activities or experienced the game activity in a different context. However, three different game conditions make it possible to understand the phenomenon and formulate considerations regarding board game types. Second, the mean age of participants in the game groups was different. Nevertheless, in the most challenging conditions, there were younger people who should feel less threatened by the level of difficulty, according to ageism stereotypes (Kang and Kim, 2022). Despite this, they were the most negatively affected. Thirdly, the final sample was less numerous due to missing data, and smaller groups reduced the test power. In addition, groups in the final sample did not have the same number of participants. Specifically, the high-difficulty condition has the largest number of missing responses, as 10 older people did not complete the final questionnaire correctly. However, despite the fewer participants in this condition, this behavior may represent another index of boredom or low motivation induced by high-difficulty games. Fourthly, the gaming well-being and satisfaction

TABLE 2 Group composition: means, standard deviations, and mean differences.

	Level of difficulty				
	Low	Medium	High		
	M (SD)	M (SD)	M (SD)	F	p
Age	75.81 (5.78)	73.32 (5.06)	72.66 (5.33)	3.978	0.021
Educational level	10.59 (4.79)	9.50 (4.03)	11.75 (4.07)	2.622	0.077
Son/Daughter	1.78 (0.96)	1.26 (1.00)	1.56 (0.97143)	2.763	0.068
Grandchildren	1.41 (1.49)	1.24 (1.46)	1.36 (1.40156)	0.140	0.869

*Significant at the level of 0.05 (2-tails) **Significant at the level of 0.01 (2-tails).

TABLE 3 Gaming well-being and level of difficulty.

	General well-being		Gaming well-being		MD	F	p	η^2
	M	SD	M	SD				
Playing with board games	2.82	1.15	3.37	1.41	+0.488	14.604	0.000	0.100
Playing and game-level								
Low level	2.81	1.27	3.69	1.18	+0.873	13.967	0.000	0.098
Medium level	2.75	1.16	3.81	1.85	+1.053	22.208	0.000	0.150
High level	2.90	1.06	2.43	1.48	−0.461	3.128	0.079	0.024

MD, mean difference.

TABLE 4 Well-being and level of difficulty: *post-hoc* analyses.

	General well-being		Gaming well-being		MD	F	p	η^2
	M	SD	M	SD				
Low level	2.81	1.27	3.69	1.18	+0.873	13.967	0.001	0.096
Medium level	2.76	1.17	3.80	1.26	+1.001	22.208	0.000	0.152
High level	2.87	1.12	2.31	1.50	−0.616	3.128	0.031	0.038

MD, mean difference.

questionnaires were not standardized or measures used in previous studies. Nevertheless, the reliability of the gaming well-being scale is satisfactory, and the satisfaction questionnaire was used for descriptive purposes. Fifth, gaming well-being corresponds more to hedonic well-being, i.e., physical and emotional pleasure, than to eudemonic well-being, i.e., satisfaction and consistency with one's values (Huta and Ryan, 2010). Although hedonic well-being is useful in reducing negative emotions such as depression or stress (Henderson et al., 2013), which is critical in older people (Hu et al., 2022), there is no evidence of its effects over the long term. Sixth, there was no manipulation check after the game experiences to verify the perception of the level of difficulty. However, the research team organized 14 telephonic interviews and two debriefing groups to better understand the study's results. Participants considered the game with a high level of difficulty too complicated for older people; the game with a medium level was evaluated as difficult but interesting, whereas the easy game was considered a little childish.

Future studies can overcome these limitations and develop new research designs. For example, longitudinal studies can provide an opportunity to explore the long-term effects of game-based experiences on well-being and to extend the findings of Bodner et al. (2024) by investigating the role of different types of board games. Other unexplored dimensions such as social

relationships, life satisfaction, or health-related quality of life may also be new unknown outcomes. Gaming activities are also related to psychological satisfaction, flow state, and cognitive stimulation (Errity et al., 2016). These outcomes should also be investigated in the older population. Otherwise, action research can be useful in developing board games in collaboration with older people: products should be able to respond to older people's needs and be specific to their age. For example, Fernandes et al. (2023) created a board game called "The Ark of Rights" with older people, and the game successfully empowered older people regarding their rights. Similar research may be useful in identifying new strategies to promote the well-being of older people. The motivations and interests of older people should not be underestimated. Indeed, the game's content and people's interests may moderate the relationships between board games and older people's well-being, and future studies should also focus on these variables.

The results are particularly important because board games can be a low-cost intervention to promote the well-being of older people. They can be easily adopted by social community centers, and playing board games can become a routine practice. Similarly, board games can also be used in family or other social contexts, as they provide a common platform for younger and older people,

and intergenerational activities have a positive impact on the health of individuals (Cès et al., 2024; Canedo-Garcia et al., 2017) and on age-related attitudes (WHO, 2023). However, given the importance of choosing the right board game with an appropriate level of difficulty, play educators represent a very important professional figure: they can be beneficiaries of specific training programs and leaders of board game activities with older people as players.

In conclusion, board games can effectively promote positive aging, provided that an appropriate difficulty level is selected. Offering board games with varying and progressively challenging difficulty levels could enhance engagement, and involving experts in game selection and facilitation would further optimize these activities for older adults.

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 the Research Ethics Committee of the University of Macerata. 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 because, after reading the informed consent and data treatment form, people proceeded to fill out the questionnaire as a form of consent to participate.

Author contributions

Funding

Conflict of interest

The author(s) declare that this study received funding from Clementoni S.p.A. Clementoni S.p.A provided board games, covered material and mobility costs, and collaborated in research dissemination activities, and public engagement. The funder was updated about the study progress, but was not involved in the study design, collection, analysis, the writing of this article, or the decision to submit it for publication.

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

Abu Elheja, R., Palgi, Y., Feldman, R., Zagoory-Sharon, O., Keisari, S., and Shamay-Tsoory, S. G. (2021). The role of oxytocin in regulating loneliness in old age. *Psychoneuroendocrinology* 133:105413. doi: 10.1016/j.psyneuen.2021.105413

Afridi, A., Rathore, F. A., and Nazir, S. N. B. (2021). Wii fit for balance training in elderly: a systematic review. *J. Coll. Physicians Surg. Pak.* 31, 559–566. doi: 10.29271/jcpsp.2021.05.559

Aguirre-Cardona, L. A., and Mendoza-Espinel, L. E. (2022). Game, toy, and elderly. A necessary approach from a systematic review. San Javier Murcia: FEADEF.

Alhasan, H., Hood, V., and Mainwaring, F. (2017). The effect of visual biofeedback on balance in elderly population: a systematic review. *Clin. Interv. Aging* 12, 487–497. doi: 10.2147/CIA.S127023

Anguera, J. A., Schachtner, J. N., Simon, A. J., Volponi, J., Javed, S., Gallen, C. L., et al. (2021). Long-term maintenance of multitasking abilities following video game training in older adults. *Neurobiol. Aging* 103, 22–30. doi: 10.1016/j.neurobiolaging.2021.02.023

Antunes, T. P. C., Oliveira, A. S. B. D., Crocetta, T. B., Antão, J. Y. F. D. L., Barbosa, R. T. D. A., Guarnieri, R., et al. (2017). Computer classes and games in virtual reality environment to reduce loneliness among students of an elderly reference center: study protocol for a randomized cross-over design. *Medicine* 96:e5954. doi: 10.1097/MD.0000000000005954

Ayed, I., Ghazel, A., Jaume-i-Capó, A., Moyà-Alcover, G., Varona, J., and Martínez-Bueso, P. (2019). Vision-based serious games and virtual reality systems for motor rehabilitation: a review geared toward a research methodology. *Int. J. Med. Inform.* 131:103909. doi: 10.1016/j.ijmedinf.2019.06.016

Azman, N., Suzuki, K., Suzuki, T., Ono, Y., Edanaka, Y., Kunieda, F., et al. (2017). Effect of dance video game training on elderly cognitive function (proc). *Jap. Soc. Med. Biol. Eng.* 55, 526–529. doi: 10.11239/jsmbe.55Annual.526

Belachew, A., Cherbuin, N., Bagheri, N., and Burns, R. (2024). A systematic review and Meta-analysis of the socioeconomic, lifestyle, and environmental factors associated with healthy aging in low and lower-middle-income countries. *J. Pop. Aging* 17, 365–387. doi: 10.1007/s12062-024-09444-x

Bodner, E., Segev, A., Chernitsky, R., and Barak, Y. (2024). Playing Kioku reduces loneliness in older adults: a pilot study. *Games Health J.* doi: 10.1089/g4h.2023.0130

Bonnechère, B., Klass, M., Langley, C., and Sahakian, B. J. (2021). Brain training using cognitive apps can improve cognitive performance and processing speed in older adults. *Sci. Rep.* 11:12313. doi: 10.1038/s41598-021-91867-z

Bruine de Bruin, W., Parker, A. M., and Strough, J. (2020). Age differences in reported social networks and well-being. *Psychol. Aging* 35, 159–168. doi: 10.1037/pag0000415

Bruner, J. S., Jolly, A., and Sylva, K. (1976). Play, its role in development and evolution. London: Penguin Books Ltd.

Buecker, S., Luhmann, M., Haehner, P., Bühler, J. L., Dapp, L. C., Luciano, E. C., et al. (2023). The development of subjective well-being across the life span: a meta-analytic review of longitudinal studies. *Psychol. Bull.* 149, 418–446. doi: 10.1037/bul0000401

Caillois, R. (1958). Théorie des jeux. *Rev. Metaphys. Morale* 63, 83–102.

Campo-Prieto, P., Rodríguez-Fuentes, G., and Cancela-Carral, J. M. (2021). Immersive virtual reality exergame promotes the practice of physical activity in older people: an opportunity during COVID-19. *Multimodal Technol. Int.* 5:52. doi: 10.3390/mti5090052

Canedo-Garcia, A., Garcia-Sanchez, J. N., and Pacheco-Sanz, D. I. (2017). A systematic review of the effectiveness of intergenerational programs. *Front. Psychol.* 8:1882. doi: 10.3389/fpsyg.2017.01882

Cès, P., Duflos, M., Tricard, E., Jhean-Larose, S., and Giraudeau, C. (2024). Playing board games to increase emotional competencies in school-age children and older people: a systematic review. *Leis. Sci.* 24, 1–24. doi: 10.1080/01490400.2024.2373415

Chen, Y. F., and Janicki, S. (2020). A cognitive-based board game with augmented reality for older adults: development and usability study. *JMIR Serious Games* 8:e22007. doi: 10.2196/22007

Chen, M.-F., and Tsai, C.-C. (2022). The effectiveness of a thanks, sorry, love, and farewell board game in older people in Taiwan: a quasi-experimental study. *Int. J. Environ. Res. Public Health* 19:3146. doi: 10.3390/ijerph19053146

Chiang, L., Cheong, D., Cordato, N. J., and Smerdely, P. (2024). Visual art therapy and its effects in older people with mild cognitive impairment: a systematic review. *Int. J. Geriatr. Psychiatry* 39:e6053. doi: 10.1002/gps.6053

Ching-Teng, Y. (2019). Effect of board game activities on cognitive function improvement among older adults in adult day care centers. *Soc. Work Health Care* 58, 825–838. doi: 10.1080/00981389.2019.1656143

Cicek, A., Ozdincler, A. R., and Tarakci, E. (2020). Interactive video game-based approaches improve mobility and mood in older adults: a nonrandomized, controlled trial. *J. Bodyw. Mov. Ther.* 24, 252–259. doi: 10.1016/j.jbmt.2020.01.005

Cousins, S. O. B., and Witcher, C. S. (2007). Who plays bingo in later life? The sedentary lifestyles of 'little old ladies'. *J. Gambl. Stud.* 23, 95–112. doi: 10.1007/s10899-006-9030-8

Crealey, G., McQuade, L., O'Sullivan, R., and O'Neill, C. (2023). Arts and creativity interventions for improving health and wellbeing in older adults: a systematic literature review of economic evaluation studies. *BMC Public Health* 23:2496. doi: 10.1186/s12889-023-17369-x

Cresswell-Smith, J., Amaddeo, F., Donisi, V., Forsman, A. K., Kalseth, J., Martin-Maria, N., et al. (2019). Determinants of multidimensional mental wellbeing in the oldest old: a rapid review. *Soc. Psychiatry Psychiatr. Epidemiol.* 54, 135–144. doi: 10.1007/s00127-018-1633-8

Csikszentmihalyi, M. (1975). Beyond boredom and anxiety. San Francisco, CA: Jossey-Bass.

Csikszentmihalyi, M. (1990). Literacy and intrinsic motivation. *Daedalus* 12, 115–140.

Cunningham, C., O'Sullivan, R., Caserotti, P., and Tully, M. A. (2020). Consequences of physical inactivity in older adults: a systematic review of reviews and meta-analyses. *Scand. J. Med. Sci. Sports* 30, 816–827. doi: 10.1111/sms.13616

Czaja, S. J., Boot, W. R., Charness, N., Rogers, W. A., and Sharit, J. (2018). Improving social support for older adults through technology: findings from the PRISM randomized controlled trial. *The Gerontologist* 58, 467–477. doi: 10.1093/geront/gnw249

De Morais, M. A., De Lima, B. E., and Bandeira Santos, L. C. (2020). Acute effect of Xbox exercise on mood states in older adults. *Act. Adapt. Aging* 44, 146–156. doi: 10.1080/01924788.2019.1618689

Dell'Angela, L., Zaharia, A., Lobel, A., Vico Begara, O., Sander, D., and Samson, A. C. (2020). Board games on emotional competences for school-age children. *Games Health J.* 9, 187–196. doi: 10.1089/g4h.2019.0050

Diniz, J. L., Coutinho, J. F. V., Marques, M. B., Santos, I. D. S., Barbosa, R. G. B., Silva, R. D. R. L., et al. (2022). Development and testing of the Prev'Quedas game for older adults in the community: a descriptive study. *Rev. Bras. Enferm.* 75:e20220098. doi: 10.1590/0034-7167-2022-0098

Dogra, S., Dunstan, D. W., Sugiyama, T., Stathi, A., Gardiner, P. A., and Owen, N. (2022). Active aging and public health: evidence, implications, and opportunities. *Annu. Rev. Public Health* 43, 439–459. doi: 10.1146/annurev-publhealth-052620-091107

Engel, G. L. (1977). The need for a new medical model: a challenge for biomedicine. *Science* 196, 129–136. doi: 10.1126/science.847460

Errity, A., Rooney, B., and Tunney, C. (2016). "Gaming" in An introduction to cyberpsychology. eds. I. Connolly, M. Palmer, H. Barton and G. Kirwan (London: Routledge), 257–270.

Estrada-Plana, V., Montanera, R., Ibarz-Estruga, A., March-Llanes, J., Vita-Barrull, N., Guzmán, N., et al. (2021). Cognitive training with modern board and card games in

healthy older adults: two randomized controlled trials. *Int. J. Geriatr. Psychiatry* 36, 839–850. doi: 10.1002/gps.5484

Fernandes, C. S., Neto, C., Silva, C., Dionísio, S., Oliveira, S., Amorim, I., et al. (2023). "The ark of rights": development of a board game to empower older adults regarding their rights. *J. Aging Longevity* 3, 107–115. doi: 10.3390/jal3010009

Festinger, L. (1962). Cognitive dissonance. *Sci. Am.* 207, 93–106. doi: 10.1038/scientificamerican1062-93

Fowler Davis, S., Benkowitz, C., Nield, L., and Dayson, C. (2024). Green spaces and the impact on cognitive frailty: a scoping review. *Front. Public Health* 11:1278542. doi: 10.3389/fpubh.2023.1278542

Gashaj, V., Dapp, L. C., Trninic, D., and Roebers, C. M. (2021). The effect of video games, exergames and board games on executive functions in kindergarten and 2nd grade: an explorative longitudinal study. *Trends Neurosci. Educ.* 25:100162. doi: 10.1016/j.tine.2021.100162

Gates, N. J., Rutjes, A. W., Di Nisio, M., Karim, S., Chong, L.-Y., March, E., et al. (2020). Computerised cognitive training for 12 or more weeks for maintaining cognitive function in cognitively healthy people in late life. *Cochrane Database Syst. Rev.* 2020:CD012277. doi: 10.1002/14651858.CD012277.pub3

Gauthier, A., Kato, P. M., Bul, K. C., Dunwell, I., Walker-Clarke, A., and Lameras, P. (2019). Board games for health: a systematic literature review and meta-analysis. *Games Health J.* 8, 85–100. doi: 10.1089/g4h.2018.0017

Gerling, K. M., Schulte, F. P., Smeddinck, J., and Masuch, M. (2012). "Game design for older adults: effects of age-related changes on structural elements of digital games," in *Entertainment computing-ICEC 2012: 11th International Conference, ICEC 2012, Bremen, Germany, September 26–29, 2012. Proceedings 11.* Berlin: Springer Berlin Heidelberg, 235–242.

Gonzalo-Iglesia, J. L., Lozano-Monterrubio, N., and Prades-Tena, J. (2018). The usage of game-based learning in university education. How to motivate and foster creativity among adult students through board games. *Proc. Play2Learn* 4, 67–84.

Goodwin, V. A., Hall, A. J., Bethel, A., Taylor, E., Tatnell, L., Turner, M., et al. (2023). Understanding joy amongst older people: a scoping review. *Arch. Gerontol. Geriatr.* 115:105118. doi: 10.1016/j.archger.2023.105118

Guardabassi, V., Cirilli, E., and Nicolini, P. (2024). "From face-to-face to screen-to-screen. Online interactive 43 game-activities to promote student well-being," in *EDULEARN24 Proceedings, 44 IATED*, 9694–9699.

Hallgren, M., Dunstan, D. W., and Owen, N. (2020). Passive versus mentally active sedentary behaviors and depression. *Exerc. Sport Sci. Rev.* 48, 20–27. doi: 10.1249/JES.0000000000000211

Hattie, J., Hodis, F. A., and Kang, S. H. (2020). Theories of motivation: integration and ways forward. *Contemp. Educ. Psychol.* 61:101865. doi: 10.1016/j.cedpsych.2020.101865

Henderson, L. W., Knight, T., and Richardson, B. (2013). An exploration of the well-being benefits of hedonic and eudaimonic behaviour. *J. Posit. Psychol.* 8, 322–336. doi: 10.1080/17439760.2013.803596

Hodent, C. (2017). The Gamer's brain: How neuroscience and UX can impact video game design. London: CRC Press.

Hodgson, J. R., Benkowitz, C., Castellani, B. C., Ellison, A., Yassaie, R., Twohig, H., et al. (2023). A scoping review of the effects of ambient air quality on cognitive frailty. *Environments* 11:4. doi: 10.3390/environments11010004

Hou, H. Y., and Li, H. J. (2022). Effects of exergame and video game training on cognitive and physical function in older adults: A randomized controlled trial. *Appl. Ergon.* 101, 103690. doi: 10.1016/j.apergo.2022.103690

Hu, T., Zhao, X., Wu, M., Li, Z., Luo, L., Yang, C., et al. (2022). Prevalence of depression in older adults: a systematic review and meta-analysis. *Psychiatry Res.* 311:114511. doi: 10.1016/j.psychres.2022.114511

Huta, V., and Ryan, R. M. (2010). Pursuing pleasure or virtue: the differential and overlapping well-being benefits of hedonic and eudaimonic motives. *J. Happiness Stud.* 11, 735–762. doi: 10.1007/s10902-009-9171-4

ISS (2014). *La Sorveglianza passi d'argento.* Available at: https://www.epicentro.iss.it/passi-argento/info/info (Accessed October 18, 2024).

Kang, H., and Kim, H. (2022). Ageism and psychological well-being among older adults: a systematic review. *Gerontol. Geriatr. Med.* 8:23337214221087023. doi: 10.1177/23337214221087023

Kaufman, D., Gayowsky, T., Sauvé, L., Renaud, L., and Duplàa, E. (2018). Older adults' perceived benefits of digital gameplay: associations with demographics and game use patterns. *Geron* 17, 56–67. doi: 10.4017/gt.2018.17.1.006.00

Khan, A., and Pearce, G. (2015). A study into the effects of a board game on flow in undergraduate business students. *Int. J. Manage. Educ.* 13, 193–201. doi: 10.1016/j.ijme.2015.05.002

Khosravi, P., Rezvani, A., and Wiewiora, A. (2016). The impact of technology on older adults' social isolation. *Comput. Hum. Behav.* 63, 594–603. doi: 10.1016/j.chb.2016.05.092

Kikuchi, H., Inoue, S., Sugiyama, T., Owen, N., Oka, K., Nakaya, T., et al. (2014). Distinct associations of different sedentary behaviors with health-related attributes among older adults. *Prev. Med.* 67, 335–339. doi: 10.1016/j.ypmed.2014.08.011

Kloep, L., Helten, A.-L., and Peifer, C. (2023). A playful way to promote team flow: evaluation of a positive psychological board game for team building. *Int. J. Appl. Posit. Psychol.* 8, 405–427. doi: 10.1007/s41042-023-00096-4

Lee, S., Oh, H., Shi, C. K., and Doh, Y. Y. (2021). Mobile game design guide to improve gaming experience for the middle-aged and older adult population: user-centered design approach. *JMIR Serious Games* 9:e24449. doi: 10.2196/24449

Lee, B.-O., Yao, C.-T., and Pan, C.-F. (2020). Effectiveness of board game activities for reducing depression among older adults in adult day care centers of Taiwan: a quasi-experimental study. *Soc. Work Health Care* 59, 725–737. doi: 10.1080/00981389.2020.1842576

Luke, J., Bartlett, C., March, S., and McIlveen, P. (2024). A systematic review of effective local, community or peer-delivered interventions to improve well-being and employment in regional, rural and remote areas of Australia. *Aust. J. Rural Health* 32, 433–454. doi: 10.1111/ajr.13113

Marquez, D. X., Aguiñaga, S., Vásquez, P. M., Conroy, D. E., Erickson, K. I., Hillman, C., et al. (2020). A systematic review of physical activity and quality of life and well-being. *Transl. Behav. Med.* 10, 1098–1109. doi: 10.1093/tbm/ibz198

Marsillas, S., De Donder, L., Kardol, T., Van Regenmortel, S., Dury, S., Brosens, D., et al. (2017). Does active aging contribute to life satisfaction for older people? Testing a new model of active aging. *Eur. J. Aging* 14, 295–310. doi: 10.1007/s10433-017-0413-8

McLaughlin, P. M., Curtis, A. F., Branscombe-Caird, L. M., Comrie, J. K., and Murtha, S. J. E. (2018). The feasibility and potential impact of brain training games on cognitive and emotional functioning in middle-aged adults. *Games Health J.* 7, 67–74. doi: 10.1089/g4h.2017.0032

McQuade, L., and O'Sullivan, R. (2023). Examining arts and creativity in later life and its impact on older people's health and wellbeing: a systematic review of the evidence. *Perspect. Public Health* 11:175791392311575. doi: 10.1177/17579139231157533

Mortenson, W. B., Sixsmith, A., and Kaufman, D. (2017). Non-digital game playing by older adults. *Can. J. Aging* 36, 342–350. doi: 10.1017/S0714980817000162

Nakao, M. (2019). Special series on "effects of board games on health education and promotion" board games as a promising tool for health promotion: a review of recent literature. *BioPsycho Soc. Med.* 13:5. doi: 10.1186/s13030-019-0146-3

Nyende, A., Ellis-Hill, C., and Mantzoukas, S. (2023). A sense of control and wellbeing in older people living with frailty: a scoping review. *J. Gerontol. Soc. Work.* 66, 1043–1072. doi: 10.1080/01634372.2023.2206438

Outley, C. W., and McKenzie, S. (2007). Older African American women: an examination of the intersections of an adult play group and life satisfaction. *Act. Adapt. Aging* 31, 19–36. doi: 10.1300/J016v31n02_02

Piaget, J. (1945). La formation du symbole chez l'enfant. Tr. It. La formazione del simbolo nel bambino. La Nuova Italia, Firenze, 1972.

Ryan, R. M., and Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: definitions, theory, practices, and future directions. *Contemp. Educ. Psychol.* 61:101860. doi: 10.1016/j.cedpsych.2020.101860

Ryan, R. M., Rigby, C. S., and Przybylski, A. (2006). The motivational pull of video games: a self-determination theory approach. *Motiv. Emot.* 30, 344–360. doi: 10.1007/s11031-006-9051-8

Seah, E. T. W., Kaufman, D., Sauvé, L., and Zhang, F. (2018). Play, learn, connect: older adults' experience with a multiplayer, educational, digital bingo game. *J. Educ. Comput. Res.* 56, 675–700. doi: 10.1177/0735633117722329

Sixsmith, J., Makita, M., Menezes, D., Cranwell, M., Chau, I., Smith, M., et al. (2023). Enhancing community participation through age-friendly ecosystems: a rapid realist review. *Geriatrics* 8:52. doi: 10.3390/geriatrics8030052

Skjæret-Maroni, N., Vonstad, E. K., Ihlen, E. A., Tan, X. C., Helbostad, J. L., and Vereijken, B. (2016). Exergaming in older adults: movement characteristics while playing stepping games. *Front. Psychol.* 7:964. doi: 10.3389/fpsyg.2016.00964

Thomson, D. R., Besner, D., and Smilek, D. (2015). A resource-control account of sustained attention: evidence from mind-wandering and vigilance paradigms. *Perspect. Psychol. Sci.* 10, 82–96. doi: 10.1177/1745691614556681

Torres, A. C. S. (2011). Cognitive effects of video games on old people. *Int. J. Disability Hum. Dev.* 10:3. doi: 10.1515/ijdhd.2011.003

Tsai, C. C., Chen, P. Y., Tsai, M. Y., Wu, C. S., and Chen, M. F. (2024). The effect of a bone-preserving board game program on the knowledge, attitudes and preventive behaviors of osteoporosis in older adults. *Geriatr. Nurs.* 56, 212–217. doi: 10.1016/j.gerinurse.2024.02.007

Vygotskij, L. S. (1934). Myslenie i rec Psichologiceskie issledovanija. Movska-Leningrad: Gosudarstvennoe Socialno-Ekonomiceskoe Izdatelstvo.

Wang, C., Li, L., and Wang, A. (2021). Research on the influence of sport dance on physical health in national fitness exercise. *Rev. Bras. Med. Esporte* 27, 481–484. doi: 10.1590/1517-8692202127042021_0077

WHO (1948). Constitution of the world health organization. Available at: https://www.who.int/about/governance/constitution (Accessed September 23, 2024).

WHO (2020). Healthy aging and functional ability. Available at: https://www.who.int/news-room/questions-and-answers/item/healthy-aging-and-functional-ability (Accessed September 23, 2024).

WHO (2022). Aging and health. Available at: https://www.who.int/news-room/fact-sheets/detail/aging-and-health (Accessed September 23, 2024).

WHO (2023). Connecting generations: planning and implementing interventions for intergenerational contact. Available at: https://www.who.int/publications/i/item/9789240070264 (Accessed September 23, 2024).

Winnicott, D. W. (1971). Playing and reality. London: Tavistock Publ. and Penguin Education Books.

WHO. (1998). *Wellbeing measures in primary health care/the DepCare Project: report on a WHO meeting: Stockholm, Sweden, 12–13 February 1998 (No. WHO/EURO: 1998-4234-43993-62027)*. World Health Organization. Regional Office for Europe.

Yang, Y., Van Schooten, K. S., McKay, H. A., Sims-Gould, J., Hoang, R. A., and Robinovitch, S. N. (2021). Recreational therapy to promote mobility in long-term care: a scoping review. *J. Aging Phys. Act.* 29, 142–161. doi: 10.1123/japa.2019-0345

Ylönen, M., Stolt, M., Kohanová, D., and Suhonen, R. (2024). Older individuals' perspectives on the prerequisites for living at home: a mixed-methods systematic review. *Int. J. Older People Nursing* 19:e12603. doi: 10.1111/opn.12603

Yu, D. S. F., Li, P. W. C., Lin, R. S. Y., Kee, F., Chiu, A., and Wu, W. (2023). Effects of non-pharmacological interventions on loneliness among community-dwelling older adults: a systematic review, network meta-analysis, and meta-regression. *Int. J. Nurs. Stud.* 144:104524. doi: 10.1016/j.ijnurstu.2023.104524

Zaharia, A., Dell'Angela, L., Sander, D., and Samson, A. C. (2022). "Play and games: means to support emotional development" in The Oxford handbook of emotional development. eds. D. Dukes, A. C. Samson and E. A. Walle. *1st* ed (Oxford, Oxford University Press), 354–370.

Check for updates

Cultural adaptation to aging: a study on digital cultural adaptation needs of Chinese older adults based on KANO model

Sheng Li[1], Marzudi Md Yunus[2]*, Rosila Bee Binti Mohd Hussain[3] and Wenyuan Lin[4]*

[1]Institute for Advanced Studies, Universiti Malaya, Kuala Lumpur, Malaysia, [2]Academy of Malay Studies, Universiti Malaya, Kuala Lumpur, Malaysia, [3]Department of Anthropology and Sociology, Faculty of Arts and Social Sciences, Universiti Malaya, Kuala Lumpur, Malaysia, [4]School of Chinese Language and Literature, Beijing Normal University, Beijing, China

Introduction: With the rapid advancement of digitalization and an aging population, China faces unprecedented challenges in older adults' digital cultural adaptation. The "54th Statistical Report on China's Internet Development" reveals that individuals aged 60 and above constitute 14.3% of total internet users. However, significant barriers persist in their digital participation, necessitating a deeper understanding of their adaptation process and needs.

Methods: This study employs the KANO model to assess older adults' digital cultural adaptation. A total of 205 respondents participated in a questionnaire survey, with data analyzed using the highest frequency method and the Better-Worse coefficient. The study categorizes digital cultural needs into three dimensions: must-be requirements, one-dimensional requirements, and attractive requirements.

Results: The findings indicate that: 1. Older adults' digital cultural needs comprise must-be requirements (basic functional design, 47.8%), one-dimensional requirements (social participation, 36.1%), and attractive requirements (innovative experiences, 66.8%). 2. Intergenerational cultural cognitive differences, digital skill levels, and the urban−rural digital divide significantly impact their adaptation process. 3. While respondents positively evaluate digital life satisfaction, personal adaptation, and digital content diversity, they express dissatisfaction and expectations regarding family guidance, age-friendly digital services, and the role of digital content in improving life quality.

Discussion: The results highlight the need for targeted strategies in technical support, content design, and service provision to enhance older adults' digital cultural adaptation. Addressing group-specific needs and preferences through coordinated measures can improve digital inclusion, foster intergenerational cultural integration, and optimize digital cultural service systems. This study offers valuable theoretical insights and practical implications for advancing policies and initiatives that support older adults in the digital era.

1 Introduction

China is experiencing the world's largest and fastest population aging process. According to the United Nations Department of Economic and Social Affairs, the global population aged 65 and above is projected to increase from 10% in 2022 to 16% by 2050 (1). China's aging trend is even more pronounced, with the "54th Statistical Report on China's Internet Development" showing that internet users aged 60 and above account for 14.3% of total users (2).

As digitalization and population aging emerge as two distinctive features of contemporary Chinese social transformation (3), promoting digital inclusion for older adults and ensuring their equal access to digital benefits has become a focal point for both government and society. Digital technology significantly empowers the older adult population, enhancing both their physical and mental health while promoting social participation (4). Particularly in digital cultural services, technology can provide older adults with richer cultural content, more convenient service access channels, and broader social interaction opportunities. However, a considerable proportion of older adults currently face an insurmountable digital divide (5). This divide not only prevents them from enjoying digital benefits but also partially excludes them from normal social functioning, leading to social isolation and digital exclusion. Research indicates that older adults' digital divide shows progressive characteristics of "digital access divide, capability divide, and outcome divide" (6). Meanwhile, significant regional and urban–rural digital disparities exist among China's older adult population: urban internet users account for 72.1% of total users (2), with rural older adults facing a more severe digital divide and weaker capacity to cope with digitalization compared to their urban counterparts (7). These disparities are manifested across multiple dimensions, including digital infrastructure accessibility, socioeconomic status, education level, and social support.

Existing research shows that older adults exhibit unique characteristics in digital technology usage. They prefer smartphones over devices like iPads and computers due to easier operation (8). Functionally, they primarily focus on communication and entertainment features, while showing lower usage frequencies of advanced functions like online shopping and mobile payments. These phenomena indicate that older adults' digital participation remains at a preliminary stage, with their participation willingness and behavior influenced by multiple factors (7).

While a rich body of literature has accumulated on older adults' digital participation, existing research in the specific field of digital cultural services has primarily focused on technical aspects (such as interface design and functional configuration), while systematic research on digital cultural content remains relatively limited. In particular, studies using the KANO model to classify and prioritize digital cultural adaptation needs of Chinese older adults are notably scarce. Moreover, most existing research is predominantly based on Western developed countries, and the unique challenges and needs faced by Chinese older adults in digital cultural adaptation have not been fully explored. Through the innovative application of the KANO model, this study not only systematically analyzes the hierarchical characteristics of Chinese older adults' digital cultural needs, but also provides quantitative assessment of need priorities through Better-Worse coefficient analysis, offering theoretical foundation and practical guidance for formulating policies to promote digital inclusive development for older adults.

2 Literature review

2.1 Cultural adaptation to aging

Older adults' cultural construction is an essential component of the cultural power strategy. With the accelerating development of an aging society, age-appropriate research and design have gained increasing attention (9). However, existing literature lacks systematic definition and research exploration of the concept "Cultural Adaptation to Aging" (10).

The "aging" in Cultural Adaptation to Aging refers not only to the older adult population but also encompasses traditional excellent cultural clusters (10). In the development of contemporary spiritual and trend culture, it is essential to maintain cultural origins, achieving dynamic inheritance, constraint, development, and integration based on traditional cultural inheritance. Particularly under China's "14th Five-Year Plan" promoting cultural industry digitalization, traditional culture needs to adapt to contemporary social, technological, and cultural development to better achieve cultural promotion and inheritance, advancing the strategic goal of building a cultural power.

Cultural adaptation refers to the adjustment of interventions to better accommodate individuals' language, cultural values, and norms (11). The objective is to achieve inclusivity, ensuring that all individuals and communities, including the most vulnerable groups, can access and utilize technology to enhance their quality of life (12). There are different models to guide the cultural adaptation of interventions. The most commonly used models are the Cultural Adaptation Process (CAP) model and the Ecological Validity Model (EVM) (13, 14). Beyond economic and physical factors, disparities in access to and use of digital health interventions are culturally driven. Creating inclusive digital health interventions is crucial to avoid systematically excluding traditionally underserved cultural groups (13). The fundamental rationale behind cultural adaptation is to improve coverage and engagement among otherwise underserved population subgroups (15, 16).

In studying the cultural adaptation of digital health interventions, there exists a complex interplay among three dimensions: culture, technology, and health. Cultural beliefs and values profoundly influence people's health perceptions and behaviors, while the introduction of digital technology transforms traditional healthcare delivery and health management approaches. Meanwhile, cultural factors determine the degree of technology adoption and usage patterns, and conversely, the application of technology may either facilitate or hinder health practices among specific cultural groups. Understanding this multidimensional interaction is crucial for developing effective digital health interventions. Although designing culturally sensitive digital health interventions from scratch might achieve optimal cultural fit, it requires substantial resources. In comparison, culturally adapting existing technologies, while still requiring time and financial investment, often presents a more feasible solution. Successful digital health interventions must simultaneously consider technological functionality, cultural adaptability, and health outcomes. This multidimensional bidirectional interaction demands a holistic approach that views cultural adaptation as an ongoing dialogue between technological capabilities and cultural needs (13).

2.2 Research on digital cultural adaptation to aging

Digital technology has significant empowering effects on older adults: it provides basic functions like healthcare and banking services, and promotes social connections and daily activity participation, thereby enhancing older adults' physical and mental health and social interaction (17, 18). Taking mobile payment as an example, its positive impact on older adults' well-being is mainly reflected in providing life convenience, optimizing consumption structure, increasing social interaction opportunities, and improving overall quality of life (18). Research indicates that the digital divide among older adults may exacerbate health disparities and social isolation (19). Tian& Li further found that Internet use plays an important moderating role in the relationship between social networks and mental health in older adults (20). Their study of 7,648 Chinese adults over 60 years old showed that Internet use exerts different moderating functions in the impact of family networks on loneliness and friend networks on mental health, highlighting the importance of utilizing Internet technology to protect the well-being of older adults in a digital society.

Current research on digital cultural adaptation to aging primarily focuses on technical aspects, such as interface design and functional configuration, including font size, color contrast, operation process simplification, and intelligent assistance functions. However, content-level research remains insufficient, lacking corresponding studies. This research status reflects both the limitations of technology-oriented thinking and highlights the necessity of conducting content-level research from user experience and service design perspectives. Digital technology significantly impacts older adult care system construction and older adults' health and can extend to education, culture, tourism, and other fields, indicating its potential to further meet older adults' spiritual and cultural needs. Beyond meeting basic life needs, reasonable application of digital technology will effectively enhance older adult group's happiness and sense of achievement (7). Digital technology is not limited to mobile payments; smart homes, as the new generation of essential terminals for future homes, have also become an important medium for intelligent older adult care at home. Related research shows that the main factors affecting older adults' use of smart home social media include user interface quality, interaction quality, content quality, and service quality. These factors influence older adults' emotional experiences and perceptions through social compensation mechanisms, thereby affecting their willingness to accept and use smart home social media (21).

2.3 Digital cultural services for Chinese older adults

In recent years, China has highly valued older adults' cultural service needs. The "Opinion on Promoting High-Quality Development of Public Cultural Services" jointly issued by 16 departments, including the National Office on Aging, clearly proposes providing more high-quality, suitable cultural products and services for older adults (10). Meanwhile, to address deepening population aging, departments including the Ministry of Industry and Information Technology have issued action plans for smart older adult care industry development, focusing on developing intelligent products and information systems, bringing new opportunities for social older adult care systems and older adults' cultural development. To meet diverse older adults' needs, age-appropriate design should not be limited to solving basic survival needs but should focus on exploring "silver economy" consumption potential and improving service quality in spiritual aspects such as emotional communication and social recognition (22).

The pie chart in Figure 1 (1) depicts global internet users by age group (23), with users aged 65 and above accounting for 4.2%. Figure 1 (2) depicts Chinese internet users by age group, with users aged 60 and above accounting for 14.3% (2).

Despite differences in age classification standards, this data indirectly reflects the relatively high internet penetration rate among Chinese older adult groups, indicating China's significant achievements in promoting digitalization among the older adult population. This high penetration rate may be closely related to China's aging population trends and digital inclusion policies.

Currently, although digital inclusion has become an essential component of active aging and Digital China strategy, existing policies mainly focus on age-friendly modifications, digital resource provision, and technology promotion, with insufficient attention to
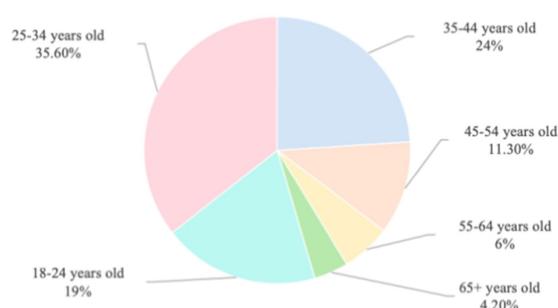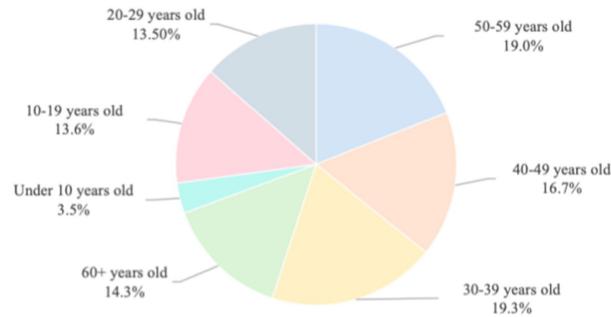
(1) Global Internet Users by Age	(2) Chinese Internet Users by Age

FIGURE 1
Distribution of internet users worldwide as of February 2024 by age group. (1) Global internet users by age (2) Chinese internet users by age.

cultural services and spiritual needs (24). Research indicates that both social and digital inclusion are significantly influenced by institutional environment and macro policies, suggesting the need for greater policy-level emphasis on older adults' cultural service needs (7).

Research on older adults' media literacy reveals a significant digital divide between older adults and young people. Studies show that older adults' digital literacy, such as internet information retrieval ability, is significantly lower than younger groups (with a 17% difference) (25). According to Lythreatis et al. (26), causes of older adults' digital exclusion can be categorized into personal, social, and environmental dimensions (5), with specific factors detailed in Figure 2 (9).

Substantial research evidence demonstrates that internet penetration has profoundly changed people's thinking patterns and behavioral modes (27, 28). Particularly in the aging process, older adult groups gradually participate in building an inclusive digital society through active use of digital technologies like smartphones (29).

However, while existing research on the digital divide primarily focuses on Western developed countries such as the UK, Canada, and Switzerland (30, 31), studies addressing the "grey digital divide" faced by Chinese older adult groups have increased in recent years.

2.4 Digital aging-related policies

To address these issues, policy strategies need to encompass aspects of enhancing digital inclusion and empowerment of older adults. In some countries, established practices of incorporating older adults in digital enhancement can be adapted or replicated in other contexts. ECE member states have developed a range of policies promoting older adults' active participation in digital research, development, and decision-making, as illustrated in Figure 3. The valuable life experiences and diverse perspectives of older adults are crucial for bridging the digital divide and contributing to a world for all ages (32).

FIGURE 2
Three dimensional indicators of digital exclusion among older adults.
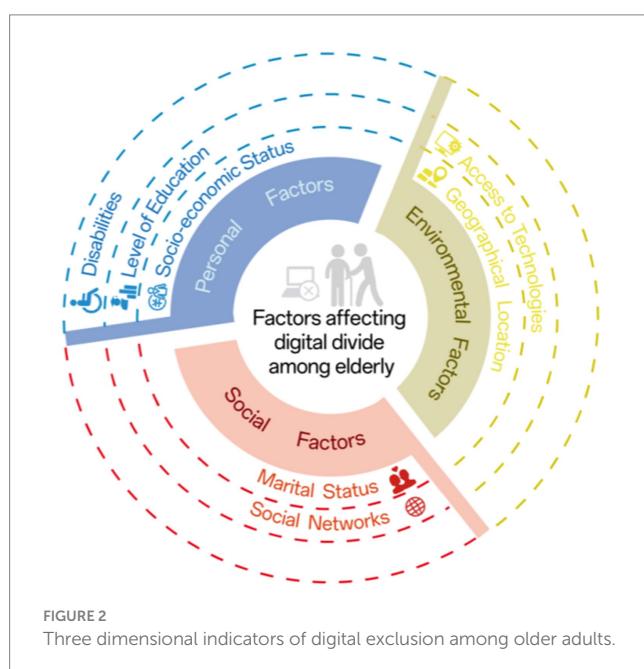
3 Research methods and data analysis

3.1 Theoretical foundation of KANO model

The KANO model, proposed by Japanese scholar KANO (33), is a user requirement analysis method based on user satisfaction and quality function availability, primarily used for user requirement classification and priority ordering. The KANO model categorizes user requirements into five types: Must-be (M), One-dimensional (O), Attractive (A), Indifferent (I), and Reverse (R) requirements (see Figure 4 and Table 1). In practical applications, the KANO model evaluates user requirement characteristics through its unique attribute matrix. The evaluation method employs the highest frequency method, determining the final attribute category by calculating the frequency of each requirement attribute type.

3.2 Theoretical framework

This study explores Chinese older adults' digital cultural adaptation needs using mixed research methods based on the KANO model theoretical framework. The theoretical basis for selecting the KANO model includes:

Scientific Quality Attribute Classification: The KANO model systematically categorizes user requirements into five types: Must-be (M), One-dimensional (O), Attractive (A), Indifferent (I), Reverse (R) and Questionable (Q), helping comprehensively grasp older adult users' requirement characteristics.

Dual-dimensional Satisfaction Assessment: Through unique evaluation methods pairing positive and negative questions, it examines both the positive impact of an attribute's presence on satisfaction and the negative impact of its absence on dissatisfaction.

Objective Priority Judgment: The Better-Worse coefficient analysis method provides quantitative evaluation standards, objectively determining requirement priority levels.

3.3 Analysis of older adult user needs based on KANO model

The KANO model has been widely applied in analyzing older adult group design user needs, particularly in age-appropriate research. For instance, Shi, Chongqing et al. analyzed the importance and influencing factors of social support service needs for urban older adults with dementia using the KANO model, employing Better-Worse coefficient and sensitivity formula methods (34). Huang Guoliang et al. applied the KANO model to determine attribute categories and user value importance of 12 functional programs in intelligent companion robots (35). While Xinxin Sun et al.'s research used Behavioral Reasoning Theory (BRT) as a framework, combined with the UTAUT2 model, and found that values significantly influence older adults' attitudes toward using companion robots (36). Chengmin Zhou et al. explored older adult individual self-care needs design requirements and user pain points using the KANO model, summarizing functional requirements for older adult-friendly digital service platforms and prioritizing key

Checklist: Ageing in the digital era

Main areas	Areas of implementation	Key elements
Access to goods and services	Universal connectivity	• Internet access for all older persons, including those living in long-term-care institutions
	Affordability	• Financial assistance to those who cannot afford digital technologies and broadband connections
	Design for all	• Accessibility regulations • Involvement of older persons in the design and development of digital technology and services to ensure they meet their needs and interests
	Support for use of digital services	• Tailored support to older user of digital services such as e-banking, e-Government, e-learning • Guidance to service providers to make online services more age-friendly
	Offline access to goods and services	• Maintain offline access to essential information, goods and services • Avoid financial penalty for offline access to services
Digital literacy	Digital skills	• Intergenerational training • Peer-to-peer training • Internet security training
	Ageism	• Avoid ageist stereotypes against older technology users • Promote intergenerational digital training and contact • Tailor programmes to enhance self-confidence of older persons in using digital technologies
Benefits of digital technology	Loneliness and social isolation	• Facilitate social connections and participation by older persons via digital communication
	Opportunities for healthy ageing and independent living	• Promote access to e-health services • Facilitate health management through the use of digital devices and services • Facilitate independent living through use of digital technologies and assistive devices
Human rights	Dignity and autonomy	• Avoid disempowering practices such as neglect of older persons' needs and preferences • Human rights-based impact assessments of digital technologies in health and social care • Guidelines on human-rights based approach to digital technology design, development and use involving technology designers, services providers, procurers and civil society • Access to medical technologies for all
	Privacy	• Ensure data protection and ethical use of data collected through the use of digital technology • Transparency on monitoring, data processing, gathering purpose, data storage and sharing
	Participation in decision-making	• Involve older persons and their representatives in decision-making processes about digital technology use • Monitor impact of digitalisation on older persons, including on the most vulnerable
	Free and informed consent	• Enable older persons to weigh risks and advantages of technology use through tailored information and training • Older persons should remain in control of what kind of information is collected, how it will be processed and who will get access to it

FIGURE 3
Checklist: UNECE policy brief on aging no. 26.

needs (37). Additionally, research has applied this model to enhance user satisfaction (38).

In age-appropriate research of digital interactive devices, the KANO model has been extensively applied to user needs in medical and health applications (39), age-appropriate reading APP design requirements (40), customized tourism APP design (41), and smart watch interaction design (42). However, research in digital cultural content remains relatively limited. While some scholars have used KANO theory to explore older adults' personalized game element selection (43) and older adult group participation in self-media needs and services (44), these studies only address older adults' needs and usage benefits regarding digital cultural content, showing insufficient systematic research and analysis of older adult group adaptation to new digital cultural content (Table 2).

FIGURE 4
KANO model quality attribute classification diagram (52).
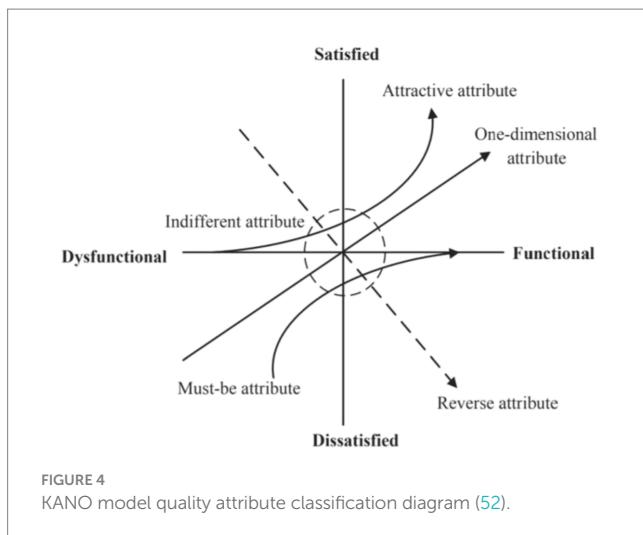
3.4 KANO questionnaire design

Based on KANO model construction principles, dimensions were confirmed through systematic literature review to customize both positive and negative questions for investigating Chinese older adult group's digital cultural adaptation. Each question provides 5 response options: "Disgusting," "Reluctant," "Indifferent," "Necessary," and "Favorite." Respondents select the most appropriate answer based on their feelings and understanding to determine requirement attributes (Table 3).

To ensure accuracy and validity, the draft questionnaire underwent pilot testing, followed by detailed revision and optimization. The final questionnaire consists of:

- Demographic information (4 items)
- Digital device usage (5 items)
- KANO model evaluation items (30 pairs of positive–negative questions)

The KANO model-based questionnaire comprises paired questions. For each indicator, the survey includes both positive and negative questions using a 5-point scale.

3.5 Questionnaire collection

This study conducted questionnaire distribution and collection through online channels. The questionnaires were distributed through WeChat community groups for older adults, online platforms of universities for older adults, and existing network channels of community activity centers for older adults, using the professional platform WJX.cn for questionnaire design and data collection. The research established clear screening criteria: respondents must be 60 years or older (conforming to China's official definition of older adults), and have basic experience using digital devices (questionnaires could be completed with assistance from children or family members).

A total of 245 questionnaires were collected, and after data cleaning and validation (excluding incomplete responses and questionnaires with obvious logical contradictions), 205 valid responses were obtained, resulting in an effectiveness rate of 83.7%.

Each questionnaire took approximately 3–5 min to complete. All collected data, including responses to both positive and negative questions, were imported into SPSS software for analysis. The research chose to distribute questionnaires during concentrated periods of community older adults' activities; this concentrated data collection strategy helped reduce potential bias from time differences, providing a reliable data foundation for subsequent statistical analysis.

3.6 Questionnaire reliability

Reliability testing examines the questionnaire results' reliability, stability, and consistency, reflecting whether measurement results can truthfully represent respondents' consistent and stable characteristics. A higher reliability coefficient indicates better representation of respondents' consistent and stable characteristics. The Cronbach's α coefficient is the most commonly used reliability coefficient, evaluating the consistency of scores across questionnaire items. It is an internal consistency reliability coefficient, where k represents the number of survey items, S_i^2 is the variance of the i-th item score, and S_T^2 is the total score variance (Table 4).

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} S_i^2}{S_T^2}\right) \quad (1)$$

3.7 Validity testing

Validity testing examines questionnaire effectiveness, measuring how accurately the tool measures the intended subject. Higher correspondence between test results and research questions indicates higher validity. Structural validity refers to the degree of correspondence between questionnaire structure and measurement values (Table 5).

4 Results analysis

4.1 Basic situation analysis

This study collected data across three dimensions to understand older adults' digital cultural adaptation needs: Demographic characteristics, Usage behavior and Barriers and needs. Through analyzing basic characteristics and digital device usage patterns across different groups, the study reveals the diversity of older adults' digital cultural needs and their main influencing factors (Table 6).

The survey respondents were predominantly aged 66–70 (38.05%), indicating younger older adults are the main digital device users. Education levels were mainly middle school and below (78.05%), with slightly higher urban township representation compared to rural areas (57.56% vs. 42.44%).

Regarding usage behavior:

- Smartphones are the primary digital device (88.78%)
- Most use devices 1–3 h daily (47.32%)

TABLE 1 KANO model highest frequency method evaluation result classification reference.

Feature/service		Negative question				
		Disgusting (1 points)	Reluctant (2 points)	Indifferent (3 points)	Necessary (4 points)	Favorite (5 points)
Positive question	Disgusting (1 points)	Q	R	R	R	R
	Reluctant (2 points)	M	I	I	I	R
	Indifferent (3 points)	M	I	I	I	R
	Necessary (4 points)	M	I	I	I	R
	Favorite (5 points)	O	A	A	A	Q

A, Attractive; O, One-dimensional; M, Must-be; I, Indifferent; R, Reverse; Q, Questionable.

TABLE 2 KANO questionnaire example: older adults' digital media usage needs assessment.

A1: If digital media platforms have special designs for older adults (large font, simple layout, important news marking)					
For having this feature/attribute, I feel:	Favorite	Necessary	Indifferent	Reluctant	Disgusting
For not having this feature/attribute, I feel:	Favorite	Necessary	Indifferent	Reluctant	Disgusting

- Main purposes: family communication (87.32%) and entertainment (78.54%)
- 43.41% seek weekly guidance from family members on device usage

Overall, while respondents show interest in digital cultural adaptation, they face limitations from education levels, urban–rural disparities, and physical conditions. Future digital service design should account for these differences to promote broader older adults' digital inclusion.

4.2 Satisfaction assessment of digital cultural adaptation among the older adult population

Based on the demographic characteristics and usage behaviors mentioned above, this study further investigated the satisfaction and evaluation of the older adult group in the process of digital culture adaptation. By analyzing the feedback of respondents in different dimensions, their actual needs can be understood.

From the five options of very dissatisfied (1 point), somewhat dissatisfied (2 points), average (3 points), basically satisfied (4 points), and very satisfied (5 points), the table below presents the statistical results of ratings in several key areas, including mean, standard deviation, skewness coefficient, and kurtosis coefficient. Among them, the mean reflects the overall evaluation tendency of the respondents, while the standard deviation reflects the degree of dispersion of individual ratings. The skewness and kurtosis coefficients are used to assess the deviation of the data from the normal distribution (Table 7).

Overall, the older adult group's satisfaction and evaluation of digital cultural life present some noteworthy characteristics. In terms

of overall satisfaction with digital life and their own adaptability, most older people hold a positive attitude, with average scores close to full marks and small individual differences. This indicates that with the continuous development of digitalization, the older adult group has gradually realized the importance of integrating into the digital society and made efforts to improve their own digital literacy.

However, in terms of family guidance and the age-appropriateness of digital services, the satisfaction of older adults is generally low, with large differences in personal evaluations. This reflects that the current digital environment still has deficiencies in its friendliness and inclusiveness toward the older adult group. Especially in terms of family support, more attention needs to be paid to strengthening intergenerational communication and interaction. Regarding digital content in the new era, older adults generally recognize its richness, but have doubts about its actual effectiveness in improving their quality of life. This suggests that when providing content, we should focus more on pertinence and emotional value, rather than just focusing on the amount of information.

From the data distribution, most scores are concentrated around the mean, but there are also certain extreme values. Satisfaction and content evaluation are generally high, while scores for family guidance and quality of life improvement are relatively low.

In summary, respondents hold positive evaluations in terms of digital life satisfaction, their own level of adaptation, and the richness and diversity of digital content in the new era. However, there is dissatisfaction and expectation in terms of satisfaction with family guidance, the age-appropriateness of digital services, and the degree to which digital content in the new era helps improve quality of life. This feedback provides valuable reference information for relevant parties and helps to further improve and optimize digital services and enhance overall user satisfaction. At the same time, the non-normal distribution characteristics of the data also remind us that when interpreting statistical results, we need to comprehensively consider the differentiated

TABLE 3 Indicator system for older adults' digital cultural adaptation needs based on KANO model.

Code	Need indicators
A1	If digital media platforms have special designs for older adults (large font, simple layout, important news marking)
A2	If social media (like WeChat) has dedicated older adult mode
A3	If able to understand and explain new internet expressions (daily phrases, greetings, compliments, trending terms)
A4	If able to understand and participate in current digital culture (short videos, live streaming, online communities)
A5	If older adult-appropriate digital learning methods are available (text, video, audio, interactive, games)
A6	If easy access to interesting digital content (health, culture, news, lifestyle)
A7	If digital platforms automatically simplify functions based on usage habits
A8	If able to understand young people's lifestyle and values through digital means
A9	If no digital divide impact in intergenerational communication
A10	If easy adaptation to digital lifestyle (online shopping, mobile payment, online appointments)
A11	If digital platforms recommend suitable entertainment and learning content
A12	If able to build rich social connections in digital world (reunions, interest groups, neighborhood interaction)
A13	If able to participate in digital cultural entertainment (viewing, interaction, creation, sharing)
A14	If able to participate in community activities, volunteer services, cultural events through digital channels
A15	If able to enjoy diverse digital entertainment (live streaming, short videos, online karaoke, puzzle games)
A16	If able to inherit and promote traditional cultural values through digital means
A17	If digital platforms make frequently used functions one-click operations
A18	If digital platform interface design considers older adults' visual needs (color contrast, button size)
A19	If all digital platform functions have voice operation options
A20	If digital product appearance has good aesthetic design
A21	If function format and operation convenience are well matched
A22	If able to accept new things while maintaining traditional values
A23	If able to distinguish authentic online information and avoid scams
A24	If understand cybersecurity knowledge to protect personal privacy and property
A25	If able to master basic digital platform usage skills
A26	If able to naturally express emotions in digital world (text, voice, emoticons, gifts)
A27	If able to share life stories, knowledge, and talents through digital means
A28	If digital cultural participation promotes personal growth

(Continued)

TABLE 3 (Continued)

A29	If digital culture enables better integration into modern society
A30	If able to access personalized digital cultural experiences

TABLE 4 Cronbach's α coefficient reliability test results.

(1) Positive questions reliability analysis		
Items	Sample size	Cronbach's α
30	205	0.956
The positive questions' reliability coefficient of 0.956 exceeds 0.9, indicating very high data reliability		

(2) Negative questions reliability analysis		
Items	Sample size	Cronbach's α
30	205	0.957
The negative questions' reliability coefficient of 0.957 exceeds 0.9, indicating very high data reliability.		

TABLE 5 KMO and Bartlett's sphericity test results.

KMO value		0.952
Bartlett's test of sphericity	Approx. Chi-Square	10712.826
	df	1770
	p-value	0.000

The KMO value of 0.952 (>0.8) indicates the research data is highly suitable for information extraction, confirming the data passes validity testing.

demands of different groups, formulate targeted service strategies and communication plans, and promote the overall improvement of digital literacy and cultural adaptation capabilities of older adults.

4.3 KANO quality survey

The research conducted in-depth analysis of questionnaire data using the KANO model to classify older adults' digital cultural service needs. The KANO model categorizes user requirements into five types: Must-be, One-dimensional, Attractive, Indifferent, and Reverse, helping clarify positive and negative impacts of different needs on satisfaction. This section summarizes KANO model analysis results and evaluates need priorities using the Better-Worse coefficient method (see Table 8) for detailed results.

According to the KANO model analysis results, older adults' digital cultural service needs can be clearly divided into four types: Must-be attributes (M), One-dimensional attributes (O), Attractive attributes (A), and Indifferent attributes (I). Through in-depth analysis of these attributes, we can better understand the core demands and experience preferences of older adult groups in their digital cultural adaptation process.

Must-be attributes: These attributes are basic guarantees provided by digital media platforms for older adults. Large fonts, simple layouts, and important news marking ensure older adults can easily read and understand information. Dedicated older adult modes and

TABLE 6 Survey respondent demographic distribution statistics.

Categories	Options	Frequency	Percentage (%)
Age	60–65 years old	26	12.68
	66–70 years old	78	38.05
	71–75 years old	56	27.32
	76–80 years old	26	12.68
	Over 80 years old	19	9.27
Education level	Primary school or below	65	31.71
	Middle school	95	46.34
	High school/ Technical	31	15.12
	College or above	14	6.83
Residence area	Township/City	118	57.56
	Rural	87	42.44
Living situation	Living alone	55	26.83
	Living with family	137	66.83
	Other	13	6.34
Current health status	Completely healthy	63	30.73
	Minor discomfort	93	45.37
	Chronic illness	31	15.12
	Limited mobility	18	8.78
Family meeting frequency	Daily	137	66.83
	Several times/week	26	12.68
	Several times/month	35	17.07
	Rarely	7	3.41
Daily smart device usage	Under 1 h	10	4.88
	1–3 h	97	47.32
	3–5 h	71	34.63
	Over 5 h	27	13.17
Digital device usage difficulty	No difficulties	119	58.05
	Some difficulties	63	30.73
	Significant difficulties	23	11.22
Frequency of asking young people for help	Never	20	9.76
	Rarely (1–2/month)	44	21.46
	Occasionally (1–2/ week)	89	43.41
	Often (3–5/week)	29	14.15
	Frequently (daily)	23	11.22
Each total		205	100

TABLE 7 Descriptive statistical results of satisfaction with digital culture adaptation among the older adult population.

Evaluation content	Average value	Standard deviation
Your current satisfaction with digital life	4.327	1.178
Your satisfaction with your own level of adaptation	2.054	1.489
Your satisfaction with the guidance from your family	4.302	1.199
Your satisfaction with the age-appropriateness of digital services	2.922	1.122
What is your evaluation of the richness and diversity of digital content in the new era, such as online education, health consultation, entertainment activities, etc	4.356	1.127
How much do you think digital content in the new era can help improve your quality of life	2.029	1.441

Attractive attributes: These attributes help older adults maintain vitality and engagement in the digital world. Understanding and participating in current popular culture, such as short videos and livestreaming, helps them maintain communication with young people and understand their lifestyles and values. Rich digital cultural entertainment activities and entertainment methods provide more choices and enjoyment. One-click and voice operation options simplify operation processes, improving older adults' user experience. Platforms should also help older adults distinguish authentic online information and protect personal privacy and property security, making them more confident and secure in the digital world.

One-dimensional attributes: These attributes emphasize older adults' social participation and personal growth in the digital world. Participating in community activities and volunteer services through digital channels helps older adults integrate into society and contribute their experience. Inheriting and promoting traditional cultural values helps older adults maintain cultural roots in the digital world. Mastering basic digital platform usage skills is fundamental for older adults' independent use of digital products. Digital cultural participation can also promote older adults' personal growth and development, improving their quality of life.

Indifferent attributes: While these attributes have less impact on older adults' digital experience, they remain important. Timely understanding and explanation of new internet expressions helps older adults overcome language barriers and better communicate with young people. Easy access to interesting digital content meets older adults' information needs. Building rich social relationships in the digital world helps older adults maintain social activity and reduce loneliness. Interface design considering older adults' visual needs improves their user experience. Meanwhile, accepting new things while maintaining traditional values is key for older adults to maintain balance and harmony in the digital world.

In conclusion, these four attributes collectively form essential components of older adults' digital experience, each indispensable, jointly creating a friendly, convenient, rich, and secure digital world for older adults.

age-appropriate digital skill learning methods help them better adapt to and use digital products. Additionally, platforms should support older adults in easily adapting to digital lifestyles, such as online shopping and mobile payments, and recommend suitable entertainment and learning content. Meanwhile, product appearance design and functional form should match operational convenience, allowing older adults to conveniently share their life stories, knowledge, and talents.

4.4 Better and worse coefficient analysis results

Addressing potential inaccuracies in relying solely on the highest frequency method for classifying user requirement attributes, and difficulties in reflecting the impact of requirement elements on overall satisfaction, Charles Berger et al. proposed the Better-Worse coefficient analysis method as an improvement (45). This method applies statistical data of various requirement attribute frequencies to calculate Better coefficients (satisfaction coefficients, typically positive) and Worse coefficients (dissatisfaction coefficients, typically negative). The Better-Worse coefficient analysis method is a tool for evaluating how requirement fulfillment affects overall satisfaction differences. The Better coefficient reflects how much a requirement's fulfillment

contributes to improving overall satisfaction, ranging from 0 to 1, with higher values indicating more significant improvement effects. The Worse coefficient measures how much unfulfilled requirements negatively impact overall satisfaction, ranging from −1 to 0, with larger absolute values indicating more severe negative impacts. The formulas for satisfaction Si, dissatisfaction Di, and reverse requirement coefficient SR are as follows:

$$\text{Better coefficient Si} = \frac{A+O}{A+O+M+I} \quad (2)$$

$$\text{Worse coefficient Di} = \frac{-(O+M)}{A+O+M+I} \quad (3)$$

TABLE 8 Summary of KANO model analysis results.

Functions/services	A	O	M	I	R	Q	Result
A1	10.24%	8.29%	47.80%	23.90%	9.76%	0.00%	M
A2	11.71%	9.76%	54.15%	14.63%	9.76%	0.00%	M
A3	18.05%	11.71%	19.51%	31.71%	19.02%	0.00%	I
A4	39.02%	12.20%	14.15%	25.37%	9.27%	0.00%	A
A5	17.07%	9.76%	44.88%	20.00%	8.29%	0.00%	M
A6	20.49%	17.56%	11.22%	37.07%	13.66%	0.00%	I
A7	40.00%	10.24%	13.17%	24.39%	12.20%	0.00%	A
A8	56.59%	5.37%	9.27%	22.44%	6.34%	0.00%	A
A9	20.49%	13.17%	13.66%	37.56%	15.12%	0.00%	I
A10	11.22%	6.34%	57.07%	17.56%	7.80%	0.00%	M
A11	5.85%	11.71%	45.85%	26.34%	10.24%	0.00%	M
A12	19.02%	15.61%	19.02%	30.73%	15.61%	0.00%	I
A13	43.41%	11.71%	10.24%	25.37%	9.27%	0.00%	A
A14	13.17%	36.10%	12.68%	25.85%	12.20%	0.00%	O
A15	66.83%	6.83%	6.83%	15.12%	4.39%	0.00%	A
A16	13.17%	32.68%	12.68%	30.24%	11.22%	0.00%	O
A17	39.51%	11.22%	13.66%	25.37%	10.24%	0.00%	A
A18	15.61%	12.68%	20.49%	35.12%	16.10%	0.00%	I
A19	65.37%	5.85%	10.24%	11.22%	7.32%	0.00%	A
A20	13.17%	9.76%	46.83%	20.98%	9.27%	0.00%	M
A21	10.73%	9.27%	47.32%	22.44%	10.24%	0.00%	M
A22	15.61%	16.59%	18.54%	32.20%	17.07%	0.00%	I
A23	65.85%	6.34%	7.80%	14.63%	5.37%	0.00%	A
A24	67.32%	6.83%	4.39%	15.61%	5.85%	0.00%	A
A25	12.68%	50.73%	9.76%	20.49%	6.34%	0.00%	O
A26	66.34%	3.41%	7.80%	16.10%	6.34%	0.00%	A
A27	12.68%	9.27%	43.90%	24.88%	9.27%	0.00%	M
A28	11.22%	52.20%	12.68%	14.63%	9.27%	0.00%	O
A29	71.71%	3.90%	4.88%	12.20%	7.32%	0.00%	A
A30	52.68%	7.32%	9.76%	22.93%	7.32%	0.00%	A

A, Attractive; O, One-dimensional; M, Must-be; I, Indifferent; R, Reverse; Q, Questionable.

By applying the aforementioned formulas to the questionnaire data, the importance and ranking of all user needs were determined in the following way (see Table 9 and Figure 5).

From the above values, we observe significant differences in older adults' preferences and needs regarding digital and social media usage. Most older adults have high expectations for customized platform designs (large fonts, simple layouts) and dedicated older adult modes, but these features are not widespread, resulting in higher "Worse" than "Better" ratios.

Older adults face major challenges in: Adapting to digital lifestyle, Mastering digital skills, and Distinguishing authentic online information. These areas show notably high "Worse" ratios.

Higher "Better" ratios appear in: Digital entertainment, Understanding younger generations' lifestyles through digital means, and Digital community participation.

They also show expectations for: Personalized entertainment and learning content recommendations, Building digital social relationships and Participating in digital cultural activities.

Strong awareness exists regarding cybersecurity and privacy protection, with high demand for security knowledge and personal privacy protection. They also desire aesthetically pleasing designs with good functionality-operation matching.

In conclusion, older adults' digital media usage presents both challenges and opportunities. Digital products and social media platforms need to focus on: Customized design, Accessible digital skill learning methods, Enhanced security and privacy features, and Rich digital cultural experiences addressing entertainment and social needs.

5 Discussion

5.1 Multidimensional challenges in digital cultural adaptation

The KANO model analysis reveals older adults' needs for digital cultural services demonstrate hierarchical characteristics. Must-be requirements primarily include age-friendly design of digital media (47.80%), dedicated older adult modes (54.15%), and suitable learning methods (44.88%), indicating older adult users prioritize basic functional accessibility. This aligns with Amann-Hechenberger et al.'s (46) findings about interface barriers.

Attractive requirements manifest in understanding and participating in emerging digital culture, such as digital security (67.32%), social expression (66.34%), and entertainment methods (66.83%). Better-Worse analysis shows these needs significantly impact older adults' satisfaction, echoing He et al.'s (18) research on digital participation promoting social integration.

One-dimensional requirements focus on social participation and skill mastery, including volunteer service participation (36.10%) and basic skill learning (50.73%). Their Better-Worse coefficients indicate these are key factors in improving older adults' digital cultural adaptation. These findings provide clear guidance for policy-making: must-be requirements should become mandatory standards for digital products; attractive features should be encouraged through government incentive programs.

5.2 Cultural value differences and adaptation mechanisms

Intergenerational cultural value differences mainly reflect in perceptions of emerging economic forms and interaction methods. Older adults tend to be conservative toward internet celebrity economy, streamers, content creators, and virtual consumption behaviors. This value difference impacts intergenerational interactions: older adults show lower willingness to share digital content and rarely participate in younger generations' digital entertainment activities.

While extensive research exists on intergenerational communication, these studies have predominantly focused on immigrant families, different ethnic groups, geographical regions, and

TABLE 9 Better-worse coefficient analysis results.

Functions/services	Better	Worse
A1	20.54%	−62.16%
A2	23.78%	−70.81%
A3	36.75%	−38.55%
A4	56.45%	−29.03%
A5	29.26%	−59.57%
A6	44.07%	−33.33%
A7	57.22%	−26.67%
A8	66.15%	−15.63%
A9	39.66%	−31.61%
A10	19.05%	−68.78%
A11	19.57%	−64.13%
A12	41.04%	−41.04%
A13	60.75%	−24.19%
A14	56.11%	−55.56%
A15	77.04%	−14.29%
A16	51.65%	−51.10%
A17	56.52%	−27.72%
A18	33.72%	−39.53%
A19	76.84%	−17.37%
A20	25.27%	−62.37%
A21	22.28%	−63.04%
A22	38.82%	−42.35%
A23	76.29%	−14.95%
A24	78.76%	−11.92%
A25	67.71%	−64.58%
A26	74.48%	−11.98%
A27	24.19%	−58.60%
A28	69.89%	−71.51%
A29	81.58%	−9.47%
A30	64.74%	−18.42%

FIGURE 5
Better-worse coefficient analysis visualization.

occupational backgrounds, with limited attention to the digital cultural divide between generations within the same cultural background (47–51). This research gap is particularly significant in the context of China's rapid digital transformation, where traditional values and emerging digital cultures create unique intergenerational dynamics.

KANO analysis further reveals significant generational differences in values. Indifferent requirements concentrate in understanding internet language (31.71%) and maintaining traditional values (32.20%), indicating older adults remain cautious about these emerging cultural elements. Better-Worse analysis shows meeting these needs has limited impact on overall satisfaction.

5.3 Digital inclusion and social support

Research shows enhancing older adults' digital cultural adaptation requires multidimensional support. Digital infrastructure needs improvement, especially regarding urban–rural disparities. The "54th Statistical Report on China's Internet Development" (2) shows urban internet users account for 72.1%, indicating room for rural digital penetration improvement.

Current digital skills training systems show clear inadequacies. As research (7) notes, few policies address specialized talent training and older adults' digital skill training paths. This lack of training support may intensify learning anxiety. Meanwhile, necessary human services and assistance

should be maintained, avoiding complete reliance on digital solutions.

Better-Worse coefficient analysis reveals hierarchical characteristics in older adults' digital service needs. Lack of basic functions leads to high dissatisfaction (Worse coefficients generally above −60%), while innovative features significantly increase satisfaction (Better coefficients up to 81.58%). This suggests digital inclusion strategies should be implemented gradually, ensuring basic service accessibility while actively developing innovative features to enhance user experience.

Digital literacy training should adopt a tiered approach: basic operations first, then social participation, and finally innovative experiences. Family support satisfaction is low (2.054) yet highly influential, suggesting policymakers should design 'digital companionship' programs encouraging young family members to participate in older adults' digital learning, such as offering volunteer credits and establishing intergenerational mentoring mechanisms.

5.4 Future development trends and policy recommendations

Based on KANO model analysis results and research findings, enhancing digital cultural services for the older adults requires comprehensive technological and policy support. Key technical improvements should focus on age-friendly design in interface

interaction and functionality configuration, aligning with Song and Gu's (8) findings on older adults' preferences for simple operations. Content services need development to meet older adults' spiritual and cultural needs (22), while learning support systems should center on family-based networks with community supplements, reflecting Chen et al.'s (17) emphasis on digital technology's positive impact on older adults' health and social participation.

Policy recommendations: (1) Establish national standards for older adult-friendly digital interfaces; (2) Develop digital adaptation assessment systems; (3) Incorporate digital cognitive education into older adults' university curricula; and (4) Set up special funds to support innovative services.

Technical development recommendations: (1) Use the KANO model to evaluate feature priorities; (2) Design interfaces adaptable to different literacy levels; (3) Strengthen security features; and (4) Incorporate family assistance functions.

Policy support should be strengthened in several areas: promoting digital inclusion and cultural service system development (7), enhancing digital cultural cognitive education to help older adults understand emerging cultural expressions, and developing tools for intergenerational communication. Essential human services should be maintained alongside digital solutions. Based on KANO model results, policy priorities include standardizing age-friendly modifications for must-be requirements, encouraging innovative service development for attractive requirements, improving digital skills training systems for one-dimensional requirements, and recognizing the potential value of indifferent requirements in providing cultural identity for older adults.

5.5 Research limitations

This study collected data through online questionnaires, which means that respondents already have a certain level of digital access. This approach introduces several limitations: recall bias may affect older adult respondents' ability to accurately report their digital usage patterns; self-assessment of digital skills may not reflect actual abilities; and the KANO model's paired positive–negative questions may present comprehension challenges despite our clear instructions. Additionally, while family assistance with questionnaire completion enabled participation from less digitally confident seniors, it might have influenced responses.

We acknowledge that our online methodology inevitably excluded older adult individuals completely disconnected from digital technologies. Future research should expand the sample size to include more older adult people who lack access to digital devices, potentially employing mixed methods combining online and offline approaches to capture experiences across the digital divide spectrum.

These findings have significant theoretical and practical implications for advancing older adults' digital inclusion and provide scientific basis for policy development. Future research could explore long-term effects of older adults' digital cultural adaptation and its impact on quality of life.

6 Conclusion

This study analyzes the digital cultural adaptation needs of Chinese older adults using the KANO model, revealing their hierarchical characteristics. Basic needs emphasize age-friendly digital product design, with must-be requirements satisfaction rates of 40–55%; advanced needs show attractive requirements like digital security and social expression reaching 60–70%, indicating high expectations for digital life quality improvement.

The older adults face multiple adaptation challenges including cognitive barriers in understanding new digital expressions and skill gaps in device usage. A significant urban–rural digital divide exists, with urban users at 72.1%. Better-Worse analysis indicates basic function absence leads to over 60% dissatisfaction, while innovative features can increase satisfaction to 81.58%.

Based on these findings, policymakers should: (1) incorporate older adult-friendly design standards into mandatory digital product regulations; (2) establish tiered digital training systems adapted to different group needs; and (3) support incentive mechanisms for family involvement in older adults' digital learning. Technology developers should: (1) prioritize ensuring basic functionality usability; (2) develop adaptive interfaces considering cognitive level differences; and (3) enhance security features, particularly focusing on privacy protection.

Through comprehensive application of technical support, content services, and policy measures, older adults' digital cultural adaptation capability can be significantly improved, promoting intergenerational cultural integration and achieving better integration of older adults into digital society.

Data availability statement

The raw data collected in this study contains sensitive personal information from elderly participants and is subject to strict privacy protections under our institutional ethics protocol (IRB Number: BNU202411270217). To protect participant confidentiality and comply with ethical guidelines regarding vulnerable populations, the original dataset will not be shared publicly or with third parties.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Faculty of Psychology, Beijing Normal 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

SL: Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. MY: Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing. RH: Conceptualization, Data curation, Formal analysis, Resources, Writing – review & editing. WL: Formal analysis, Methodology,

Resources, Software, Writing – original draft, Writing – review & 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.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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. United Nations Department of Economic and Social Affairs, P. D. World population prospects 2022: summary of results. United Nations. (2022). Available online at: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

2. China Internet Network Information Center. The 54th statistical report on internet development in China. (2024). Available online at: https://www.cnnic.cn/NMediaFile/2024/0911/MAIN1726017626560DHICKVFSM6.pdf

3. Bin W. Performance, causes, and new paths for governance of digital disability in the elderly from the perspective of digital dividend. *J Yunnan Minzu Univ*. (2024) 41:60–7. doi: 10.13727/j.cnki.53-1191/c.20240305.006

4. Yang B, Jin D. The digital divide in elderly: manifestations, motivation exploration, and bridging pathways. *Acad J Zhongzhou*. (2021) 43:74–80.

5. Mohan R, Saleem F, Voderhobli K, Sheikh-Akbari A. Ensuring sustainable digital inclusion among the elderly: a comprehensive analysis. *Sustainability*. (2024) 16:7485. doi: 10.3390/su16177485

6. Dewan S, Riggins FJ. The digital divide: current and future research Directions1. *J Assoc Inf Syst*. (2005) 6:298–337. doi: 10.17705/1jais.00074

7. Zhao Y, Zhu B. An evaluation of digital inclusion response policies for elderly in China. *Policy Internet*. (2024) 16:294–316. doi: 10.1002/poi3.399

8. Song Y, Gu L. Practical plights and optimization paths in the governance of the digital divide among elderly from a holistic perspective. *Lanzhou Acad J*. (2023) 44:109–20.

9. Li S, Yunus MM, Binti Mohd Hussain RB, Guo S. Cultural adaptation to aging: strategies and challenges for the elderly in the new digital cultural environment. *Pak J Life Soc Sci*. (2024) 22:12955–67. doi: 10.57239/PJLSS-2024-22.2.00926

10. Sheng L, Puyi W, Jianxin C. Research on the development and inheritance of intangible cultural heritage in the context of cultural aging adaptation. *J Southeast Univ*. (2023) S2:143–7.

11. Parker LJ, Marx KA, Nkimbeng M, Johnson E, Koeuth S, Gaugler JE, et al. It's more than just language: cultural adaptation of a proven dementia care intervention for Hispanic/Latino caregivers. *The Gerontologist*. (2023) 63:558–67. doi: 10.1093/geront/gnac120

12. Köttl H., Mannheim I. Ageism & digital technology: policy measures to address ageism as a barrier to adoption and use of digital technology. EuroAgeism. (2021). Available online at: https://euroageism.eu/project_publications/euroageism-policy-briefs/

13. Nittas V, Daniore P, Chavez SJ, Wray TB. Challenges in implementing cultural adaptations of digital health interventions. *Commun Med*. (2024) 4:7. doi: 10.1038/s43856-023-00426-2

14. Wong KLY, Hung L. Cultural adaptation in television technology for older adults with dementia in care settings. *Front Dementia*. (2023) 1:1098446. doi: 10.3389/frdem.2022.1098446

15. Barrera M, Berkel C, Castro FG. Directions for the advancement of culturally adapted preventive interventions: local adaptations, engagement, and sustainability. *Prev Sci*. (2017) 18:640–8. doi: 10.1007/s11121-016-0705-9

16. O'connor S, Hanlon P, O'donnell CA, Garcia S, Glanville J, Mair FS. Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. *BMC Med Inform Decis Mak*. (2016) 16:1–15. doi: 10.1186/s12911-016-0359-3

17. Chen Y, Wu L, Guo Z. Does mobile internet use affect the depression of young Chinese adults? An instrumental variable quantile analysis. *Int J Environ Res Public Health*. (2022) 19:4473. doi: 10.3390/ijerph19084473

18. He T, Huang C, Li M, Zhou Y, Li S. Social participation of the elderly in China: the roles of conventional media, digital access and social media engagement. *Telematics Inform*. (2020) 48:101347. doi: 10.1016/j.tele.2020.101347

19. 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

20. Tian J, Li H. Social networks and the mental health among Chinese older adults: the mediating role of loneliness and moderating role of internet use. *Front Public Health*. (2023) 11:1242356. doi: 10.3389/fpubh.2023.1242356

21. Ma K, Gao M, Guida FE, He R. Understanding the influencing factors and mechanism of social compensation for Chinese older adults using social media in the context of smart home: a qualitative analysis. *Front Public Health*. (2023) 11:1174920. doi: 10.3389/fpubh.2023.1174920

22. Ge Z. The coupling logic and path construction of elderly care service system and silver hair economy. *Acad J Zhongzhou*. (2024) 10:80–8.

23. Semrush. Distribution of internet users worldwide as of February 2024, by age group. (2024). Available online at: https://www.statista.com/statistics/272365/age-distribution-of-internet-users-worldwide

24. Li S, Yin Y, Yunus MM. Elderly people in the digital cultural environment: social media use, environmental stress, and intergenerational interaction. *Environ Behav Proc J*. (2025) 10:433–9. doi: 10.21834/e-bpj.v10i31.6643

25. Tenzer F. (2022). Statistiken zur smartphone-nutzung in deutschland. Available at: https://de.statista.com/themen/6137/smartphone-nutzung-in-deutschland/#topicOverview

26. Lythreatis S, Singh SK, El-Kassar A-N. The digital divide: a review and future research agenda. *Technol Forecast Soc Chang*. (2022) 175:121359. doi: 10.1016/j.techfore.2021.121359

27. Bhaskar S, Bradley S, Chattu VK, Adisesh A, Nurtazina A, Kyrykbayeva S, et al. Telemedicine as the new outpatient clinic gone digital: position paper from the pandemic health system REsilience PROGRAM (REPROGRAM) international consortium (part 2). *Front Public Health*. (2020) 8:410. doi: 10.3389/fpubh.2020.00410

28. Loh KK, Kanai R. How has the internet reshaped human cognition? *Neuroscientist*. (2016) 22:506–20. doi: 10.1177/1073858415595005

29. Scullin MK, Jones WE, Phenis R, Beevers S, Rosen S, Dinh K, et al. Using smartphone technology to improve prospective memory functioning: a randomized controlled trial. *J Am Geriatr Soc*. (2022) 70:459–69. doi: 10.1111/jgs.17551

30. Friemel TN. The digital divide has grown old: determinants of a digital divide among seniors. *New Media Soc*. (2016) 18:313–31. doi: 10.1177/1461444814538648

31. Neves BB, Waycott J, Malta S. Old and afraid of new communication technologies? Reconceptualising and contesting the 'age-based digital divide. *J Sociol*. (2018) 54:236–48. doi: 10.1177/1440783318766119

32. United Nations Economic Commission for Europe (UNECE). Ageing in the digital era. (2021). 28. doi: 10.18356/27083047-26

33. Mikulić J, Prebežac D. A critical review of techniques for classifying quality attributes in the Kano model. *Managing Serv Qual Int J*. (2011) 21:46–66. doi: 10.1108/09604521111100243

34. Shi C, Cai C, Wang Y, Zhu Y, Pan S, Yang Y. Research on the demand and influencing factors of home care social support services for the elderly with dementia in cities. *Chinese J Pract Nurs*. (2023) 21:1263–70.

35. Huang K-L, Jiang J, Cheng Y-Y. On improving the acceptance of intelligent companion robots among Chinese empty-nesters with the application of emotional design In: M Kurosu, S Yamamoto, H Mori, DD Schmorrow, CM Fidopiastis and NA Streitzet al, editors. HCI international 2022—Late breaking papers. Multimodality in advanced interaction environments. Cham: Springer Nature Switzerland (2022). 257–70.

36. Sun X, Chen Z, Jiang Q. An empirical study on the willingness of young elderly to use elderly companion robot. *Int J Hum Comput Interac.* (2024) 1–22:1–22. doi: 10.1080/10447318.2024.2344918

37. Zhou C, Guo J, Zhang Y, Huang T, Kaner J. A home health management app designed in the post-epidemic era using empirical evidence based on the demand collection of elderly users. *Human Soc Sci Commun.* (2024) 11:1–13. doi: 10.1057/s41599-024-03042-0

38. Rotar LJ, Kozar M. The use of the Kano model to enhance customer satisfaction. *Organ.* (2017) 50:339–51. doi: 10.1515/orga-2017-0025

39. Mao T, Liu J, Zhao Q. Research on the priority content of medical and health APP from the perspective of user demand. *J Modern Inform.* (2024) 44:87–97.

40. Wang S. Visual communication design of mobile app interface based on digital. *Int J Inform Syst Supply Chain Manag.* (2024) 17:1–17. doi: 10.4018/IJISSCM.348063

41. Rao Y, Su X, Feng Y, Fu R. Design and research of ageing-appropriate social app for customized health tourism. *HCI Int 2023 Late Breaking Pap.* (2023) 14055:171–90. doi: 10.1007/978-3-031-48041-6_13

42. Cao Y. Interaction design of elderly-friendly smartwatches: a KANO-AHP-QFD theoretical approach In: Q Gao and J Zhou, editors. Human aspects of IT for the aged population, vol. *14725*. Cham: Springer Nature Switzerland (2024). 13–30.

43. Guo Y, Yuan T, Yue S. Designing personalized persuasive game elements for older adults in health apps. *Appl Sci.* (2022) 12:6271. doi: 10.3390/app12126271

44. Liang Y-W, Wang J, Yu S-P, Lin J-K, Chung A. Creating a healthy life for the elderly through participation in self-media: a study on the demands of the elderly in self-media. *Int J Environ Res Public Health.* (2022) 19:12774. doi: 10.3390/ijerph191912774

45. Berger C, Blauth R, Boger D, Bolster C, Burchill G, DuMouchel W, et al. Kano's methods for understanding customer-defined quality. *Center Qual Manag J.* (1993) 2:3–35.

46. Amann-Hechenberger B, Buchegger B, Erharter D, Felmer V, Fitz B, Jungwirth B, et al. Tablet & smartphone: seniorinnen und senioren in der mobilen digitalen welt. *Forschungsbericht Zum Projekt Mobi Senior A.* (2015)

47. Cemalcilar Z, Secinti E, Sumer N. Intergenerational transmission of work values: a meta-analytic review. *J Youth Adolesc.* (2018) 47:1559–79. doi: 10.1007/s10964-018-0858-x

48. Merz E-M, Özeke-Kocabas E, Oort FJ, Schuengel C. Intergenerational family solidarity: value differences between immigrant groups and generations. *J Fam Psychol.* (2009) 23:291–300. doi: 10.1037/a0015819

49. Phinney JS, Ong A, Madden T. Cultural values and intergenerational value discrepancies in immigrant and non-immigrant families. *Child Dev.* (2000) 71:528–39. doi: 10.1111/1467-8624.00162

50. Phinney JS, Vedder P. Family relationship values of adolescents and parents: intergenerational discrepancies and adaptation. In J. W. Berry, J. S. Phinney, D. L. Sam and P. Vedder (editors). Immigrant youth in cultural transition: Acculturation, identity, and adaptation across national contexts. Lawrence Erlbaum Associates Publishers. (2022). 167–184. doi: 10.4324/9780415963619-7

51. Uskul AK, Lalonde RN, Konanur S. The role of culture in intergenerational value discrepancies regarding intergroup dating. *J Cross Cult Psychol.* (2011) 42:1165–78. doi: 10.1177/0022022110383311

52. Xie Z, Li W, Xie Y, Wang L. Demand and satisfaction analysis of short health videos among Chinese urban youth: a mixed-methods study based on the KANO model. *Human Soc Sci Commun.* (2024) 11:740. doi: 10.1057/s41599-024-03266-0

Perceptual-vision training as a strategy for healthy aging in adults with intellectual disability: a study protocol

Luca Cavaggioni[1]*[†], Damiano Formenti[1][†], Paolo Castiglioni[1,2], Luca Paolo Ardigò[3]*[‡] and Giampiero Merati[1,2][‡]

[1]Department of Biotechnology and Life Sciences, University of Insubria, Varese, Italy, [2]IRCCS Fondazione don Carlo Gnocchi, Milan, Italy, [3]Department of Teacher Education, NLA University College, Oslo, Norway

Aging leads to changes in motor-cognitive performance. Despite the importance of physical activity for healthy aging and the need for health promotion interventions in individuals with intellectual disability (ID), there is a lack of empirically strategies for promoting health in adults with ID. Therefore, we are conducting a clinical trial (NCT06628999 on clinicaltrials.gov) to investigate a strategy for promoting healthy aging by targeting physical and cognitive domains in ID individuals. The present work aims to provide a detailed account of the study protocol of the proposed trial to promote transparency and dissemination of the ongoing research. Specifically, this project will study the effect of a vision training program on cognitive performance and physical fitness in adults with ID. A secondary aim is to examine the association between mental and physical performance outcomes. Participants will be randomly allocated into a vision training group (VT, $n = 28$), a vision training-detraining group (VTD, $n = 28$), and a control group (C, $n = 28$). During the first 8 weeks, the VT and VTD groups will follow the same training protocol (based on vision oculomotor exercises combined with postural control exercises). From weeks 9 to 16, the VT group will continue the training protocol, whereas the VTD group will abstain from training (detraining). Cognitive performance and physical fitness will be assessed at baseline, mid- and post-training intervention. Overall, a vision training program can positively impact various aspects of life for individuals with ID promoting autonomy, and social integration to counteract the aging process.

KEYWORDS

down syndrome, cognitive performance, intellectual impairment, visual training, physical activity

1 Introduction

The United Nations expects that by 2050, a fifth of the global population will be older, with 15% of the population having some form of disability (Santos et al., 2022). Healthy aging involves developing functional abilities for wellbeing in older age and encompasses physical capabilities, cognitive functioning, metabolic health and psychological wellbeing (John et al., 2023). Aging is linked to changes in the locomotor system and reduced cognitive processing, leading to deterioration in motor-cognitive performance. In this sense, research has consistently demonstrated the crucial role of physical activity in improving physical fitness and preserving cognition in healthy older individuals (Erickson et al., 2019). However, as the majority of the literature focusedon

healthy aging among the general population (Wollesen et al., 2020), there is also a need to focus on wellness promotion among individuals with intellectual disabilities. While most adults with cognitive disabilities have relatively few life co-existing conditions, some of them may experience severe health issues that impact their wellbeing (Reynolds et al., 2019). Compelling evidence suggests that adults with intellectual disabilities generally face unhealthy lifestyle habits, inadequate physical activity or poor nutrition health outcomes compared to their able-bodied individuals (McGuire et al., 2007). To sum up, a better comprehension on which type of intervention could contribute to ameliorate healthier old age outcomes for adults with cognitive impairments is fundamental.

Intellectual disability (ID) represents a heterogeneous condition based on the cognitive deficit and a wide range of comorbidities with a negative impact on aging (Krahn and Fox, 2014). ID includes some genetic syndromes (e.g., Down syndrome and Fragile X syndrome) with a remarkable effect on intellectual and adaptive behavior during childhood (U.S. National Library of Medicine, 2024), leading to deficits in motor development (Belluscio et al., 2019), sensorial context (Chokron et al., 2020) and visuospatial cognition (Giuliani et al., 2011; Wilkinson and Light, 2014). Notably, vision and eye tracking play a key role in spatial orientation, stimulating several brain areas (Henderson, 2003) and people with ID display anomalous visual movements, spatial organization and cognitive performance (Giuliani et al., 2011). In addition, an earlier acquisition of essential visual functions may have a protective effect on subsequent intellectual development (Dale and Sonksen, 2002).

With this in mind, multicomponent motor-cognitive training is a promising exercise category that stimulates multiple physical and cognitive skills, showing more remarkable similarities to daily life activities. In this sense, vision training with oculomotor eye-tracking stimuli has positively affected cognitive functions (Edlin and Lyle, 2013; Formenti et al., 2019). In older people, gross–motor coordination training and cognitive tasks counter age-related cognitive decline (Forte et al., 2023). Conversely, motor-cognitive interventions can also positively affect global cognition and inhibition (Wollesen et al., 2020). A recent review analyzed current interventions to support healthy aging in individuals with ID, highlighting physical activity as a crucial factor for healthy aging while emphasizing the need for more practical health promotion strategies to enhance the wellbeing of individuals with ID (Santos et al., 2022). However, there is a paucity of literature addressing feasible strategies that target both the physical and cognitive domains in individuals with ID to counteract the age-related decline. Therefore, we are conducting an interventional randomized clinical trial to investigate a potential strategy for promoting healthy aging by targeting physical and cognitive outcomes in individuals with ID. Aim of the present work is to provide a detailed account of the study protocol of our clinical trial to promote transparency and dissemination of the ongoing research. Specifically, the proposed protocol aims to investigate the effects of a 16-week vision training programme on cognitive and motor performance in individuals with ID.

1.1 Study objectives

The overall main purpose of this research project is to determine the effectiveness of perceptual-vision training on cognition and physical functioning in individuals with intellectual disabilities.

Specifically, the primary endpoint is to identify the role of eye training on cognitive performance in terms of inhibitory control. The secondary endpoints are to verify the contribution of vision training on postural control, upper and lower body strength and agility outcomes. The tertiary endpoint aims to verify any potential effect of age, reinforcing the concept of promoting healthy aging.

Our primary hypothesis is that perceptual vision training intervention will promote a greater increase in cognitive and motor performance compared to the usual care control group. In addition, the secondary hypothesis is that a period of detraining could slightly attenuate the training-induced gains achieved during the previous intervention period. The third hypothesis is to detect whether there is an age-related effect on the outcomes measured.

2 Material and methods

This study was approved by the University of Insubria Ethics Committee (protocol number 0119168, date 12.03.2024) and registered in ClinicalTrials.gov (NCT06628999) in compliance with the Helsinki Declaration. Written informed consent will be obtained from patients following the tenets of the Declaration of Helsinki on studies with human participants (Holt, 2014).

2.1 Study population

Participants will be recruited from local communities dwelling in Northern Italy. The inclusion criteria include age between 40 and 70 years with a low-to-mild intellectual disability (Intellectual Quotient, IQ = 51–69) defined with the Wechsler Scale of Intelligence (WAIS-IV), a scale particularly suited for individuals with an age range from 16 to 90 years composed by four sub-tests that would provide a comprehensive general intelligence index. The exclusion criteria are (a) inability to understand essential verbal communication, (b) strict dependence on personnel or assistive support devices, (c) presence of concomitant sensorial or physical impairments and (d) presence of behavioral problems or any other clinical condition that may compromise the practice of regular physical activity.

2.2 Study design

This project is a three-arm, parallel, randomized controlled trial. In detail, Figure 1 highlights the flow diagram of the overall design setting. At the beginning, participants will have their body mass and height measured. After that, a 1-week familiarization period will be implemented during which participants will adapt to the exercise techniques used throughout the study. Following 1 week of baseline testing, participants will be randomly assigned

to three groups: (i) a Visual Training Group (VT, $n = 28$) that will perform oculomotor exercises combined with postural control exercises (Formenti et al., 2019) for 16 weeks; (ii) a Visual Training-Detraining group (VTD, $n = 28$) that will follow the same training protocol of VT for the first 8 weeks, abstaining from any training for the following 8-weeks period (from week 9 to week 16) and (iii) a control group (C, $n = 28$) in which no intervention will be implemented. Randomization will be achieved using a random-number generator (https://www.random.org using a 1:1:1 ratio) and to ensure adequate allocation concealment this procedure will be carried out by a blinded external researcher. An independent researcher will conduct the allocation sequence until the interventions are assigned. A research team collaborator will enroll and assign participants to the three groups. Baseline testing will be repeated after 8 weeks (mid-training testing) and at the end of week 16 (post-training testing).

2.3 Intervention protocol

The intervention programs for VT and VTD groups will be performed using the premium equipment of the S.V.T.A. training kit (S.V.T.A. method©, Carmagnola, Italy). This method combines visual skills (e.g., peripheral vision, saccadic eye movements, accommodation and vergence skills) with postural control actions. Each training session will be structured in a circuit-training format composed of 5 stations in which participants will perform the prescribed exercises for 6 min. Each station will be characterized by different panels fixed on a wall about 1.5 m from ground level, with colors, letters, and numbers as targets. VT and VTD groups will perform the same motor-cognitive oculomotor training combined with postural control exercises structured in four incremental sub-phases, as proposed by Formenti et al. (2019): phase 1 (weeks 1–4), phase 2 (weeks 5–8), phase 3 (weeks 9–12) and phase 4 (weeks 13–16). The difficulty of the oculomotor task increases progressively from Phase 1 to Phase 4 (for example, from bipedalism to monopodial stance and from close to far). The training circuit is composed of 5 stations (represented in Figure 2):

Station 1. A square board with nine points on a wall. Participants must move their gaze on external points in clockwise and anticlockwise directions, maintaining their focus on the central point.

Station 2. A rectangular board with an infinity profile on a wall. The infinity profile comprises a sequence of randomized red and blue points. Participants have to move their gaze from one point to another following the infinity profile while pronouncing the color of the point identified.

Station 3. A square board of four circles formed by a random sequence of red and blue letters fixed on a wall. Participants must move their gaze from one letter to another while pronouncing the identified one, maintaining the visual focus on the central point.

Station 4. A square board of 81 cells is fixed on the wall. Red or blue cells contain a random number from 0 to 9. Each participant holds a board comprising an image like the one on the wall. Participants have to read the numerical digit on the board in

their hands and localize the same numerical digit on the board on the wall.

Station 5. Two boards with black-colored numerical digits (0 to 9) are fixed vertically on the wall. Participants must read digits while shifting their gaze from one board to another in mediolateral and sagittal directions.

2.4 Measurements and procedures

2.4.1 Anthropometric variables

Body height and mass will be measured to the nearest 0.1 cm and 0.1 kg, respectively, using a beam scale (SECA 220, Hamburg, Germany).

2.4.2 Cognitive performance

Inhibitory control will be measured by the Flanker Task, previously used in ID individuals (Van Biesen et al., 2017) (Figure 3A). Participants will be requested to indicate the direction of a left- or right-pointing target arrow as quickly as possible while ignoring two flanking arrows on each side pointing in the same or opposite direction. The task includes two conditions: congruent and incongruent. The congruent condition consists of trials in which both the target arrow and the four flanking arrows are pointed in the same direction (left: $<<\boldsymbol{<}<<$ or right: $>>\boldsymbol{>}>>$). The incongruent condition consisted of trials in which the flanking arrows point in the opposite direction of the target arrow ($<<\boldsymbol{>}<<$ or $>>\boldsymbol{<}>>$). Participants have to press button A on the keyboard when the target arrow points to the left (i.e., $<$) and L when the target arrow points to the right (i.e., $>$). Two sets of 50 trials each will be randomly proposed. The mean response time of the correct responses and the percentage of correct responses will be computed for each condition as the outcome.

2.4.3 Physical fitness

Different biomotor abilities will be measured and visually shown in multipaneled Figure 3. Postural control will be screened by the modified Balance Error Scoring System (M-BESS) performed in an upright stance while conserving stability in three positions for 20 s (i.e., bipedalism, tandem or monopodial) on a firm surface (Figure 3B). The examiner will count the person's errors while maintaining the proper stance (Azad et al., 2016).

The integration between the agility domain and cognitive performance will be assessed by the time up-and-go test (TUG) (Figure 3C). Outcomes of the TUG test are: (i) the time a participant takes to get up from a chair, to walk and turn around a cone positioned 3 m far away and to walk backwards to the chair again while carrying a full glass of water in one hand (Maranhão-Filho et al., 2011) and (ii) the number of times the participant spills water on the ground (Kachouri et al., 2024).

Lower-body muscle strength will be assessed using the five-repetition sit-to-stand (5STS) by asking the patient to rise and sit down for five consecutive repetitions with arms crossed over the chest. This procedure is particularly suited to patients with disabilities (Polidori et al., 2024). Performance time in seconds will be obtained using a stopwatch (Figure 3D).

FIGURE 1
CONSORT diagram of the research.
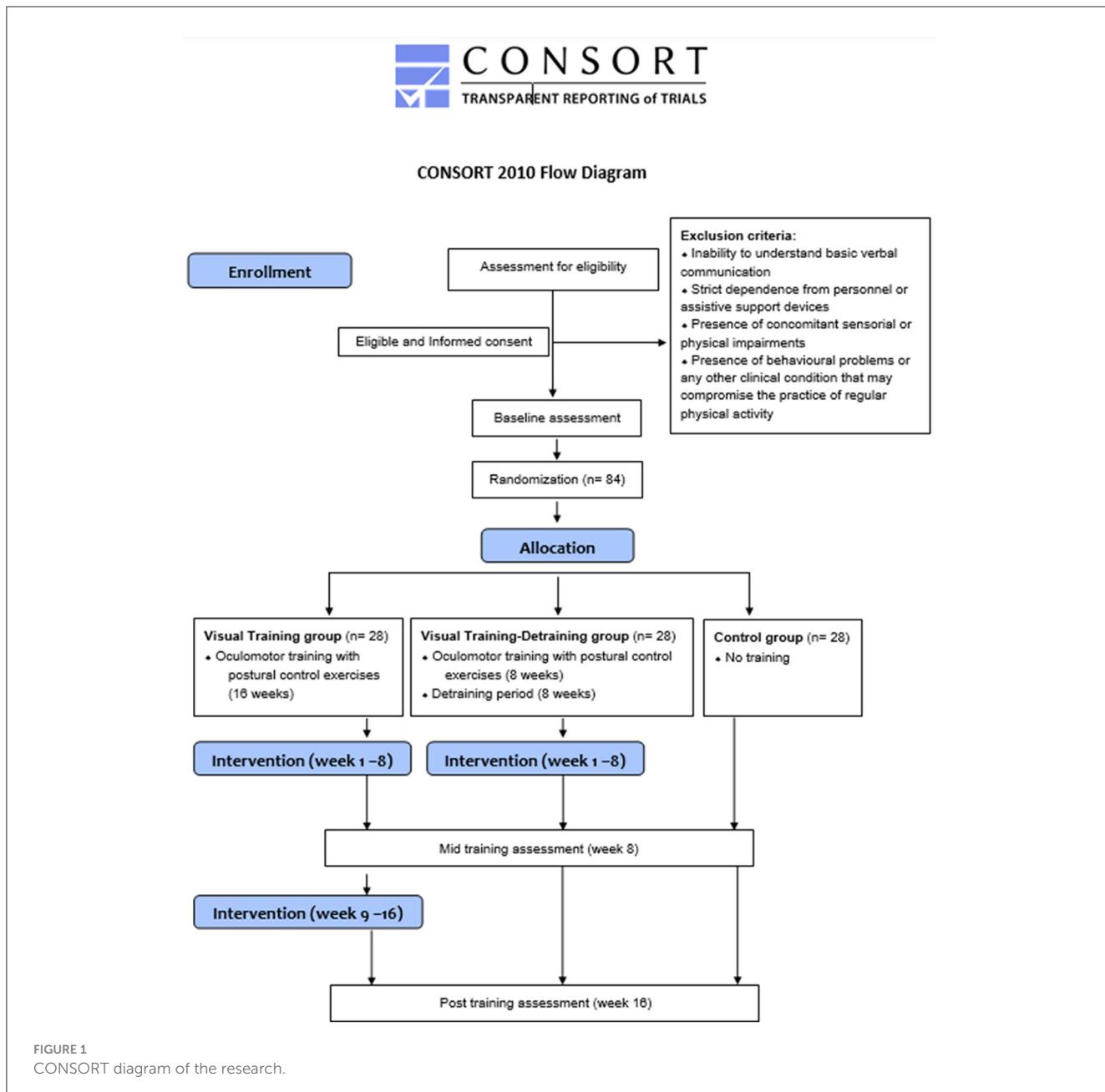
Upper-body strength will be detected with the handgrip strength test (HST), with the patient sitting on a chair while exerting the maximum isometric grip (Mathiowetz et al., 1985) (Figure 3E). A Camry dynamometer (CAMRY EH101, Sensun Weighing Apparatus Group Ltd, Guangdong, China), which provided excellent validity and reliability among adult-aged community-dwelling individuals (Huang et al., 2022), will be used to detect the maximal handgrip strength.

It is worth noticing that for M-BESS, TUG, 5STS, and HST procedures, the same tester will conduct three trials while respecting an interval rest of 60 s to detect the consistency and reliability of the measures.

2.5 Statistical analysis

The sample-size calculation is established based on a previous study (Formenti et al., 2019) on the primary outcome (incongruent condition of the Flanker task) using G*Power software. From a priori power analysis, observing a sample size of up to 84 individuals ($\beta = 0.9$) is requested, respecting a large effect size (Cohen's f equal to 0.4) with a type I error rate of $\alpha = 0.05$. All data will be presented as mean $\pm$ standard deviation. The dataset will be tested for normal distribution using Shapiro–Wilk's normality test. Based on the study's design, the primary independent endpoints are the treatment groups and time. A two-way (treatment $\times$ time) repeated measures ANOVA will be used on each outcome

FIGURE 2
Vision training panel kit (reprinted with permission by Formenti et al., 2019).

FIGURE 3
Testing procedures pictorial setting. **(A)** Cognitive performance, Flanker Task test. **(B)** Postural control, Modified Balance Error Scoring System. **(C)** Agility, Time Up and Go test. **(D)** Lower-body muscle strength, Five Repetition Sit-to-Stand test. **(E)** Upper-body muscle strength Handgrip Strength Test.

variable to determine the interaction between the three time points (baseline, 8 weeks, 16 weeks) and groups (VT, VTD, C). If an interaction exists, the simple effect and pairwise comparisons will detect differences between groups at each time point. Subsequently an additional age stratification and comparison will be performed to check any age-related difference. If a main effect is detected, data

FIGURE 4
Study protocol design setting.
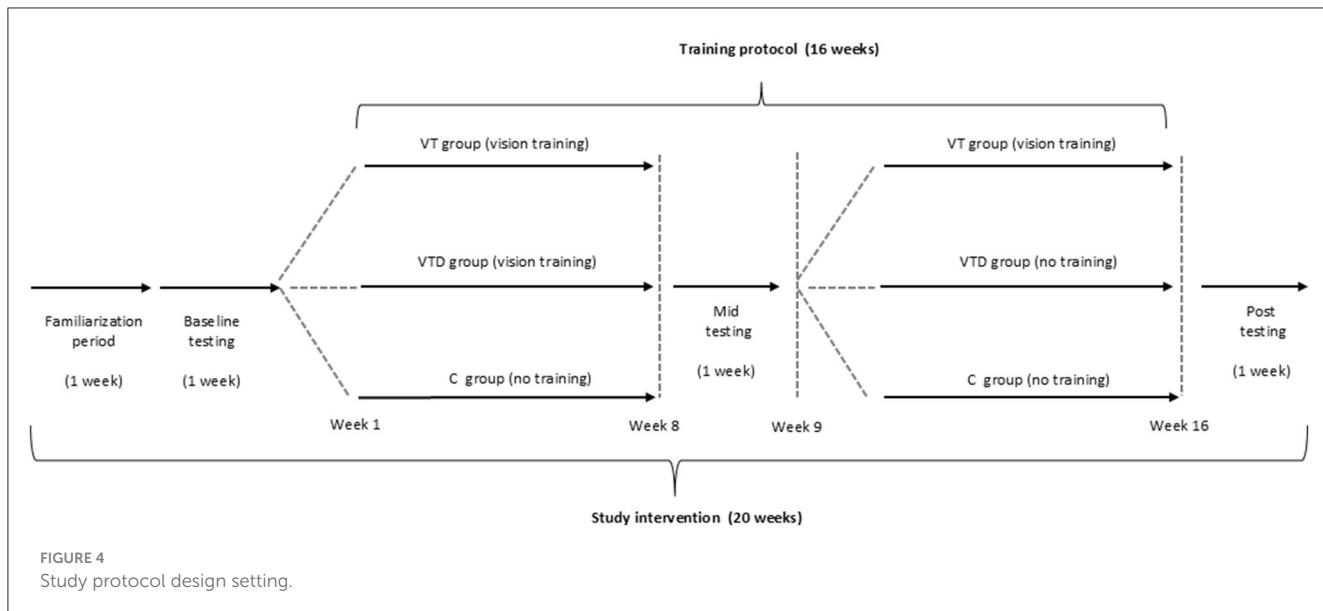
will be analyzed using a *post-hoc* analysis (Bonferroni test). The significance level will be set at $p < 0.05$. Partial eta squared (Part 2) effect size will be used to estimate the magnitude of the difference within each group, respecting a threshold for small (0.01), moderate (0.06) and large effects (0.14) (Cohen, 2013).

If the Shapiro-Wilk's normality test is not passed, non-parametric tests will be applied. The Friedman Test will be performed to detect differences between groups over time in both primary and secondary outcomes. In addition, to examine where the differences occur, a Wilcoxon Signed Rank test with Bonferroni adjustment will be used as a *post-hoc* analysis. Also, in these tests, the significance level will be set at $p < 0.05$.

3 Expected results and discussion

This study protocol is designed to investigate the effectiveness of a 16-week training program on cognitive performance and physical fitness in individuals with ID (Figure 4). The present research results are estimated to provide valuable data regarding a supervised exercise protocol to deal with IDs in a real-world context. The results will help to develop exercise prescription guidelines for individuals with ID to counteract the age-related physical and cognitive decline.

In detail, the VT group is expected to improve outcomes of both cognitive and physical domains at the end of week 16. Conversely, the VTD group during the detraining period is expected to slightly attenuate the training-induced gains achieved during the previous 8 weeks. Indeed, a short-term detraining period (i.e., 8–12 weeks) appears sufficient to rapidly lose previously gained physical adaptations (Bosquet et al., 2013), probably due to an attenuation of motor unit recruitment (Lemmer et al., 2000). When investigating the potential mediators in the association between physical fitness and cognitive function, it seems that molecular changes along with adaptations in brain structure, function and emotional factors are less impacted by short interruptions in training when compared to traditional fitness parameters (i.e., muscular strength). As a result,

a detraining period may still preserve cognition and executive functions in older adults (Rodrigues et al., 2020). However, further research is necessary to clarify the effects of detraining on the potential mediators associated with physical exercise and cognitive performance in individuals with ID. Moreover, regarding the secondary aim, a positive association between cognitive outcomes and physical fitness is another expected result, given the physiological deterioration observed in the ID population (Reguera-García et al., 2023; Hartman et al., 2015; Haynes and Lockhart, 2012). Lastly, as for the tertiary aim, the expected findings are an effect of age on visual stimuli and neural changes. Thus, it is plausible to hypothesize that older individuals with ID may obtain fewer cognitive performance benefits compared to younger individuals with ID due to neurophysiological changes associated with the aging process of the visual and cognitive systems.

Interestingly, vision training combined with postural control exercises in individuals with ID holds promising practical implications across various domains. First, such a program can significantly enhance the individuals' overall functional independence by improving their ability to perform daily activities requiring cognitive and motor actions (Belva and Matson, 2013). In account to this, future perspectives could encompass a specific measurement of functional independence through the adoption of the Functional Independence Measure (FIM) scale. Potential limitations would address the lack of comparison with individuals with different disabilities (i.e., motor impairments) or the lack of an arm that would perform general physical exercise without vision training stimuli (Whitson et al., 2007).

Moreover, improved physical fitness can reduce the risk of falls by enhancing overall wellbeing (Jacob et al., 2023). Furthermore, the acquired motor skills and increased confidence can translate into greater opportunities for social interaction and meaningful relationships, fostering a sense of belonging within the individual and their community.

Overall, a vision training program has the potential to positively impact various aspects of individuals with ID in terms of spatial cognition and orientation (Henderson, 2003). From a practical

perspective, educators, trainers, and therapists may benefit from incorporating visual stimuli in their exercise routines for the ID population, as this offers the possibility of directly targeting cognitive performance (Giuliani et al., 2011; Dale and Sonksen, 2002) while respecting individual differences by emphasizing body awareness and perceptions (Cavaggioni et al., 2019; Raiola et al., 2022; D'Isanto et al., 2022). Additionally, the acquisition of independence is a crucial aspect of community participation and daily life activities, and this protocol could represent an innovative solution when dealing with aging individuals with ID.

4 Ethics and dissemination

Informed consent forms for this study will be provided in several languages, including Italian, English, French and Dutch. All communication will emphasize the voluntary nature of participation and the fact that all necessary care will be provided. Data will be anonymised before publication. The results will be presented to interested individuals, community-dwellings who have explicitly asked for insight into the outcomes, clinicians, hospitals, private health institutions, and patient associations. Moreover, dissemination will include the study's submission to peer-reviewed journals, and results will be presented at relevant national and international congresses or symposia.

Author contributions

LC: Writing – original draft, Writing – review & editing. DF: Writing – original draft, Writing – review & editing. PC: Writing –
review & editing, Writing – original draft. LPA: Writing – review & editing, Writing – original draft. GM: Writing – review & editing, Writing – original draft.

Funding

Conflict of interest

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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

Azad, A. M., Juma, S. A., Bhatti, J. A., and Delaney, J. S. (2016). "Modified Balance Error Scoring System (M-BESS) test scores in athletes wearing protective equipment and cleats," in *BMJ Open Sport—Exercise Medicine, vol. 2*. Available online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5117076/ doi: 10.1136/bmjsem-2016-000117 (accessed September 30, 2024).

Belluscio, V., Bergamini, E., Salatino, G., Marro, T., Gentili, P., Iosa, M., et al. (2019). Dynamic balance assessment during gait in children with Down and Prader-Willi syndromes using inertial sensors. *Hum. Mov. Sci.* 63, 53–61. doi: 10.1016/j.humov.2018.11.010

Belva, B. C., and Matson, J. L. (2013). An examination of specific daily living skills deficits in adults with profound intellectual disabilities. *Res. Dev. Disabil.* 34, 596–604. doi: 10.1016/j.ridd.2012.09.021

Bosquet, L., Berryman, N., Dupuy, O., Mekary, S., Arvisais, D., Bherer, L., et al. (2013). Effect of training cessation on muscular performance: a meta-analysis. *Scand. J. Med. Sci. Sports.* 23, e140–149. doi: 10.1111/sms.12047

Cavaggioni, L., Trecroci, A., Tosin, M., Iaia, F. M., and Alberti, G. (2019). Individualized dry-land intervention program for an elite paralympic swimmer. *J. Sports Med. Phys. Fitness.* 59, 82–6. doi: 10.23736/S0022-4707.18.08242-7

Chokron, S., Kovarski, K., Zalla, T., and Dutton, G. N. (2020). The inter-relationships between cerebral visual impairment, autism and intellectual disability. *Neurosci. Biobehav. Rev.* 114, 201–210. doi: 10.1016/j.neubiorev.2020.04.008

Cohen, J. (2013). *Statistical Power Analysis for the Behavioral Sciences* (Milton Park: Routledge), 689.

Dale, N., and Sonksen, P. (2002). Developmental outcome, including setback, in young children with severe visual impairment. *Dev. Med. Child Neurol.* 44, 613–622. doi: 10.1111/j.1469-8749.2002.tb00846.x

D'Isanto, T., D'Elia, F., Esposito, G., Altavilla, G., and Raiola, G. (2022). Examining the effects of mirror therapy on psychological readiness and perception of pain in ACL-injured female football players. *J Funct Morphol Kinesiol.* 7, 113. doi: 10.3390/jfmk7040113

Edlin, J. M., and Lyle, K. B. (2013). The effect of repetitive saccade execution on the attention network test: enhancing executive function with a flick of the eyes. *Brain Cogn.* 81, 345–351. doi: 10.1016/j.bandc.2012.12.006

Erickson, K. I., Hillman, C., Stillman, C. M., Ballard, R. M., Bloodgood, B., Conroy, D. E., et al. (2019). Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. *Med. Sci. Sports Exerc.* 51, 1242–1251. doi: 10.1249/MSS.0000000000001936

Formenti, D., Duca, M., Trecroci, A., Ansaldi, L., Bonfanti, L., Alberti, G., et al. (2019). Perceptual vision training in non-sport-specific context: effect on performance skills and cognition in young females. *Sci. Rep.* 9, 18671. doi: 10.1038/s41598-019-55252-1

Forte, R., Trentin, C., Tocci, N., Lucia, S., Aydin, M., Di Russo, F., et al. (2023). Motor-cognitive exercise with variability of practice and feedback improves functional ability and cognition in older individuals. *Aging Clin. Exp. Res.* 35, 2797–2806. doi: 10.1007/s40520-023-02568-8

Giuliani, F., Favrod, J., Grasset, F., and Schenk, F. (2011). Accurate memory for object location by individuals with intellectual disability: absolute spatial tagging instead of configural processing? *Res. Dev. Disabil.* 32, 986–994. doi: 10.1016/j.ridd.2011.01.055

Hartman, E., Smith, J., Westendorp, M., and Visscher, C. (2015). Development of physical fitness in children with intellectual disabilities. *J. Intell. Disabil. Res.* 59, 439–49. doi: 10.1111/jir.12142

Haynes, C. A., and Lockhart, T. E. (2012). Evaluation of gait and slip parameters for adults with intellectual disability. *J. Biomech*. 45, 2337–41. doi: 10.1016/j.jbiomech.2012.07.003

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends Cogn. Sci*. 7, 498–504. doi: 10.1016/j.tics.2003.09.006

Holt, G. R. (2014). Declaration of Helsinki-the world's document of conscience and responsibility. *South. Med. J*. 107, 407. doi: 10.14423/SMJ.0000000000000131

Huang, L., Liu, Y., Lin, T., Hou, L., Song, Q., Ge, N., et al. (2022). Reliability and validity of two hand dynamometers when used by community-dwelling adults aged over 50 years. *BMC Geriatr*. 22, 580. doi: 10.1186/s12877-022-03270-6

Jacob, U. S., Pillay, J., Johnson, E., Omoya (Tomi), O., Adedokun, A. P. (2023). A systematic review of physical activity: benefits and needs for maintenance of quality of life among adults with intellectual disability. *Front Sports Act Living*. 5, 1184946. doi: 10.3389/fspor.2023.1184946

John, E. E., Astell-Burt, T., Yu, P., Brennan-Horley, C., and Feng, X. (2023). Development of a composite healthy ageing score: evidence from middle-to-older aged Australians. *Health Promot Int*. 38, daad043. doi: 10.1093/heapro/daad043

Kachouri, H., Jouira, G., Rebai, H., and Sahli, S. (2024). The effect of motor dual-task training on gait and mobility performances in children with intellectual disabilities. *J. Intellect. Disabil*. 17446295241284722. doi: 10.1177/17446295241284722

Krahn, G. L., and Fox, M. H. (2014). Health disparities of adults with intellectual disabilities: what do we know? What do we do? *J. Appl. Res. Intellect. Disabil*. 27, 431–446. doi: 10.1111/jar.12067

Lemmer, J. T., Hurlbut, D. E., Martel, G. F., Tracy, B. L., Ivey, F. M., Metter, E. J., et al. (2000). Age and gender responses to strength training and detraining. *Med. Sci. Sports Exerc*. 32, 1505–12. doi: 10.1097/00005768-200008000-00021

Maranhão-Filho, P. A., Maranhão, E. T., Lima, M. A., and da Silva, M. M. (2011). Rethinking the neurological examination II: dynamic balance assessment. *Arq. Neuropsiquiatr*. 69, 959–63. doi: 10.1590/S0004-282X2011000700022

Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., Rogers, S., et al. (1985). Grip and pinch strength: normative data for adults. *Arch. Phys. Med. Rehabil*. 66, 69–74.

McGuire, B. E., Daly, P., and Smyth, F. (2007). Lifestyle and health behaviours of adults with an intellectual disability. *J. Intellect. Disabil. Res*. 51, 497–510. doi: 10.1111/j.1365-2788.2006.00915.x

Polidori, A., Malagoli, M., Giacalone, R., Brichetto, G., Monti Bragadin, M., Prada, V., et al. (2024). 30-Second Chair stand and 5-times sit-to-stand tests are interesting

tools for assessing disability and ability to ambulate among patients with multiple sclerosis. *Life*. 14, 703. doi: 10.3390/life14060703

Raiola, G., D'Isanto, T., Di Domenico, F., and D'Elia, F. (2022). Effect of teaching methods on motor efficiency, perceptions and awareness in children. *Int. J. Environ. Res. Public Health*. 19, 10287. doi: 10.3390/ijerph191610287

Reguera-García, M. M., Fernández-Baró, E., Diez-Vega, I., Varona-Echave, I., and Seco-Calvo, J. (2023). Explanatory capacity of postural control and physical fitness in cognitive impairment and support needs among individuals with intellectual disabilities—a cross-sectional pilot study. *Brain Sci*. 13, 1213. doi: 10.3390/brainsci13081213

Reynolds, M. C., Palmer, S. B., and Barton, K. N. (2019). Supporting active aging for persons with severe disabilities and their families across the life course. *Res. Pract. Pers. Severe Disabil*. 44, 211–223. doi: 10.1177/1540796919880561

Rodrigues, L., Bherer, L., Bosquet, L., Vrinceanu, T., Nadeau, S., Lehr, L., et al. (2020). Effects of an 8-week training cessation period on cognition and functional capacity in older adults. *Exp. Gerontol*. 134, 110890. doi: 10.1016/j.exger.2020.110890

Santos, F. H., Zurek, J., and Janicki, M. P. (2022). Efficacy of healthy aging interventions for adults with intellectual and developmental disabilities: a systematic review. *Gerontologist* 62, e235–e252. doi: 10.1093/geront/gnaa192

U.S. National Library of Medicine (2024). *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition Source Information*. Available online at: https://www.nlm.nih.gov/research/umls/sourcereleasedocs/current/DSM-5/index.html (accessed 30 Jan 2024).

Van Biesen, D., McCulloch, K., Janssens, L., and Vanlandewijck, Y. C. (2017). The relation between intelligence and reaction time in tasks with increasing cognitive load among athletes with intellectual impairment. *Intelligence*. 64, 45–51. doi: 10.1016/j.intell.2017.06.005

Whitson, H. E., Cousins, S. W., Burchett, B. M., Hybels, C. F., Pieper, C. F., Cohen, H. J., et al. (2007). *The Combined Effect of Visual Impairment and Cognitive Impairment on Disability in Older People*. Available online at: https://agsjournals.onlinelibrary.wiley.com/doi/10.1111/j.1532-5415.2007.01093.x (accessed March 27, 2025)

Wilkinson, K. M., and Light, J. (2014). Preliminary study of gaze toward humans in photographs by individuals with autism, down syndrome, or other intellectual disabilities: implications for design of visual scene displays. *Augment. Altern. Commun*. 30, 130–146. doi: 10.3109/07434618.2014.904434

Wollesen, B., Wildbredt, A., van Schooten, K. S., Lim, M. L., and Delbaere, K. (2020). The effects of cognitive-motor training interventions on executive functions in older people: a systematic review and meta-analysis. *Eur. Rev. Aging Phys. Act*. 17, 1–22. doi: 10.1186/s11556-020-00240-y

The effect of mahjong/bridge intellectual sports on the subjective wellbeing of middle-aged and older adults: an empirical analysis from the mixed cross-section data of CHARLS in China

Qi-fei Xia[1], Guo-you Qin[2]*, Fei-long Yang[1] and Zheng Li[3]

[1]School of Physical Education, Ankang College, Ankang, China, [2]College of Physical Education, Hanjiang Normal University, Shiyan, China, [3]Faculty of Education, Shenzhen University, Shenzhen, China

Background: As China's population ages, intellectual sports have become a key leisure activity with a significant impact on the subjective wellbeing of middle-aged and older adult individuals. These activities promote social engagement, counteract the "empty nest" phenomenon, and offer a pathway to successful aging.

Methods: This study utilized mixed cross-sectional data from the China Health and Retirement Longitudinal Study (CHARLS), encompassing 36,934 adults aged 45 and above. The relationship between intellectual sports, such as mahjong and bridge, and subjective wellbeing was analyzed using ordinal logistic regression modeling.

Results: Participation in mahjong and bridge was positively associated with subjective wellbeing, a finding that remained consistent across multiple regression tests. Social interaction and cognitive ability emerged as critical mediators, enhancing wellbeing through increased social engagement and cognitive stimulation. Retirement status moderated this relationship, with retired individuals showing a stronger propensity to engage in these activities, thereby boosting their wellbeing. It is noteworthy that this positive impact was more pronounced among women and rural and eastern participants.

Conclusion: This study elucidates the mechanisms through which mahjong and bridge influence the subjective wellbeing of middle-aged and older adult Chinese individuals. The findings offer valuable insights for policymakers, suggesting that promoting diverse cultural and sports activities within older adult communities could foster socialization, prevent cognitive decline, and ultimately enhance wellbeing.

1 Introduction

According to the World Health Organization (WHO), the global population of individuals over 60 is rapidly increasing, projected to double to 2.1 billion by 2025 (1). In China, the world's most populous developing country, the aging population is expanding even more quickly, with those aged 60 and over expected to comprise 28% of the population by 2040 (2). This accelerated demographic shift will place increasing demands on healthcare resources, potentially compromising the quality of life for older adults and exacerbating challenges within the public healthcare system. Given these demographic changes, the wellbeing of middle-aged and older adults warrants close examination. The "Opinions of the Central Committee of the Communist Party of China and the State Council on Strengthening the Work of the Elderly in the New Era" emphasize the need to enhance the sense of fulfillment, happiness, and security among the older adult (3). Subjective wellbeing has thus become a crucial indicator of quality of life, alongside economic and social progress (4–6). As China's population ages, the pursuit of wellbeing has entered a new phase, reflecting more comprehensive and elevated standards of living. Enhancing the wellbeing of the middle-aged and older adult has become a key concern in China's modernization and development efforts. The 14th Five-Year Plan for the Development of the National Aging Career and Pension Service System explicitly encourages the development of sports and fitness programs tailored to older adults, including platforms for related competitions and demonstrations, in line with the concept of active aging (7). One such initiative is "mind sports," a term popularized by the International Federation of Mind Sports in 2005 to describe intellectual games aimed at developing cognitive abilities. In China, intellectual sports like mahjong, bridge, and chess have been integrated into community life and are particularly popular among middle-aged and older adult individuals. Studies indicate that these activities not only reduce the risk of dementia (8) and alleviate anxiety (9, 10) but also promote social interaction (11), enrich leisure time (12), support active aging (13), and potentially enhance subjective wellbeing. Numerous studies have explored the impact of physical exercise on the wellbeing of the older adult, such as fitness qigong (2), air volleyball (14), and walking (15), all of which have been shown to significantly improve subjective wellbeing. However, the role of intellectual sports in enhancing wellbeing remains underexplored, particularly in comparison to these physical activities. Chinese society, with its rich history and cultural heritage, has long embraced traditional intellectual games such as mahjong and card games. These activities, with their diverse regional rules and standards, have become integral to the leisure lives of many, especially among the middle-aged and older adult. While mahjong, bridge, and other intellectual sports are popular in China and other developing countries, there is a lack of clear research on their impact on subjective wellbeing. Few studies have examined intellectual exercise as a core factor influencing the wellbeing of older adults, and the potential mechanisms at play remain underexplored. This study, utilizing data from the China Health and Retirement Longitudinal Study (CHARLS), aims to address this gap by using ordered logistic regression to investigate the relationship between intellectual sports, such as mahjong and bridge, and the subjective wellbeing of middle-aged and older adult people. The study also seeks to analyze the possible mechanisms involved. The main contributions of this study are threefold. First, while intellectual sports like Sudoku, solitaire, and checkers have been shown to affect health and wellbeing in developed countries, there is a scarcity of large-scale surveys extending these findings to other regions. This research, focused on China, the world's largest developing country, synthesizes data from several significant surveys to explore whether these activities influence wellbeing, thereby providing essential evidence and practical solutions for older adult service centers, nursing care institutions, and gerontological education centers in China. Second, the study delves into the mechanisms and regulatory factors underlying the relationship between intellectual sports and wellbeing, utilizing a variety of tests to ensure robust results. It also considers the heterogeneity of subjective wellbeing among middle-aged and older adult individuals, accounting for factors such as gender culture and the urban–rural divide, to offer more contextually relevant insights. Finally, as China faces the challenges of an aging society, issues such as lack of childcare, low social participation, and spiritual emptiness may exacerbate the difficulties associated with "empty-nest" syndrome, affecting both the physical and mental health of older adults (16). By exploring the impact of intellectual sports on subjective wellbeing, this study not only promotes social participation and a sense of happiness in old age but also provides targeted policy recommendations to address the multifaceted needs of China's aging population.

2 Literature review

2.1 Explanation of the connotation of subjective wellbeing

China's economic development and technological reforms have significantly improved living conditions, shifting the public's pursuit of subjective wellbeing from mere survival to higher-quality goals focused on enjoyment and development. Subjective wellbeing, a key indicator of mental health and quality of life, has long been a topic of scholarly interest in Chinese society. Historically, Confucianism and Taoism have shaped perspectives on wellbeing, with Confucian thought emphasizing the transformation of sorrow into joy and Taoism advocating concern for collective happiness (17). These philosophical traditions reflect a deep-rooted aspiration for a better life. As society progresses, the desire for happiness has intensified, drawing the attention of numerous scholars across disciplines. Subjective wellbeing is now explored from various perspectives. Psychologists commonly define it as the balance of positive and negative emotions, where greater positive emotions lead to higher happiness (18). Sociologists, however, view subjective wellbeing from a developmental perspective, encompassing both the pleasure individuals derive from life and the sense of value achieved through self-actualization (19). It represents an individual's overall assessment of their environment and societal functioning, reflecting life satisfaction and value attribution (20). In 1974, economist Richard Easterlin introduced the "Easterlin Paradox," prompting economists to re-evaluate the pursuit of happiness (21). Some scholars, from the perspectives of happiness economics and hedonism, assess subjective wellbeing through subjective evaluations and positive emotional responses to consumption activities (22). Today, self-assessed subjective wellbeing is commonly used in sociological and economic research as a proxy for evaluating happiness (23). Theoretical frameworks provide rich analytical tools for studying subjective

wellbeing. Self-discrepancy theory (24) suggests that cognitive biases between one's real, ideal, and perceived selves influence emotional experiences, with positive emotions enhancing psychological functioning and wellbeing (25). Goal content theory further emphasizes that subjective wellbeing is closely tied to intrinsic needs and internal drives, with happiness increasing when these needs are met or goals are achieved (26, 27).

In summary, subjective wellbeing can be measured through multidimensional or unidimensional approaches, with various disciplines exploring its core connotations, measurement methods, and constituent dimensions. Life satisfaction, a cognitive dimension of wellbeing (28), is a subjective evaluation of an individual's quality of life based on personal standards (29) and is commonly used to measure subjective wellbeing (30, 31). Due to differences in living environments, life experiences, and self-worth, individuals lack a unified standard for evaluating subjective wellbeing, which can fluctuate with subjective and objective influences. Building on previous studies (32), this research focuses on life satisfaction as the primary variable to comprehensively analyze trends in subjective wellbeing among middle-aged and older adult individuals, providing robust support for empirical research.

2.2 Mahjong/bridge intellectual sports and subjective wellbeing

The World Mind Games, initiated by the International Mind Sports Alliance (IMSA), integrates board and card games like Mahjong, Bridge, and Chess into an international sporting event, highlighting their social value through diversity, innovation, and popularization. Mahjong and other intellectual sports are particularly popular among the older adult in China, serving as a social and entertaining activity that requires hand-eye coordination, mental agility, and interaction (33). Research shows that middle-aged and older adult individuals who regularly engage in social activities like visiting friends, playing mahjong, or participating in sports clubs can effectively alleviate depressive symptoms (34). Longitudinal studies indicate that loneliness increases with age, but regular participation in leisure activities, such as mahjong or card games, helps maintain social connections, reducing loneliness and enhancing wellbeing (35). Psychosocial adaptation during aging is crucial for promoting healthy aging. Persistence theory (36) and continuity theory (37) suggest that older adults achieve greater satisfaction by maintaining continuity with their younger selves. Engaging in enjoyable and meaningful activities, such as square dancing, mahjong, or chess, fosters positive social adaptation and better integration into social groups (38). Activity theory further emphasizes the link between activity and wellbeing (39). Older adults who maintain active social participation and positive social relationships tend to experience better health and wellbeing in later life (40). As middle-aged and older adult individuals transition from occupational to leisure roles, activities like playing mahjong or cards become essential for spending time, relieving stress, and fostering interests, hobbies, and skills, thereby enriching their spiritual lives. Based on this, the following hypotheses are proposed:

> *Hypothesis H1*: Participation in mahjong/bridge intellectual sports significantly contributes to the subjective wellbeing of middle-aged and older adult people.

2.3 Mechanisms related to the effect of mahjong/bridge intellectual sports on subjective wellbeing of middle-aged and older adult people

Mahjong and bridge, as intellectual sports, possess both social and recreational attributes that significantly impact the subjective wellbeing of middle-aged and older adult individuals. Participation in these activities not only enhances social interactions and cognitive abilities but also serves as a key mechanism influencing wellbeing. Social interaction, in particular, plays a crucial role. Defined as interactions between individuals or groups under certain conditions (41), social interaction is essential for emotional and social wellbeing. Harvard University researchers found that, regardless of age, playing mahjong fosters emotional connections, expands social networks, and stimulates the release of oxytocin and endorphins, promoting health and comfort (42). Social interaction theory and social exchange theory suggest that individuals exist within a network of social relationships, where social interaction involves exchanging rewards and punishments (43, 44). In the context of Chinese society, the motivation for middle-aged and older adult people to participate in intellectual sports like mahjong or bridge may stem less from a desire for social engagement and more from the pursuit of material gain through winning, which in turn shapes social relationships. Moreover, the benefits of social interaction on subjective wellbeing are increasingly evident. Leisure activities with friends are recognized as important social resources (45), and the trust, mutual support, and respect that emerge from deep emotional bonds can enhance the wellbeing of older adults (46). Studies have also found that older individuals with close social networks report higher happiness scores (47). Improved interpersonal skills and relationships lead to greater social capital, embedding individuals within a social network that fosters a stronger sense of identity and value (48). Cognitive ability may also serve as a key mechanism (49). Engaging in intellectually demanding activities like playing mahjong or cards requires coordination of various cognitive abilities, including attention, observation, memory, language, and communication (50). Numerous studies have shown that intellectual sports such as mahjong and bridge enhance cognitive performance in middle-aged and older adults (51–53). Frequent participation in these games not only involves upper extremity physical activity but also provides rich emotional and environmental stimuli, which may increase cerebral blood flow, stimulate the central nervous system, improve brain metabolism, and promote adaptive changes in brain structure and function (34, 54, 55). However, evidence linking social activities to cognitive functioning remains limited, as highlighted by a randomized controlled trial (56). Theoretically, social activities like mahjong may stimulate cognitive reserve, potentially supporting cognitive outcomes and promoting healthy aging in middle-aged and older adults (57, 58). This protective effect against cognitive decline (59) is significant, as cognitive deterioration can impair quality of life and limit independence (60). A longitudinal study in the UK found a link between cognitive performance and positive wellbeing in older adults, with exercise mitigating the adverse effects of lower wellbeing on cognitive function (61). Older adults with higher cognitive abilities exhibit greater emotional resilience, showing smaller decreases in positive emotions and smaller increases in negative emotions when exposed to stressors (62). Therefore, it is hypothesized that

participation in intellectual sports like mahjong or card games can protect cognitive abilities in middle-aged and older adults, leading to higher levels of wellbeing. Based on this, the following hypothesis is proposed:

> *Hypothesis H2*: Participation in mahjong/bridge intellectual sports can enhance subjective wellbeing by promoting social interaction among middle-aged and older adult people.

> *Hypothesis H3*: Participation in mahjong/bridge intellectual sports can enhance subjective wellbeing by improving the cognitive ability of middle-aged and older adult people.

2.4 Moderating effects of retirement

In addition to exploring the mechanisms described, it is crucial to examine the potential moderating effects of retirement among middle-aged and older adults. Retirement marks a significant transition, influencing work status, social networks, income, and lifestyle (63). Retirement systems differ between China, which primarily enforces mandatory retirement, and the West, where voluntary or flexible retirement is more common. This distinction affects how middle-aged and older adult individuals utilize their free time and experience aging (64). Grossman's study suggests that lower income post-retirement encourages a shift from health behaviors to social activities, such as playing mahjong and poker (65). With increased free time and a slower pace of life, retirees may seek leisure activities like dancing, playing cards, chess, or attending senior centers to enrich their lives and enhance life satisfaction (66). However, as the global retirement age rises, the opportunity for such leisure activities may diminish, potentially reducing subjective wellbeing. A study in Spain using a dynamic rational expectations model found that delaying retirement by 2 years increases labor supply and reduces pension costs but results in significant welfare losses (67). Based on this, the following hypothesis is proposed:

> *Hypothesis H4*: Retirement plays a moderating role in the effect of participation in mahjong/bridge intellectual sports on subjective wellbeing of middle-aged and older adults.

Through the theoretical analysis and hypothesis derivation above, the theoretical model of participation in mahjong/bridge intellectual sports and subjective wellbeing of middle-aged and older adult people was constructed to quantitatively assess and analyze the causal relationship and mechanism of action. See Figure 1.

3 Materials and methods

3.1 Data sources

The data for this study were primarily sourced from the China Health and Retirement Longitudinal Study (CHARLS), which aims to provide high-quality microdata representing households and individuals aged 45 and above in China. The CHARLS surveys, conducted in 2011, 2013, 2015, and 2018, focus on issues related to population aging, including health, work, and retirement. The surveys cover 150 county-level units, 450 village-level units, and approximately 17,000 individuals across 10,000 households, ensuring good national representation. Because the 2020 data collection coincided with the peak of the epidemic, the survey methodology was replaced by partial telephone interviews for face-to-face interviews, resulting in a significant decline in respondent participation, and the impact of the epidemic itself on health behaviors and psychological status may have obscured trend analysis, this study used data from the four-period CHARLS mixed cross-section survey, and the 2020 data were subjected to a robustness test, with data retained only for people aged 45 years and older Middle-aged and older adult survey sample. After excluding cases with missing values and outliers, we obtained 36,934 valid samples: 8,196 from 2011, 9,555 from 2013, 10,123 from 2015, 9,060 from 2018, 12,002 from 2020.

3.2 Variable selection

3.2.1 Dependent variable

The dependent variable is subjective wellbeing. Life satisfaction is a stable measure of people's long-term wellbeing based on the sum of individual respondents' multidimensional evaluations of life (68). Therefore, the life satisfaction index in the CHARLS
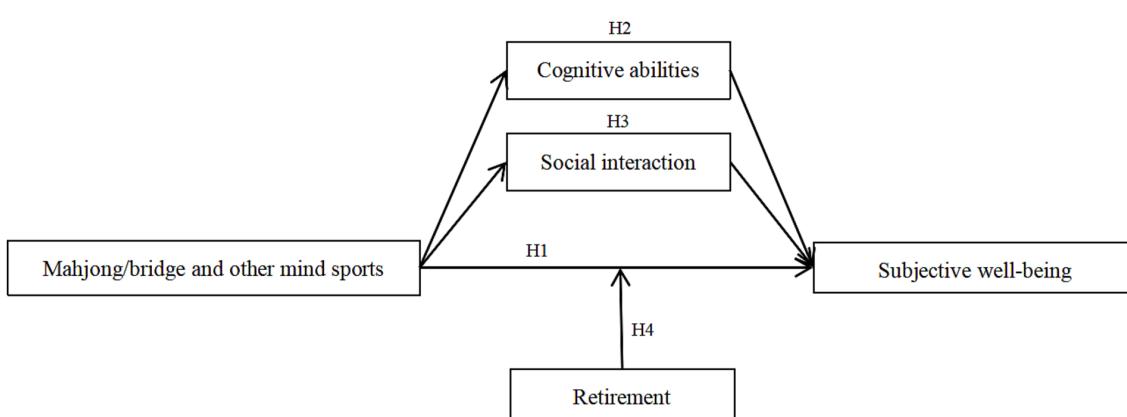
FIGURE 1
Theoretical framework.

questionnaire was used to measure subjective wellbeing, with the question "In general, are you satisfied with your life?." The question was "In general, are you satisfied with your life?," and the answers, "not at all satisfied, not too satisfied, relatively satisfied, very satisfied, extremely satisfied," were assigned values from 1 to 5, meaning that the higher the value, the higher the subjective happiness of the middle-aged and older adult.

3.2.2 Independent variable

The independent variable is mahjong/bridge intellectual sports, etc. The CHARLS questionnaire question is "Have you done any of the following activities in the past month - playing mahjong, chess, cards, etc.," and the answer yes is assigned a value of 1, and no is assigned a value of 0, making it a dichotomous variable.

3.2.3 Mediating variables

The mediator variables were social interaction and cognitive functioning. Social interaction was measured using the CHARLS questionnaire item, "Have you done any of the following activities in the past month—visiting, socializing with friends?" This was coded as a dichotomous variable (yes = 1, no = 0). Cognitive ability, following Lei's framework (69), included memory and mental condition. Memory was assessed through immediate and delayed recall, ranging from 0 to 10. Mental status comprised time orientation, calculation ability, and graph recognition and drawing, with a total score of 11. The combined cognitive ability score (0–21) was used, with higher values indicating better cognitive function in middle-aged and older adult individuals.

3.2.4 Moderator variables

The moderating variable is the retirement status of middle-aged and older adults. The CHARLS questionnaire is titled "Have you taken retirement (including early retirement) or retired internally?"

Respondents answered yes with a value of 1, otherwise with a value of 0, a dichotomous variable.

3.2.5 Control variables

Control variables included the basic characteristics of the middle-aged and older adults: gender (female = 0, male = 1); age (year of residence minus year of birth); household registration (rural = 0, urban = 1); marital status (not in marriage = 0, in marriage = 1); ethnicity (other ethnicity = 0, Han = 1); health status (very unhealthy = 1, relatively unhealthy = 2, average = 3, relatively healthy = 4, very healthy = 5); smoking (no = 0, yes = 1); alcohol consumption (no = 0, yes = 1); and region (West = 0, Central = 2, East = 3). Refer to Table 1.

3.3 Research methods

Based on the research hypotheses, data processing and statistical analysis were conducted using STATA 17.0. Given that the explanatory variable, subjective wellbeing, is an ordered categorical variable, an Ologit regression analysis (ordered logistic Steele model) was employed to better capture the dominant impact effect. The benchmark model was specified as follows:

$$SWB_{i,t} = \beta_0 + \beta_1 MS_{i,t} + \beta_{2-5} \sum Control + \delta_{i,t} \qquad (1)$$

In equation 1, Where i stands for sample individual i, t stands for time, SWB stands for individual subjective wellbeing, MS stands for mahjong/bridge intellectual sports, Control stands for a series of related control variables such as gender, household registration, etc.,

TABLE 1 Descriptive statistics for each variable.

Variables	Full sample (N = 36,934)		Participation in mahjong/ bridge mind games (N = 7,625)		No mahjong/bridge mind games (N = 29,309)	
	Mean	SD	Mean	SD	Mean	SD
Mahjong/bridge intellectual sports	0.206	0.405	1	0	0	0
SWB	3.220	0.589	3.334	0.496	3.190	0.607
Social interaction	0.369	0.482	0.570	0.495	0.316	0.464
Cognitive ability	12.354	3.327	13.274	2.865	12.114	3.396
Retirement	0.151	0.358	0.198	0.399	0.138	0.345
Gender	0.519	0.500	0.604	0.488	0.496	0.499
Age	59.294	8.820	58.617	8.536	59.469	8.884
Marital status	0.903	0.296	0.921	0.269	0.898	0.302
Household registration	0.761	0.426	0.690	0.462	0.779	0.414
Ethnicity	0.934	0.249	0.961	0.191	0.926	0.261
Health status	3.097	0.930	3.166	0.882	3.079	0.940
Smoking	0.447	0.497	0.551	0.497	0.420	0.493
Alcohol consumption	0.480	0.500	0.556	0.496	0.459	0.498
Region	2.031	0.815	2.050	0.769	2.026	0.826

β_1 to β_5 are the regression coefficients of each variable, and δ is the residual term. If based on the assumptions made in this study, β_1 is significantly positive or negative.

In order to test the two important mechanisms of action of social interaction and cognitive ability, the stepwise regression method proposed by Baron and Kenny (70) was borrowed to initially test whether there is a mediating effect in the above research hypotheses. The setup model is as follows:

$$SWB_i = \alpha_0 + \alpha_1 MS_i + \alpha_x Control_i + \delta_i \quad (2)$$

$$Mediation_i = \beta_0 + \beta_1 MS_i + \beta_x Control_i + \delta_i \quad (3)$$

$$SWB_i = \gamma_0 + \gamma_1 MS_i + \gamma_2 Mediation_i + \gamma_x Control_i + \delta_i \quad (4)$$

In Equation 1, the model MS variable is intellectual sports, including playing mahjong, cards, chess, etc., SWB_i is the probability of sports participation, $Control_i$ is the relevant control variable, and α_1 is the parameter to be estimated. Equations 2, 3 variable interpretation is the same as Equation 1, and $Mediation_i$ is the mediating variable social interaction, cognitive ability (Equation 4). The regression model is used to test whether the core independent variables have a significant effect on the dependent variable, and if it is significant, the core independent variables are further estimated whether the core independent variables have a significant effect on each of the mediating variables, and finally the core independent variables and the mediating variables are jointly estimated in the regression, and if the mediation mechanism is established, it is necessary to satisfy the existence of significance at the same time of α_1, β_1, and γ_2. When γ_1 is not significant then it is a full mediating effect, on the contrary, if γ_1 is significant and $\gamma_1 < \alpha_1$, then it is a partial mediating effect. However, there are some problems that cannot be ignored; the method does not fully focus on the share of the mediating effect in the total effect, its efficacy is low, and the estimation of the effect may be biased. In order to more accurately express the role played by the mediating variables, Sobel test was used to test the reliability of the results obtained from the mediating effects, and the KHB decomposition method developed by Karlson et al. (71) was also used to analyze the significance and percentage of the model's direct effects, indirect effects and total effects.

In order to test whether there is a moderating effect of retirement, model (1) was established with subjective wellbeing as the dependent variable, intellectual sports such as mahjong/bridge as the independent variable, and retirement as the moderating variable to verify whether the main effect hypothesis is valid. The hierarchical regression model is as follows:

$$SWB_1 = \alpha_0 + \sum \alpha_i MS_i + \sum \alpha_j X_j \sum \alpha_k X_k + \delta_i \quad (5)$$

In Equation 5, SWB is subjective wellbeing, MS is mahjong/bridge intellectual sports, X_j is retirement moderating variable, X_k is series of control variables such as gender, household registration, etc., and δ is

random interference term. On this basis, the interaction term between intellectual sports such as mahjong/bridge and retirement is constructed, and model (2) is established to verify whether the moderating effect of retirement is valid. The hierarchical regression model is as follows:

$$SWB_2 = \alpha_0 + \sum \alpha_i MS_i + \sum \alpha_j X_j + \sum \alpha_k X_k + \sum \alpha_i X_i \sum \alpha_j X_j + \delta_i \quad (6)$$

In Equation 6, SWB_2 represents the dependent variable subjective wellbeing, MS_i is the independent variable mahjong/bridge and other intellectual sports, X_j is the retirement moderator variable, X_k is a series of control variables such as gender, household registration, etc., $\sum \alpha_i MS_i \sum \alpha_j X_j$ refers to the interaction term of the independent and moderator variables, and δ is a random disturbance term.

4 Empirical results

4.1 Main characteristics of the survey sample

To better understand the variability in the baseline survey of middle-aged and older adults over recent years, we categorized the dependent, independent, mediating, moderating, and control variables by year. Table 2 shows that subjective wellbeing is highest in terms of comparative satisfaction (66.53%), with stability observed between comparative satisfaction and extreme satisfaction from 2011 to 2018. Intellectual sports participation, such as mahjong or bridge, remains low, with 79.36% of participants not engaging and no significant trend over time. Social interaction is reported by 36.87% of the older adult, peaking in 2013 at 40.66%, then declining annually. Cognitive ability, measured as a continuous variable, averaged 12.354 across the sample, indicating a relatively low level. For moderating variables, 84.90% of older adults are retired or retired early, with a gradual decline in the proportion of non-retirees from 2011 to 2018. We also observed that there were a large number of missing values for alcohol consumption in the 2020 data, so they were not included in the study. The distribution of each variable among middle-aged and older adults showed overall stratified differences due to the 2020 epidemic.

4.2 Baseline regression results

Table 3 presents the benchmark regression results. In model (1), participation in mahjong/bridge intellectual sports positively predicts the subjective wellbeing of middle-aged and older adult individuals, with a significant regression coefficient of 0.452 ($p < 0.01$) and an odds ratio (OR) of 1.571. This indicates a 57.1% higher probability of enhanced wellbeing for participants compared to non-participants. Model (2), which includes control variables, shows that the predictive effect remains significant ($\beta = 0.523$, $p < 0.01$) with an OR of 1.686, suggesting a 68.6% higher probability of improved wellbeing. The model's explanatory power increased, with R^2 rising from 0.004 to 0.075. Control variable coefficients indicate higher wellbeing among males, older adults, married individuals, urban residents, those in good health, non-smokers, non-drinkers, and residents of the eastern region, while ethnicity showed no significance. Models (3) to (6),

TABLE 2 Statistics on the main characteristics of middle-aged and older adult people.

Categories		Master Sample	2011	2013	2015	2018	2020
Totally		36,934 (100%)	8,196 (22.19%)	9,555 (25.87%)	10,123 (27.41%)	9,060 (24.53%)	12,002 (100%)
SWB	Not at all satisfied	285 (0.77%)	71 (0.87%)	80 (0.84%)	56 (0.55%)	78 (0.86%)	225 (1.87%)
	Not too satisfied	1,920 (5.2%)	625 (7.63%)	552 (5.78%)	388 (3.83%)	355 (3.92%)	808 (6.73%)
	Relatively satisfied	24,572 (66.53%)	5,893 (71.9%)	6,872 (71.92%)	5,909 (58.37%)	5,898 (65.10%)	6,937 (57.79%)
	Very satisfied	9,696 (26.25%)	1,563 (19.07%)	1,977 (20.69%)	3,580 (35.37%)	2,576 (28.43%)	3,475 (28.95%)
	Extremely satisfied	461 (1.25%)	44 (0.54%)	74 (0.77%)	190 (1.88%)	153 (1.69%)	558 (4.65%)
Mahjong/Bridge Intellectual Sports	No	29,309	6,639	7,403	7,928	7,339	9,996
		(79.36%)	(81%)	(77.48%)	(78.32%)	(81%)	(83.28%)
	Yes	7,625	1,557	2,152	2,195	1,721	2,007
		(20.64%)	(19%)	(22.52%)	(21.68%)	(19%)	(16.72%)
Gender	Female	17,764 (48.1%%)	4,050 (49.41%)	4,702 (49.21%)	4,837 (47.78%)	4,175 (46.08%)	5,803 (48.35%)
	Male	19,170 (51.90%)	4,853 (50.79%)	3,432 (47.03%)	5,286 (52.22%)	4,885 (53.92%)	6,200 (51.65%)
Age	Continuous variable						
Marital status	Not in marriage	3,589 (9.72%)	738 (9%)	878 (9.19%)	1,019 (10.07%)	954 (10.53%)	1,415 (11.79%)
	Marriage	33,345 (90.28%)	7,458 (91%)	8,677 (90.81%)	9,104 (85.93%)	8,106 (89.47%)	10,588 (88.21%)
Household registration	Rural	8,814 (23.86%)	1,765 (21.53%)	2,188 (22.90%)	2,329 (23.01%)	2,532 (27.95%)	5,103 (42.51%)
	Urban	28,120 (76.14%)	6,431 (78.47%)	7,367 (77.10%)	7,794 (76.99%)	6,528 (72.05%)	6,900 (57.49%)
Ethnicity	Other ethnicity	2,456 (6.65%)	572 (6.98%)	629 (6.58%)	648 (6.40%)	607 (6.70%)	732 (6.10%)
	Han	34,478 (93.35%)	7,624 (93.02%)	8,926 (93.42%)	9,475 (93.60%)	8,453 (93.30%)	11,271 (93.90%)
Health status	Very unhealthy	1,396 (3.78%)	261 (3.18%)	368 (3.85%)	361 (3.57%)	406 (4.48%)	690 (5.75%)
	Relatively unhealthy	6,416 (17.37%)	1,627 (19.85%)	1,608 (16.83%)	1,600 (15.81%)	1,581 (17.45%)	1,960 (16.33%)
	Average	20,063 (54.32%)	4,300 (52.46%)	5,326 (55.74%)	5,641 (55.72%)	47.96 (52.94%)	6,331 (52.75%)
	Relatively healthy	5,325 (14.42%)	1,493 (18.22%)	1,386 (14.51%)	1,257 (12.42%)	1,189 (13.12%)	1,547 (12.89%)
	Very healthy	3,734 (10.11%)	515 (6.28%)	867 (9.07%)	1,264 (12.49%)	1,088 (12.01%)	1,475 (12.29%)
Smoking	No	20,416 (55.28%)	4,810 (58.69%)	5,352 (56.01%)	5,437 (53.71%)	4,817 (53.17%)	6,597 (54.96%)
	Yes	16,518 (44.72%)	3,386 (41.31%)	4,203 (43.99%)	4,686 (46.29%)	4,243 (46.83%)	5,406 (45.04%)
Alcohol consumption	No	19,223	4,764	4,978	5,151	4,330	
		(52.05%)	(58.13%)	(52.10%)	(50.88%)	(47.79%)	
	Yes	17,711	3,432	4,577	4,972	4,730	
		(47.95%)	(41.87%)	(47.90%)	(49.12%)	(52.21%)	
Region	West	11,696	2,563	3,076	3,260	2,797	4,548

(Continued)

TABLE 2 (Continued)

Categories		Master Sample	2011	2013	2015	2018	2020
		(31.67%)	(31.27%)	(32.19%)	(32.20%)	(30.87%)	(37.89%)
	Central	12,384 (33.53%)	2,756 (33.63%)	3,150 (32.97%)	3,332 (32.92%)	3,146 (34.72%)	3,072 (25.59%)
	East	12,854 (34.80%)	2,877 (35.10%)	3,329 (34.84%)	3,531 (34.88%)	3,117 (34.40%)	4,383 (36.52%)
Social interaction	No	23,318 (63.13%)	5,337 (65.12%)	5,670 (59.34%)	6,426 (63.48%)	5,885 (64.96%)	7,843 (65.34%)
	Yes	13,616 (36.87%)	2,859 (34.88%)	3,885 (40.66%)	3,697 (36.52%)	3,175 (35.04%)	4,160 (34.66%)
Cognitive ability	Continuous variable						
Retirement	No	31,358 (84.90%)	7,179 (87.59%)	8,202 (85.84%)	8,646 (85.41%)	7,331 (80.92%)	9,588 (79.89%)
	Yes	5,576 (15.10%)	1,017 (12.41%)	1,353 (14.16%)	1,477 (14.59%)	1,729 (19.08%)	2,414 (20.11%)

covering sub-year samples from 2011 to 2018, confirm the consistent positive impact of mahjong/bridge on wellbeing over time, all significant at the 1% level. Models (7) and (8), which include mediating variables, reveal that social interaction and cognitive ability positively influence wellbeing, both significant at the 1% level. In model (9), the overall R^2 increases to 0.096, further enhancing the model's explanatory power while maintaining the significance of the findings. To enhance the clarity of the regression results for each variable, we visualized the data using the Coefplot command in Stata 17.0. This approach effectively illustrates the advantages of the dependent variables and presents the estimated coefficients along with confidence intervals, facilitating significance assessment. Figure 2 displays the standardized regression distributions, which align closely with the model's estimation results.

4.3 Robustness testing

In order to ensure the heterogeneity and stability of the results of the test of the effect of intellectual sports such as mahjong/bridge on the subjective wellbeing of middle-aged and older adult people, four ways will be taken to conduct the robustness test. (1) Supplementary empirical data. 2020 fifth-round survey data were collected at the beginning of the New Crown epidemic outbreak, which made middle-aged and older adult people unavoidably feel panicked and overwhelmed at the beginning of public health emergencies. Therefore, we only subjected the 2020 data to robustness tests, and found that intellectual sports such as mahjong/bridge still had a significant effect on the subjective wellbeing of middle-aged and older adult people in model (1), suggesting that participation in intellectual sports such as home-based mahjong/bridge could eliminate epidemic prevention anxiety to a certain extent during the quarantine period of the epidemic, thus enhancing subjective wellbeing. (2) Replacing the empirical model. A multiple linear regression model (OLS model) was established to test its robustness, and the results showed that the effect of intellectual sports such as mahjong/bridge on the subjective wellbeing of middle-aged and older adult people was significantly positive, which verified the reliability of the results. (3) Change the dependent variable. The regression analysis of the dependent variable subjective wellbeing, with "quite satisfied, very satisfied and extremely satisfied" classified as 1 and "not at all satisfied and not very satisfied" classified as 0, found that the coefficient of the impact effect was still significantly positive, confirming the robustness of the results (Table 4). (4) Propensity score matching. To address potential selection bias in the regression analysis of the effects of mahjong/bridge on the subjective wellbeing of middle-aged and older adult individuals, we employed Propensity Score Matching (PSM). Given that PSM requires dichotomous variables, we calculated the average treatment effect using K-nearest neighbor matching (1:4), radius matching, and kernel matching, with subjective wellbeing as the dependent variable. The PSM results showed that the T-values for the average treatment effect (ATT) exceeded the critical value (Table 5). Additionally, PSM kernel density plots demonstrated a significant reduction in mean line distance post-matching, suggesting reduced selection bias and consistent results (Figures 3, 4).

TABLE 3 Regression results of mahjong/bridge intellectual sports on subjective wellbeing of middle-aged and older adult people.

Variables	(1) SWB	(2) SWB	(3) 2011	(4) 2013	(5) 2015	(6) 2018	(7) SWB	(8) SWB	(9) SWB
Mahjong/bridge intellectual sports	0.452***	0.523***	0.615***	0.626***	0.422***	0.493***	0.473***	0.444***	0.405***
	(0.0259)	(0.0273)	(0.0619)	(0.0550)	(0.0497)	(0.0562)	(0.0278)	(0.0276)	(0.0282)
Gender		0.129***	0.213***	0.140**	0.193***	0.104	0.144***	−0.00893	0.00423
		(0.0344)	(0.0724)	(0.0705)	(0.0656)	(0.0706)	(0.0344)	(0.0348)	(0.0349)
Age		0.0368***	0.0376***	0.0364***	0.0231***	0.0413***	0.0377***	0.0525***	0.0530***
		(0.00135)	(0.00308)	(0.00283)	(0.00243)	(0.00277)	(0.00136)	(0.00144)	(0.00144)
Marital status		0.337***	0.346***	0.240***	0.344***	0.383***	0.348***	0.270***	0.280***
		(0.0400)	(0.0910)	(0.0839)	(0.0729)	(0.0776)	(0.0400)	(0.0402)	(0.0402)
Household registration		0.249***	0.172***	0.150***	0.274***	0.398***	0.257***	0.549***	0.552***
		(0.0265)	(0.0602)	(0.0552)	(0.0493)	(0.0511)	(0.0265)	(0.0280)	(0.0280)
Ethnicity		−0.0158	0.112	−0.0713	0.0659	−0.179**	−0.00683	−0.0131	−0.00606
		(0.0462)	(0.0995)	(0.0956)	(0.0868)	(0.0909)	(0.0462)	(0.0463)	(0.0464)
Health status		0.786***	0.770***	0.811***	0.792***	0.755***	0.784***	0.777***	0.776***
		(0.0129)	(0.0300)	(0.0270)	(0.0238)	(0.0250)	(0.0129)	(0.0130)	(0.0131)
Smoking		−0.144***	−0.243***	−0.119*	−0.148**	−0.192***	−0.145***	−0.102***	−0.104***
		(0.0326)	(0.0691)	(0.0669)	(0.0619)	(0.0667)	(0.0326)	(0.0329)	(0.0329)
Alcohol consumption		−0.0822***	−0.0369	−0.191***	−0.124**	−0.0970*	−0.0916***	−0.0902***	−0.0977***
		(0.0264)	(0.0596)	(0.0548)	(0.0483)	(0.0524)	(0.0264)	(0.0266)	(0.0266)
Region		0.0340**	0.00147	0.0406	0.0283	0.0721**	0.0304**	−0.0221	−0.0243*
		(0.0141)	(0.0311)	(0.0290)	(0.0258)	(0.0286)	(0.0141)	(0.0143)	(0.0143)
Social interaction							0.217***		0.173***
							(0.0237)		(0.0239)
Cognitive ability								0.138***	0.137***
								(0.00391)	(0.00391)
Pseudo R^2	0.004	0.075	0.067	0.077	0.075	0.078	0.076	0.095	0.096
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	36,934	36,934	8,196	9,555	10,123	9,060	36,934	36,934	36,934

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.
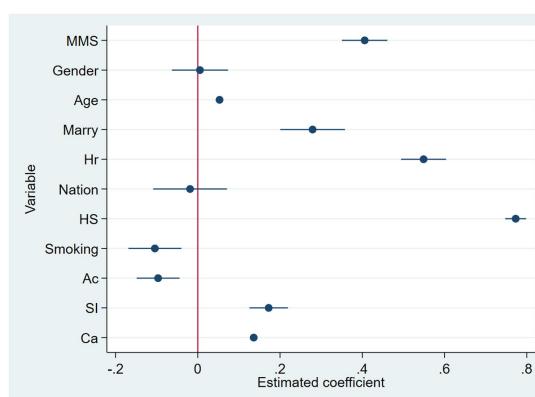
FIGURE 2
Visual analysis of regression results.

TABLE 4 Robustness test results.

	2020	Replacement of empirical models	Changing the dependent variable
Mahjong/bridge intellectual sports	0.265***	0.140***	0.0617***
	(0.0474)	(0.00720)	(0.00554)
Pseudo R^2	0.039	0.122	0.094
Observations	12,002	36,934	36,934

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

TABLE 5 Results of propensity score matching.

Matching method	Process group	Control group	ATT	SE	T-stat
Prematch	3.334	3.190	0.143	0.007	19.06***
After matching					
Nearest neighbor matching	3.334	3.204	0.129	0.008	16.20***
Nuclear matching	3.334	3.194	0.139	0.006	20.47***
Radius matching (0.01)	3.334	3.195	0.138	0.006	20.18***

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

4.4 Mechanism of action analysis

4.4.1 Stepwise regression test

Following the mediation effect test procedure, we conducted preliminary tests using stepwise regression to examine the mediation effects of social interaction and cognitive ability. The results indicate that both social interaction and cognitive ability significantly and positively influence the subjective wellbeing of middle-aged and older adult individuals, with significance at the 1% level. Notably, the main effect coefficients in models (3) and (5) are lower than in model (1), suggesting the presence of an indirect effect mediated by social interaction and cognitive ability. (See Table 6).

4.4.2 Tests for mediating effects

Building on the initial stepwise regression analysis, we further investigated the mechanisms of social interaction and cognitive ability using KHB decomposition, Sobel test, and Bootstrap methods. The results, presented in Table 6, indicate that 10.33 and 18.98% of the effects of middle-aged and older adult participation in mahjong/bridge intellectual sports on subjective wellbeing can be attributed to social interaction and cognitive ability, respectively, with both mediating effects being significant. The Sobel test results also support this, with Z-values greater than 1.96 and p-values below 0.01, confirming the significance of these mediating effects. Additionally, the Bootstrap method showed that the 95% confidence intervals for both direct and indirect effects did not include zero, further affirming that social interaction and cognitive ability partially mediate the relationship between mahjong/bridge intellectual sports and subjective wellbeing (See Table 7).

4.5 Moderating effects test

To assess the moderating effect of retirement on the relationship between mahjong and bridge intellectual sports and subjective wellbeing, interaction terms were constructed. Model (1) shows that
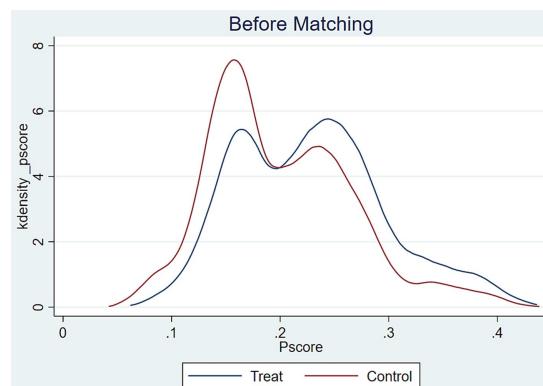
FIGURE 3
Kernel density function plot before PSM matching.
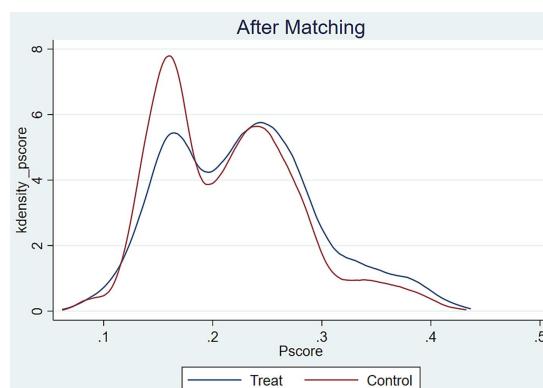
FIGURE 4
Kernel density function plot after PSM matching.

TABLE 6 Stepwise regression test results for social interaction, cognitive ability.

Variables	(1)	(2)	(3)	(4)	(5)
	SWB	Social interaction	SWB	Cognitive ability	SWB
Mahjong/bridge intellectual sports	0.523***	1.055***	0.473***	0.417***	0.444***
	(0.0273)	(0.0269)	(0.0278)	(0.0225)	(0.0276)
Social interaction			0.217***		
			(0.0237)		
Cognitive ability					0.138***
					(0.00391)
Pseudo R^2	0.075	0.043	0.076	0.035	0.095
Observations	36,934	36,934	36,934	36,934	36,934

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

retirement positively predicts subjective wellbeing among middle-aged and older adult individuals ($\beta = 0.131$, $p < 0.01$), indicating that retired individuals tend to experience higher subjective wellbeing. In Model (2), the interaction term between mahjong/bridge participation and retirement was significant ($\beta = 0.202$, $p < 0.01$), suggesting that retirement enhances the positive effect of mahjong/bridge intellectual sports on subjective wellbeing. Thus, retirement acts as a moderator in this relationship (See Table 8).

4.6 Heterogeneity analysis

There may be some differences in the effects of intellectual sports such as mahjong/bridge on the subjective wellbeing of middle-aged and older adult people with different characteristics, and this paper examines the heterogeneity of demographic characteristics of the middle-aged and older adult groups. The results showed that for different gender groups, intellectual sports such as mahjong/bridge

TABLE 7 Mediating effects of social interaction and cognitive ability.

	Social interaction			Cognitive ability		
	Coefficient	Lower limit	Upper limit	Coefficient	Lower limit	Upper limit
Total effect	0.527***	0.474	0.581	0.547***	0.493	0.601
Direct effect	0.473***	0.418	0.527	0.443***	0.389	0.498
Indirect effect	0.054***	0.042	0.066	0.103***	0.092	0.115
Percentage of contribution		10.33%			18.98%	

Sobel test		
Sobel	0.016***	0.027***
Goodman-1 (Aroian)	0.016***	0.027***
Goodman-2	0.016***	0.027***
Z	10.44	17.32

Bootstrap Results − 1000reps		
Indirect effect (95% CI)	[0.013, 0.019]	[0.024, 0.029]
Direct effect (95% CI)	[0.110, 0.135]	[0.100, 0.125]
p-value	0.000***	0.000***

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

TABLE 8 Results of the moderating effect of retirement.

Variables	(1)	(2)
	SWB	SWB
Mahjong/bridge intellectual sports	0.521***	0.483***
	(0.0273)	(0.0302)
Retirement	0.131***	0.0741*
	(0.0403)	(0.0447)
Mahjong/bridge intellectual sports × Retirement		0.202***
		(0.0687)
Pseudo R^2	0.075	0.075
Observations	36,934	36,934

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

TABLE 9 Heterogeneity test regression results for gender and household registration.

Variables	(1)	(2)	(3)	(4)
	Female	Male	Rural	Urban
Mahjong/bridge intellectual sports	0.589***	0.479***	0.703***	0.473***
	(0.0417)	(0.0363)	(0.0546)	(0.0318)
Pseudo R^2	0.073	0.076	0.092	0.072
Observations p	17,764	19,170 0.024	8,814	28,120 0.000

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

had a significant positive effect on subjective wellbeing for both females and males. Therefore, the difference in coefficients between groups was tested by the method of seemingly uncorrelated model (SUEST), and the p-value of the coefficient of difference between groups was less than 0.05, which indicates that intellectual sports such as mahjong/bridge have a significantly higher effect on subjective wellbeing in females than in males. In terms of domicile, intellectual sports such as mahjong/bridge had a significant positive

effect on the subjective wellbeing of both rural and urban middle-aged and older adult people. The coefficient of difference between groups in the seemingly unrelated model was significant ($p < 0.01$), indicating that intellectual sports such as mahjong/bridge have a greater effect on the subjective wellbeing of rural middle-aged and older adult people. See Table 9. According to the World Health Organization's criteria for classifying the age of the older adult, 45–59 years old is the low old age, 60–74 years old is the middle old

TABLE 10 Regression results of heterogeneity tests for age, region and marriage.

Variables	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Lower age	Middle old age	High old age	Western	Central	East	Not in marriage	marriage
Mahjong/bridge intellectual sports	0.497***	0.506***	0.651***	0.551***	0.429***	0.568***	0.607***	0.511***
	(0.0366)	(0.0432)	(0.123)	(0.0519)	(0.0441)	(0.0471)	(0.0941)	(0.0285)
Pseudo R^2	0.070	0.070	0.061	0.064	0.077	0.079	0.091	0.073
Observations	19,804	15,011	2,119	11,696	12,384	12,854	3,589	33,345
$p = 0.869, 0.182, 0.215$				$p = 0.044, 0.790, 0.017$			$p = 0.253$	

The parentheses are standard errors, ***, **, and * indicate significance at 1, 5, and 10% levels, respectively.

age, and 75 years old and above is the high old age (72), which was used as a categorical variable for the regression. The results show that intellectual sports such as mahjong/bridge have a significant positive effect on the subjective wellbeing of middle-aged and older adult people in different age groups, and the coefficient of variation between groups has a *p*-value greater than 0.05, so there is no significant between-group difference in this effect. According to the geographic division of China, the regression of regional samples was conducted separately, and it was found that mahjong/bridge and other intellectual sports had a significant positive effect on the subjective wellbeing of middle-aged and older adult people in different regions, but the effect was greater in the eastern region (*p*-value of the regression coefficient test for the two–two subgroups was 0.044, 0.790, 0.017, respectively). As far as marriage is concerned, the effect of intellectual sports such as mahjong/bridge on the subjective wellbeing of the older adult not in marriage is more obvious, and the coefficients of the core explanatory variables of the two groups of samples tweed are not significantly different (*p* = 0.253). See Table 10.

5 Discussion

Using data from the China Health and Elderly Tracking Mixed Cross-Sectional Survey, we investigated the association between intellectual sports such as mahjong and bridge and subjective wellbeing among middle-aged and older adult populations. This study provides empirical insights for enhancing subjective wellbeing in these age groups, both within China and potentially in other regions. Our analysis also examines the underlying mechanisms linking these activities to wellbeing and evaluates how this relationship varies under different retirement scenarios, contributing to the existing body of research. Our results indicate that 66.53% of Chinese middle-aged and older adult individuals report a relatively high level of subjective wellbeing, aligning closely with the findings of Sun (73) and Zhao et al. (74). Compared to low-and middle-income countries like India and Viet Nam, China benefits from more developed eldercare infrastructure, public welfare and cultural programs, and social welfare subsidies (75, 76), which support a comfortable life in later years. However, disparities in happiness levels are observed when compared to European countries (77), likely influenced by regional cultural and economic factors. Among the control variables—gender, age, marital status, household registration, health status, smoking, alcohol consumption, and region—all showed significant effects on subjective wellbeing, except for ethnicity. This may be due to the substantial socio-economic advancements in ethnic minority regions in China, which have improved both material conditions and cultural life, contributing to a heightened sense of wellbeing. Notably, some ethnic minorities, such as the Uighurs and Hui, report higher happiness levels than the Han Chinese (78). These findings suggest that the development of a strong national community since China's reform and opening up has played a critical role in fostering a sense of wellbeing.

We employed an ordered logistic (Ologit) regression model to assess the independent impact of mahjong and bridge on the subjective wellbeing of middle-aged and older adult individuals. Our analysis revealed that these intellectual sports significantly enhance subjective wellbeing, consistent with previous studies (79, 80). Given China's accelerated aging and the increasing number of empty nesters, the financial burden on healthcare and public health services has grown (81). Promoting participation in leisure activities such as square dancing and mahjong can improve health outcomes and contribute to healthy aging (82). A cohort study of older adults in Japan found a significant association between leisure activities and lower mortality rates, with varying effects across different activities (83). In China, intellectual games like mahjong and poker are culturally significant and competitive. Middle-aged and older adult individuals often engage in these activities collectively, enjoying the mental stimulation and social interaction they provide, which significantly enhances their sense of wellbeing. The benefits of these games are multifaceted: physiologically, regular participation in group social activities like mahjong and bridge improves mental health, reduces depression risk, and counteracts age-related brain atrophy (84). Psychologically, these games involve complex rules that enhance hand-eye coordination and provide positive emotional experiences (79). Group intellectual sports such as mahjong, cards, and chess can effectively reduce loneliness, foster a positive self-concept, and offer social support, thereby significantly enhancing subjective wellbeing (8).

As middle-aged and older adult individuals face declining physical functions, increased comorbidity risks, and diminishing social roles, they are prone to negative emotional experiences, which can weaken their subjective wellbeing. Engaging in intellectual sports like mahjong and bridge not only fills leisure time and enriches life but also provides mental exercise, promotes social interaction, and improves overall life satisfaction. However, it is important to note that prolonged engagement in these activities can lead to sedentary behavior, increasing the risk of chronic diseases. For instance, excessive time spent on mahjong has been linked to negative effects on cardiovascular and digestive

systems (12). Therefore, middle-aged and older adult individuals should regulate their participation in these intellectual sports, maintain moderation, and adopt a healthy lifestyle to prevent addiction and associated health risks. This study validated the partial mediating role of social interaction and cognitive ability, confirming that participation in intellectual sports such as mahjong and bridge enhances subjective wellbeing through two key pathways: fostering social interaction and improving cognitive ability. On one hand, intellectual sports like mahjong and bridge, which require minimal external resources and can be played in various settings, facilitate group activities that boost interpersonal connections and social support, thereby increasing wellbeing (85). The social bonds formed through these activities provide middle-aged and older adult participants with a greater sense of community and enjoyment.

On the other hand, evidence suggests that older adults who regularly engage in card games or mahjong demonstrate better performance in attention, long-term memory, and logical reasoning (86). Cognitive function, as a protective factor, contributes to more positive emotions and a stronger sense of wellbeing (62). Consequently, participation in these intellectual sports not only expands social networks and enhances emotional connections but also promotes hand-eye coordination, maintains memory and cognitive skills, reduces the risk of depression, and improves overall wellbeing. These findings offer policy recommendations for relevant government departments, emphasizing the importance of promoting moderate participation in intellectual sports like mahjong or solitaire through community outreach and health education. Additionally, policies should be developed to support the health and social activities of the older adult, including the provision of accessible venues, financial support, and the design of barrier-free spaces that accommodate the diverse cultural backgrounds of the older adult population. Retirement moderates the relationship between participation in mahjong and bridge intellectual sports and subjective wellbeing. Our data indicate that deeply engaged retired older adults experience a positive effect on subjective wellbeing (87). With more leisure time, retired individuals often choose activities like mahjong and card games to meet personal needs and enhance life satisfaction. According to activity theory, older adults require active engagement in various roles to maintain vitality (88). The shift from work to retirement prompts seniors to cultivate interests and hobbies, integrate into social life, and fulfill growing emotional needs, thereby enhancing their sense of belonging and wellbeing. This underscores the importance of providing diverse and personalized recreational activities in communities to promote social participation and improve wellbeing among retired individuals. Our study found that participation in mahjong and bridge intellectual sports had the greatest impact on enhancing subjective wellbeing among female and rural middle-aged and older adult individuals. In Chinese family culture, women often bear the responsibility for childcare and household tasks, leading them to prefer more static leisure activities like mahjong and meditation to promote health and relieve stress (89). In contrast, older men tend to engage in competitive activities such as brisk walking and tai chi. In rural China, where local sentiment and clan concepts are strong, group activities like playing mahjong and chess are common forms of entertainment for the older adult, fostering social capital and improving subjective wellbeing. Regionally, the development of China's social security system for the older adult is characterized by a regional imbalance of "high in the east and low in the west" (90), with the rise in the level of socialized pensions in the eastern region giving more and more middle-aged and older adult people more leisure time to participate in the intellectual activities of mahjong and an easier time gaining a sense of satisfaction. Although the study found that there was no significant difference between the coefficients of age and marriage between groups. However, it is worth exploring that, as age continues to grow, the effect of recreational activities such as mahjong/bridge is conducive to meeting the spiritual needs of the middle-aged and older adult, but still needs to be avoided as a kind of gambling tool to spend the rest of their lives in the wilderness. Meanwhile, the absence of marriage may bring about the shrinkage of social network and more dependence on family support, while participation in intellectual activities such as mahjong can make individuals gain pleasure and positive emotions, which makes them more optimistic to face the difficulties and pressures of life.

However, this study has several limitations. First, the data were primarily collected through self-reports, which may introduce bias due to the Hawthorne effect. Future research should incorporate interviews and other methods to enhance data accuracy. Second, our study focused only on whether middle-aged and older adults participate in intellectual sports, without analyzing the frequency and intensity of participation, which should be addressed in subsequent studies. Third, while we explored the relationship between playing intellectual sports and subjective wellbeing, various confounding factors, such as community environment and public service management, were not measured. These should be considered in future research. Lastly, to gain a broader understanding of intellectual activity participation among middle-aged and older adult individuals, future studies should include cross-sectional comparisons using multi-country data, examining differences in subjective wellbeing across diverse social backgrounds, racial groups, and geographic regions.

6 Conclusion

Using cross-sectional data from the China Health and Elderly Tracking Survey, this study investigates the impact of intellectual sports such as mahjong and bridge on the subjective wellbeing of middle-aged and older adult Chinese individuals. We identify social interaction and cognitive ability as key mechanisms, and further explore the heterogeneous effects of retirement on these outcomes. Our findings reveal that participation in these activities significantly enhances subjective wellbeing, with results robust across different time points. Notably, social engagement and cognitive maintenance appear critical in mediating the positive effects of these intellectual sports. Middle-aged and older adult participants, particularly those in retirement, experience the greatest benefits. Additionally, Chinese women, rural areas and middle-aged and older adult people in the eastern region are more enthusiastic about playing mahjong, poker and other intellectual sports to spend leisure time together and gain a sense of wellbeing. These insights offer valuable directions for policymakers and healthcare providers in improving the health and quality of life for aging populations, thereby contributing to the broader goal of successful aging.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://charls.pku.edu.cn/en/.

Author contributions

Q-fX: Conceptualization, Formal analysis, Methodology, Software, Validation, Writing – original draft, Writing – review & editing. G-yQ: Conceptualization, Data curation, Investigation, Visualization, Writing – original draft, Writing – review & editing. F-lY: Supervision, Writing – original draft, Writing – review & editing. ZL: Supervision, Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

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.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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.2025.1552180/full#supplementary-material

References

1. World Health Organization. Decade of healthy ageing: baseline report. Available online at: https://www.who.int/publications/i/item/9789240017900 (Accessed July 29, 2024).

2. Wong MYC, Ou KL, Chung PK, Chui KYK, Zhang CQ. The relationship between physical activity, physical health, and mental health among older Chinese adults: a scoping review. *Front Public Health*. (2023) 10:914548. doi: 10.3389/fpubh.2022.914548

3. Opinions of the Central Committee of the Communist Party of China and the State Council on Strengthening Work on Aging in the New Era. (2021). Available online at: https://www.gov.cn/zhengce/2021-11/24/content_5653181.htm (Accessed July 30, 2024).

4. Nguyen AW, Chatters LM, Taylor RJ, Mouzon DM. Social support from family and friends and subjective well-being of older African Americans. *J Happiness Stud*. (2016) 17:959–79. doi: 10.1007/s10902-015-9626-8

5. Xu G, Zhao C, Li Q. Subjective well-being and mortality among the older people in China. *China Popul Dev Stud*. (2021) 5:1–24. doi: 10.1007/s42379-021-00076-8

6. Donnelly HK, Solberg VSH, Zaff JF. Impact of community well-being on individual well-being: a longitudinal multinational study with 155 countries. *J Community Psychol*. (2023) 51:1300–13. doi: 10.1002/jcop.22922

7. Circular of the State Council on the Issuance of the "14th Five-Year Plan" for the Development of the National Aging Career and the Pension Service System. (2022). Available online at: https://www.gov.cn/zhengce/content/2022-02/21/content_5674844.htm (Accessed July 30, 2024).

8. Tian G, Shuai J, Li R, Zhou T, Shi Y, Cheng G, et al. Association between playing cards/mahjong and risk of incident dementia among the Chinese older adults: a prospective cohort study. *Front Aging Neurosci*. (2022) 14:966647. doi: 10.3389/fnagi.2022.966647

9. Lin Q, Cao Y, Gao J. The impacts of a GO-game (Chinese chess) intervention on Alzheimer disease in a northeast Chinese population. *Front Aging Neurosci*. (2015) 7:163. doi: 10.3389/fnagi.2015.00163

10. Cheng ST, Chow PK, Edwin CS, Chan AC. Leisure activities alleviate depressive symptoms in nursing home residents with very mild or mild dementia. *Am J Geriatr Psychiatry*. (2012) 20:904–8. doi: 10.1097/JGP.0b013e3182423988

11. Lee YH, Chang YC, Shelley M, Liu CT. A panel analysis of the mahjong card game and social activity with sleep-related measurements among Chinese older adults. *Sleep Biol Rhythms*. (2020) 18:109–19. doi: 10.1007/s41105-019-00249-6

12. Xiao Y, Yin L. Impact of mahjong game on the physical, mental and cognitive health of the elderly in China. *Am J Health Behav*. (2023) 47:1138–46. doi: 10.5993/AJHB.47.6.6

13. Zhang J, Yamaguchi H. Wellness mahjong—an effective recreational activity and healthy pathway to fulfilling active aging for elderly. *Innov Aging*. (2018) 2:220. doi: 10.1093/geroni/igy023.810

14. Skaliy A, Skaliy T, Kuangaliyeva T, Kenzhin Z, Meergul A, Letkiewicz S. The influence of complex motor activities on the morphofunctional and psychoemotional state of elderly people from different countries of Europe and Asia. *Слобожанський науково-спортивний вісник*. (2024) 28:92–9. doi: 10.15391/snsv.2024-2.006

15. Dal Bello-Haas VP, Thorpe LU, Lix LM, Scudds R, Hadjistavropoulos T. The effects of a long-term care walking program on balance, falls and well-being. *BMC Geriatr*. (2012) 12:1–8. doi: 10.1186/1471-2318-12-76

16. Shen S, Li F, Tanui JK. Quality of life and old age social welfare system for the rural elderly in China. *Ageing Int*. (2012) 37:285–99. doi: 10.1007/s12126-011-9130-3

17. Pang W, Esping A, Plucker JA. Confucian conceptions of human intelligence. *Rev Gen Psychol*. (2017) 21:161–9. doi: 10.1037/gpr0000103

18. Bradburn NM. The structure of psychological well-being by N. (pp. 318; illustrated; price not stated.) Aldine: Chicago, 1969. *Psychol Med*. (1976) 6:161. doi: 10.1017/S0033291700007637

19. Ryff CD, Singer B. Psychological well-being: meaning, measurement, and implications for psychotherapy research. *Psychother Psychosom*. (1996) 65:14–23. doi: 10.1159/000289026

20. Keyes CLM. Social well-being. *Soc Psychol Quart*. (1998) 61:121–40. doi: 10.2307/2787065

21. Rojas Gerena S. Happiness and the provisioning of public goods: an answer to the Easterlin paradox. (2017). Available at: http://hdl.handle.net/1992/39333 (Accessed August 12, 2024).

22. Graham C. The economics of happiness. *World Econ*. (2005) 6:41–55. Available at: https://www.researchgate.net/publication/237809673_The_Economics_of_Happiness (Accessed August 12, 2024).

23. Thorbecke E, Babcock H. Happiness and economics: Bruno S. Frey and Alois Stutzer. *J Socio-Econ*. (2002) 31:581–2. doi: 10.1016/S1053-5357(02)00208-1

24. Higgins ET. Self-discrepancy: a theory relating self and affect. *Psychol Rev*. (1987) 94:319–40. doi: 10.1037/0033-295X.94.3.319

25. Hicks S, Tinkler L, Allin P. Measuring subjective well-being and its potential role in policy: perspectives from the UK office for national statistics. *Soc Indic Res*. (2013) 114:73–86. doi: 10.1007/s11205-013-0384-x

26. Xiang G, Li Q, Du X, Liu X, Xiao M, Chen H. Links between family cohesion and subjective well-being in adolescents and early adults: the mediating role of self-concept clarity and hope. *Curr Psychol*. (2022) 41:76–85. doi: 10.1007/s12144-020-00795-0

27. Diener E, Ryan K. Subjective well-being: a general overview. *S Afr J Psychol*. (2009) 39:391–406. doi: 10.1177/008124630903900402

28. Diener E. Traits can be powerful, but are not enough: lessons from subjective well-being. *J Res Pers*. (1996) 30:389–99. doi: 10.1006/jrpe.1996.0027

29. Diener E, Pressman SD, Hunter J, Delgadillo-Chase D. If, why, and when subjective well-being influences health, and future needed research. *Appl Psychol Health Well Being*. (2017) 9:133–67. doi: 10.1111/aphw.12090

30. Vemuri AW, Costanza R. The role of human, social, built, and natural capital in explaining life satisfaction at the country level: toward a National Well-Being Index (NWI). *Ecol Econ*. (2006) 58:119–33. doi: 10.1016/J.ECOLECON.2005.02.008

31. Abdallah S, Thompson S, Marks N. Estimating worldwide life satisfaction. *Ecol Econ*. (2008) 65:35–47. doi: 10.1016/j.ecolecon.2007.11.009

32. Shi Y, Joyce C, Wall R, Orpana H, Bancej C. A life satisfaction approach to valuing the impact of health behaviours on subjective well-being. *BMC Public Health*. (2019) 19:1547–11. doi: 10.1186/s12889-019-7896-5

33. Zhang H, Peng Y, Li C, Lan H, Xing G, Chen Z, et al. Playing mahjong for 12 weeks improved executive function in elderly people with mild cognitive impairment: a study of implications for TBI-induced cognitive deficits. *Front Neurol*. (2020) 11:178. doi: 10.3389/fneur.2020.00178

34. Wang R, Chen Z, Zhou Y, Shen L, Zhang Z, Wu X. Melancholy or mahjong? Diversity, frequency, type, and rural-urban divide of social participation and depression in middle-and old-aged Chinese: a fixed-effects analysis. *Soc Sci Med*. (2019) 238:112518. doi: 10.1016/j.socscimed.2019.112518

35. Teh JKL, Tey NP. Effects of selected leisure activities on preventing loneliness among older Chinese. *SSM Popul Health*. (2019) 9:100479. doi: 10.1016/j.ssmph.2019.100479

36. Guillory JJ, Geraci L. The persistence of inferences in memory for younger and older adults: remembering facts and believing inferences. *Psychon Bull Rev*. (2010) 17:73–81. doi: 10.3758/PBR.17.1.73

37. Atchley RC. A continuity theory of normal aging. *Gerontologist*. (1989) 29:183–90. doi: 10.1093/geront/29.2.183

38. Menec VH. The relation between everyday activities and successful aging: a 6-year longitudinal study. *J Gerontol Ser B Psychol Sci Soc Sci*. (2003) 58:S74–82. doi: 10.1093/geronb/58.2.s74

39. Lemon BW, Bengtson VL, Peterson JA. An exploration of the activity theory of aging: activity types and life satisfaction among in-movers to a retirement community. *J Gerontol*. (1972) 27:511–23. doi: 10.1093/geronj/27.4.511

40. Park NS, Jang Y, Chiriboga DA, Chung S. Profiles of social engagement and their association with loneliness and self-rated health among older Korean immigrants. *Res Aging*. (2020) 42:300–11. doi: 10.1177/0164027520927963

41. Crandall R. Social interaction, affect and leisure. *J Leis Res*. (1979) 11:165–81. doi: 10.1080/00222216.1979.11969394

42. Waldinger R, Schulz M. The good life: lessons from the world's longest scientific study of happiness Simon and Schuster (2023).

43. Turner JH. A theory of social interaction Stanford University Press (1988). doi: 10.2307/2579266

44. Cropanzano R, Mitchell MS. Social exchange theory: an interdisciplinary review. *J Manag*. (2005) 31:874–900. doi: 10.1177/0149206305279602

45. Adams R. G., Blieszner R. Older adult friendship: structure and process. (1989). Available online at: https://cir.nii.ac.jp/crid/1130282269469999360 (Accessed August 16, 2024).

46. Zhang J, Cao F, Yang C. How does social support affect subjective well-being among Chinese widowed older adults? *Front Public Health*. (2024) 12:1352585. doi: 10.3389/fpubh.2024.1352585

47. Grünjes CE, Macdonald B, Hülür G. The role of social interaction modality for well-being in older adults. *Psychol Aging*. (2024) 39:364–77. doi: 10.1037/pag0000816

48. Carmona S, Ribeiro M. Influence of social interaction in personal wellbeing of older adults. *Int J Hispanic Psychol*. (2013) 6:143. Available at: https://xueshu.baidu.com/usercenter/paper/show?paperid=1g5j04y0k14w0va06h1y00d0ux145011&site=xueshu_se (Accessed August 16, 2024).

49. Cheng ST, Chan AC, Yu EC. An exploratory study of the effect of mahjong on the cognitive functioning of persons with dementia. *Int J Geriatr Psychiatr*. (2006) 21:611–7. doi: 10.1002/gps.1531

50. Wang J, Liu N, Zhao X. Association of Playing Cards or mahjong with cognitive function in Chinese older adults. *Int J Environ Res Public Health*. (2022) 19:9249. doi: 10.3390/ijerph19159249

51. Chen PJ, Hsu HF, Chen KM, Belcastro F. Effects of tabletop games on cognition in older adults: a systematic review and meta-analysis. *Games Health J*. (2022) 11:225–35. doi: 10.1089/g4h.2021.0132

52. Li B, Bi J, Wei C, Sha F. Specific activities and the trajectories of cognitive decline among middle-aged and older adults: a five-year longitudinal cohort study. *J Alzheimers Dis*. (2021) 80:1039–50. doi: 10.3233/JAD-201268

53. Zhu L, Wang Y, Wu Y, Wilson A, Zhou H, Li N, et al. Longitudinal associations between the frequency of playing mahjong and cognitive functioning among older people in China: evidence from CLHLS, 2008–2018. *Front Public Health*. (2024) 12:1352433. doi: 10.3389/fpubh.2024.1352433

54. Ding M, Ouyang H, Zhang C, Jiang L, Zhuang R, Dong X, et al. Mahjong playing and leisure physical activity alleviate cognitive symptoms in older community residents. *J Aging Phys Act*. (2021) 30:89–97. doi: 10.1123/japa.2020-0383

55. Wu YJ, Tsai JJ, Huang CW. Nonketotic hyperglycemia-related reflex epileptic seizures induced by Mah-Jong playing. *Epilepsy Behav*. (2010) 19:533–5. doi: 10.1016/j.yebeh.2010.09.005

56. Wang HX, Xu W, Pei JJ. Leisure activities, cognition and dementia. *Biochim Biophys Acta (BBA) Mol Basis Dis*. (2012) 1822:482–91. doi: 10.1016/j.bbadis.2011.09.002

57. 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

58. Dias EG, de Oliveira Duarte YA, Morgani MH, Lebrão ML. As Atividades avançadas de vida diária como componente da avaliação funcional do idoso. *Revista de Terapia Ocupacional da Universidade de São Paulo*. (2014) 25:225–32. doi: 10.11606/issn.2238-6149.v25i3p225-232

59. Sposito G, Neri AL, Yassuda MS. Cognitive performance and engagement in physical, social and intellectual activities in older adults: the FIBRA study. *Dement Neuropsychol*. (2015) 9:270–8. doi: 10.1590/1980-57642015DN93000010

60. Bárrios H, Narciso S, Guerreiro M, Maroco J, Logsdon R, de Mendonça A. Quality of life in patients with mild cognitive impairment. *Aging Ment Health*. (2013) 17:287–92. doi: 10.1080/13607863.2012.747083

61. Allerhand M, Gale CR, Deary IJ. The dynamic relationship between cognitive function and positive well-being in older people: a prospective study using the English longitudinal study of aging. *Psychol Aging*. (2014) 29:306–18. doi: 10.1037/a0036551

62. Wilson RS, Boyle PA, Segawa E, Yu L, Begeny CT, Anagnos SE, et al. The influence of cognitive decline on well-being in old age. *Psychol Aging*. (2013) 28:304–13. doi: 10.1037/a0031196

63. Fang H, Xiong Z, Li Y, Cui W, Cheng Z, Xiang J, et al. Physical activity and transitioning to retirement: evidence from the China health and retirement longitudinal study. *BMC Public Health*. (2023) 23:1937. doi: 10.1186/s12889-023-16870-7

64. Luborsky MR, LeBlanc IM. Cross-cultural perspectives on the concept of retirement: an analytic redefinition. *J Cross Cult Gerontol*. (2003) 18:251–71. doi: 10.1023/B:JCCG.0000004898.24738.7b

65. Grossman M. Index In: Determinants of health: an economic perspective. New York, Chichester, West Sussex: Columbia University Press (2017). 779–806.

66. Nimrod G. Retirees' leisure: activities, benefits, and their contribution to life satisfaction. *Leis Stud*. (2007) 26:65–80. doi: 10.1080/02614360500333937

67. Sánchez-Martin AR, Garcia-Perez JI, Jiménez-Martín S. Delaying the normal and early retirement ages in Spain: behavioural and welfare consequences for employed and unemployed workers. *De Economist*. (2014) 162:341–75. doi: 10.1007/s10645-014-9235-7

68. Veenhoven R. Happiness: also known as "life satisfaction" and "subjective well-being" In: Handbook of social indicators and quality of life research. Dordrecht: Springer Netherlands (2011). 63–77.

69. Lei X, Hu Y, McArdle JJ, Smith JP, Zhao Y. Gender differences in cognition among older adults in China. *J Hum Resour*. (2012) 47:951–71. doi: 10.3368/jhr.47.4.951

70. Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol*. (1986) 51:1173–82. doi: 10.1037/0022-3514.51.6.1173

71. Karlson KB, Holm A, Breen R. Comparing regression coefficients between same-sample nested models using logit and probit: a new method. *Sociol Methodol*. (2012) 42:286–313. doi: 10.1177/0081175012444861

72. Wu XP, Liao EY, Zhang H, Dai RC, Shan PF, Cao XZ, et al. Determination of age-specific bone mineral density and comparison of diagnosis and prevalence of primary osteoporosis in Chinese women based on both Chinese and World Health Organization criteria. *J Bone Miner Metab*. (2004) 22:382–91. doi: 10.1007/s00774-004-0499-x

73. Sun S, Chen J, Johannesson M, Kind P, Burström K. Subjective well-being and its association with subjective health status, age, sex, region, and socio-economic characteristics in a Chinese population study. *J Happiness Stud*. (2016) 17:833–73. doi: 10.1007/s10902-014-9611-7

74. Zhao L, Zhang K, Gao Y, Jia Z, Han S. The relationship between gender, marital status and depression among Chinese middle-aged and older people: mediation by subjective well-being and moderation by degree of digitization. *Front Psychol*. (2022) 13:923597. doi: 10.3389/fpsyg.2022.923597

75. Muhammad T, Srivastava S, Sekher TV. Association of self-perceived income status with psychological distress and subjective well-being: a cross-sectional study among older adults in India. *BMC Psychol*. (2021) 9:82. doi: 10.1186/s40359-021-00588-5

76. Dang TNH, Sukontamarn P. Education and subjective well-being among older Vietnamese: exploring gender differences. *J Popul Soc Stud.* (2019) 28:22–37. doi: 10.25133/JPSSv28n1.002

77. Read S, Grundy E, Foverskov E. Socio-economic position and subjective health and well-being among older people in Europe: a systematic narrative review. *Aging Ment Health.* (2016) 20:529–42. doi: 10.1080/13607863.2015.1023766

78. Yang J, Wang Q. Economic development, social integration, and the subjective well-being of residents in the western regions of China: based on the perspective of multi-ethnic China. *Int J Anthropol Ethnol.* (2021) 5:3. doi: 10.1186/s41257-021-00044-7

79. Tse ZCK, Cao Y, Chau BKH, Yeung MK, Leung C, Shum DH. Does playing mahjong benefit older individuals? A scoping review. *J Prev Alzheimers Dis.* (2024) 11:1363–77. doi: 10.14283/jpad.2024.102

80. Rahmah ADN, Isnaini NI. The effect of playing cards with mosquito claps on cognitive function and happiness in elderly residents. *Jurnal Ilmiah Kesehatan (JIKA).* (2024) 6:1–13. doi: 10.36590/jika.v6i1.719

81. Zhang Y, Petrini MA. Empty-nest elderly: mahjong and Chinese square dance for improving the cognitive function in the community. *Front Nurs.* (2019) 6:71–6. doi: 10.2478/fon-2019-0011

82. Cai J, Hu T, Zhou L, Jiang H, Gao Y. Effects of leisure activities and general health on the survival of older people: a cohort study in China. *Front Public Health.* (2023) 11:1273074. doi: 10.3389/fpubh.2023.1273074

83. Kobayashi T, Tani Y, Kino S, Fujiwara T, Kondo K, Kawachi I. Prospective study of engagement in leisure activities and all-cause mortality among older Japanese adults. *J Epidemiol.* (2022) 32:245–53. doi: 10.2188/jea.JE20200427

84. Hirabayashi N, Honda T, Hata J, Furuta Y, Shibata M, Ohara T. Japan prospective studies collaboration for aging and dementia (JPSC-AD) study. Association between frequency of social contact and brain atrophy in community-dwelling older people without dementia: the JPSC-AD study. *Neurology.* (2023) 101:e1108–17. doi: 10.1212/WNL.0000000000207602

85. Li Y, Niu S, Mou Y. Gender difference in the Chinese middle-aged and elderly of pocket park use: a case study of Zongbei park. *Front Environ Sci.* (2022) 10:978935. doi: 10.3389/fenvs.2022.978935

86. Chu-Man L, Chang MY, Chu MC. Effects of mahjong on the cognitive function of middle-aged and older people. *Int J Geriatr Psychiatry.* (2015) 30:995–7. doi: 10.1002/gps.4307

87. Zhang Z, Zhang J. Social participation and subjective well-being among retirees in China. *Soc Indic Res.* (2015) 123:143–60. doi: 10.1007/s11205-014-0728-1

88. Woll A, Bratteteig T. Activity theory as a framework to analyze technology-mediated elderly care. *Mind Cult Act.* (2018) 25:6–21. doi: 10.1080/10749039.2017.1375528

89. Xiao S, Lin H, Zhao C, Zheng X, Shi L, Zhang J, et al. Impact of different type and frequency of social participation on depressive symptoms among older Chinese adults: is there a gender difference? *Front Psych.* (2021) 12:758105. doi: 10.3389/fpsyt.2021.758105

90. Chen X, Zhang M, Wang Y, Xu X, Liu S, Ma L. Coupling and coordination characteristics and influencing factors of the livable environment system for the elderly in China. *Chin Geogr Sci.* (2022) 32:1052–68. doi: 10.1007/s11769-022-1283-3

frontiers | Frontiers in Public Health

Integration and completion: life wisdom and happiness of Chinese older adults from a life course perspective

Sheng-Li Cheng[1]*, Xin Zhang[2], Shushan Liu[1]*, Chenxu Zhao[1] and Sizhen Bi[1]

[1]School of Philosophy and Social Development, Shandong University, Jinan, China, [2]Bussiness School, Shandong Agriculture and Engineering University, Jinan, China

Introduction: Life course theory posits that historical events that transpired in the past shape an individual's well-being. In the last century, China experienced a series of significant events in rapid succession, including the Anti-Japanese War (AJW), the Civil War (CW), the Great Famine (GF), the Cultural Revolution (CR), and the Reform and Opening of China (ROC). These early life experiences may have lasting effects on older adults. Concurrently, given the discrepancies in life course, there may be discrepancies in well-being and perceptions of life between Chinese and Western older adults.

Methods: A qualitative study was conducted within a constructivist paradigm. In-depth interviews were carried out with 16 older adults using a standardized inventory. A theoretical framework was constructed through the effects of temporary breakdown on the life course and "vital involvement in the necessary disinvolvements of old age (VINDOA)." Data were coded using the Nvivo-12 software.

Results: The themes of well-being and life wisdom among Chinese older adults centered on (1) valuing education, strong family ties, and active social participation, which were associated with personal experiences of well-being. (2) Satisfaction and gratitude for social welfare, being happy and worried about current social situation in the same time, which are related to older adults' values of society. (3) Expectations, encouragement, and transmission of wisdom to youth are related to their views of young people and youthfulness.

Conclusion and discussion: A key finding is that how older adults perceive life strongly influences their present experiences and sense of well-being. In addition, the social class in which older people live plays an important role in the connection between a challenging past and a fulfilling present. Furthermore, social development has a positive impact on the well-being of older adults, while the level of social participation of older adult people exerts a further influence on their own well-being and their capacity to contribute to society.

KEYWORDS

life courses, Chinese older adults, life wisdom, happiness, qualitative research

1 Introduction

The concept of the "life course" is used to analyze the process of change in human life, with a focus on the time, context, and historical processes that shape an individual's life from birth to death. In Western life course research, a common question is how a changing society affects the development of individuals. Elder (1) emphasizes the impact of social forces on life outcomes and the shaping of individual trajectories. As life course theory has evolved, increasing attention has been paid to the interplay between social pathways and both historical and developmental contexts (2). Mastery of the past life course is necessary to gain a deeper understanding of an individual's later years. Role histories, shaped by past events, influence health, adjustment, and well-being in later life (2–4).

Erikson's life cycle theory outlines eight stages of psychosocial development, with the final stage being older adulthood. In this stage, individuals are tasked with reflecting on their past while staying engaged in the present (5–7). Re-experiencing past events is a key psychological task at this stage (8, 9). In *The Life Cycle Completed*, Erikson defines "wisdom" as the strength gained in the struggle between integration and despair. In *Vital Involvement in Old Age*, he states more directly that integration and despair are two diametrically opposed tensions that the individual will face in old age. Furthermore, the individual must strive to achieve a balance between these two opposing forces, integrating each psychosocial theme, and fostering a sense of integration as the dominant experience during old age. Additionally, the pursuit of "wisdom" and maintaining "the vital involvement in the necessary disinvolvements of old age (VINDOA)" is essential for meaningful aging (6, 9).

The successful aging perspective (SAP) is a widely used concept in western research on older adults' well-being. However, Stowe and Cooney (10) criticized it for neglecting cultural and historical context, as well as the influence of social relationships and structures. They proposed rethinking SAP through a life course lens. The life course paradigm (LCP) integrates multiple theories (11–13) and suggests that early life events — such as learned skills, coping strategies, and formative experiences — shape later well-being and life satisfaction (14–16).

In China, both policymakers and scholars increasingly promote the concept of positive aging. Official documents and academic studies now define health not only in physical terms but also as psychological and social adaptation in old age (17–19). Current research on the well-being of the older adults focuses on three aspects: the current status of subjective well-being (20, 21), the causal relationship between different aging modes and subjective well-being (22, 23), and the study of influencing factors (24, 25). Compared to the West, China's 20th-century historical process was more complex and changeable. Research on the well-being of Chinese older adults who grew up during this period needs to be integrated with the relevant social context. Major events such as the Anti-Japanese War (AJW), Civil War (CW), Great Famine (GW), Cultural Revolution (CR), and the Reform and Opening-up of China (ROC) have influenced the personality traits of citizens during that era. As people navigate life's challenges, adversity often becomes a source of resilience, reinforcing beliefs such as the idea that "hardship must precede success" (26). Additionally, Da (27) suggests that subjective well-being is a personal evaluation of one's life satisfaction based on individual standards and social realities. It increases when real-life conditions exceed the set standard and decreases when they fall below it. Also, comparing the current living conditions with the past living conditions is an important criterion for people to measure subjective well-being (28).

In light of the considerations above, we propose the following research question for this paper: from a life course perspective, how do Chinese older adults understand life and what factors shape their well-being in old age? Life course research emphasizes the inter-constructive nature of macro-social structure and micro-individual life. The mutual construction is characterized by the constraints of social structure and the autonomy of individual action (29). By examining the tension between integration and despair in the context of China's historical transformation, we aim to gain deeper insight into the life wisdom and well-being of Chinese older adults.

2 Theorizing life courses

Life course theory originated in the 1920s and has developed significantly over the past century. It offers a perspective for studying individual well-being that begins with significant events and behavioral patterns throughout an individual's or group's lifespan. Elder (30) presented four paradigmatic themes of the life course. Firstly, the time and environmental context in which it takes place. An individual's life course is often epitomized by the events they have experienced over the years of their life, as well as being shaped by those times and events. Secondly, the impact of significant events at different ages. The effects of transitions and events vary depending on when they occur in an individual's life and on the expectations and beliefs available at that age. Thirdly, the impact of interdependent social relationships on life. Life exists in the interdependence of kinship or other relationships, and socio-historical influences are manifested through this network of shared relationships. Fourthly, the impact of individual choices and actions on life. Individuals are able to construct their life course through their own choices and actions, utilizing the opportunities available to them and overcoming the constraints of historical and social circumstances.

The interviewees experienced various historical events and life transitions, facing difficulties and uncertainties throughout their lives. When comparing older adults in China to those in western countries, differences can be observed in their life plans, stages of purpose, and resulting sense of well-being and happiness. However, it is important to acknowledge that historical events in the western countries have also shaped people's life trajectories, which can also be used for comparison and analysis.

2.1 Different stages of the life course

The life of an average person can be divided into five stages: early childhood, adolescence, adulthood, middle age, and old age (31, 32). Each stage has its own unique characteristics and developmental tasks that drive the socialization process. These tasks include experiencing social roles, building social networks, and assuming social division of labor. Old age is often associated with desocialization, which can lead to poorer health and changes in social roles. However, it can also provide individuals with more free time and opportunities for introspection, both of which can have an impact on their well-being

and happiness. The situation in China adds further complexity. Chinese older adults have experienced significant societal changes throughout their lifetime. When they were young, Chinese society was in the early stages of internal and external conflict and regime establishment. Over time, China has developed into a moderately prosperous society. The war, institutional collapse, and disorder have significantly impacted the lives of the population. Individuals experience various challenges and opportunities due to social change and the need to adapt to new social environments and role positions. This is known as the post-transitional life course (33). Individuals who spent their early childhood and adolescence during this era often recount not only their personal experiences and upbringing, but also significant societal events and changes that occurred during this period.

2.2 Experiences of well-being within the context of modernity

The post-transition life course comprises two new stages associated with modernity. A living older people may be born in the pre-transition life course expectation or die in the post-transition life course expectation (34). Our respondents experienced both the pre-transition suffering and post-transition prosperity of Chinese society. Experiencing both phases of the life course at the same time resulted in different experiences of well-being for individuals.

Currently, there is little academic attention paid to the question of the well-being experiences expected to result from an individual's dual life course. On the one hand, a person's life course changes from pre-transition to post-transition imply that social change is accomplished in a short period of time, which is uncommon in many countries. On the other hand, few studies have focused on the impact of social change as an external factor on an individual's life course. Through a review of existing literature, this study has found that Sweden's social transformation can provide valuable insights. Gunnarsson (35) conducted interviews with 20 older adults who were born before the World War II and found that Sweden experienced rapid economic development in the last century, transitioning from a poor country to a welfare state. Most of the interviewees lived in rural areas before moving to cities for education and work as urbanization increased. These senior citizens have witnessed the establishment and growth of the welfare state. The economic development and various welfare policies implemented by the state have provided them with more opportunities and convenience in their lives. The study by Lennartsson et al. (36) found that socioeconomic status in childhood was associated with health in old age, after analyzing the socioeconomic status of the older adults born between 1925 and 1934 and their health outcomes. Additionally, the study found that increases in years of education are directly associated with good health in middle age. The government's educational policies have facilitated more equitable access to educational resources for citizens. At the same time, these policies have mitigated some of the negative effects of lower socio-economic status on health outcomes.

2.3 Changes in well-being resulting from ephemeral breakdown

The outbreak of the World War II caused extensive disruption to people's lives worldwide, with many young individuals involved in the

campaign. Smith et al. (37) conducted semi-structured interviews with World War II veterans and their family members. The study found that the war brought great pain and fear to the soldiers. Only troop camaraderie was a positive emotion that was maintained and continued among inter-service members. After the war ended, many military personnel struggled to reintegrate into civilian life due to traumatic memories. Some military partners and children also experienced domestic violence and grief as a result of the emotional toll on military personnel (37, 38). A longitudinal study by Ardelt et al. (39) confirmed that crises and stresses associated with war may propel resilient service members to achieve higher levels of wisdom and well-being. However, these same experiences may have more negative physical and mental health effects on individuals who are not resilient.

In addition to veterans, the lives and well-being of the general population have been affected to a significant degree. World War II survivors and their family members who experienced a variety of traumas in early childhood and adolescence developed some degree of depressive symptoms and PTSD (40, 41), and the impact of wartime trauma on an individual's life course is diminished if the trauma occurs at an earlier age (42). Whereas factors such as access to high-quality education, strong family relationships and volunteer work in old age can contribute to achieving a better level of mental health and resilience (41).

The Great Depression of the 1930s disrupted lives in the United States, and the economic status and quality of life of the unemployed population reached its lowest point. The Great Depression resulted in widespread unemployment and social unrest. Workers began to recognize the inherent risks and uncertainties in their careers (43). Additionally, many working-class and unemployed residents were evicted from the city, causing significant harm to their personal interests and well-being (44). However, there were still some positive developments during the Great Depression. Historical statistics show that the physical health of citizens was not adversely affected. Moreover, some studies have found that the experience of economic hardship can promote personal growth and the accumulation of reflective introspection and life wisdom to resolve crises, which can buffer against the negative social effects of economic crises (45, 46).

Regarding the impact of traumatic events, such as wars and economic crises, on individuals, discourse in conventional Western life history research has primarily focused on the effects of ephemeral breakdown in an individual's otherwise stable and predictable life course, as well as changes in an individual's physical and psychological well-being (47–49). Most studies on the life course and social change confirm that disruptions to the stable life course often have negative consequences. However, some sociologists have also explored the positive impact that these traumatic experiences may have on individuals, as well as the buffering effect of factors such as education and social networks (41, 50, 51).

In China, the phrase "Yiku Sitian" (contrast past misery with present happiness) has been officially mentioned and advocated, with past suffering serving as a backdrop message to highlight the happiness of the present. During the Cultural Revolution, the "The educated youth (Zhiqing) Going to the Countryside Movement" mobilized young people to move away from urban areas to live and work in remote villages, mines, and factories. However, research has confirmed that this high-pressure environment promoted the development of independent personalities among these youths, which

was conducive to improving their adaptability and interpersonal skills (52). The role of Zhiqing's mentality in labor participation is also significant (53). Many urban youths responded to the CPC and government's call to proactively experience life in rural and remote areas. According to Wang and Liu (54), the collective memory of the Zhiqing youths serves as a means for a generation to locate and trace their youthful years. They argue that this 'rose-colored glasses' review also closely connects the fate of individuals with the history of the country. To this day, China continues to use this spirit of hard struggle as an important method for carrying out ideological and political work with young people (55).

Kahn and Juster (56) define resilience as the speed and completeness of recovery from a crisis event. They confirm that older adults' resilience buffers their adaptation to stress and challenges. The magnitude and duration of negative events have different impacts on the level of resilience and well-being of the older adults. The duration of the mourning effect is prolonged when faced with events such as the death of a loved one. If these challenges can be anticipated in advance, the resulting negative effects can be moderated. Kahn and Juster refer to these life-course disruptions as "variability", emphasizing that illness, death, or other crises bring varying degrees of shock and resilience. However, what if we were to consider these events as "permanent", with the effects of a breakdown lasting from early childhood to old age?

2.4 Chinese scholarship on well-being in later life

In recent years, there has been an increasing amount of research linking life course interruptions to well-being in later life. The most commonly studied measure is the level of health in old age. Jiao and Bao (57) argue that childhood is a critical period in the life course and that adverse circumstances in childhood not only have a direct impact on health in adulthood, but also later in life. For instance, the older adults who experienced the Holodomor in childhood had worse health outcomes than those who did not. Moreover, the experience of famine during childhood had a negative impact on education, socialization, and lifestyle (58). These factors, in turn, continued to have a detrimental effect on the health of the older adults (59). Meanwhile, the positive influence exerted by educational attainment on health levels in later life is generally confirmed. Older adults who recall significant youth experiences having lower levels of self-assessment of their health, and years of education as a mediator variable showing a positive correlation with the older adults' mental health levels (60)

In later life, well-being is composed of a sense of worthiness and happiness. Peng (61) posits that the older adults' income level increases when they have "Going to the Countryside" experiences. However, their happiness decreases as a result. This may be due to the fact that challenging life experiences hone an individual's will and have a positive impact on their career. Nevertheless, an individual's perception of time changes after experiencing these critical moments, and suffering and negative events can cause them to perceive time as longer, leaving behind painful memories. Retrospective life stories can help older adults return to the center of their individual narratives and give full play to their subjective initiative, enhancing their sense of value and quality of life (62).

3 Methods

3.1 Data collection

This study employed constructivism as its research paradigm and employed qualitative research methods. Sixteen Chinese older adults residing in Jinan City, Shandong Province, were identified for interviews through purposive sampling. The rationale for selecting Jinan as the study site has been previously described in detail in a related study (34). The participants included both Jinan local residents and those who were born in rural areas and later went to school or worked and settled in Jinan, as well as those who followed their children and relocated to Jinan when they were old. During the participant recruitment process, the research team conducted field visits to various public venues across different districts and counties of Jinan City, such as community centers, parks, and senior activity centers. By engaging older adult individuals in casual conversations and building initial trust, the researchers invited those who met the study's inclusion criteria to participate in the interviews. After the initial contact, the purpose, content, and procedures of the study, as well as the voluntary nature of participation and confidentiality measures, were thoroughly explained to the potential participants. Formal interviews were conducted only after obtaining informed consent.

At the end of 2012, the research team conducted semi-structured interviews with 16 participants, each lasting approximately 1–2 h. The interviews encompassed a range of topics, including memories of different life stages, current living conditions, outlook on future life, wisdom transmission and sharing, and other aspects. In preparation for the interviews, the research team developed a formal interview outline, which the interviewer could use with relative flexibility during the interviews to ensure that the interviewed people could tell their life stories without restrictions. In this study, the interview outline was developed under the concept of standardized biography, whereas the vein of sharing the older adults' life stories was non-standardized (34, 63).

The research team adhered to ethical standards. First, the staff members who determined the list of interviewees were not acquainted with the interviewees, ensuring the relative independence of the sampling and interviewing process. Second, the older adults selected for the interview had the final say on whether or not to be interviewed. If someone declined, the interviewer would establish contact with the next people to be interviewed. Finally, prior to the commencement of the interviews, participants were clearly informed that all data would be utilized for academic purposes only and that all personal information disclosed would be anonymized.

The interviewed people were born between the late 1930s and early 1950s and were aged 61 to 75 at the time of the interviews. Having experienced both the devastation of war and the scarcity of food in their early years, as well as the bountiful period of national wealth and prosperity in their later years, these two stages are associated with modernity and are consistent with the characteristics of life course of the post-transition period. The gender ratio and urban–rural distribution of the interviewees are relatively balanced, with 8 men and 8 women each, and 8 urban and 8 rural residents each. The data from the interviews is presented in Table 1.

3.2 Data analysis

The older adults had experienced significant challenges throughout their lives, including the AJW, CW, GF, and CR. These events had a profound impact on their life course, resulting in long-lasting effects (34). Concurrently, they are at the end of the life course, the stage of old age. During this stage, older adults must overcome despair and fear in order to achieve integration and completion. This process leads to the realization of life-cycle harmony and unity (64). The pervasive influence of ephemeral breakdown on the life course and the phenomenon of VINDOA are intricately intertwined, collectively shaping the invaluable life wisdom of the Chinese older adults and the sense of well-being that accompanies it. This sense of well-being is presented in three dimensions: individual, social, and future-oriented. The theoretical framework established by the study is shown in Figure 1.

The study imported 16 interviews into the Nvivo-12 and coded them according to these three dimensions. This resulted in 3 themes, 8 sub-themes, 30 initial concepts, and 256 informational reference points. These included perceptions of life, perceptions of society, and expectations for younger generations. Subsequently, the study undertook a process of sorting and refining the intrinsic logical relationships among the three levels of coding. This was followed by the identification of the content and vein of what is included in the life wisdom and well-being of Chinese older people from a life course perspective.

4 Results

4.1 A preliminary analysis

The majority of the interviewees expressed contentment with their current state of life, demonstrated strong familial ties, and exhibited a

profound sense of responsibility towards their dependents. They were all born into large families with four to five siblings, and are now starting their own families, with the majority having three or four children. This aligns with the original familial structure. Prior to retirement, the majority of respondents were "unit people," a term derived from China's planned economy. This designation signifies that the unit is responsible for the life, death, and sickness of its employees. Consequently, it is challenging for them to transition to alternative employment opportunities during their working years. Following retirement, these individuals exhibit a high degree of autonomy, focusing their daily lives on the care of their grandchildren, exercise, and the cultivation of their own hobbies. They are satisfied with the protection and services provided by the state.

The challenging experiences of their early lives have imbued the lives of Chinese older people with a distinctive depth of meaning. The profound changes that have occurred in the context of the times have intensified their understanding of their current lives. The objective reality of societal prosperity and progress is evident, and the contrast between the present and the past has heightened the subjective sense of happiness experienced by the Chinese older adults. The majority of the interviewees' later lives are characterized by an integration of their past experiences with their current circumstances, resulting in the formation of their distinctive wisdom. This wisdom is not only manifested in the realization and fulfillment of their personal lives but also pervades their comprehension of social development and their expectations for the growth of younger generations.

4.2 Experiences of personal well-being: insights into the lives of older Chinese people and the path to happiness

Our interviewees have experienced 70 years of upheaval, change, and development. Three important themes—education, family, and social participation—run through their life stories. The overwhelming majority of our interviewees consider themselves to be happy. Their assessment of happiness is not only based on absolute and objective criteria, but also on their past life experiences, which have been gradually transformed into their unique wisdom through lifelong of experience and comparisons between the present and the past.

4.2.1 Education

The interruption of education for the majority of the interviewees was a consequence of the war and the CR. The poverty of social conditions and the breakdown of education system by the social environment also made continuous education very difficult. However, the interviewees who lived through those years (e.g., interviewee 1, 2, 4, 10, 13) cherished the opportunity of education more and became more self-reliant as a result.

4.2.1.1 Disruption of education, self-empowerment, and valuing education

The war resulted in the disruption of education for many individuals at the time. The majority of the interviewees who were of school age at the time were unable to receive an education due to social unrest. The subsequent CR resulted in the collapse of the education system, creating a profound memory of interrupted education for many interviewees. At the same time, this experience

TABLE 1 Characteristics of the study participants.

No.	Gender	Age	Year of birth	Region	Occupation
1	Female	63	1949	Rural	Accountant
2	Female	73	1939	Urban	University Teacher
3	Male	64	1948	Urban	Worker
4	Male	71	1941	Rural	Educator
5	Male	71	1941	Rural	Farmer
6	Female	70	1942	Urban	Worker
7	Female	63	1949	Urban	Accountant
8	Male	74	1938	Rural	Professor
9	Male	75	1937	Rural	Teacher
10	Male	66	1946	Rural	Farmer
11	Male	72	1940	Urban	Farmer
12	Female	74	1938	Rural	Nurse
13	Female	61	1951	Urban	Worker
14	Female	74	1938	Urban	Civil Servant
15	Male	72	1940	Rural	Worker
16	Female	74	1938	Urban	Doctor

FIGURE 1
Theoretical analysis framework.

was perceived as a regret, as it prevented them from pursuing higher education and realizing their life aspirations.

> *"Actually, I did not go to elementary school for very long time, because we fled as a refugee when the AJW started."(No. 2, born 1939)*

> *"The CR started in 1966. Students didn't have classes then, schools were closed, and no class for us to attend. Until the CR ended, people like me started to have chance to go to high school by recommendation."(No. 1, born 1949)*

The older adults, particularly those who had received an education, attached great importance to education, having experienced the scarcity of educational resources themselves. As No. 3, born in 1948, stated, *"In my memory, my father was strict to us, always telling us to study hard. At that time, we went to school all by ourselves, and the conditions were not as good as they are today".*

Despite the challenging circumstances of their education, the interviewees held a positive outlook, cherishing the educational opportunities they had obtained. For the older adults, the ability to access education despite the difficulties they faced kept them in a positive frame of mind. As No. 3 stated, *"Although life was hard then, our mental outlook is very good, very positive, there is no complaining and dragging on".*

As a consequence of fleeing from the war, No. 2 received almost no primary education. During the CR, she endured significant torture and suppression, and also observed the suffering of her mother and teachers. These experiences have reinforced her conviction that education can facilitate the transformation of one's destiny, as it can provide a means of making an impact and protecting oneself and one's family in times of crisis.

> *"At that time, you needed to study hard if you wanted to stand out of people and survived in hard world. You could only change your fate by going to university…" (No. 2, born 1939)*

4.2.2 The inter-connectivity between family members

Most of the interviewees had experienced family breakups and displacement of relatives due to social instability such as wars. The Chinese people have long valued the concept of the family, and family breakups have had a profound impact on them, which also affects their subsequent values and education of their offspring, emphasizing that respect for parents and solidarity between siblings have become important themes in their lives.

4.2.2.1 The dissolution of families, the reverence for parents, and the assistance of siblings

When the interviewees were still in their formative years, they were particularly vulnerable and in need of the nurturing and support of their families. However, during that period, the war-torn and poverty-stricken society brought them a childhood full of suffering and sadness. Some of the elders discussed how their displacement from their homes during their early years and their loss of contact with important family members had caused many childhood deficiencies. Accordingly, in the accounts of the interviewees, their childhood experiences were invariably shadowed by the anguish and helplessness engendered by transient crises such as the loss of loved ones and the dissolution of families.

> *"I couldn't get my father's care when I was a young child. When I was two years old, when the AJW was going on, my father went to join the People's liberation army to fight Japanese imperialism." (No 9, born 1937).*

> *"I never saw my father and didn't know what he looked like. Before I was born, my father went to join the army and became a spy of the CPC. My father was the only son of my grandfather and was also the youngest among his siblings." (No 12, born 1938)*

The experiences of childhood displacement and the absence of a complete family unit have led to a heightened appreciation for familial love. The accounts of the interviewees revealed a profound reflection

of the traditional Chinese concept of filial piety, with the majority of them assuming the obligation of supporting their parents to the fullest extent possible and demonstrating a strong sense of responsibility towards their families.

> "I took care of my mother for 13 years before she moved to my young sister's apartment after my brother in law (his sister's husband) died because their apartment was larger."(No 16, born 1938)

> "My grandmother was not healthy when she was old. My sister and I took care of our grandmother in turn."(No 6, born 1941)

Similarly, the interviewees demonstrated a profound focus on sibling solidarity and mutual assistance, which may be related to the significant turbulence and family breakups they experienced in their early years. The majority of the interviewees resided in families comprising numerous siblings. However, they exhibited a remarkably unified and amicable relationship with one another, providing mutual assistance, exhibiting a tendency to prioritize self-interest over kinship, and instilling in each other the motivation to live a fulfilling life in the present due to their shared experiences of adversity.

> "I felt most important person for me was my elder cousins, because my family was very poor at that time, my female elder cousin worked in a factory and my male elder cousin worked at accounting college, they often aided my family, and I also went to their home." (No. 3, born 1948)

> "I am the oldest child in my family, and have several brothers and sisters. I felt responsibility to be the oldest brother to take good care of young brother and sisters. Being the oldest brothers I should let them eat first when there were good foods, do work first when there are farm work in field. That is the responsibility which the oldest brother should take." (No. 10, born 1946)

4.2.3 Active social participation

Social participation can be defined as the role-playing and involvement of participants in social interactions with the objective of achieving resource sharing and the fulfillment of personal needs within society (65). The interviewees, from their early years to their current age, have experienced and witnessed the development and progress of society. In comparison to their previous poverty and suffering, they now enjoy a happy life, which fills them with gratitude and contentment towards society and their country. Consequently, they also wish to participate in society, integrate into the collective, and dedicate themselves to the collective. Moreover, for our interviewees, the majority of their early life experiences were characterized by sadness and pain. However, these experiences have instilled in them a resilience that enables them to navigate life's challenges, including physical deterioration. Instead of being overwhelmed by these difficulties, they have adopted a more optimistic outlook, leading to a more fulfilling and colorful life in the present.

4.2.3.1 Gratitude to society, recreational life, and utilizing one's spare time at work

As they recounted, the previous life was not only constrained by harsh conditions but also lacked autonomy. They described a sense of confinement in their work and life, with their work being assigned to

them, leaving little time for personal interests. The contrast between the living conditions and environments of the past and the present led our interviewees to express feelings of contentment and gratitude for the present society.

> "In the past, people couldn't follow their interest to choose their job, but now people can follow their interest to choose job, you can freely develop your interest, you can search and try to find what you like to do." (No. 8, born 1938)

> "You don't know how comfortable life you are living. When I was as young as you are now, it was very difficult for me to have money to spend. There was little money or no money, no good food to be eaten." (No. 1, born 1949)

Additionally, the majority of the interviewees expressed a sense of optimism and positivity regarding their future senior years. For instance, No. 14 and No. 15 aspire to enrich their daily lives through extensive participation in community activities. Their future plans prioritize physical health, with even exercise becoming a form of social participation and socialization.

> "I do exercise every day now, and I am healthier than before. I come to this little forest square here in Shandong University to do exercise every morning." (No. 15, born 1940)

> "I put the papers with words on trees and sang these songs together with other old people." (No. 14, born 1938)

Nevertheless, some respondents, having endured a challenging early life, expressed discomfort with the prospect of a comfortable retirement. They were not accustomed to the sudden ease and leisure that came with retirement. Many respondents also expressed a desire to continue working in order to utilize their spare time effectively and maximize their value in their later years, thereby enriching their lives.

> "I felt I was not old enough and want to do something then. Later I continually run a small dining table program which serves food for students who do not go back home to have lunch or dinner for about 6-7 years." (No. 13, born 1951)

> "I felt a sense of loss sometimes after I retired, I felt I wasn't done, I was only 55 then." (No. 15, born 1940)

4.3 Perceptions of society: social changes and values from the perspective of older people

In discussing their perceptions of contemporary society, the older adults (e.g., Nos. 4, 5, 7, 9, 10, 11, 13, and 16) employed similar evaluative criteria, and their perceptions of contemporary society encompassed both positive and negative aspects, as well as concerns related to social issues and social change.

4.3.1 Contentment and gratitude

The older adults, having experienced economic development and social progress, are now able to enjoy a contented and happy life. No.

1 said: *"I had never dreamed this kind of life before. I believed that life would be better and better because of social policies we have."* This older woman, born in 1949, experienced GF and CR despite the war having ended before her birth. During the period of poverty, hunger, and chaos that followed, she contemplated that life would never improve. Consequently, she is profoundly grateful for the present life and its opportunities.

4.3.1.1 Social participation, social security, and services

From their narratives, it becomes evident that the state and society have provided them with the requisite social security and services, including financial support and medical care in their later years, as well as community cultural construction and the improvement of public infrastructure in their daily lives. In their past life of suffering, they seldom envisioned happiness after difficulties, and now these guarantees and services have become a consistent and important criterion for them to evaluate today's society.

> *"Every aspects of my life were quite good, you see, my pension rise a lot recently, my life was quite good…, I realized what I wanted. I never dreamed I could have today's good life. How dared I dream for this kind life before; I had never dreamed this kind of life before. I believed that life will be better and better because of social policies we have."(No. 1, born 1949)*

> *"I am very satisfied with my life now. The state gives me life subsidy every month, and I live here where I can get care needed; I can get reimbursement when I go to see doctor and pay medical fee." (No. 10, born 1946)*

The views of individuals on societal issues are shaped by their past and present life experiences. Those who have experienced poverty, hunger, and war often express concern about the economy and the challenges of securing their livelihoods in retirement. As age, older adults tend to prioritize the protection that society can provide, particularly in light of the decline in their physical abilities. The provision of pensions, especially medical insurance, and the steady rise in the level of protection have undoubtedly increased the satisfaction of the older adults with today's society and the degree of happiness in their old age.

> *"The state gives me 4000 yuan per month as pension. I told my wife that 'socialist system is really good'. People are easier to be sick and should pay more medical fee when they are old, but we were covered by social medical insurance."(No. 9, born 1937)*

> *"I am satisfied about my whole life with nothing to be regretted…I was covered by social security system after I retired, such as social medical insurance." (No. 7, born 1949)*

Despite having withdrawn from the workforce, our interviewees continue to engage in social activities (e.g., Nos. 2, 3, 4, 7, 10, 14, 15, and 16). They enrich and integrate their later life through exercise, recreation, and study. The cultural development of the community and the development of public service facilities have provided them with more opportunities to continue to build their social networks, which helps to achieve a balance between a sense of despair and a sense of

integration. This, in turn, has enhanced their satisfaction with today's society.

> *"Community culture activities are very good. I attend all kind if activities, such as rope skipping, shuttlecock kicking etc. I am not a person who is willing to stay at home lonely." (No. 7, born 1949)*

> *"The community organizes activities including teaching people to use computer and knowledge about nutrition." (No. 13, born1951)*

The narratives of our interviewees reveal a pervasive sentiment of satisfaction and contentment. These individuals have endured a multitude of challenges in the past, yet they have persevered and dedicated themselves to their country, society, and families amidst their struggles. In the present, they have benefited from a range of protections and services, which have enabled them to integrate their past experiences with their current circumstances. As a result, they feel a sense of fulfillment and joy.

4.3.2 Joy and worry

Our interviewees have witnessed the development and changes of the times in their life course, and they tend to evaluate our society from the perspective of development and put forward their views with historical significance. As witnesses of wars and famines, they are happy about the prosperity of our society, but the changing society also raises some questions and concerns.

4.3.2.1 Development, changes, and problems

In their narratives, we can discern the evolution and transformation of the country and society, which have become more prosperous and affluent. These changes have also bolstered the interviewees' confidence and positivity. One individual stated, *"In my opinion, our society developed better and better. Now we are not afraid of being invaded by foreign countries because China has become strong. We will not be afraid anymore when we become strong."* This old woman, born in 1938 (No. 16), experienced AJW and CW in her childhood, GF and CR in her youth. She now perceives China's increasing strength and feels relieved and joyful because we no longer have to fear other countries.

From a social development perspective, our interviewees observed positive changes in society. Poverty, hunger, and chaos gradually disappeared, replaced by affluence and harmony. A version that directly reflects development is as follows:

> *"After the founding of the People's Republic of China, people became richer gradually, but it was not possible to become richer very quickly…" (No. 11, born 1940)*

Development also came with problems. The country and society were no longer poor, and the economic boom bred problems of corruption. For interviewees who have experienced poverty and hunger, the embezzlement of people's money is the last thing they want to see. A significant proportion of our interviewees expressed strong criticism and blame for corruption.

> *"The corruption of government officials couldn't be solved till now." (No. 3, born 1948)*

"Though it is better than before, but the gap is still very big. Corruption is also very serious." (No. 4, born 1941)

"Our country now, corruption can't be managed." (No. 11, born 1940)

The existence of hunger, poverty, and war in the past does not negate the existence of positive aspects of the past. Older adults did not lose their zest for life due to poverty and hunger; rather, they demonstrated resilience and solidarity in overcoming these challenges. *"My class director of primary school who treated me as same as my mother did. At that time, people treated each other with affection, not like today, affectional relation between people is quite weak, most relationships were built on money."* This woman born in 1949 (No. 7) shows us a story full of human feelings and emotions.

Today, people no longer trust each other so much as before. Social development has brought about affluence, but it has also taken away the emotion of "mutual help." *"Trust between people generally lowers, cohesion of society is not high, and there are also a lot of social problems. Such as food safety, in the past, fruits and vegetables can be eaten directly, which causes no problems, but it is not OK now (No. 4, born 1941)."* Contaminated food is served on people's tables, and the problem of food safety is a typical manifestation of a crisis of confidence in society. This interviewee directly pointed out the correlation between the two.

Other interviewees were also concerned about food safety. *"Our country is seriously polluted now, there are no vegetable unpolluted, vegetables and food supplies are all polluted (No. 11, born 1940)".*

Our interviewees were able to integrate the past and the present and to evaluate today's society from a holistic perspective. A common theme among the interviewees was the joy of social development, accompanied by concerns about the potential consequences of this progress. The changes that have occurred in society, as well as the contrasts between the past and the present, have become an important criterion for their evaluation of society.

4.4 Expectations for youth: encouragement and inheritance for the next generation

Regarding the current young generation, our interviewees expressed uniformly positive expectations for them. The older adults focused their attention on the growth and success of the youth group, and were able to identify and assess the encounters and opportunities in the context of the new era in which the young generation is living. In reflecting on their own lives, the elders integrated their experiences and lessons, condensed their life wisdom, and hoped that the young generation would learn and pass on their wisdom, and continue to maintain their good style of hard work and endeavor.

4.4.1 Youth in our time

Our interviewees look at the young generation from the perspective of the development of the era. Nowadays, the family and society can offer the younger generation more favorable conditions for living, education, and employment, which in turn allows them to achieve remarkable things. The opportunities of the times are as valuable as a vibrant youth, and the elders expressed their earnest expectations and encouragement.

4.4.1.1 Hope, opportunities, and challenges

Many of our interviewees thought that they now lived in a prosperous, strong, open, and inclusive society that offers better conditions and opportunities for young people than the previous generation. This can be exemplified by the following direct version: *"You did not experience the hardship. You are so fortunate and blessed to be able to catch up with this era,"* stated an old woman born in 1938 (No. 12), whose father left home to join the army when she was born, and who was only able to graduate from junior high school before joining the workforce. This experience led her to believe that young people nowadays are catching up with a good era, as exemplified by the following: *"You are catching up with a good era now, how could girls be allowed to go to graduate school? (No. 12, born 1938)"*

The expectations of young people are related to their experiences and events of their own youth. Similar to the woman previously mentioned (No. 12), many of the interviewees expressed views based on inter-generational comparisons. They noted that in times past, people lacked access to basic necessities such as money, food, and education, as well as the right to choose their own work. *"Your young generation is insatiate; your life is much better than mine when I was a child. When I was as young as you are now, it was very difficult for me to have money to spend. There was little money or no money, no good food to be eaten (No. 1, born 1949)".*

One of the older adults talked about the lack of autonomy in their lives, the inability to pursue their passions, and the lack of flexibility in their lifestyle. After graduating from university, he had to obey the assignment and was not free to choose his work and life. *"I was subject to appointment of government office when I finished my university education, I went to where I was asked to go and did what I was asked to do." (No. 8, born 1938).* No. 8 posits that a greater number of free and selective young people should be able to identify their passions and pursue them with dedication, recognizing the value of the opportunities available to them and avoiding the waste of time. He asserts, *"You will not succeed if you do not work hard and find your way to make a living…"* This older adult's account is a common narrative of the era (e.g., Nos. 4 and 16).

In addition to the comparison between the present and the past made from the perspective of the times, our interviewees also focused their attention on the youth group itself. The period of youth is precious, and people in their youthful years have vigorous physical strength and plenty of time. *"You have enough of time, how lucky you are still very young" (No. 2, born 1939).* Interviewees in their later years placed their hopes for building the country on the younger generation, one subject stated, *"I envy that you are so young. The future of our country is relying on your generation" (No. 10, born 1946).*

The contemporary era is the achievement of the collective efforts of the Chinese people, and the pursuit of a fulfilling life is a testament to their resilience. In this era of abundant opportunities and aspirations, the younger generation must appreciate the significance of this era and seize the opportunity to contribute to the advancement of the nation and society.

"I have a request towards young people like you that you should know it is not easy to achieve today's good life, don't just intent to covet personal wealth; you should try your best to contribute more to the country." (No. 11, born 1940)

4.4.2 Inheritance of wisdom

In considering the expectations for young people, our interviewees look back on their own lives and integrate past experiences, extracting from them the positive qualities that they or their contemporaries possess, and condensing the wisdom of their own lives. This wisdom is derived from the lessons of past lives, sublimated in suffering, and integrated into old age. They hope that the young generation can learn from their excellent character and style, and then pass on the wisdom of life. In addition, the interviewees identified the current challenges facing young people.

4.4.2.1 Problems, expectations, and encouragement

Some of the interviewees discussed the perceived characteristics of the youth in their eyes. They identified several challenges facing young people, including a lack of resilience, an inability to withstand adversity, and a tendency to prioritize enjoyment over perseverance. One interviewee noted, *"The main problem is today's young people are not surefooted. Another one is hedonism, today's young people are unwilling to endure hardship." (No. 8, born 1938)* This old man who experienced CW, GF, and CR, criticized his daughter for her hedonistic tendencies. He advocated that the spirit of hard work should be cultivated in young people, and believe that only through hard work can they ultimately achieve happiness.

Our interviewees had all experienced a life of hunger and poverty, and a lack of food and clothing were common memories. The poverty of their early lives prompted them to adopt frugal and thrifty living habits. Conversely, young people who have not experienced a period of material deprivation may lack a sense of thrift, which our interviewees expressed concern about.

> *"I felt pity that many young people threw away boxes of apples and some other things which were still useful. I felt that other sides of today's young people were OK, but they wasted too much." (No. 5, born 1941)*

> *"I hope that young generation would keep being frugal and hardworking." (No. 14, born 1938)*

One of the older adults observed that younger individuals exhibited several deficiencies, including a lack of exercise, impatience, a tendency towards emotional volatility, a lack of patience, a lack of vocational skills, and a general lack of basic life skills. *"I feel that today's young people are relatively lazy. Another point is that today's young people are not surefooted, and are relatively impetuous. Still, another issue is that many young people just rely on their parents to make a living, do not try to find a job and make a living all by themselves." (No. 4, born 1941)* In response to these deficiencies, the man advocates for young people to reflect on their circumstances and implement necessary changes, such as regular exercise, positive mental attitude, and spiritual growth. *"In my opinion, no matter how good today's life condition is, young people should have some life skills… There are many issues that young people should think through, they should learn to reflect themselves".*

From the narratives, it is evident that the expectations of older adults towards the younger generation are numerous. These include the importance of cherishing time, continuous self-improvement, striving for advancement, and making a meaningful contribution to the country and society. A straightforward version is: *"You should study hard to requite your parents and society"* (No. 12, born 1938).

From the narratives, it is evident that the conventional wisdom among older adults is that young people should prioritize the value of their time, pursue continuous self-improvement and contribute to their communities. One illustrative example is the following assertion: *"You should study hard to repay your parents and society for their investment in you" (No. 12, born 1938).*

A veteran (No. 10), born in 1946, who was wounded in the army and served as a village branch secretary for more than 10 years after he returned to his hometown after being discharged from the army, recounted his story by mentioning that: *"I felt a responsibility to be the oldest brother and to take good care of my younger siblings."* As the eldest of his siblings, he felt a sense of responsibility and obligation. When discussing the encouragement and expectations he had for the younger generation, he highlighted that many young people who are only children lack exercise and have not experienced much hardship. *"However, the majority of you are the only child of your parents and have not experienced hardship, lack of discipline, or been spoiled by your parents. Consequently, you must develop good discipline. If you work hard and study hard, you will undoubtedly be promising in the future".*

In discussing life lessons, an old woman born in 1939 (No. 2) posits that life is about experiencing suffering initially, followed by a period of sweetness. *"I realize that people are blessed later after they suffered in early time."* She witnessed the loss of her loved ones and faced discrimination. Nevertheless, she maintains that life is about experiencing hardship initially and then being blessed later. *"I also asked my son this way, which was to study hard and get a high education, we have nothing to rely on, what we only own is our knowledge and skill."* She urged her son to study hard and utilize her knowledge and skill. This is an illustrative example of an older individual imparting life wisdom to the younger generation.

4.5 Summary of key themes

In summary, the findings reveal that a dynamic interplay of individual experiences, societal transformations, and future-oriented expectations shapes the life wisdom and happiness of Chinese older adults. Personal well-being is grounded in the pursuit of education, family bonds, and active social participation. Their perceptions of society demonstrate a balance between contentment and critical reflection. Furthermore, their aspirations for the next generation emphasize resilience and the transmission of accumulated wisdom. These dimensions collectively illustrate a nuanced portrait of aging in contemporary China, as summarized in Table 2.

5 Conclusion and discussion

Based on the interview data, the study revealed that the themes of happiness and life wisdom among Chinese older adult are mainly centered on several aspects: First, they place a strong emphasis on education, maintain close relationships with their families, and actively engage in social activities, reflecting a close connection between personal well-being and interpersonal involvement. Second, they express satisfaction and gratitude for social welfare, while simultaneously experiencing both joy and concern regarding social

development, illustrating their internalization and critical reflection on societal values. Finally, they hold high expectations for the younger generation, encouraging them and passing on their wisdom, thereby demonstrating their acceptance and recognition of their entire life experiences and deep emotional attachment to the youth.

The narratives of the interviewed older adults indicate that in contrast to the turbulence of their early lives (34), structure, continuity, and predictability are the dominant tones of their midlife and current lifestyles. Furthermore, the future trajectory of their lives remains within a predictable range. In Western countries, the oscillation between integration and despair in old age is often viewed as a process of harmonizing the life cycle. Consequently, the concept of VINDOA emerges as a crucial area for further investigation, particularly regarding how older adults perceive the individual, society, and the future, as well as how they narrate their experiences.

A significant finding is that the way older people view life has a profound impact on their personal experience and well-being in the present moment. This philosophy of life fosters self-compassion in old age and overcome the negativity that comes from their past and present life. According to Erikson et al. (64), the fundamental conflict in this stage arises from the tension between integration and despair. In this stage, older adults make every effort to integrate the various psychosocial themes of their lives, striving to achieve balance, while simultaneously facing the challenges brought by the proximity of death and the decline of physical functions. On the one hand, individuals strive to perpetuate their current state of happiness and thus achieve the integrity of their life course (62, 66). Conversely, as life draws to a close and physical functioning declines, feelings of exhaustion and inferiority emerge, creating a sense of being unable to keep up with the times. Additionally, fear and helplessness are negative emotions that older adults must overcome (67, 68). In many narratives, older adults prioritize their health, return to their families, establish new social networks, and embrace a slower, steadier pace of life. For some, such as No. 12 and No. 8, there is a discrepancy in their perceptions of their children, students, and other descendants, which in turn leads to the decision to be alone or to enter a relatively isolated life. These two opposing tensions became an important aspect of our respondents' current life stage, finding a balance between a sense of persistent integration and a sense of fearful helplessness and despair. This process of integration can be regarded as an embodiment of wisdom, which emerges as individuals reconcile life experiences and achieve inner harmony, even in the face of inevitable decline (Erikson, 1963) (69, 70). At this stage, wisdom is not merely a matter of knowledge or cognitive

ability, but more fundamentally involves emotional resilience and the capacity to adapt to the final phase of life. It enables individuals to find meaning in the aging process itself and to maintain the vital involvement in the necessary disinvolvements of old age.

Consciously and unconsciously, these older adults are also attempting to reconcile earlier psycho-social themes, including the dichotomy between reproduction and stagnation (71, 72), intimacy and loneliness (73, 74), and the tension of self-sameness and identity disorganization (34, 75), along with other earlier psychosocial themes, is reconciled through their integration with the current stage of old age. Having been verbally abused and beaten during the Cultural Revolution, No. 2 now confesses that he does not discriminate against those who hurt him. This is a philosophy of life that transforms the negative effects of a bitter experience into a motivation to live a positive life. It can be postulated that our interviewees did their utmost to integrate each psycho-social theme, including the memory of the structural breakdown brought about by the ephemeral breakdown, in an attempt to achieve a balance that would make the whole life cycle integrated.

Another finding was that to be able to make connections between the suffering past and the happy present, the groups studied had to be categorized within a more refined social stratification. Social stratification may play a crucial role in the dissolution of the negative impact of early life ephemeral breakdown on an individual's happiness in later life. Older individuals from different social strata exhibit disparate comprehension of historical events, which is closely linked to their urban–rural backgrounds (76, 77), educational attainment (78, 79) and type of occupation (80, 81). Individuals in higher social classes tend to report a higher current quality of life. However, this does not imply that they did not necessarily avoid adverse experiences, such as war and famine, earlier in their lives.

No. 2 and No. 8 are both retired university professors. In No. 2's account, she spent her childhood on the run and barely attended elementary school. No. 8 lost his mother in childhood and his family gave his biological sister away because they were poor. The upheavals experienced in childhood and youth serve as the impetus for class leaps and the current high quality of life, which is markedly different from the mainstream Western discussion of the development of the stages of the life course (82–84). The impact of education is evident in many of the stories. No. 7's middle school studies were disrupted during CR, and she began working after her father's death. After completing high school and college while working, her living conditions improved significantly. The early years of life also brought more than just painful memories; in the contrast between the past and the present, the informant expresses a fondness for the closer relationships and good social mores of the past.

Prolonged homebound status among retired older adults, coupled with a reduction in socialization and access to technological products, can result in feelings of disconnection or separation from their surroundings and activities in their social, family, and personal lives (85, 86). In contrast to the "despair of abandonment," most of the older interviewed demonstrated contentment and optimism in their current lives. Rather than diminishing their passion for life, many became more proactive in forging connections with the community. This is a more desirable state of life in old age, as described by Erikson et al. (64). The motto of No. 3 is "A contented mind is perpetual feast," and he often discusses with his children the lack of food in the past, which emphasizes the happiness of his current life. In old age, a sense of

TABLE 2 Themes of life wisdom and happiness.

Topic	Dimensions	Themes
Life wisdom and happiness	Individuals	1. Education: valuing education
		2. The inter-connectivity between family members
		3. Active social participation
	Society	1. Contentment and gratitude to society
		2. Joy and worry: caring about society
	Future	1. Youth in our Time: caring about the next generation
		2. Inheritance of Wisdom

integration becomes the dominant harmonious tendency, balanced with a pervasive sense of despair. This culminates in a particular form of life wisdom. This life wisdom is rooted in mature hope, will, purpose, loyalty, love, and caring. Although physical and mental functions are declining, life wisdom dissolves despair more skillfully and integrates and transmits it to the next generation.

These narratives prompt us to consider the influence of social development on the lives of older individuals. China's GDP has grown exponentially since the ROC, with a value that has exceeded 300 times its original value (87). Furthermore, as survivors of disasters such as wars and famines, interviewees expressed greater satisfaction with their current standard of living. The advancement of social development has had a positive impact on the well-being of older adults and has facilitated the realization of VINDOA and the harmonization of the life course. At the same time, as a society with a high degree of aging, the level of social participation of older people exerts a further influence on the direction of social development. If we shift our focus to what is occurring concurrently with universal modernization, we find that the value of suffering changes over time. No. 8 explicitly states that his children are not willing to suffer and tend to be hedonistic, suggesting that education on suffering history is still necessary for young people. The experience of suffering in early life is distilled into a significant component of the wisdom of old age. This wisdom not only has a positive impact on the well-being of the older adults but also continues to be transmitted to the next generation through verbal and nonverbal communication, thereby exerting a cultural influence.

6 Significance and need for further research

6.1 Significance

The study has a certain degree of significance. In terms of theoretical research, we present the life stories of Chinese older adults based on qualitative interview data, which enriches the life course theory and related research on happiness in old age. In terms of practical application, through the presentation of the tension between integration and despair, it provides a Chinese case study for understanding VINDOA and provides a reference for the study of the life course of groups experiencing continuous social change, development and transformation. Furthermore, the study advances our understanding of individual agency and demonstrates that resilience and wisdom in life can mitigate the negative impact of suffering. This, in turn, offers insights that can inform the development of gerontological social work.

6.2 Need for further research

The current study demonstrates the current stage of the Chinese older adults' lifestyles and levels of well-being, which are embedded in older adults' life wisdom and happiness. We have researched the life wisdom of the Chinese older adults, and further research is necessary to investigate how the understanding of life philosophy and well-being of older Chinese and Westerners is similar and different.

Our material illustrates the integration and fulfillment of the Chinese older adults' life stories, but in fact, the disruption and

fragmentation are also of interest. Whether older adults can self-heal from the "despair" in their lives by reviewing their life histories and telling their life stories offers the potential for new longitudinal research using narrative therapy and other methods.

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 Ethics Committee of Shandong 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

S-LC: Conceptualization, Investigation, Software, Writing – review & editing. XZ: Data curation, Methodology, Supervision, Writing – review & editing. SL: Methodology, Writing – original draft, Writing – review & editing. CZ: Formal analysis, Project administration, Validation, Writing – original draft. SB: Funding acquisition, Resources, Visualization, Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research 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.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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. Elder GH. Time, human agency, and social change: perspectives on the life course. *Soc Psychol Q.* (1994) 57:4–15. doi: 10.2307/2786971

2. Elder GH. The life course as developmental theory. *Child Dev.* (1998) 69:1–12. doi: 10.1111/j.1467-8624.1998.tb06128.x

3. Elder GHSocial Science Research Council (U.S.). Life course dynamics: Trajectories and transitions, 1968–1980: PBK. PBK Ithaca, NY: Cornell University Press (1985).

4. Elder GH, Shanahan MJ, Clipp EC. When war comes to men's lives: life-course patterns in family, work, and health. *Psychol Aging.* (1994) 9:5–16. doi: 10.1037/0882-7974.9.1.5

5. Erikson EH. Reflections on the last stage-and the first. *Psychoanal Study Child.* (1984) 39:155–65. doi: 10.1080/00797308.1984.11823424

6. Erikson EH, Homburger E. The life cycle completed: A review. New York: Norton (1982).

7. Haiqun N, Xue D, Benyu G. Development and innovation of life cycle theory. *J. Nanjing Xiaozhuang Univ.* (2023) 1:90–5.

8. Bugajska BE. The ninth stage in the cycle of life – reflections on E. *Herikson's Theory Ageing Soc.* (2017) 37:1095–110. doi: 10.1017/S0144686X16000301

9. Erikson EH, Erikson JM, Kivnick HQ. Vital involvement in old age. The experience of old age in our time. New York: W. W. Norton & Company (1986).

10. Stowe JD, Cooney TM. Examining Rowe and kahn's concept of successful aging: importance of taking a life course perspective. *The Gerontologist.* (2015) 55:43–50. doi: 10.1093/geront/gnu055

11. Mathur A. George P. Moschis tribute special issue: his philosophy and contributions – part I. *J Glob Scholars Market Sci.* (2019) 29:359–71. doi: 10.1080/21639159.2019.1613914

12. Mathur A. George P. Moschis tribute special issue: his philosophy and contributions (part II). *J Glob Scholars Market Sci.* (2020) 30:1–3. doi: 10.1080/21639159.2020.1686863

13. Moschis GP. Consumer behavior over the life course: Research frontiers and new directions (1st ed.). Cham, Switzerland: Springer International Publishing AG (2019).

14. Mayer KU, Tuma NB. (Eds.). Life course research and event history analysis: An overview In: Event history analysis in life course research. Madison, Wis.: University of Wisconsin Press (1990). 3–20. Available at: https://hdl.handle.net/21.11116/0000-0002-088F-5

15. Moschis GP. Life course perspectives on consumer behavior. *J Acad Mark Sci.* (2007) 35:295–307. doi: 10.1007/s11747-007-0027-3

16. Prakitsuwan P, Moschis GP. Well-being in later life: a life course perspective. *J Serv Mark.* (2021) 35:131–43. doi: 10.1108/JSM-08-2019-0316

17. Chen Y, Sun YJ. Active aging: concept, limitation and expansion. *J Hangzhou Normal Univ.* (2024) 1:113–26. doi: 10.19925/j.cnki.issn.1674-2338.2024.01.012

18. Ding YY. Research on education policy for the elderly in China under the background of active aging. Nanchang, China: Nanchang University (2023).

19. Wu CP, Peng QY. Reinterpreting the scientific meaning of "active aging". *China Soc Work.* (2018) 17:28–9.

20. Chen Y, Zhang YQ. Survey on the measurement of well-being of the elderly in China. *J Econ Res.* (2020) 13:40–3.

21. Xing ZJ. The application of subjective well-being scale of Chinese urban residents in the elderly group. *Chin J Gerontol.* (2003) 10:648–51.

22. Huang DR, Wang J, Fang HL, Qu G, Liu JY, Han JM. Research hotspot and evolution trend of subjective well-being of the elderly at home and abroad from 2003 to 2022. *J Nurs.* (2023) 22:1–6. doi: 10.16460/j.ssn1008-9969.2023.22.001

23. Yang JH, Zhao XY. Subjective well-being of the elderly under different old-age care methods in rural areas of Sichuan Province. *Chin J Gerontol.* (2018) 8:2003–4.

24. Dan T, Jun Z, Jiliang S, Zhang L. Influencing factors of elderly people's subjective well-being. *Chin J Mental Health.* (2006) 3:160–2.

25. Xu JM. Research on subjective well-being of the elderly and its influencing factors. *Chin J Gerontol.* (2009) 24:3241–3.

26. Tao Y. Home as home: a theoretical illustration of family resilience in China. *New Horiz.* (2023) 4:80–8.

27. Da HM. 10 years of research on subjective well-being of Chinese older adults: review and outlook. *Chin J Gerontol.* (2019) 9:2288–94.

28. Bai L. Research on the subjective well-being of the elderly after retirement and its influencing factors. Tianjin, China: Tianjin Normal University (2014).

29. Tao Y, Chu MY. Life course theory: the glimmer of thought in perspective of social change and institutional change. *Reg Govern.* (2019) 40:65–7.

30. Elder G. H. (2018). Children of the great depression. Routledge, 426–432.

31. Ferguson HJ, Brunsdon VE, Bradford EE. The developmental trajectories of executive function from adolescence to old age. *Sci Rep.* (2021) 11:1382. doi: 10.1038/s41598-020-80866-1

32. Riediger M, Voelkle MC, Schaefer S, Lindenberger U. Charting the life course: age differences and validity of beliefs about lifespan development. *Psychol Aging.* (2014) 29:503–20. doi: 10.1037/a0036228

33. Brown JS, Lynch SM. A demographer's view: population structures tell a story about lifecourses. *Popul Ageing Lifec Persp.* (2015) 334:13–27. doi: 10.2307/j.ctt1t89106.7

34. Cheng SL, Johansson S, Liu S, Li Y. Western life courses challenged in life stories collected in contemporary China. *Front Public Health.* (2023) 11:1282704. doi: 10.3389/fpubh.2023.1282704

35. Gunnarsson E. 'I think I have had a good life': the everyday lives of older women and men from a lifecourse perspective. *Ageing Soc.* (2009) 29:33–48. doi: 10.1017/S0144686X08007642

36. Lennartsson C, Eyjólfsdóttir HS, Celeste RK, Fritzell J. Social class and infirmity. The role of social class over the life-course. *SSM-Popul Health.* (2018) 4:169–77. doi: 10.1016/j.ssmph.2017.12.001

37. Smith B, Parsons M, Hand J. War leaves an enduring legacy in combatants' lives. *J Gerontol Soc Work.* (2014) 57:790–809. doi: 10.1080/01634372.2014.898006

38. Spiro A III, Settersten RA, Aldwin CM. Long-term outcomes of military service in aging and the life course: a positive re-envisioning. *The Gerontologist.* (2016) 56:5–13. doi: 10.1093/geront/gnv093

39. Ardelt M, Landes SD, Vaillant GE. The long-term effects of world war II combat exposure on later life well-being moderated by generativity. *Res Hum Dev.* (2010) 7:202–20. doi: 10.1080/15427609.2010.504505

40. Rzeszutek M, Lis-Turlejska M, Pięta M, Karlsen M, Backus H, Florek W, et al. Knowledge about traumatic world war II experiences among ancestors and subjective well-being of young adults: a person-centred perspective. *PLoS one.* (2020) 15:e0237859. doi: 10.1371/journal.pone.0237859

41. Tran US, Glück TM, Lueger-Schuster B. Influence of personal and environmental factors on mental health in a sample of austrian survivors of world war II with regard to PTSD: is it resilience? *BMC Psychiatry.* (2013) 13:47–7. doi: 10.1186/1471-244X-13-47

42. Lis-Turlejska M, Plichta A, Luszczynska A, Benight CC. Jewish and non-Jewish world war II child and adolescent survivors at 60 years after war: effects of parental loss and age at exposure on Weil-being. *Am J Orthopsychiatry.* (2008) 78:369–77. doi: 10.1037/a0014166

43. Hernandez DJ, Napierala JS. Disparities in US parental employment insecurity and child well-being across income groups: before, during, and after the great recession. *Child Indic Res.* (2020) 13:741–75. doi: 10.1007/s12187-019-09713-8

44. Clair CC. The scene of eviction: reification and resistance in depression-era narratives of dispossession. *Am Lit.* (2022) 94:497–525. doi: 10.1215/00029831-10084526

45. Ardelt M. Social crisis and individual growth: the long-term effects of the great depression. *J Aging Stud.* (1998) 12:291–314. doi: 10.1016/S0890-4065(98)90005-6

46. Tapia Granados JA, Diez Roux AV. Life and death during the great depression. *Proc Natl Acad Sci.* (2009) 106:17290–5. doi: 10.1073/pnas.0904491106

47. Poortman AR, Van Tilburg TG. Past experiences and older adults' attitudes: a lifecourse perspective. *Ageing Soc.* (2005) 25:19–39. doi: 10.1017/S0144686X04002557

48. Ramirez D, Haas SA. The long arm of conflict: how timing shapes the impact of childhood exposure to war. *Demography.* (2021) 58:951–74. doi: 10.1215/00703370-9114715

49. Settersten RA Jr, Dannefer D, Elder GH Jr, Mortimer JT, Kelley JA. Studying social change in human lives: a conversation. *Longit Life Course Stud.* (2024) 15:5–18. doi: 10.1332/17579597Y2023D000000005

50. Kuh D, Hardy R, Rodgers B, Wadsworth ME. Lifetime risk factors for women's psychological distress in midlife. *Soc Sci Med.* (2002) 55:1957–73. doi: 10.1016/S0277-9536(01)00324-0

51. Moen P. The uneven stress of social change: disruptions, disparities, and mental health. *Society Mental Health.* (2022) 12:85–98. doi: 10.1177/21568693221100171

52. Jia J, Ke R, Lu WB, Huang LX. Adolescent stress as wealth or disaster--evidence from the "going to the mountains and going to the countryside" experience. *Southern Econ.* (2018) 8:128–48. doi: 10.19592/j.cnki.scje.351634

53. Li QN. Exploring the mentality of intellectual youth going to the mountains and going to the countryside. *Quest.* (2004) 1:236–8. doi: 10.16059/j.cnki.cn43-1008/c.2004.01.085

54. Wang HS, Liu YQ. Social memory and its construction: a study on the collective memory of intellectual youth. *Society.* (2006) 3:46–68+206. doi: 10.15992/j.cnki.31-1123/c.2006.03.003

55. Li YC, Ye MX. On the innovative use of "remembering the bitter and sweet" in college students' hardship education. *Educ Career.* (2011) 14:45–7. doi: 10.13615/j.cnki.1004-3985.2011.14.066

56. Kahn RL, Juster FT. Well–being: concepts and measures. *J Soc Issues.* (2002) 58:627–44. doi: 10.1111/1540-4560.00281

57. Jiao KS, Bao ZM. Social change, life course and health in old age. *Sociol Res.* (2020) 1:149–169+245. doi: 10.19934/j.cnki.shxyj.2020.01.007

58. Huang W, Zhou Y. Effects of education on cognition at older ages: evidence from China's great famine. *Soc Sci Med*. (2013) 98:54–62. doi: 10.1016/j.socscimed.2013.08.021

59. Liu Y, Diao L, Xu L. The impact of childhood experience of starvations on the health of older adults: evidence from China. *Int J Health Plann Manag*. (2021) 36:515–31. doi: 10.1002/hpm.3099

60. Ye X, Zhu D, He P. The long-term impact of adversity in adolescence on health in middle and older adulthood: a natural experiment from the Chinese send-down movement. *Am J Epidemiol*. (2021) 190:1306–15. doi: 10.1093/aje/kwab035

61. Peng SH. The impact of uphill and downhill experience on the income and well-being of intellectual youths. *Res Labor Econ*. (2016) 1:106–22.

62. Chen X, Wang J. Critical moments and time reconstruction in the life course based on elderly cancer patients and social work intervention. *Society*. (2021) 41:192–217. doi: 10.15992/j.cnki.31-1123/c.2021.02.008

63. Brückner H, Mayer KU. De-standardization of the life course: what it might mean? And if it means anything, whether it actually took place? *Adv Life Course Res*. (2005) 9:27–53. doi: 10.1016/S1040-2608(04)09002-1

64. Erikson EH, Erikson JM, Kivnick HQ. Vital involvement in old age. New York: WW Norton & Company (1994).

65. Xiang YH, Ding YY, Huang R. Life participation, healthy aging and well-being of the elderly. *Decision Inform*. (2024) 2:29–40.

66. Ardelt M, Gerlach KR, Vaillant GE. Early and midlife predictors of wisdom and subjective well-being in old age. *J. Gerontol. Series B*. (2018) 73:1514–25. doi: 10.1093/geronb/gby017

67. Depaola SJ, Neimeyer R, Ross SK. Death concern and attitudes toward the elderly in nursing home personnel as a function of training. *OMEGA-J Death Dying*. (1994) 29:231–48. doi: 10.2190/T0LY-W07Y-VVX0-NMAP

68. Kilic D, Aslan G, Ata G, Bakan ABS. Relationship between the fear of COVID-19 and social isolation and depression in elderly individuals. *Psychogeriatrics*. (2023) 23:222–9. doi: 10.1111/psyg.12924

69. Parisi JM, Rebok GW, Carlson MC, Fried LP, Seeman TE, Tan EJ, et al. Can the wisdom of aging be activated and make a difference societally? *Educ Gerontol*. (2009) 35:867–79. doi: 10.1080/03601270902782453

70. Zadworna M. Effects of wisdom on mental health in old age: exploring the pathways through developmental tasks attainment and self-rated health. *Psychol Res Behav Manag*. (2023) 16:4541–54. doi: 10.2147/PRBM.S429918

71. Gilleard C. More age, less growth? Secular stagnation and societal ageing. *Int J Sociol Soc Policy*. (2023) 43:1–16. doi: 10.1108/IJSSP-09-2021-0228

72. Nusser L, Zimprich D, Wolf T. Themes of trust, identity, intimacy, and generativity in important autobiographical memories: associations with life periods and life satisfaction. *J Pers*. (2023) 91:1110–22. doi: 10.1111/jopy.12786

73. Abu Khait A, Menger A, Rababa M, Moldovan T, Lazenby M, Shellman J. The mediating role of religion and loneliness on the association between reminiscence functions and depression: a call to advance older adults' mental health. *Psychogeriatrics*. (2024) 24:58–71. doi: 10.1111/psyg.13041

74. Mah K. Existential loneliness and the importance of addressing sexual health in people with advanced cancer in palliative care. *Psycho-Oncology*. (2019) 28:1354–6. doi: 10.1002/pon.5092

75. Cho Y-A. 노년의 정체성 정립을 위한 해석학적 모색: 리쾨르의 이야기 정체성을 중심으로. 현대유럽철학연구. (2017) 47:65–91.

76. Ide K, Tsuji T, Kanamori S, Jeong S, Nagamine Y, Kondo K. Social participation and functional decline: a comparative study of rural and urban older people, using Japan Gerontological evaluation study longitudinal data. *Int J Environ Res Public Health*. (2020) 17:617. doi: 10.3390/ijerph17020617

77. Ma L, Tang Z, Zhang L, Sun F, Li Y, Chan P. Prevalence of frailty and associated factors in the community-dwelling population of China. *J Am Geriatr Soc*. (2018) 66:559–64. doi: 10.1111/jgs.15214

78. Crystal S, Shea D, Krishnaswami S. Educational attainment, occupational history, and stratification: determinants of later-life economic outcomes. *J Gerontol*. (1992) 47:S213–21. doi: 10.1093/geronj/47.5.S213

79. Hoffmann R, Kröger H, Tarkiainen L, Martikainen P. Dimensions of social stratification and their relation to mortality: a comparison across gender and life course periods in Finland. *Soc Indic Res*. (2019) 145:349–65. doi: 10.1007/s11205-019-02078-z

80. Borrell C, Muntaner C, Benach J, Artazcoz L. Social class and self-reported health status among men and women: what is the role of work organisation, household material standards and household labour? *Soc Sci Med*. (2004) 58:1869–87. doi: 10.1016/S0277-9536(03)00408-8

81. Visser M, Gesthuizen M, Kraaykamp G, Wolbers MH. Inequality among older workers in the Netherlands: a life course and social stratification perspective on early retirement. *Eur Sociol Rev*. (2016) 32:370–82. doi: 10.1093/esr/jcw013

82. Johnson MK, Crosnoe R, Elder GH Jr. Insights on adolescence from a life course perspective. *J Res Adolesc*. (2011) 21:273–80. doi: 10.1111/j.1532-7795.2010.00728.x

83. Szydlik M. Generations: connections across the life course. *Adv Life Course Res*. (2012) 17:100–11. doi: 10.1016/j.alcr.2012.03.002

84. Wickrama KA, Lee TK, Wickrama T, Sutton TE. How do family adversity and youth stressful experiences lead to adult economic adversity? An integration of multiple life course mechanisms. *J Fam Stud*. (2024) 30:681–99. doi: 10.1080/13229400.2024.2315416

85. Bodner E. On the origins of ageism among older and younger adults. *Int Psychogeriatr*. (2009) 21:1003–14. doi: 10.1017/S104161020999055X

86. Warnes AM, Law CM. The elderly population of Great Britain: locational trends and policy implications. *Trans Inst Br Geogr*. (1984) 9:37–59. doi: 10.2307/621866

87. Liu C, Bai Y. Is China's labor income dominant—labor income share remeasurement and international comparison. *J Econ*. (2022) 7:31–50.
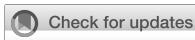
Emotional needs for smart products: a case study of older people living alone in Chengdu, China

Liu Yun[1,2]*, Rosalam Che Me[2,3]* and Irwan Syah Md Yusoff[4]

[1]Department of Product Design, Faculty of Fine Arts and Design, College of Chinese & ASEAN Arts, Chengdu University, Chengdu, China, [2]Department of Industrial Design, Faculty of Design and Architecture, University Putra Malaysia, Serdang, Selangor, Malaysia, [3]Malaysian Research Institute on Ageing (My Ageing), University Putra Malaysia, Serdang, Malaysia, [4]Department of Resource Management and Consumer Studies, Faculty of Human Ecology, University Putra Malaysia, Serdang, Selangor, Malaysia

Older people living alone (OPLA) face significant challenges in maintaining emotional well-being, especially in the context of rapid urbanization and social change. Smart products are increasingly viewed as promising tools to support healthy and independent aging. This study explores the emotional needs of urban OPLA in Chengdu, China, and examines their perceptions and use of smart products as emotional support tools. Using a qualitative approach, in-depth interviews were conducted with 20 OPLA aged 60 and above. Thematic analysis revealed three key themes: (A) Emotional well-being of OPLA due to living alone, (B) Efforts to satisfy emotional needs, and (C) The use of smart products to satisfy emotional needs. While many older adults adopt self-regulatory strategies and express interest in technology, low motivation and usability barriers hinder their engagement with smart products. This study highlights the need for emotionally responsive, user-friendly, and culturally attuned smart technologies. The findings offer theoretical and practical insights into promoting smart aging through inclusive design and inform policies aimed at improving emotional well-being among older adults living alone.

KEYWORDS

ageing, older people living alone (OPLA), emotional needs, smart product, thematic analysis

1 Introduction

According to the World Health Organisation (WHO), one-fifth of the global population will be over the age of 60 by 2050. (United Nations, 2020). As the world's second-largest economy with a population of 1.4 billion, there will be 400 million people over the age of 65 in China by 2050 (Fang et al., 2015). With the increasing prevalence of the aging population, as well as changes in social and family structures, an obvious trend of family miniaturization has emerged, with a significant increase in the number of older people living alone (OPLA) or empty nesters, amounting to 118 million in China in 2015 (Han et al., 2020). Studies have shown that OPLA patients are more likely to suffer from social isolation, loneliness, depressive symptoms, and suboptimal social support (Kawamoto et al., 2005). While living alone in China may be a response to improved housing quality and abundant alternative living arrangements, it is critical to examine how older Chinese people cope with their emotional needs in the face of such changes. As the physical and perceptual abilities of older people regress, their main needs shift from material needs centered on caregiving to spiritual needs centered on

socialization, respect, and self-actualization. Western scholars refer to these needs as the "3Ms," i.e., money, medical, and mental needs, which represent financial, medical, and spiritual needs (Mo, 2010). Therefore, as part of spiritual needs, emotional well-being is an integral part of older adults' well-being (Malatesta and Kalnok, 1984).

In literature, there is a rich body of knowledge on the daily life experiences of OPLA from other countries. The British Geriatrics Society (British Geriatrics Society (BGS), 2017) considers OPLA a vulnerable group, stating that OPLA requires health, housing, financial assistance, transportation, and social care to maintain a healthy lifestyle and enjoy it later. Similarly, a Korean study revealed that older adults living with relatives scored significantly higher on several physical and mental health indicators than did OPLA adults (You and Lee, 2006). In contrast, an Australian study reported the benefits of living alone, as the time provides an opportunity for self-reflection and spiritual activity (Stanley et al., 2010).

In qualitative research, reality is constructed within cultural, historical, and social contexts (Korstjens and Moser, 2017). Owing to the differences in cultural context and lower socioeconomic levels between China and the West, research should be conducted to explore the daily lives of OPLA in the Chinese context. Culturally, older Chinese adults are not expected to live alone, as the family remains the traditional provider of old-age care. In contrast to Western communities, solitary living arrangements are associated with more stigma (Jia et al., 2023) and greater levels of loneliness (Gu et al., 2019; Chou and Chi, 2000) in China. Therefore, older people living alone face greater challenges in maintaining their physical and mental health in China. Moreover, with the development of science and technology, smart products have shown some potential in meeting the physical and mental needs of the elderly population.

The advent of smart home technologies in recent years has offered a promising solution to help older adults stay at home and live independently while maintaining good quality of life at an affordable cost and with minimum human resource requirements (Curumsing et al., 2019). Smart products contain sensory and computing capabilities to conduct interactive activities with people at the physical level and emotional level (Luo et al., 2023). However, despite the growing literature on ageing and technology, few studies have combined interdisciplinary theoretical frameworks (e.g., social gerotechnology and affective design theory) to examine how OPLAs in urban China perceive and emotionally interact with smart products in their daily lives. Existing research has tended to focus on physical or safety needs, ignoring the emotional dimensions and cultural contexts that influence the adoption of technology in older populations, and emotional neglect in product design can lead to rejection or underutilization of technology. Therefore, this study provides design insights for emotionally intelligent and culturally resonant smart products by capturing the personal experiences of OPLA in a Chinese city, informing inclusive policies and service systems that truly meet the multifaceted needs of this vulnerable population. The findings can be used to make recommendations on promising practices and policies, such as improving the design of relevant smart products, measures, and services through theories such as user experience design or emotional design to meet the emotional needs of OPLA. Thus, two related research questions were posed: (1) What strategies did urban OPLA take to meet their emotional needs in their daily life experiences? (2) What was the attitude of urban OPLA toward using smart products to meet their emotional needs?

2 Materials and methods

2.1 Literature synthesis

In recent years, there has been a growing academic interest in the intersection between smart products and emotional wellbeing, particularly in an ageing society. Research has shown that smart technologies, from home assistants to interactive devices, contribute not only to the physical health of older people, but also to their psychological and emotional lives (Ghorayeb et al., 2021). Smart products equipped with sensing and computing capabilities enable two-way interactions that enhance the user's sense of companionship, control, and autonomy (Lucia-Palacios and Pérez-López, 2021). However, the affective efficacy of these technologies remains underexplored, especially for older adults living alone in non-Western cultural contexts.

OPLA face significant psychological needs related to social connectedness and emotional well-being (Hou and Zhang, 2023; Abell and Steptoe, 2021), which are exacerbated by technological and access barriers (Peek et al., 2014). Hong et al. (2022) highlights a global research trend, noting that assistive technology-equipped smart homes can help meet a variety of needs of older people, including emotional, social and physical fulfilment. Research suggests that emotional and physical usability are critical; older adults need environments that not only facilitate daily tasks but also evoke a sense of security and belonging (Lee and Kim, 2020). In addition, trust and acceptance are key barriers to the adoption of smart technologies by older adults. Lou and Hong (2023) found that perceptions of trust, ease of use, and affordability strongly influence technology acceptance. Expressed the same view, noting that older adults in China are ready to adopt smart care products but still face challenges related to emotional connection and perceived utility. For example, in less developed regions such as the west, efforts are needed to increase digital literacy and user engagement with smart care technologies, reflecting broader social support systems (Wang et al., 2024). Whilst digital technologies provide valuable tools to enhance social interactions, issues such as low digital literacy, lack of confidence in operating smart devices, and concerns about privacy or trust are still prominent. Overcoming these barriers requires multifaceted strategies that emphasize improving digital skills, improving access, and fostering positive attitudes toward technology adoption among this vulnerable group (Tsai et al., 2015; Raihan et al., 2024; Pérez-Escolar and Canet, 2023).

To better understand how design can address these issues, emotional design and emotional health frameworks are increasingly being adopted. Emotional design focuses on the creation of products and interfaces that promote positive emotional responses, while emotional health addresses an individual's overall emotional well-being and life satisfaction. Integrating these concepts can significantly improve the quality of life of older people through supportive technologies and interventions. Norman (2004) emphasizes that good design should appeal to the emotional and cognitive dimensions of the user, influencing usability and satisfaction. Peine et al. (2021) propose Socio-Gerontechnology to understand the interaction between older people and technology from a sociological and philosophical perspective of science and technology, emphasizing that technology and ageing are co-constructed. In addition, Morville (2005) UX Honeycomb framework provides a structured approach to

assessing how users interact with a product along seven dimensions: useful, usable, desirable, findable, accessible, trustworthy and valuable. These dimensions provide a holistic perspective for evaluating older users' experience of smart products, particularly in relation to their emotional resonance and perceived value. The implications of emotional design extend to interventions aimed at improving emotional well-being. For example, horticultural therapy and intergenerational approaches have shown promise for improving the emotional health of older adults (Han et al., 2018; Whear et al., 2023). By applying affective design principles to such interventions, it may be possible to foster closer emotional connections and avoid feelings of loneliness and depression, thereby promoting overall well-being. In summary, the intersection of emotional design and emotional well-being provides an opportunity to effectively support older adults living alone. By incorporating emotional design principles into technological solutions and emotional interventions, it may be possible to improve quality of life, encourage social interactions, and promote emotional resilience in this vulnerable population.

Despite the growing body of related literature, few studies have combined these theoretical frameworks with qualitative, in-depth research on how urban Chinese OPLAs perceive and emotionally interact with smart products in their daily lives. At the same time, the intersection of smart technologies with the emotional needs of older adults requires a nuanced approach that encompasses usability, emotional support, and community engagement. This study aspires to continue to bridge the gap in understanding these dynamics to better serve the aging population at home and abroad.

2.2 Study design

This study used qualitative research methods to conduct in-depth face-to-face interviews. This study was conducted in accordance with relevant ethical guidelines and regulations, including the Declaration of Helsinki and institutional ethical standards. Ethical approval for this study was obtained from the Ethics Committee for Research Involving Human Subjects University Putra Malaysia (Approval No.: JKEUPM-2024-673).

All participants provided informed consent before participation. They were informed of the research objectives, procedures, and their right to withdraw at any time without consequences. To ensure confidentiality, all identifying information was removed from the data, and anonymous codes were used during analysis.

2.2.1 Settings and participants

The study was conducted from June 2024 to July 2024 in Chengdu, an inland city in China. It is the core city of the Chengdu–Chongqing region's twin-city economic circle, with an urbanization rate of 74.4% (Chengdu Municipal Bureau of Statistics, 2020). The city of Chengdu was selected for three main reasons: (1) Chengdu is located in the heart of Southwest China (Figure 1). It is the capital of Sichuan Province and one of the largest cities in China (Wang, 2012), with a deep history and culture. (2) A high degree of globalization whereby 252 of the world's top 500 companies had established operations in Chengdu by the end of 2013. The rapid globalization process introduced Western culture and ideas to local people. (3) Aging phenomenon: According to the 6th census, the elderly population (over 65 years old) accounts for 9.7% of the total population (Banister et al., 2012), and the old-age dependency ratio (ODR) is reported to be 16.3. Thus, the elderly population in Chengdu is 2.1% greater than the national population (Banister et al., 2012). A high proportion of the OPLA stay in the city, some in a restricted living environment, hence likely giving rise to some problems.

Five main urban areas in Chengdu (Jinniu, Qingyang, Wuhou, Chenghua, and Jinjiang) with prominent aging populations were selected as the study area. These five areas were home to 992,815 elderly people aged 60 years and above, accounting for 26.4% of the overall population in Chengdu (Zhang et al., 2023). Participants were selected through purposive sampling (Lincoln and Guba, 1985) to recruit older adults living alone in urban communities. To ensure

FIGURE 1
Study site (redrawn and annotated by the authors).

diversity in experiences, a maximum variation sampling strategy (Patton, 1990) guided the inclusion of individuals across age, gender, socioeconomic status, and duration of solitary living (1–25 years). Collaboration with local stakeholders including social workstations, neighborhood committees, community health centers, and grassroots organizations facilitated participant identification. Screening was carried out by trained community workers recruited through short interviews during the organization of community events.

They were recruited while they were participating in community activities organized by the above organizations or as members of the case consultation.

The interviews were conducted in separate meeting rooms or in the homes of OPLA to ensure a quiet and private environment (Figure 2). The inclusion criteria included older adults who (1) were 60 years of age or older; (2) lived alone or, if they had children, were not in the same community as their children and received a low frequency of caregiving; (3) had basic mobility; and (4) had comprehension and were able to communicate and express themselves comfortably. The exclusion criteria for the subjects were as follows: (1) living alone but in the same community as their children, with a high frequency of care, and (2) having cognitive disabilities or being unable to communicate normally.

2.2.2 Instruments

The interview guide was developed based on a literature review (Minichiello et al., 2008) and refined by researchers and community workers. It contains three main sections: (1) Demographic and background information about the older person; (2) OPLA's daily life experiences and emotional needs; and (3) Perceptions and attitudes of OPLA toward using smart products to fulfill emotional needs. Please see Table 1 for a detailed interview outline. Each interview was recorded and transcribed verbatim. The interviews lasted between 45 and 60 min.

2.2.3 Data collection and analysis

In-depth interviews, a commonly used method in qualitative research, rely on the informative power of the interview process (Malterud et al., 2015). The sample population should be neither too small nor too large (Kvale, 1996; Sandelowski, 1995). Saturation is often mentioned as a criterion for sample size determination in qualitative research (Saunders et al., 2018). Saturation occurs when the researcher no longer receives information from the participants that adds to the theory that has been developed (Malterud et al., 2015). No new themes emerged after the 18th interviewee in the coding process, and two more were subsequently interviewed. The sample size for the qualitative interviews ($N = 20$) was determined based on the point at which thematic saturation was achieved (Guest et al., 2006). Specifically, thematic saturation was monitored through an iterative coding cycle in which two researchers independently coded transcripts after every five interviews and conducted intercoder comparisons. Saturation was considered to have been reached when new interviews yielded repeated codes and redundant themes across key emotional and behavioral dimensions (Saunders et al., 2018).

Prior to the interview, the researcher purposefully screened the OPLA sample by contacting community staff. The research team comprised three members: an inclusive design researcher (PhD candidate, female, 10 years of experience in inclusive design studies), a social work practitioner (MSW, male, 5 years of experience), and a student on industrial design (Master candidate, female). To minimize bias, all researchers documented their preconceptions about the topic in reflexive journals prior to data collection. Regular team discussions were held to critically examine how personal experiences might influence data interpretation. No conflicts of interest were identified. During the session, one researcher led the questioning, while the other two focused on notetaking and recording.

All participants provided written informed consent to participate in the study. Following informed consent, semi structured in-depth interviews were conducted. Examples of vivid and convincing excerpts were selected and analyzed. The transcripts were uploaded to ATLAS.ti (ATLAS.ti version 23, 2018) and analyzed because of "A Method for Identifying, Analyzing, and Reporting Patterns (Themes) in Data" (Braun and Clarke, 2006). There were several stages of data analysis (Figure 3): (a) Independent coding at a general level, such as applying user profiling to compress the data into analyzable units; (b) identification of major and minor themes discussed during the

FIGURE 2
Interview photos (partial).

TABLE 1 Interview outline.

Question category	Question content
Section1. Demographic and background information	Name, gender, age group, marital status, education level, occupation, living arrangements, Residential Stability, Social Interaction with Family, Caregiving and Support System.
Section 2. Daily life experiences and emotional needs	Can you describe a typical day in your life? What kind of activities do you usually participate in during the day or week? Do you attend any community activities or social events? If so, how often and what kind? Do you often feel lonely or emotionally distressed? When do these feelings occur most frequently? What strategies or habits help you feel emotionally better or more connected? Do you have any hobbies or personal routines that bring you joy or comfort? What kinds of emotional support (if any) do you wish you had more of?
Section 3. Attitudes toward using smart products for emotional support	Are you familiar with or have you used any smart products at home? Can you describe your experience using these products? What do you like or dislike about them? Do you use any technology to communicate with your family or friends? Do you think smart products can help meet your emotional needs? Why or why not? What challenges do you face when using smart products? What kind of smart product features would make you feel more emotionally supported or accompanied? If you could design your own smart product to support your emotional well-being, what would it look like or do?
Section 4. Closing questions	Is there anything else you would like to share about your daily life or how technology could help improve your emotional well-being? Would you be willing to participate in future follow-up interviews or product design workshops?

interviews; (c) analysis that involved grouping the thematic data through the creation of conceptual categories; (d) cross-sectional analysis that tabulates the collected data with various social factors (e.g., gender, age, socioeconomic conditions, and educational background) into a table; and finally, (e) preparation of the results of the analysis on the basis of the research questions and literature review into an analytical report.

Each transcript was analyzed simultaneously via a descriptive qualitative approach to add depth and quality to the data analysis (Vaismoradi et al., 2013). To ensure the validity of the findings, a method of data triangulation, which Denzin (1978) labeled researcher triangulation, was used throughout the analysis, whereby each interview was analyzed by two lead researchers (Charpentier and Kirouac, 2022). Finally, the findings were discussed among all the researchers and then validated against the results of researcher triangulation.

3 Results

3.1 Sample characteristics

The study outlines the heterogeneous sociodemographic characteristics in terms of the family background, cultural background, and socioeconomic conditions of the study participants, shown in Table 2 sample characteristics (N = 20). Their ages ranged from 60 to 85 years (mean 73.5 years), with 55% (=11) of them aged 60–79 years and 45% (=9) aged 80 years and over. More than half of them were female (55.0%), and 45% were college educated. Most participants (n = 18; 90%) were widowed, whereas 5% (= 1) were divorced or separated.

In terms of health status, 20 of them reported chronic physical health problems (e.g., coronary heart disease, diabetes, osteoarthritis, and myocardial ischemia). One patient had limited mobility due to hemiplegia. Most of the respondents (70%) lived in multistory apartments, whereas the remaining 30% lived in high-rise apartments. Some stayed on the first floor with a garden. A few of them who lived on higher floors seldom went downstairs due to the lack of elevators or mobility problems; thus, they had to rely on their children to buy supplies for them.

3.2 Qualitative findings

The three main themes from the qualitative interviews were (A) the emotional well-being of OPLA due to living alone, (B) efforts to satisfy emotional needs, and (C) the use of smart products to satisfy emotional needs. The themes and subthemes related to the emotional needs of OPLA are summarized in Figure 4, and discussed in more detail below, together with illustrative quotes from the participants.

### 3.2.1 Theme (A): emotional well-being of OPLA due to living alone

The first theme captures the emotional vulnerability experienced by OPLA, which is shaped by their unique living arrangements. The definition of the community is more specific among OPLA. However, in some instances, the community cannot take care of all the OPLA due to the special nature of the community. For example, some of the study participants stayed in different communities from their children, who seldom visited them. Some OPLAs were unmarried and required different types of attention and care. Overall, most of them yearned to receive some attention from their children or relatives and friends so that they could feel needed and have a sense of belonging.

3.2.1.1 Subtheme 1. Susceptibility to loss and loneliness

Many participants reported chronic feelings of emotional emptiness, isolation, or abandonment, often triggered by widowhood, child estrangement, or shrinking social circles. Loneliness was a dominant emotion that negatively affected their mental health (Victor and Yang, 2012).

> "Our biggest need is that we want someone to come to see us and talk to us. Every day, apart from watching TV, we do not have the chance to talk to others. Less communication makes us prone to brain atrophy." [Grandpa Fei, 75], lives alone in his home, and his son comes back once a year as he works in another province.

> "It is just that sometimes I stay at home and feel bored. My children sometimes call me to ask me to wrap some dumplings, so I wrap them and freeze them in the freezer and wait for them to come." [Grandma Song, 74, whose two children meet her at home weekly].
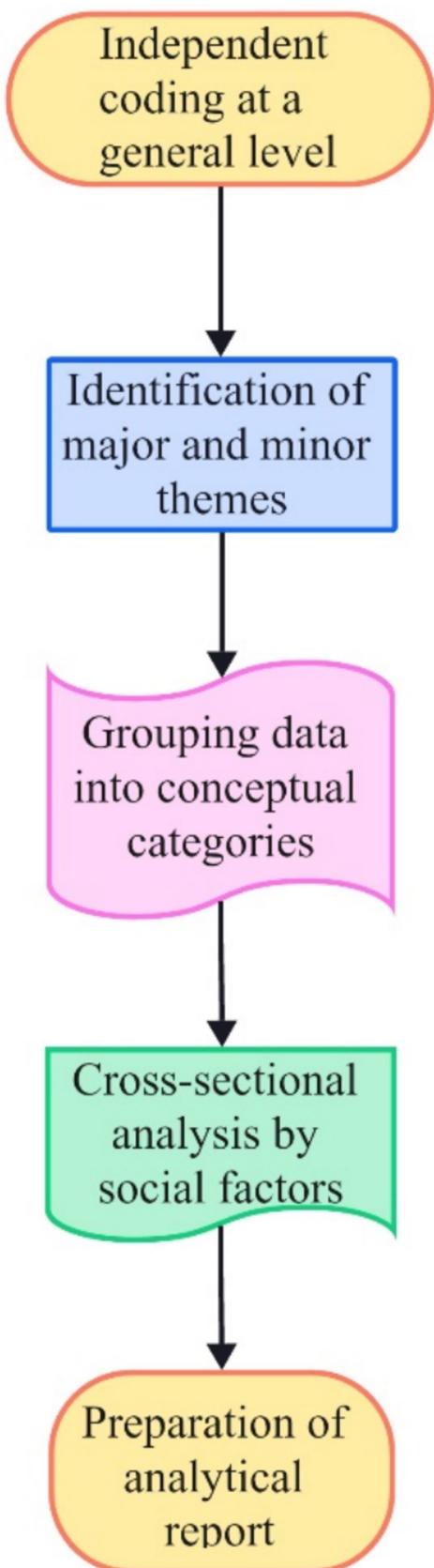
Home is the place where OPLAs have lived for most of their lives. When their children grow up and leave or their partners pass away, their homes can change from a lively and joyful appearance to an "island." When OPLAs see things that remind them of their loved ones, they can evoke a strong sense of loss and loneliness.

3.2.1.2 Subtheme 2. Difficulty in gaining a sense of control

With worsening health, it is difficult for elderly people to gain a sense of control, as they live alone at home with no one around them to rely on. Many are very worried about having an accident alone at home without anyone noticing. Most participants felt that they had lived long enough to not fear death but rather how they would die.

> "I wish someone would call me every morning and ask if I am still alive." [Grandma Deng, 80, suffers from coronary heart disease and is seldom visited by her two children who are busy with work].

> "I suffer from myocardial ischaemia and worry that I may faint at any time; thus, I hardly ever go out or take public transportation." [Grandma Wei, 70, suffering from chronic diseases such as myocardial ischemia].

Living alone led some participants to feel a loss of autonomy or helplessness in their daily lives, especially when faced with unexpected events (e.g., illness, accidents), and the lack of immediate support led to emotional insecurity and a reduced sense of autonomy.

3.2.1.3 Subtheme 3. Neglecting and repressing one's own needs

Many elderly people do not pay attention to their emotional needs, as they accept it as the inevitable process of aging. They also suppress their needs because they do not want to trouble their children and relatives. In traditional Chinese culture, elderly people are more likely to hope for the best for their future generations. When asked about their aspirations, most of the study participants wished for their children and grandchildren to have better future development, often ignoring their needs. As a result of the long-term repression of demand, their mental health and physical health can be neglected.

> "Children are busy, and I understand that. I just hope that they live well. My biggest wish is not to disturb them. I can do everything myself." [Grandpa Wei, 76, whose children are in other provinces and visit only once or twice a year].

Participants often downplayed or ignored their emotional needs, prioritizing pragmatism and survival over self-care. This tendency may reflect generational attitudes and longstanding habits of emotional inhibition that impede emotional expression and coping.

These findings highlight the psychosocial consequences of living alone in old age and emphasize the need for emotional support from OPLA in everyday life.

3.2.2 Theme (B): efforts to satisfy emotional needs

Despite the emotional difficulties described above, many OPLA have developed adaptive strategies to address their emotional well-being. These include physical, social, and spiritual activities.

TABLE 2 Sample characteristics (*N* = 20).

Demographics	Number or % of the participants
Age	
60–69	2
70–76	8
77–84	9
85 and above	1
Gender	
Women	11
Men	9
Marital status	
Married	18
Other marital status	2
Education	
Primary school	3
junior or high school	12
College or higher	5
Monthly income (CNY)	
RMB 2999 or lower	7
RMB 3000–4,999	6
RMB 5001 or higher	7
Number of children	
0	3
1	10
2	5
3	2
Housing conditions	19
Multistory apartments	14
High-rise apartments	6

100 RMB = 14.53 USD.

3.2.2.1 Subtheme 4. Development of recreational sports

In the interviews, the hobbies of the elderly participants included going out for a walk, drinking tea, chatting, playing cards, and mahjong. Elderly people with a higher level of education like to read and listen to audiobooks. Those with reduced mobility tend to watch TV and read news or novels on their cell phones. Some elderly people also spend more time in religious activities, such as worshipping Buddha and chanting sutras. Even though some such as flowers and plants were planted, those remaining in apartment buildings were limited by space availability. However, they resort to growing ornamental or edible plants via ceramic pots or foam boxes on the balcony or security windows.

> "I will take care of some flowers and plants, such as ornamental flowers, plums, orchids, etc. I will use my cell phone to look up some knowledge about planting flowers and plants." [80-year-old Wang Granny is one of the few senior citizens who graduated from a university].

Participation in physical and group activities such as square dancing, walking, and tai chi served not only as a means of maintaining physical health but also as a medium for social interaction and emotional expression. As demonstrated in prior work, such communal activities can enhance mood and mitigate feelings of loneliness among older populations (Cattan et al., 2005).

3.2.2.2 Subtheme 5. Promotion of socialization through online and offline methods

Some communities provide conducive public spaces and infrastructures, as well as organize regular enrichment activities to bring older people together in a group setting. Some of the activities include afternoon social events, weekly happy hours, sewing, knitting, card games, art classes, and games such as mahjong and darts to fulfil the mental needs of the OPLA through social activities. Some seniors also chat with friends through social media, such as WeChat and Jitterbugs, to relieve their boredom. However, this also poses some risks, as seniors are prone to scams.

> "The most common topic for old neighbors to get together is to talk about the past, and it is a pleasure to pass the time by chatting at the damper tea stalls." [Grandpa Fei, 75, lives alone at home with his son returning once a year from another province].

> "I will communicate with netizens through WeChat every day to discuss some topics of interest with everyone." [A 78-year-old retired middle school teacher who lost his son in middle age].

While traditional in-person interactions (e.g., with neighbors or at community centers) remained central to the social lives of participants, some older adults—particularly those with higher digital literacy—also engaged in digital communication via smartphones and online platforms. However, the digital divide remains significant, especially among less educated or older cohorts (Friemel, 2016).

3.2.2.3 Subtheme 6. Helping others or recourse to religion

Elderly people often derive great satisfaction and happiness from helping others. When they recount their experiences of helping others, they become very talkative and happy. Some elderly people also turn to religion in the hope of eliminating their sins and praying for happiness in the afterlife.

> "I sponsored some poor college students to complete their studies, and they expressed their gratitude to me through WeChat or cell phone text messages. However, I am contented even if they do not repay me in any way." [78-year-old retired middle school teachers].

> "Sometimes they will pray to Buddha and chant sutras to learn some principles of being a human and to gain peace of mind." [80-year-old retired employee].

Some respondents found emotional fulfillment through altruistic behavior (e.g., volunteering) or through religious and spiritual
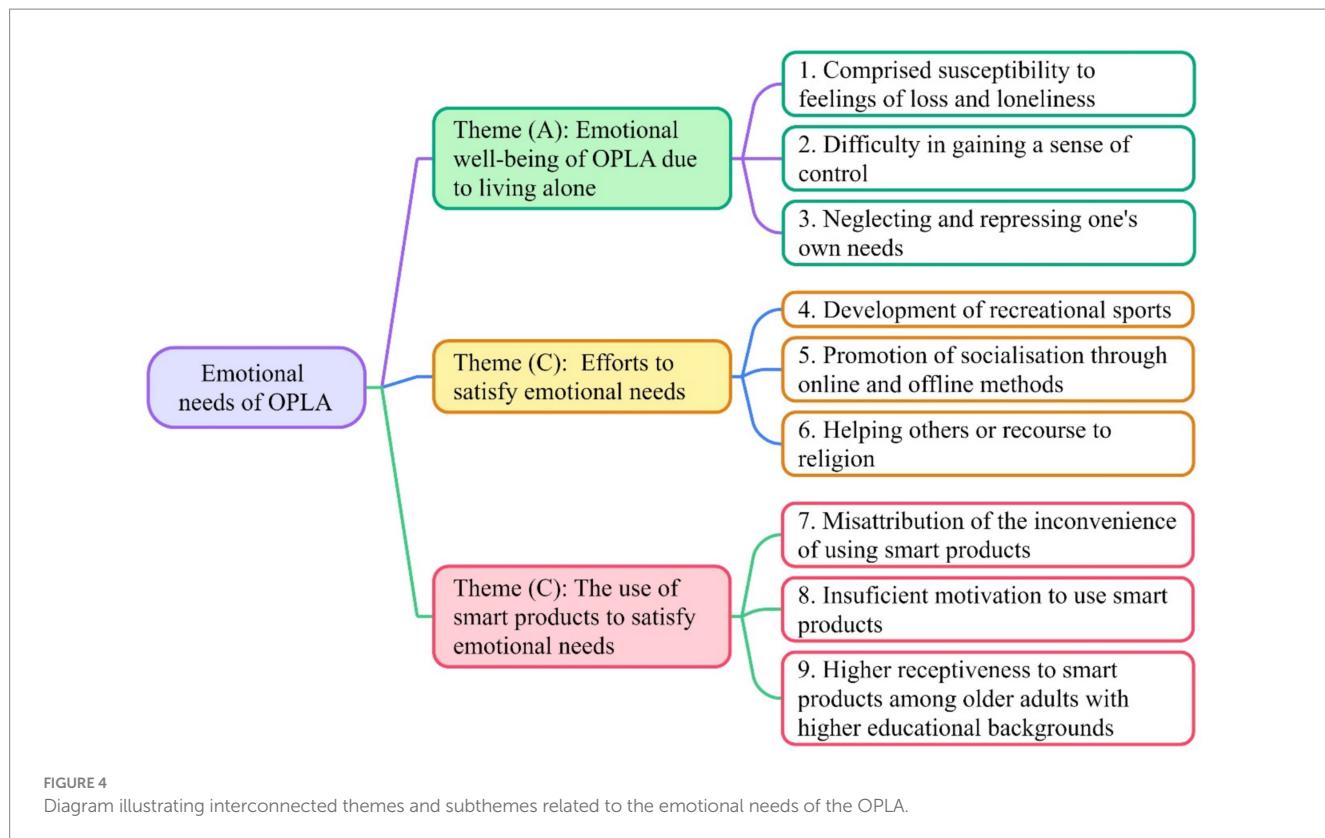
FIGURE 4
Diagram illustrating interconnected themes and subthemes related to the emotional needs of the OPLA.

practices. These pathways offered participants a sense of purpose and belonging, consistent with socioemotional selectivity theory, which suggests that older adults prioritize emotionally meaningful activities (Carstensen et al., 1999).

These findings suggest that older adults actively seek meaningful engagement and social connections to mitigate the emotional impact of living alone, although their access to coping strategies and preferences vary.

3.2.3 Theme (C): The use of smart products to satisfy emotional needs

The third theme explores the role of smart products in addressing the emotional needs of older adults, revealing both opportunities and barriers. Most of the OPLAs interviewed use a smaller variety of smart products, only use smartphones or smart TVs, or alarms to meet the basic needs of life, as they felt that physical operating interfaces would be easier to operate and that they would be less burdened with information.

3.2.3.1 Subtheme 7. Misattribution of the inconvenience of using smart products

Research has shown that older people often misunderstand or misinterpret technological features due to cognitive decline, leading to difficulties in interaction and subsequent inconvenience or even distress when using smart products (Dermody et al., 2021; Vaportzis et al., 2017). Previous bad user experiences can create a misconception whereby all smart products are bad and expensive among elderly people. They suffer from frustration of not being able to use smart products, believing that it is because of their deteriorating functions. However, in most cases, the root cause lies in the inadequate

incorporation of aging-friendly design principles during the product development process.

> "Older people are not accustomed to the use of smart products, for fear of operating errors and damage to the items. They are accustomed to old objects in their own homes, so learning to use new products is slightly difficult. The instruction wordings are not readable, and the products are not convenient to use." [A 77-year-old woman, Granny Deng, widowed 2 years ago, lives alone and has sleep problems].

Many participants struggled with the complexity of digital interfaces and blamed themselves for their inability to operate smart devices. This phenomenon—rooted in low self-efficacy—may result in avoidance behavior, consistent with Bandura's (1997) theory of self-efficacy, which asserts that perceived personal competence influences behavior and motivation.

3.2.3.2 Subtheme 8. Insufficient motivation to use smart products

The consumption concept among the elderly is still relatively conventional. Even though they may have the ability to consume, they still lack the habit of consuming due to the lifelong habit of thrift and frugality, which manifests as low desire and nonconsumption in the later years of their lives, especially among those who have experienced scarcity in their youth.

> "Smart products are expensive and difficult to learn. I am used to my current lifestyle, so it is okay for me not to use it." [Grandpa

Fei, 75 years old, lives alone and his son returns once a year from another province].

In many cases, participants expressed little motivation to engage with smart technologies, citing perceived irrelevance, low trust, or a steep learning curve. Prior studies have similarly highlighted low perceived usefulness and high effort expectancy as critical barriers to technology adoption among the elderly (Venkatesh et al., 2003).

3.2.3.3 Subtheme 9. Greater receptiveness to smart products among older adults with higher educational backgrounds

More than 45% of the study participants graduated from universities. They showed greater acceptance of smart products, and most of them reported a positive user experience for smart products. This could be due to better learning ability to adopt new technology, as well as a higher disposable income that is linked to a greater intention to purchase smart products.

"It would certainly be better if there were similar products. It is just that we know fewer channels and do not know that there are such products that can make life easier. Money is not a problem for me." [Grandma Liu, 82 years old, was widowed 2 years ago, living alone, with a university degree and a high economic level].

A clear pattern emerged wherein participants with higher levels of education demonstrated more interest and confidence in using smart products. This aligns with findings that education enhances digital literacy and openness to technology-mediated solutions (Charness and Boot, 2009).

These results suggest that while smart technologies hold potential for enhancing emotional well-being in older adults, disparities in education, digital literacy, and motivation significantly mediate their effectiveness.

4 Discussion

This study explored how OPLA in Chengdu, China, cope with emotional challenges and how they perceive the potential of smart products in meeting their emotional needs. The findings not only highlight the complex emotional landscape of OPLA but also reveal the opportunities and limitations of current smart products in enhancing their well-being. In this section, the findings are further interpreted through relevant theoretical lenses and discussed in terms of theoretical contribution, practical implications, and future research directions.

4.1 Lived experiences of living alone, emotion, and technology among OPLA

4.1.1 Theme (A): emotional well-being of OPLA due to living alone

Theme A highlights the critical role of emotional support from family and friends in the well-being of Chinese older people living alone (OPLA). Rooted in Confucian values, the family remains a primary source of emotional security and social identity in Chinese culture (Luo and Yeh, 2012). Maintaining close connections with children and peers fosters a sense of social belonging, a fundamental human need (Smith, 2017). In contrast, the absence of meaningful social ties often leads to loneliness, depression, and anxiety (Heinrich and Gullone, 2006).

Recent studies confirm that family support correlates positively with mental health and overall well-being in Chinese older adults (Chen et al., 2022), while living with children is associated with higher life satisfaction compared to independent living (Wang et al., 2014). Although living alone may not be emotionally detrimental in some Western contexts (Stanley et al., 2010; Mellor et al., 2008), research shows that in China and other Asian societies, it significantly undermines emotional well-being due to strong cultural expectations around intergenerational cohabitation (Lim and Kua, 2011; Kawamoto et al., 2005; You and Lee, 2006).

Additionally, older adults tend to suppress emotional expression, which may negatively impact on their physical and mental health over time (Carstensen et al., 2000). These findings suggest that emotional support and meaningful relationships remain central to healthy aging, particularly in cultures where family ties are deeply embedded.

4.1.2 Theme (B): efforts to satisfy emotional needs

Under Theme B, OPLA were found to maintain their emotional well-being and sense of independence through leisure activities—voluntary, enjoyable non-work pursuits such as hobbies, exercise, and social interactions (Hills and Argyle, 1998). Participation in such activities has been shown to reduce depression (Fancourt and Tymoszuk, 2019) and enhance happiness and vitality in older adults (Sarid et al., 2010). Engaging with peers and social networks also mitigates loneliness and fosters emotional health (Lee and Ishii-Kuntz, 1987). In various contexts, including the UK and Malaysia, spirituality has been identified as a key dimension of active and healthy aging (Malone and Dadswell, 2018; Tohit et al., 2012).

To sustain independence despite functional decline, tailored support such as assistive technologies and smart products plays a vital role (Buffel et al., 2019). While living alone often leads to social isolation, technologies that facilitate social interaction or help form new connections—such as online support groups—can partially address emotional needs (Tsai and Tsai, 2011; Weinert et al., 2008; Paredes et al., 2021). Although the evidence remains limited regarding the effectiveness of digital interventions for older adults in urban settings (Cohen-Mansfield and Perach, 2015), their potential to support emotional well-being should not be overlooked.

However, age-related emotional characteristics influence user experience. Stereotypes that portray older adults as technology-incompetent may diminish their willingness to adopt new tools. According to Socioemotional Selectivity Theory, as people age, they prioritize emotionally meaningful goals—such as staying connected with family—over knowledge acquisition (Carstensen, 2021). This suggests that emotionally resonant design is more relevant than cognitively demanding interfaces. Moreover, older adults may resist technologies explicitly labeled for seniors, fearing a loss of perceived competence and independence (Astell et al., 2020). In the Chinese context, this aligns with Confucian mianzi ("face") culture, where

preserving dignity discourages use of assistive technologies that imply vulnerability. We describe this tension as "affective-technological dissonance," underscoring the need to move from "age-friendly" to "culturally and emotionally congruent" design paradigms.

4.1.3 Theme (C): the use of smart products to satisfy emotional needs

Older adults' misattribution of inconvenience to smart products often stems from a combination of cognitive decline, usability issues, and emotional factors. As cognitive processing slows with age, complex interfaces can become overwhelming, leading to misunderstanding, frustration, and even avoidance (Dermody et al., 2021). These challenges highlight the importance of age-appropriate design, as well as the inclusion of user feedback during development, which has been shown to enhance usability and satisfaction (Borelli et al., 2019).

Moreover, technological anxiety—often rooted in past negative experiences or unfamiliarity—can intensify emotional resistance to smart products (Lou and Liu, 2023). Many older adults desire technology that genuinely improves quality of life but feel alienated by tools that are not designed with their emotional and cognitive needs in mind (Huang et al., 2024). When design fails to support their self-image as independent and competent, particularly in cultural contexts like China's mianzi (face) culture, it can lead to what we term "affective-technological dissonance." This highlights the need for a shift from merely "age-friendly" interfaces to culturally and emotionally congruent designs.

Financial concerns also hinder adoption. Many OPLA perceive smart products as expensive or inaccessible, especially in lower-income urban settings (Li and Woolrych, 2021). Although they recognize the potential benefits of technology for aging, they believe only wealthier groups can afford these tools. Government subsidies and community-based support programs are therefore essential to improve both access and motivation (Chen et al., 2022; Kong et al., 2023). Interview data also revealed that older adults with higher education levels exhibited greater emotional adaptability and technological openness, a finding consistent with research on wisdom traits such as empathy, self-reflection, and emotion regulation (Jeste and Lee, 2019). With adequate support—social, emotional, and financial—older adults are more likely to overcome resistance and engage meaningfully with digital solutions that enhance their well-being (Paredes et al., 2021).

In summary, Theme A indicates that living alone generally has a negative effect on the emotional well-being of older adults. This effect is exacerbated by the stoicism and emotional inexpressiveness often observed in older Chinese adults, which further harms their physical and mental health. Theme B highlights that Chinese seniors living alone take proactive steps to maintain their independence despite facing physical and mental risks. Theme C reveals that older adults often blame themselves for difficulties in using smart products, leading to negative experiences such as frustration. However, those with higher educational backgrounds tend to learn more easily and show greater acceptance of these technologies. Therefore, incorporating elements that address the emotional needs of seniors into smart products is crucial. This approach enhances the perceived usability and overall user experience, conveys positive product semantics, and enables older adults to seamlessly benefit from technological advancements.

4.2 Practical revelations

The findings of this study offer valuable guidance for improving smart product design, enhancing elderly care services, and informing policy development, as shown in Figure 5. The emotional needs of older people living alone deserve urgent attention, as social isolation and loneliness can significantly affect their physical and mental health, posing a growing public health concern.

To begin with, in the realm of smart product design, a human-centered approach should be prioritized to reduce the barriers older adults face when using digital technologies. Simplified interfaces, intuitive interaction processes, and features such as one-button shortcuts or "elderly-friendly" modes can minimize frustration and improve accessibility (Wang et al., 2020). Moreover, smart products should move beyond functionality and incorporate emotional care elements—such as music, companionship features, or voice assistants that detect and respond to users' emotional states—to promote psychological well-being (Curumsing et al., 2019). Emotional engagement through design can effectively enhance motivation and long-term adoption among older users.

Furthermore, elderly care service providers should strengthen their attention to emotional and social support. Beyond meeting daily living needs, community-based organizations can regularly organize cultural and recreational activities to help older adults expand their social networks and reduce feelings of isolation. At the same time, improving digital literacy through structured programs can empower older people to use smart products with greater confidence, creating a more inclusive digital environment that supports emotional well-being (Ngiam et al., 2022). Initiatives such as psychological counseling or peer support groups can further address emotional loneliness and foster a sense of belonging.

Finally, government efforts are essential to address the digital divide and support the emotional needs of older populations (State Council Office of the People's Republic of China, 2020). Authorities should establish design standards for age-appropriate technologies, promote the development of simplified interfaces and functions, and encourage enterprises to consider the specific needs of different subgroups. In addition, maintaining offline service channels, simplifying digital service procedures, and offering financial subsidies or incentives can significantly improve access to smart technologies for older adults with limited digital skills or income. These policy-level interventions will help create a supportive digital environment where smart products and services can more effectively meet the emotional and practical needs of the aging population.

4.3 Research limitations and future research

Despite the study offering meaningful insights, several limitations should be acknowledged. The research was based on qualitative interviews with 20 relatively healthy and independent older adults living alone in urban Chengdu, recruited through non-random sampling. This limits the generalizability of the findings, as it excludes other subgroups such as rural residents, those with frail health, or those living with family members. The reliance on self-reported data and thematic analysis may also introduce subjectivity. Furthermore, due to cultural stigma and internalized shame, older adults may avoid

FIGURE 5
Multi-level strategies for supporting the emotional needs of OPLA.
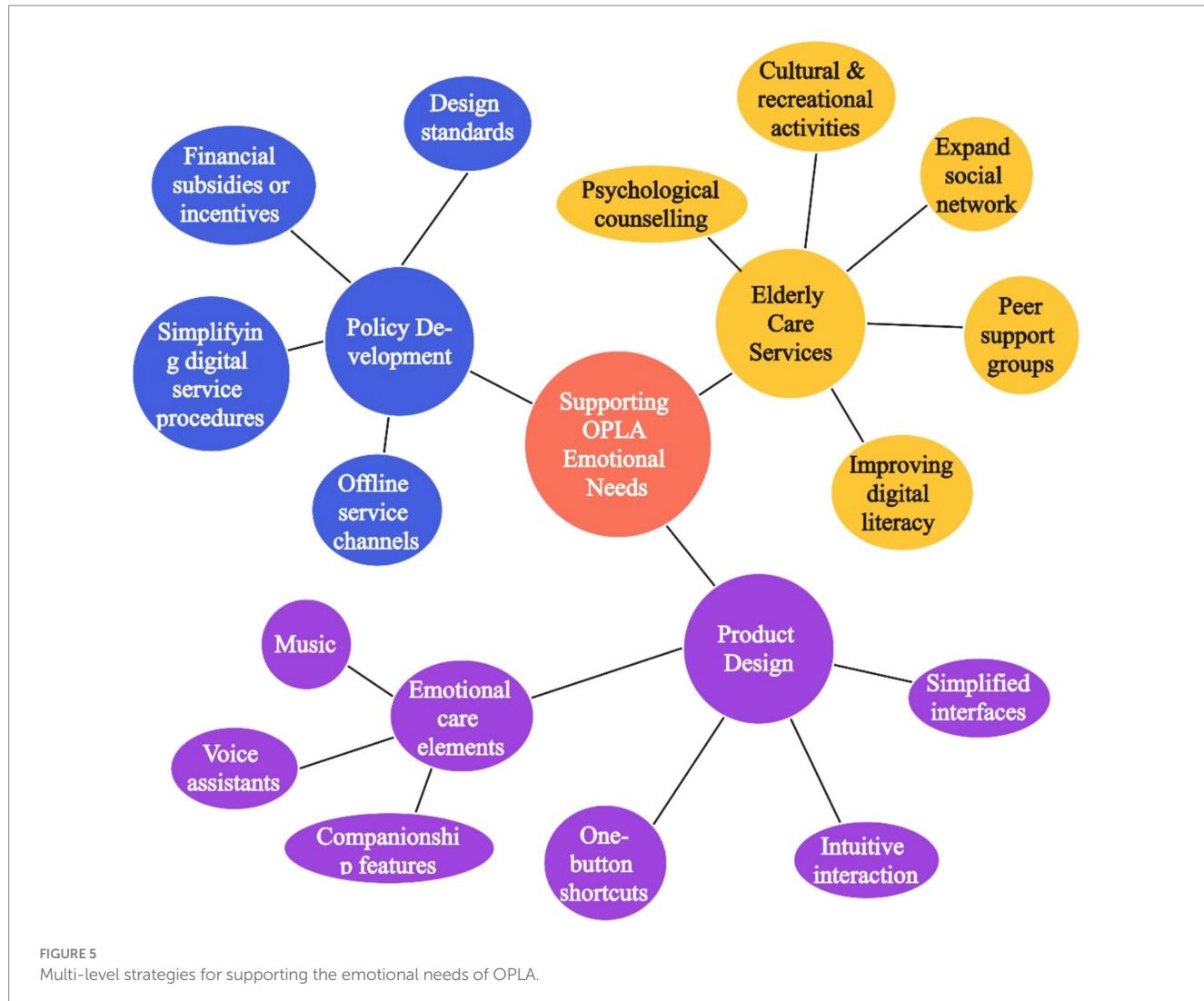
expressing emotional vulnerability directly, often using neutral terms like "boredom" to describe deeper emotional distress (Grenade and Boldy, 2008), which suggests the need for carefully designed, culturally sensitive interview protocols. To enhance external validity and reliability,

5 Conclusion

This study contributes to a deeper understanding of the emotional needs of older people living alone (OPLA) in urban China and their complex relationship with smart technology. Through qualitative interviews, it reveals that emotional well-being among OPLA is closely tied to living arrangements and is often challenged by feelings of anxiety, loneliness, and diminished autonomy. While many older adults develop self-regulatory strategies such as engaging in leisure activities or maintaining social connections to cope with these challenges, their engagement with smart products remains limited due to low motivation, usability barriers, and the lack of age-sensitive design. These findings underscore the urgent need to shift from a purely functional view of aging technology to one that centers emotional responsiveness and cultural relevance. Future

research should explore participatory and context-sensitive design strategies that embed emotional needs into product development. Furthermore, a collaborative effort among policymakers, designers, community organizations, and technology developers is essential to foster inclusive digital ecosystems that support emotional well-being, promote independent living, and enable active aging in a rapidly evolving technological landscape.

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.

Ethics statement

requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YL: Writing – original draft, Writing – review & editing. RC: Writing – original draft, Writing – review & editing. IY: Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

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.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

References

Abell, J. G., and Steptoe, A. (2021). Why is living alone in older age related to increased mortality risk? A longitudinal cohort study. *Age Ageing* 50, 2019–2024. doi: 10.1093/ageing/afab155

Astell, A. J., McGrath, C., and Dove, E. (2020). 'That's for old so and so's!': Does identity influence older adults' technology adoption decisions? *Ageing & Society* 40, 1550–1576. doi: 10.1017/S0144686X19000230

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W.H. Freeman.

Banister, J., Bloom, D. E., and Rosenberg, L. (2012). "Population aging and economic growth in China" in The Chinese economy: A new transition. eds. M. Aoki and J. Wu (London: Palgrave Macmillan UK).

Borelli, E., Paolini, G., Antoniazzi, F., Barbiroli, M., Benassi, F., Chesani, F., et al. (2019). HABITAT: an IoT solution for independent elderly. *Sensors* 19:1258. doi: 10.3390/s19051258

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp063oa

Braun, V., and Clarke, V. (2012). "Thematic analysis" in APA handbook of research methods in psychology. ed. H. Cooper, vol. *2*. Research designs (Washington, DC: American Psychological Association), 57–71.

British Geriatrics Society (BGS). (2017). Fit for frailty: Consensus best practice guidance. Available online at: https://www.bgs.org.uk/resources/resource-series/fit-for-frailty

Buffel, T., Phillipson, C., and Rémillard-Boilard, S. (2019). "Age-friendly cities and communities: new directions for research and policy" in Encyclopedia of gerontology and population aging. eds. G. Danan and M. E. Dupre (Cham: Springer International Publishing), 1–10.

Carstensen, L. L., Isaacowitz, D. M., and Charles, S. T. (1999). Taking time seriously: a theory of socioemotional selectivity. *Am. Psychol.* 54, 165–181. doi: 10.1037/0003-066X.54.3.165

Carstensen, L. L., Pasupathi, M., Mayr, U., and Nesselroade, J. R. (2000). Emotional experience in everyday life across the adult life span. *Journal of Personality and Social Psychology* 79, 644–655. doi: 10.1037/0022-3514.79.4.644

Carstensen, L. L. (2021). Socioemotional selectivity theory: The role of perceived endings in human motivation. *The Gerontologist* 61, 1188–1196. doi: 10.1093/geront/gnab116

Cattan, M., White, M., Bond, J., and Learmouth, A. (2005). Preventing social isolation and loneliness among older people: a systematic review of health promotion interventions. *Ageing Soc.* 25, 41–67. doi: 10.1017/S0144686X04002594

Charness, N., and Boot, W. R. (2009). Aging and information technology use: potential and barriers. *Curr. Dir. Psychol. Sci.* 18, 253–258. doi: 10.1111/j.1467-8721.2009.01647.x

Charpentier, M., and Kirouac, L. (2022). Experiences of loneliness among older people living alone. A qualitative study in Quebec (Canada). *Ageing Soc.* 42, 2832–2853. doi: 10.1017/S0144686X21000349

Chen, X., Giles, J., Yao, Y., Yip, W., Meng, Q., Berkman, L., et al. (2022). The path to healthy ageing in China: a Peking University-lancet commission. *Lancet* 400, 1967–2006. doi: 10.1016/S0140-6736(22)01546-X

Chengdu Municipal Bureau of Statistics (2020). Chengdu statistical yearbook 2020. Chengdu: Chengdu Municipal Bureau of Statistics.

Chou, K.-L., and Chi, I. (2000). Comparison between elderly Chinese living alone and those living with others. *J. Gerontol. Soc. Work.* 33, 51–66. doi: 10.1300/J083v33n04_05

Cohen-Mansfield, J., and Perach, R. (2015). Interventions for alleviating loneliness among older persons: a critical review. *Am. J. Health Promot.* 29, e109–e125. doi: 10.4278/ajhp.130418-LIT-182

Curumsing, M. K., Fernando, N., Abdelrazek, M., Vasa, R., Mouzakis, K., and Grundy, J. (2019). Emotion-oriented requirements engineering: a case study in developing a smart home system for the elderly. *J. Syst. Softw.* 147, 215–229. doi: 10.1016/j.jss.2018.06.077

Denzin, N. K. (1978). The research act: A theoretical introduction to sociological methods. *2nd* Edn. New York: McGraw-Hill.

Dermody, G., Fritz, R., Glass, C., Dunham, M., and Whitehead, L. (2021). Factors influencing community-dwelling older adults' readiness to adopt smart home technology: a qualitative exploratory study. *J. Adv. Nurs.* 77, 4847–4861. doi: 10.1111/jan.14996

Fancourt, D., and Tymoszuk, U. (2019). Cultural engagement and incident depression in older adults: evidence from the English longitudinal study of ageing. *Br. J. Psychiatry* 214, 225–229. doi: 10.1192/bjp.2018.267

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

Friemel, T. N. (2016). The digital divide has grown old: Determinants of a digital divide among seniors. *New Media & Society* 18, 313–331. doi: 10.1177/1461444814538648

Ghorayeb, A., Comber, R., and Gooberman-Hill, R. (2021). Older adults' perspectives of smart home technology: are we developing the technology that older people want? *Int. J. Hum. Comput. Stud.* 147:102571. doi: 10.1016/j.ijhcs.2020.102571

Grenade, L., and Boldy, D. (2008). Social isolation and loneliness among older people: issues and future challenges in community and residential settings. *Austral. Health Rev.* 32:468. doi: 10.1071/AH080468

Gu, D., Feng, Q., and Yeung, W.-J. J. (2019). Reciprocal dynamics of solo-living and health among older adults in contemporary China. *J. Gerontol.* 74, 1441–1452. doi: 10.1093/geronb/gby140

Guest, G., Bunce, A., and Johnson, L. (2006). How many interviews are enough: an experiment with data saturation and variability. *Field Methods* 18, 59–82. doi: 10.1177/1525822X05279903

Han, Y., He, Y., Lyu, J., Canqing, Y., Bian, M., and Lee, L. (2020). Aging in China: perspectives on public health. *Global Health J.* 4, 11–17. doi: 10.1016/j.glohj.2020.01.002

Han, A.-R., Park, S.-A., and Ahn, B.-E. (2018). Reduced stress and improved physical functional ability in elderly with mental health problems following a horticultural therapy program. *Complement. Ther. Med.* 38, 19–23. doi: 10.1016/j.ctim.2018.03.011

Heinrich, L. M., and Gullone, E. (2006). The clinical significance of loneliness: a literature review. *Clin. Psychol. Rev.* 26, 695–718. doi: 10.1016/j.cpr.2006.04.002

Hills, P., and Argyle, M. (1998). Positive moods derived from leisure and their relationship to happiness and personality. *Personal. Individ. Differ.* 25, 523–535. doi: 10.1016/S0191-8869(98)00082-8

Hong, Y.-K., Wang, Z.-Y., and Cho, J. Y. (2022). Global research trends on smart homes for older adults: bibliometric and Scientometric analyses. *Int. J. Environ. Res. Public Health* 19:14821. doi: 10.3390/ijerph192214821

Hou, B., and Zhang, H. (2023). Latent profile analysis of depression among older adults living alone in China. *J. Affect. Disord.* 325, 378–385. doi: 10.1016/j.jad.2022.12.154

Huang, Y., Li, X., Ling, S., and Zheng, C. (2024). An analysis of how smart home product attributes influence older adults avoidance psychology: the sequential mediation role of product identity and trust. *Behav. Sci.* 14:1060. doi: 10.3390/bs14111060

Jeste, D. V., and Lee, E. E. (2019). Emerging empirical science of wisdom: definition, measurement, neurobiology, longevity, and interventions. *Harv. Rev. Psychiatry* 27, 127–140. doi: 10.1097/HRP.0000000000000205

Jia, Q., Duan, Y., Gong, R., Jiang, M., You, D., and Yi, Q. (2023). Living arrangements and depression of the older adults– evidence from the Chinese longitudinal healthy longevity survey. *BMC Public Health* 23:1870. doi: 10.1186/s12889-023-16730-4

Kawamoto, R., Yoshida, O., Oka, Y., and Kodama, A. (2005). Influence of living alone on emotional well-being in community-dwelling elderly persons. *Geriatr Gerontol Int* 5, 152–158. doi: 10.1111/j.1447-0594.2005.00285.x

Kong, D., Liu, S., Hong, Y., Chen, K., and Luo, Y. (2023). Perspectives on the popularization of smart senior care to meet the demands of older adults living alone in communities of Southwest China: a qualitative study. *Front. Public Health* 11:1094745. doi: 10.3389/fpubh.2023.1094745

Korstjens, I., and Moser, A. (2017). Series: practical guidance to qualitative research. Part 2: context, research questions and designs. *Eur. J. General Pract.* 23, 274–279. doi: 10.1080/13814788.2017.1375090

Kvale, S. (1996). The 1,000-page question. *Qual. Inq.* 2, 275–284. doi: 10.1177/107780049600200302

Lee, G. R., and Ishii-Kuntz, M. (1987). Social interaction, loneliness, and emotional well-being among the elderly. *Res. Aging* 9, 459–482. doi: 10.1177/0164027587094001

Lee, L. N., and Kim, M. J. (2020). A critical review of smart residential environments for older adults with a focus on pleasurable experience. *Front. Psychol.* 10. doi: 10.3389/fpsyg.2019.03080

Li, Y. (2013). A perspective on health Care for the Elderly who Lose Their Only Child in China. *Scand. J. Public Health* 41, 550–552. doi: 10.1177/1403494813490252

Li, M., and Woolrych, R. (2021). Experiences of older people and social inclusion in relation to smart "age-friendly" cities: a case study of Chongqing, China. *Front. Public Health* 9:779913. doi: 10.3389/fpubh.2021.779913

Lim, L. L., and Kua, E.-H. (2011). Living alone, loneliness, and psychological well-being of older persons in Singapore. *Current Gerontol. Geriatrics Res.* 2011:e673181, 1–9. doi: 10.1155/2011/673181

Lincoln, Y. S., and Guba, E. G. (1985). *Naturalistic inquiry*, Beverly Hills, CA: Sage Publications. 438–439.

Lou, S., and Liu, H. (2023). Awareness, use, and need of smart Care for Older Adults: a comparative study based on a survey in Macao, China. *Front. Public Health* 11:1135164. doi: 10.3389/fpubh.2023.1135164

Lucia-Palacios, L., and Pérez-López, R. (2021). How can autonomy improve consumer experience when interacting with smart products? *J. Res. Interact. Mark.* 17, 19–37. doi: 10.1108/JRIM-02-2021-0031

Luo, J., Lu, C., Chen, Y., Wu, X., Zhu, C., Cui, W., et al. (2023). Nuclear translocation of cGAS orchestrates VEGF-A-mediated angiogenesis. *Cell Reports* 42:112328. doi: 10.1016/j.celrep.2023.112328

Luo, J.-D., and Yeh, Y.-C. (2012). Neither collectivism nor individualism: Trust in the Chinese Guanxi Circle. *J. Trust Res.* 2, 53–70. doi: 10.1080/21515581.2012.660355

Lou, Y., and Hong, Y. (2023). Nash equilibrium computation in subnetwork zero-sum games with switching communications. *IEEE Transactions on Automatic Control* 68, 1234–1245. doi: 10.1109/TAC.2022.3145678

Malatesta, C. Z., and Kalnok, M. (1984). Emotional experience in younger and older adults. *J. Gerontol.* 39, 301–308. doi: 10.1093/geronj/39.3.301

Malone, J., and Dadswell, A. (2018). The role of religion, spirituality and/or belief in positive ageing for older adults. *Geriatrics* 3:28. doi: 10.3390/geriatrics3020028

Malterud, K., Siersma, V. D., and Guassora, A. D. (2015). Sample size in qualitative interview studies: guided by information power. *Qual. Health Res.* 26, 1753–1760. doi: 10.1177/1049732315617444

Mellor, D., Stokes, M., Firth, L., Hayashi, Y., and Cummins, R. (2008). Need for belonging, relationship satisfaction, loneliness, and life satisfaction. *Personal. Individ. Differ.* 45, 213–218. doi: 10.1016/j.paid.2008.03.020

Minichiello, V., Aroni, R., and Hays, T. N. (2008). In-depth interviewing: principles, techniques, analysis. *Pearson Educ. Austral.*

Mo, J. (2010). The research on the elderly's emotional needs in urban communities. Beijing: Social Sciences Academic Press.

Morville, P. (2005). Ambient findability: What we find changes who we become. Sebastopol, CA: O'Reilly Media, Inc.

Ngiam, N. H. W., Yee, W. Q., Teo, N., Yow, K. S., Soundararajan, A., Lim, J. X., et al. (2022). Building digital literacy in older adults of low socioeconomic status in Singapore (Project Wire Up): Nonrandomized controlled trial. *J. Med. Inter. Res.* 24:e40341. doi: 10.2196/40341

Norman, D. A. (2004). Emotional design: Why we love (or hate) everyday things. New York, NY: Basic Books.

Paredes, M., Alejandra, E. E., Lee, L. C., Gupta, S., Palmer, B. W., Palinkas, L. A., et al. (2021). Qualitative study of loneliness in a senior housing community: the importance of wisdom and other coping strategies. *Aging Ment. Health* 25, 559–566. doi: 10.1080/13607863.2019.1699022

Patton, M. Q. (1990). *Qualitative evaluation and research methods, 2nd ed.* qualitative evaluation and research methods. *2nd* Edn. Thousand Oaks, CA, US: Sage Publications, Inc.

Peek, S. T. M., Wouters, E. J. M., van Hoof, J., Luijkx, K. G., Boeije, H. R., and Vrijhoef, H. J. M. (2014). Factors influencing acceptance of technology for aging in place: a systematic review. *Int. J. Med. Inform.* 83, 235–248. doi: 10.1016/j.ijmedinf.2014.01.004

Peine, A., Marshall, B., Martin, W., and Neven, L. (2021). Socio-Gerontechnology: Interdisciplinary critical studies of ageing and technology. London: Routledge.

Pérez-Escolar, M., and Canet, F. (2023). Research on vulnerable people and digital inclusion: toward a consolidated taxonomical framework. *Univ. Access Inf. Soc.* 22, 1059–1072. doi: 10.1007/s10209-022-00867-x

Raihan, M. M. H., Subroto, S., Chowdhury, N., Koch, K., Ruttan, E., and Turin, T. C. (2024). Dimensions and barriers for digital (in)equity and digital divide: a systematic integrative review. *Digital Transform. and Soc.* 4, 111–127. doi: 10.1108/DTS-04-2024-0054

Sandelowski, M. (1995). Sample size in qualitative research. *Res. Nurs. Health* 18, 179–183. doi: 10.1002/nur.4770180211

Sarid, O., Melzer, I., Kurz, I., Shahar, D. R., and Ruch, W. (2010). The effect of helping behavior and physical activity on mood states and depressive symptoms of elderly people. *Clin. Gerontol.* 33, 270–282. doi: 10.1080/07317115.2010.502105

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., et al. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual. Quant.* 52, 1893–1907. doi: 10.1007/s11135-017-0574-8

Smith, E. E. (2017). The power of meaning: The true route to happiness. London: River.

Stanley, M., Moyle, W., Ballantyne, A., Jaworski, K., Corlis, M., Oxlade, D., et al. (2010). 'Nowadays You Don't even see your Neighbours': loneliness in the everyday lives of older Australians. *Health Soc. Care Community* 18, 407–414. doi: 10.1111/j.1365-2524.2010.00923.x

State Council Office of the People's Republic of China. (2020). Circular of the general Office of the State Council on the implementation plan for effectively addressing the difficulties of the elderly in the use of intelligent technology. Available online at: https://www.gov.cn/zhengce/content/2020-11/24/content_5563804.htm (Accessed July. 2024).

Tohit, N., Browning, C. J., and Radermacher, H. (2012). 'We want a peaceful life Here and hereafter': healthy ageing perspectives of older Malays in Malaysia. *Ageing Soc.* 32, 405–424. doi: 10.1017/S0144686X11000316

Tsai, H.-y. S., Shillair, R., Cotton, S. R., Winstead, V., and Yost, E. (2015). Getting grandma online: are tablets the answer for increasing digital inclusion for older adults in the U.S.? *Educ. Gerontol.* 41, 695–709. doi: 10.1080/03601277.2015.1048165

Tsai, H.-H., and Tsai, Y.-F. (2011). Changes in depressive symptoms, social support, and loneliness over 1 year after a minimum 3-month videoconference program for older nursing home residents. *J. Med. Internet Res.* 13:e1678:e93. doi: 10.2196/jmir.1678

United Nations. (2020). The sustainable development goals report 2020. New York: United Nations. Available online at: https://unstats.un.org/sdgs/report/2020/ (Accessed January 31, 2024)

Vaismoradi, M., Turunen, H., and Bondas, T. (2013). Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. *Nurs. Health Sci.* 15, 398–405. doi: 10.1111/nhs.12048

Vaportzis, E., Clausen, M. G., and Gow, A. J. (2017). Older adults perceptions of technology and barriers to interacting with tablet computers: a focus group study. *Front. Psychol.* 8:01687. doi: 10.3389/fpsyg.2017.01687

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Q.* 27, 425–478. doi: 10.2307/30036540

Victor, C. R., and Yang, K. (2012). The prevalence of loneliness among adults: A case study of the United Kingdom. The. *Journal of Psychology: Interdisciplinary and Applied* 146, 85–104. doi: 10.1080/00223980.2011.613875

Wang, Y. (2012). Urban development and urban planning in contemporary China: A case study of Chengdu. Montana State University - Bozeman, College of Letters & Science. Available online at: https://scholarworks.montana.edu/xmlui/handle/1/2500 (Accessed July 30, 2024).

Wang, J., Chen, T., and Han, B. (2014). Does co-residence with adult children associate with better psychological well-being among the oldest old in China? *Aging Ment. Health* 18, 232–239. doi: 10.1080/13607863.2013.837143

Wang, C.-M., Tseng, S.-M., and Huang, C.-S. (2020). Design of an Interactive Nostalgic Amusement Device with user-friendly tangible interfaces for improving the health of older adults. *Healthcare* 8:179. doi: 10.3390/healthcare8020179

Wang, J., Yang, Q., and Bei, W. (2023). Effects of care arrangement on the age of institutionalization among community-dwelling Chinese older adults. *J. Aging Soc. Policy* 35, 595–610. doi: 10.1080/08959420.2020.1726720

Wang, Y., Zeng, H., Lv, F., and Wang, J. (2024). Analysis of demand and influencing factors for smart senior care among older adults in underdeveloped regions of Western China: a case study of Lanzhou. *Front. Public Health* 12:1337584. doi: 10.3389/fpubh.2024.1337584

Weinert, C., Cudney, S., and Hill, W. G. (2008). Rural women, technology, and self-Management of Chronic Illness. *Canad. J. Nurs. Res.* 40, 114–134

Whear, R., Campbell, F., Rogers, M., Sutton, A., Robinson-Carter, E., Sharpe, R., et al. (2023). What is the effect of intergenerational activities on the wellbeing and mental health of older people?: a systematic review. *Campbell Syst. Rev.* 19:e1355. doi: 10.1002/cl2.1355

You, K. S., and Lee, H. O. (2006). The physical, mental, and emotional health of older people who are living alone or with relatives. *Arch. Psychiatr. Nurs.* 20, 193–201. doi: 10.1016/j.apnu.2005.12.008

Zhang, S., Li, X., Yang, M., and Song, H. (2023). Older adults' heterogeneous preferences for climate-proof urban blue-green spaces: a case of Chengdu, China. *Urban For. Urban Green.* 90:128139. doi: 10.1016/j.ufug.2023.128139

Check for updates

The impact of internet use on the subjective age of older adults: evidence and mechanisms

Zeyu Kong and Anqin Zhu*

School of Government, Nanjing University, Nanjing, China

Background: In the context of digitalization and population aging, leveraging Internet technology to reduce the subjective age of older adults helps to promote active aging and healthy aging, thereby contributing to the realization of the development of high-quality national undertakings for the aged.

Methods: Data from the Chinese Longitudinal Aging Social Survey (CLASS) in 2020 were analyzed. Regression analyses and instrumental variable methods were employed to examine the main effects, heterogeneous effects, and mechanisms of Internet use on the subjective age of older adults. Latent class models and multinomial treatment effect models were used to explore the impact of Internet use patterns on the subjective age of older adults.

Results: Internet use has a significant negative effect on the subjective age of older adults. This conclusion still holds after ruling out endogeneity using instrumental variables methods and conducting various robustness tests. The mechanism test shows that Internet use lowers subjective age by improving health status, self-efficacy, and social capital. Heterogeneity analysis demonstrates that the impact of Internet use on reducing subjective age is more significant among young-old individuals, those with non-agricultural hukou, and those in better economic conditions. Further analysis suggests that different Internet use patterns have varying effects on the subjective age of older adults.

Conclusion: This research suggests that Internet use reduces subjective age among older adults. This effect is primarily realized through improvements in health, self-efficacy, and social capital and varies by age, hukou, economic conditions, and Internet use patterns. These findings contribute to the theoretical understanding of how Internet use can delay subjective aging and offer policy implications for enhancing the digital dividend for older adults.

1 Introduction

Population aging is evolving into a global challenge. As the country with the highest degree of aging, China's older adult population and its growth rate significantly exceed the international average. From 2000 to 2022, China transitioned from an aging society to an aged society, with the number of people aged 60 and above increasing from 126 million to 280 million, and the proportion rising from 10.46 to 19.8%, with an average annual growth rate of 3.88%. The rapid aging of the population has led to a gradual decline of the demographic dividend and a continuous increase in pension security and healthcare expenditures, presenting significant challenges for economic and social development. Given this context,

promoting active aging and healthy aging and enhancing the quality of life of older adults has become a critical concern for both policymakers and scholars.

Subjective age, defined as an individual's self-perception of their age, is a crucial psychological indicator of older adults' quality of life (1–3). Previous studies have shown that older adults perceive their subjective age as younger than their chronological age (2). A younger subjective age reflects a positive age identity and serves as an effective self-protection strategy that enables older adults to resist negative stereotypes of aging (2, 3). It has also been associated with increased economic and social participation, improved physical function, a lower incidence of chronic diseases, reduced anxiety and depressive symptoms, a lower risk of cognitive decline, decreased mortality risk, and enhanced subjective well-being (1–4). However, Chinese older adults' subjective age is, on average, 4.8% younger than their chronological age (5), whereas this discrepancy is approximately 11% in Germany (6), 15–16% in the United States (1), and exceeds 20% in Denmark (7). Currently, China has a relatively low level of old-age security and an underdeveloped public health infrastructure, and a higher subjective age further exacerbates the disadvantaged status of older adults. Given this context, a comprehensive analysis of the mechanisms shaping subjective age is essential for developing strategies that delay subjective aging and promote well-being among older adults.

The rapid development of information and communication technologies (ICTs) has transformed older adults' lifestyles and social interactions, offering the potential to delay subjective aging. As of 2023, there were approximately 170 million older Internet users in China, with an Internet penetration rate of 57.4% among this age group. Examining the impact of Internet use on subjective age therefore holds significant theoretical and policy relevance. Research has increasingly explored both the determinants of subjective age and the impact of Internet use among older adults. The existing literature primarily employs the bio-psycho-social model to examine the factors influencing subjective age, highlighting the significant roles of health status, psychological resources, personality traits, socioeconomic status, and social capital (8–17). However, the role of Internet use has received limited attention. Studies on Internet use among older adults have predominantly focused on its effects on health outcomes, self-efficacy, social capital, and subjective well-being (18–24). Although some research has explored the relationship between Internet/social media use and attitudes toward aging (25–27), studies directly investigating its impact on subjective age remain scarce. Consequently, further research is needed to confirm whether Internet use affects the subjective age of older adults.

The present study analyzes the effects and mechanisms of Internet use on subjective age among older adults, using data from the Chinese Longitudinal Aging Social Survey (CLASS) in 2020. This study makes several contributions. First, it introduces a new research perspective to the literature on subjective aging by integrating symbolic interactionism, social comparison theory, and social constructionism to examine the main effects of Internet use on subjective age, as well as incorporating the bio-psycho-social model to explore the underlying mechanisms. Second, it employs the instrumental variable approach to address potential endogeneity, enhancing the robustness of the findings. Third, it explores the heterogeneous effects of Internet use on subjective age and the impact of different Internet use patterns,

providing empirical insights relevant to bridging the digital divide and enhancing the digital dividend for older adults.

2 Literature review and research hypotheses

2.1 Subjective age of older adults and its determinants

Subjective age refers to how old an individual perceives themselves to be, and is typically measured using felt age (3). Older adults tend to report a felt age lower than their chronological age (2). Stereotype threat theory suggests that negative age-related stereotypes can harm the behavior, health, and subjective well-being of older adults; thus, a younger subjective age can help mitigate these stereotypes and restore a sense of self-worth (2). Consequently, maintaining a younger subjective age is considered a positive self-concept that can encourage older adults to continue participating in socio-economic activities, improving their financial situation, promoting interpersonal interactions, and enhancing quality of life (1, 2). The bio-psycho-social model provides a comprehensive theoretical framework for explaining the determinants of subjective aging indicators such as subjective age (2), awareness of age-related changes (28), and subjective life expectancy (29). From an information processing perspective, this model suggests that individuals form their subjective age based on biological, psychological, and social cues about aging (2). Therefore, we categorize the determinants of subjective age into biological, psychological, and social factors.

Biological factors include various health indicators. Physical decline and cognitive impairments are key signs of biological aging; thus, worsening health is associated with an increase in subjective age among older adults. Subjective health, an individual's perception of their health status, reflects their actual health levels. Indicators such as self-rated health and health satisfaction are associated with a lower subjective age (8, 9). Several studies have used the concept of subjective health to measure subjective aging (29, 30), which may introduce confounding biases. Consequently, related research has used objective health indicators such as activities of daily living, bodily pain, chronic diseases, BMI, depressive symptoms, and cognitive abilities to confirm that better health status is associated with a lower subjective age (8, 9). Other research has explored the relationship between biomarkers and subjective age, finding that a balanced body composition and better respiratory and muscle system function also contribute to a lower subjective age (10).

Psychological factors include psychological resources and personality traits. The stress process model suggests that aging is accompanied by negative events, such as mental decline, changes in family structure, and the loss of social relationships, which increase stress and lead to negative aging perceptions among older adults (11). Psychological resources, such as positive emotions and self-efficacy, can enhance coping abilities, mitigate the consequences of stress, and reduce subjective age. For instance, positive emotions can broaden cognitive patterns, strengthen psychological resilience, and foster a positive age identity in older adults (11). Self-efficacy—an individual's belief in their ability to manage their life and environment and achieve their goals—encourages older adults to actively engage with society and mobilize available resources for

self-regulation, reducing subjective age (12, 13). Personality traits are related to stress coping strategies and can influence vulnerability to stress and its consequences. Specifically, those with higher openness to experience and extraversion tend to adopt cognitive patterns similar to those of younger individuals, typically reporting a lower subjective age. Those with higher conscientiousness are more likely to expend extra effort when facing challenges to achieve their goals, helping to buffer against the effects of stress and delay subjective aging. Agreeableness promotes social integration, prevents feelings of loneliness, and reduces subjective age. Emotional stability can reduce perceived stress, negative aging experiences, and subjective age (14).

Social factors include socio-economic status and social capital. Continuity theory suggests that withdrawal from socio-economic activities in old age leads to role loss and a decline in status, making it difficult for subjective age to align with the middle-aged years. Socio-economic status can offset the resource losses and status decline brought about by aging and also influence the timing of role transitions. Privileged groups tend to marry, have children, and retire later, thus avoiding the "downward extension of adultlike experience" and delaying subjective aging (15). Consequently, education and income are associated with reduced subjective age, while retirement is associated with increased subjective age (5, 16). Social capital can mitigate the negative consequences of stress events (29) and compensate for the role losses associated with aging, ensuring continuity with middle-aged roles and maintaining a younger subjective age (17). Components of social capital, such as social networks, social participation, and social support, are associated with a lower subjective age (16, 17).

2.2 Main effects of internet use on subjective age of older adults

In the context of population aging, studies on the digital divide among older adults have explored the determinants of their access to the Internet, use pattern, and digital skills (18, 19), and have analyzed the impact of Internet use on their health status, quality of life, and self-concept (20–24). However, subjective age, as a component of self-concept, has received relatively little attention. Therefore, drawing on symbolic interactionism, social comparison theory, and social constructionism, this study explores the main effects of Internet use on older adults' subjective age from the perspective of self-concept.

Symbolic interactionism posits that individuals construct their self-concept through interactions with others, which are based on symbols that carry shared meanings (31). Individuals convey symbols through their actions, which others then assign meaning to and provide feedback on, ultimately leading individuals to internalize others' perceptions and form their own self-concept (3). Regarding subjective age, individuals can alter others' perceptions by adopting behaviors typically associated with youth, thereby lowering their subjective age. The age distribution of Internet users has consistently skewed younger, with older adults often labeled "digital refugees." This has transformed Internet use into a symbol with age-related connotations—as a typical activity for younger people, it has become a marker of youth identity (24). Thus, older adults' Internet use can serve as a means to express age identity and

establish a distinction between themselves and older adults who do not use the Internet, influencing others' perceptions and fostering a younger subjective age (24).

Social comparison theory suggests that an individual's self-concept is shaped by comparisons with others (32). Individuals form differentiated self-concepts by comparing themselves to others along specific dimensions. Perceiving others as superior leads to upward social comparisons, resulting in a negative self-concept. Conversely, downward social comparisons, perceiving others as inferior, foster a positive self-concept (15). Driven by self-protective motivations, older adults tend to engage in downward social comparisons, devaluing those with more visible signs of aging to elevate their own status, thereby forming a younger subjective age to counteract age-related stereotypes (33). However, the outcome of social comparisons depends on the availability of comparison targets—in the absence of inferior comparison targets, individuals may be forced to compare themselves with superior others, undermining the self-protective effect (32). The Internet increases the accessibility of information, expanding the pool of comparison targets, which may lead to more downward social comparisons and reduce subjective age. Additionally, the self-protective motivation of older adults can trigger motivated reasoning, leading them to interpret, distort, or ignore information strategically to manipulate social comparisons and improve their self-concept (32). Furthermore, the Internet's algorithmic recommendation systems synergize with these prior motivations, creating a "beneficial online echo chamber" (34) that provides more opportunities for downward social comparisons and further lowers subjective age.

Social constructionism posits that an individual's self-concept is shaped through public discourse construction (27). Mainstream public discourse views aging as a symbol of vulnerability, associating it with negative labels such as frailty and dependency. Individuals internalize these age-related stereotypes during their early life through literature and mass media; as they age, they associate these stereotypes with themselves, leading to self-directed ageism and increased subjective age (2). However, age-related stereotypes are not fixed. The decentralization and user-driven nature of the Internet have transformed information dissemination patterns, shifting from a top-down mass media model to a bottom-up self-media model, providing marginalized groups with opportunities for self-expression. By leveraging the Internet's information dissemination mechanisms, older adults can negotiate, resist, and reconstruct prevailing negative and static age-related stereotypes to foster a positive age identity. For instance, older adults can use online self-presentation to counteract the negative associations between aging and physical decline or diminished attractiveness. Additionally, they can share personal experiences to highlight the diversity of the aging process and publicly expose age discrimination to advocate for the establishment of an age-friendly society, transforming the public's negative perceptions of aging and fostering a younger subjective age (27).

Empirical research examining the impact of Internet use on older adults' subjective age is limited. However, several studies focusing on other subjective aging indicators provide evidence for the above theories. Specifically, Cody et al. (25) found that Internet training improved older adults' attitudes toward aging. McGrath (26) noted that middle-aged and older adults' self-presentation on Instagram increased their visibility, helping them integrate into mainstream culture and resist ageism. Ng and Indran (27) found that older TikTok users were actively engaged in discussions about growing older, with

the potential to reconstruct negative perceptions of aging. Based on this, the following hypothesis is proposed:

> *H*1: Internet use can reduce the subjective age of older adults.

2.3 Mechanism of internet use on subjective age of older adults

The bio-psycho-social model suggests that individuals form their subjective age based on biological, psychological, and social cues. As a novel information dissemination mechanism, the Internet can generate a series of biological, psychological, and social effects, influencing the input into the subjective age formation system and, consequently, its outcomes. Based on this model and relevant empirical research, the present study proposes that Internet use lowers the subjective age of older adults by improving health status, self-efficacy, and social capital.

2.3.1 Health status

Older adults' health status can be improved through health-related Internet use (HRIU), online social interactions, and cognitive stimulation. HRIU includes activities such as online consultations, medication services, communication with fellow patients, and health information-seeking (35). Online consultations and medication services reduce the cost of offline medical visits and increase accessibility to healthcare resources, thus improving health (20); communication with fellow patients fosters social connections, helping to alleviate psychological distress caused by illness (36); and health information-seeking improves health literacy, promoting healthy behaviors and enhancing physical and mental health (35). Online social interaction involves instant messaging tools, online forums, and social media. In the context of family downsizing, online social interaction overcomes the limitations of time and space, strengthens social ties with family and friends, and alleviates loneliness and depression (21). Cognitive stimulation refers to the role of Internet use in exercising visual analysis, executive functions, and memory, thus improving cognitive functions and reducing the risk of dementia (22). As health status is a key indicator of biological aging, improving health can reduce subjective age. Thus, we propose the following hypothesis:

> *H*2a: Internet use lowers the subjective age of older adults by improving health status.

2.3.2 Self-efficacy

According to the concept of psychological empowerment (37), Internet use can improve older adults' self-efficacy through several channel outcomes, including enactive attainment, vicarious experience, verbal persuasion, and emotional arousal state. First, Internet applications such as health management, online financial planning, remote education, and government services can improve older adults' ability to live independently, helping them achieve their goals in the face of physical, psychological, and social barriers, thereby accumulating enactive mastery experiences and enhancing self-efficacy (21, 23). Second, the Internet's information-seeking and social networking functions help older adults observe the others' behaviors, which can promote social learning, accumulate vicarious experiences,

and further enhance self-efficacy (36). Third, verbal persuasion includes advice, encouragement, and praise from others. The Internet can enhance social connections for older adults, providing them with advice and encouragement when facing difficulties, receiving praise after achieving goals, and gaining positive feedback through "likes," "shares," and other novel social media symbols, thereby improving self-efficacy (36). Last, the entertainment features of the Internet can alleviate fatigue, reduce anxiety, and improve emotional state, thus promoting self-efficacy (23). As a crucial psychological resource, self-efficacy can improve older adults' coping abilities, reduce the negative consequences of stress, and lower the subjective age. Thus, we propose the following hypothesis:

> *H*2b: Internet use lowers the subjective age of older adults by improving self-efficacy.

2.3.3 Social capital

Internet use can improve older adults' social capital through mechanisms such as the maintenance and expansion of social networks, the enhancement and spillover of social participation, and improvements in the quantity and quality of social support. First, the immediacy of the Internet reduces the cost of contact with others, helping to maintain existing social networks and facilitating the formation of new networks based on geographic or occupational connections, thereby expanding and constructing unfamiliar and more diverse social networks (38). Second, the Internet has introduced new communication modes, such as live streaming, video calls, and online sharing, which enhance online social interactions and improve intimate relationships (24). Additionally, because the rate of Internet addiction among older adults is low (21), online social interactions can produce offline spillover effects, further enriching social participation (24). Third, the Internet's anonymity and de-personalized communication features can produce a disinhibition effect, thus increasing self-disclosure of painful and embarrassing experiences, enhancing trust, and leading to a greater quantity and quality of social support (36, 39). As components of social capital, social networks, social participation, and social support help mitigate the status decline and role loss caused by aging, thereby reducing subjective age. Thus, we propose the following hypothesis:

> *H*2c: Internet use lowers the subjective age of older adults by improving social capital.

3 Methodology

3.1 Data

The Chinese Longitudinal Aging Social Survey (CLASS) is a nationally representative survey conducted by the National Survey Research Center at Renmin University of China. To ensure the relevance and the availability of key variables, the present study used the CLASS 2020 data for empirical analysis. CLASS 2020 covers 28 provincial-level administrative regions across China, with respondents aged 60 and above. The survey includes data on sociodemographic characteristics, health status, self-efficacy, social capital, and subjective age, making it suitable for this study. To enhance statistical power, we excluded samples with missing values in the dependent variable, independent variable,

and control variables, while retaining samples with missing values in the mechanism variables. The sample size for the main effect analysis is 9,531, whereas the sample size for certain mechanism tests is smaller. Potential attrition bias arising from missing values in mechanism variables will be addressed using the inverse probability of attrition weighting (IPAW) method in subsequent analyses.

3.2 Variables

3.2.1 Dependent variable

The dependent variable was subjective age. Following the approach used in previous literature (5), subjective age was measured as the discrepancy between felt age and chronological age. Felt age was assessed using the following question: "How old do you feel most of the time?" A larger discrepancy between felt age and chronological age indicates a higher subjective age.

3.2.2 Independent variable

The independent variable was Internet use, measured as follows: never = 0, a few times per year = 1, at least once a month = 2, at least once a week = 3, and daily = 4.

3.2.3 Mechanism variables

The mechanism variables included health status, self-efficacy, and social capital.

First, given that using subjective health to explain subjective age may introduce confounding biases, this study used objective health indicators, including activities of daily living (ADL), instrumental activities of daily living (IADL), chronic diseases, depressive symptoms, and cognitive ability. ADL was measured using the Katz Index, which includes six activities: feeding, dressing, bathing, toileting, continence, and transferring. The total number of activities that respondents could independently complete was used as the ADL index. IADL was measured using the Lawton Scale, which includes eight activities: using the telephone, taking medication, going out, using public transportation, shopping, handling finances, preparing food, and housekeeping. The total number of activities that respondents could independently complete was used as the IADL index. Chronic diseases were measured by the number of chronic diseases a respondent had been diagnosed with by doctors. Depressive symptoms were measured using the Center for Epidemiologic Studies Depression (CES-D) Scale, which includes nine emotions: sadness, loneliness, sorrow, disappointment, loss of appetite, sleep disturbances, worthlessness, emptiness, and loss of interest. Respondents were asked to rate these emotions on a three-point scale: never = 1, sometimes = 2, and often = 3. The total score was used as the depressive symptom index. Cognitive ability was measured using the Minimum Mental State Examination (MMSE) scale, which includes 16 items, each worth 1 point, with the total score used as the cognitive ability index.

Second, based on the approach by Ding and Wang (40), self-efficacy was measured using three items: "As I get older, I find it harder to make new friends," "Older people are better at handling life problems," and "I still feel like a useful person to society." Responses range from "strongly disagree" to "strongly agree" on a five-point scale. After reverse coding the first item, the average score was used as the self-efficacy index.

Finally, the available social capital indicators in the CLASS 2020 data include social participation and social networks. Specifically, the measure of social participation was based on the frequency with which respondents engage in six activities: religious activities, training courses, watching television, singing, board games, and square dancing. The response options are coded as follows: not participating = 0, a few times a year = 1, at least once a month = 2, at least once a week = 3, and almost daily = 4. The average score was used as the social participation index. Social networks were measured using the Lubben Social Network Scale, which includes six items that focus on the number of close friends or relatives the respondent has daily contact and discusses personal matters with, and receives assistance from. Responses are scored from "none" to "9 or more" on a six-point scale, with the average score used as the social network index.

3.2.4 Control variables

This study controlled for the following variables: gender (female = 0, male = 1), age (chronological age), ethnicity (Han = 0, minority = 1), religious belief (no = 0, yes = 1), hukou type (agricultural hukou = 0, non-agricultural hukou = 1), marital status (single = 0, married = 1), political status (non-CPC members = 0, CPC members = 1), education (years of education), retirement status (no = 0, yes = 1), pension (no = 0, yes = 1), economic condition (poorer = 1, average = 2, better = 3), number of houses, family size, number of children, and living arrangement (live without children = 0, live with children = 1). To account for unobservable macroeconomic confounders, province fixed effects were included in the analysis. Descriptive statistics are presented in Table 1. Respondents' characteristics are described by means and standard deviations (SD) for numerical variables and numbers and percentages for categorical variables.

3.3 Model specification

3.3.1 Main effect models

This study employed the following linear regression model to examine the main effect of Internet use on the subjective age of older adults, as shown in Equation (1):

$$Sub\_age_i = \alpha_0 + \alpha_1 Internet_i + \alpha_2 X_i + Province_i + \varepsilon_i, \quad (1)$$

where Sub_age_i denotes subjective age, $Internet_i$ represents Internet use, X_i is a vector of control variables, $Province_i$ represents province fixed effects, and ε_i is the error term. The coefficients α_0, α_1, and α_2 are parameters to be estimated. To address potential heteroskedasticity, robust standard errors were employed in the estimation.

The above regression model may, however, suffer from endogeneity. Specifically, unobserved factors such as personality traits may influence both subjective age (14) and Internet use (41), resulting in omitted variable bias. Furthermore, as Internet use is a typical behavior of younger individuals, a lower subjective age increases the likelihood that older adults will use the Internet (30), leading to simultaneity bias. To address the potential endogeneity, we followed the approach of existing literature (42–44) and used household broadband access as an instrumental variable, constructing the following two-stage least squares (2SLS) model. The first-stage is specified as Equation (2) and the second-stage is specified as Equation (3):

$$Internet_i = \beta_0 + \beta_1 Broadband_i + \beta_2 X_i + Province_i + \zeta_i \quad (2)$$

TABLE 1 Descriptive statistics.

Variables	N	Mean (SD) / %
Subjective age	9,531	−3.069 (6.460)
Internet use	9,531	1.065 (1.699)
ADL	9,531	5.692 (0.963)
IADL	9,531	7.340 (1.684)
Chronic diseases	9,531	1.639 (1.445)
Depressive symptoms	8,483	15.656 (3.291)
Cognitive ability	9,531	13.476 (3.061)
Self-efficacy	7,796	3.009 (0.710)
Social participation	9,531	0.835 (0.588)
Social networks	9,531	2.379 (0.844)
Gender		
Female	4,701	49.323%
Male	4,830	50.677%
Age	9,531	71.419 (6.566)
Ethnicity		
Han	9,014	94.576%
Minority	517	5.424%
Religious belief		
No	9,080	95.268%
Yes	451	4.732%
Hukou type		
Agricultural hukou	5,320	55.818%
Non-agricultural hukou	4,211	44.182%
Marital status		
Single	2,367	24.835%
Married	7,164	75.165%
Political status		
Non-CPC members	9,134	95.835%
CPC members	397	4.165%
Education	9,531	5.965 (4.116)
Retirement status		
No	5,373	56.374%
Yes	4,158	43.626%
Pension		
No	2,121	22.254%
Yes	7,410	77.746%
Economic condition	9,531	2.067 (0.533)
Number of houses	9,531	1.076 (0.400)
Family size	9,531	2.694 (1.308)
Number of children	9,531	2.364 (1.284)
Living arrangement		
Live without children	6,275	65.838%
Live with children	3,256	34.162%

$$Sub\_age_i = \gamma_0 + \gamma_1 \widehat{Internet_i} + \gamma_2 X_i + Province_i + \eta_i, \tag{3}$$

where $Broadband_i$ is the instrumental variable, and $\widehat{Internet_i}$ is the fitted value of Internet use obtained from the first-stage regression (Equation 2). Since household broadband access is a prerequisite for Internet use, it satisfies the strong first-stage condition. Additionally, broadband access is assumed to affect subjective age only indirectly through its influence on Internet use among older adults, satisfying the exclusion restriction. Previous studies have also employed similar instrumental variables to address the endogeneity of Internet use. For example, Zhang and Li (42), using data from the 2017 Chinese General Social Survey (CGSS), employed household Internet connectivity as an instrumental variable to estimate the impact of Internet use on older adults' social networks. Ma et al. (43), based on data from the 2018 and 2020 China Health and Retirement Longitudinal Study (CHARLS), used broadband access as an instrumental variable to estimate the effect of Internet use on middle-aged and older adults' self-rated health. Zhang et al. (44), using survey data from four Chinese cities in 2019, employed Internet accessibility as an instrumental variable to estimate the impact of Internet use on the mental health of older adults. Taken together, these examples demonstrate the plausibility of using broadband access as an instrumental variable for Internet use in the present study. In the following empirical analysis, we further tested the validity of the instrumental variable through weak instrument tests and randomization inference (45). We also assessed the robustness of the 2SLS estimates using the union of confidence intervals (UCI) and the local-to-zero (LTZ) methods. Therefore, γ_1 provides an unbiased estimate of the causal effect of Internet use on subjective age of older adults.

3.3.2 Mechanism analysis models

To examine the mechanisms by which Internet use impacts the subjective age of older adults, we followed the approach of existing studies (46, 47) and constructed the following stepwise regression models. The model for the mechanism variable is presented in Equation (4), while the model for the dependent variable incorporating the mechanism variable is specified in Equation (5):

$$M_i = a_0 + a_1 \widehat{Internet_i} + a_2 X_i + Province_i + \mu_i \tag{4}$$

$$Sub\_age_i = b_0 + b_1 \widehat{Internet_i} + b_2 M_i + b_3 X_i + Province_i + \xi_i, \tag{5}$$

where M_i represents the mechanism variables, including health status, self-efficacy, and social capital; $\widehat{Internet_i}$ is the fitted value of Internet use from Equation 2; coefficient a_1 captures the effect of Internet use on the mechanism variables; b_1 represents the direct effect of Internet use on subjective age; and b_2 measures the effect of the mechanism variables on subjective age. If both a_1 and b_2 are statistically significant and b_1 is smaller than the Internet use coefficient in the main effect model, this provides evidence that Internet use influences subjective age through the specified mechanism variable.

It is worth noting that due to missing values for the depressive symptoms and self-efficacy measures, the sample size for their corresponding mechanism analysis models is smaller than that of the main effect model, which may introduce attrition bias. To address this issue, we adopted the IPAW method, following Falisse et al.'s (48) approach, to adjust for the imbalances between the full and attrition samples. Specifically, we estimated a probit model to predict the denominator of the weight using the independent variables, control variables, and province dummies, and then excluded covariates that are significantly correlated with the probability of attrition to predict the numerator of the weight. This ensures the representativeness of the mechanism analysis results and enhances their comparability with the main effect analysis.

3.3.3 Further analysis models

Given the heterogeneity in Internet use patterns among older adults, it is necessary to explore how different patterns affect subjective age. To this end, we first constructed a latent class model to classify Internet use patterns, using 11 types of online activities as observed indicators: voice and video chatting, text chatting, online shopping, reading news, browsing information, playing music and video, playing games, transportation and travel, health management, financial management, and learning and training. The optimal number of latent classes was determined using multiple criteria, including the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-size adjusted BIC (SSABIC), entropy, and the p-values from the Lo–Mendell–Rubin likelihood ratio test (LMR) and the bootstrap likelihood ratio test (BLRT). This classification yields the Internet use pattern variable.

We then estimated the effect of Internet use patterns on the subjective age of older adults by employing a multinomial treatment effect model (MTEM), using non-Internet users as the reference group and broadband access as an instrumental variable. The MTEM is estimated via a two-stage regression procedure. In the first stage, we estimated a mixed multinomial logit model to assess the determinants of Internet use patterns, as shown in Equation (6):

$$Pattern_{ij}^* = c_0 + c_1 Z_i + c_2 l_{ij} + c_3 Broadband_i + \varphi_{ij} \tag{6}$$

where subscript j refers to a specific Internet use pattern, $Pattern_{ij}^*$ denotes the latent Internet use patterns, Z_i includes control variables and province dummies, l_{ij} represents latent variables influencing Internet use patterns, and $Broadband_i$ is the instrumental variable.

In the second stage, we estimated the impact of Internet use patterns on subjective age using linear regression model, as shown in Equation (7):

$$E\left(Sub\_age_i \mid Pattern_i, Z_i, l_i\right) = d_0 + d_1 Z_i + \sum_j d_j Pattern_{ij} + \sum_j d_j l_{ij}. \tag{7}$$

Here, the latent variable l_{ij}, assumed to follow a standard normal distribution, captures unobserved heterogeneity that may lead to endogeneity. The two-stage model was jointly estimated using maximum simulated likelihood, yielding consistent estimates of the effects of Internet use patterns on subjective age of older adults.

4 Results

4.1 Baseline regression analysis

Table 2 presents the baseline regression analysis. Column 1 includes the core explanatory variable, while columns 2–4 successively incorporate individual, family, and provincial level control variables. The full model in column 4 shows that Internet use significantly

TABLE 2 Baseline regression analysis.

Variables	(1)	(2)	(3)	(4)
Internet use	−0.094*** (0.036)	−0.339*** (0.042)	−0.365*** (0.042)	−0.411*** (0.042)
Gender		0.021 (0.133)	0.020 (0.133)	0.089 (0.131)
Age		−0.237*** (0.013)	−0.230*** (0.013)	−0.249*** (0.013)
Ethnicity		1.165*** (0.231)	1.099*** (0.232)	−0.008 (0.245)
Religious belief		−2.266*** (0.399)	−2.277*** (0.395)	−0.634* (0.373)
Hukou type		−0.273 (0.200)	−0.509** (0.204)	−0.341* (0.201)
Marital status		−0.545*** (0.158)	−0.727*** (0.192)	−0.416** (0.189)
Political status		−1.219*** (0.366)	−1.345*** (0.367)	−0.989*** (0.367)
Education		−0.058*** (0.019)	−0.063*** (0.019)	−0.028 (0.019)
Retirement status		0.116 (0.211)	0.068 (0.211)	−0.012 (0.219)
Pension		0.457** (0.181)	0.435** (0.181)	−0.265 (0.199)
Economic condition		−0.109 (0.130)	−0.121 (0.129)	0.068 (0.125)
Number of houses			0.841*** (0.181)	0.284 (0.183)
Family size			0.374*** (0.099)	0.171* (0.102)
Number of children			−0.169*** (0.062)	0.001 (0.063)
Living arrangement			−0.231 (0.294)	0.166 (0.296)
Constant	−2.969*** (0.082)	15.029*** (0.993)	13.404*** (1.008)	13.624*** (1.032)
Province fixed effects	No	No	No	Yes
N	9,531	9,531	9,531	9,531

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; Robust standard errors in parentheses.

negatively affects subjective age, supporting hypothesis H1. Regarding the control variables, age significantly negatively affects subjective age. Due to the internalization of aging stereotypes as chronological age increases, felt age will become younger than chronological age, driven by self-protection motivations, leading to a decrease in subjective age (5). Religious belief significantly negatively affects subjective age. Religion helps older adults form positive life attitudes, encourages them to adopt a regular lifestyle, and promotes participation in religious activities, improving physical and mental health, enhancing social participation, and reducing subjective age. Hukou type significantly negatively affects subjective age. The segmentation of Hukou exacerbates the economic vulnerability of rural older adults and increases their subjective age. Marital status significantly negatively affects subjective age. Marriage relationships compensate for the loss of social relationships caused by aging, increase social support, enrich psychological resources, and reduce subjective age. Political status significantly negatively affects subjective age. CPC membership, as a form of political capital, can increase income, expand social networks, and lower subjective age. Family size significantly positively affects subjective age. A larger family size may lead older adults to focus on household activities, crowd out social participation, and potentially provoke family conflicts, increasing stress levels, thus raising subjective age. The effects of the remaining control variables are non-significant.

4.2 Endogeneity test

To address the endogeneity issue in the baseline regression model, this study followed the approach of existing literature (42–44),

TABLE 3 Endogeneity test.

Variables	Reduced-form	First-stage	Second-stage
Internet use			−0.204** (0.093)
Instrumental variable	−0.329** (0.150)	1.611*** (0.031)	
Control variables	Yes		
Province fixed effects	Yes		
N	9,531		
Kleibergen-Paap rk Wald F statistic	2678.121		
Anderson-Rubin Wald test	4.820**		
DWH test	5.963**		
UCI test	[−0.930, −0.022]		
LTZ test	−0.476*** (0.160)		

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; Robust standard errors in parentheses.

employing household broadband access as an instrumental variable and constructing a two-stage least squares (2SLS) model to estimate the effect of Internet use on older adults' subjective age. The first-stage regression results presented in Table 3 show that the instrumental variable significantly positively affects Internet use. The Kleibergen–Paap Wald rk F-statistic is 2678.121, which is greater than the critical value of 16.38 at the 10% significance level. The Anderson–Rubin
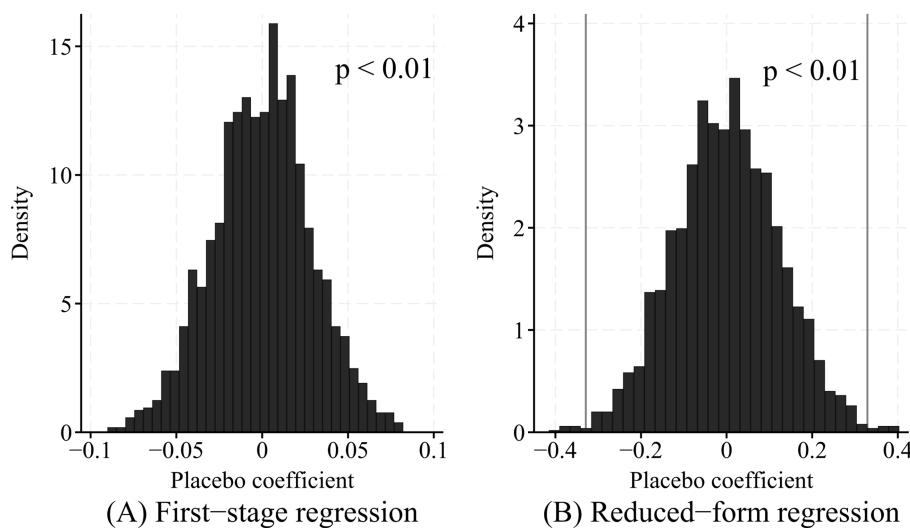
FIGURE 1
Randomization inference. The panels plot histograms of the placebo coefficients of instrumental variable. Panel **(A)** examine the first-stage placebo effect of instrumental variable on Internet use. Panel **(B)** examine the reduced-form placebo effect of instrumental variable on subjective age. The *p*-value reflects the share of placebo coefficients with absolute values exceeding that of the actual coefficient, i.e., the portions beyond the gray vertical lines. Given that the first-stage placebo coefficient is substantially smaller than the actual coefficient, the gray vertical line is omitted in Panel **(A)**.

Wald test results are significant, rejecting the null hypothesis that the sum of the regression coefficients of the endogenous variables equals zero, indicating no weak instrument problem. The second-stage regression results presented in Table 3 show that Internet use significantly negatively affects subjective age, confirming that the baseline findings still hold after ruling out endogeneity. The Durbin–Wu–Hausman (DWH) test results are also significant, indicating that Internet use is an endogenous variable and that the baseline regression analysis results suffer from downward bias, while the 2SLS results provide unbiased estimates. The instrumental variable regression results are presented in the following analysis.

Since the number of instrumental variables equals the number of endogenous variables, an overidentification test cannot be conducted. Following the approach of Chen et al. (45), this study employed a randomization inference method to assess the exclusion restriction of the instrumental variable. Specifically, placebo values for the instrumental variable were randomly generated, and their effects on Internet use (i.e., the first-stage regression) and subjective age (i.e., the reduced-form regression) were estimated. This procedure was repeated 2,000 times, yielding 2,000 placebo coefficients for each regression. Figure 1 presents histograms of the placebo estimates from the first-stage and reduced-form regressions. The results indicate that the placebo instrument has much less power to predict both Internet use and subjective age than the actual instrument, with the majority of placebo coefficients being close to zero. Evaluated by the *p*-value, fewer than 1% of the placebo coefficients have an absolute value larger than that of the actual coefficient, in both the first-stage and reduced-form regressions. These findings suggest that the instrumental variable is unlikely to affect subjective age through channels other than Internet use.

To further assess the robustness of the 2SLS estimates, this study used the UCI approach and the LTZ to test the sensitivity of the 2SLS results when the instruments are plausibly exogenous. The UCI test

shows that the 95% confidence interval for the Internet use coefficient is [−0.930, −0.022], which does not include zero. The LTZ test reveals that the Internet use coefficient is significantly negative. Therefore, the estimated results remain robust even when relaxing the exclusion restriction of the instrumental variable.

4.3 Robustness checks

4.3.1 Substitution of dependent variable

In the previous analysis, the dependent variable was measured as the discrepancy between felt age and chronological age. Here, following relevant literature (1, 5, 16), the dependent variable was replaced with felt age (SA_1), the ratio of the discrepancy between felt age and chronological age to chronological age (SA_2), and whether felt age is greater than or equal to chronological age (SA_3). The 2SLS and IV-Probit models were used for regression. Panel A of Table 4 shows that Internet use significantly negatively affects all different subjective age indicators, validating the robustness of the previous findings.

4.3.2 Winsorization of dependent variable

To avoid the impact of extreme values of the dependent variable on the regression results, subjective age was winsorized at the 0.5, 1, and 5% levels from both tails, followed by a 2SLS regression. Panel B of Table 4 shows that Internet use still significantly negatively affects subjective age, confirming the robustness of the previous findings.

4.3.3 Correction for self-selection bias

The previous analysis constructed the independent variable based on older adults' Internet use frequency. However, there may be systematic differences between Internet users and non-users that could also be related to subjective age, leading to self-selection bias. To address this, Internet use was converted into a binary variable

TABLE 4 Robustness checks.

Methods	Results	Control variables	Province fixed effects	N
Panel A. Substitution of Dependent Variable				
SA$_1$, 2SLS	−0.204** (0.093)	Yes	Yes	9,531
SA$_2$, 2SLS	−0.003** (0.001)	Yes	Yes	9,531
SA$_3$, IV-Probit	−0.125*** (0.020)	Yes	Yes	9,531
Panel B. Winsorization of Dependent Variable				
Winsorized at 0.5% levels	−0.181** (0.089)	Yes	Yes	9,531
Winsorized at 1% levels	−0.174** (0.087)	Yes	Yes	9,531
Winsorized at 5% levels	−0.151** (0.072)	Yes	Yes	9,531
Panel C. Correction for Self-Selection Bias				
PSM, Nearest-neighbor matching	−1.115*** (0.288)	Yes	Yes	9,479
PSM, Radius matching	−1.476*** (0.251)	Yes	Yes	9,479
PSM, Kernel matching	−1.473*** (0.240)	Yes	Yes	9,479
IPW	−1.477*** (0.188)	Yes	Yes	9,531
ESR	−0.978*** (0.037)	Yes	Yes	9,531
Panel D. Boundary Analysis				
Test 1	3.985	Yes	Yes	9,531
Test 2	−0.562*** (0.054)	Yes	Yes	9,531

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$; Robust standard errors in parentheses.

(non-users = 0, users = 1), and methods including propensity score matching (PSM), inverse probability weighting (IPW), and endogenous switching regression (ESR) were used to estimate the average treatment effect on the treated (ATT). Specifically, the PSM method was used to estimate the propensity scores of Internet use based on observed covariates and employed nearest-neighbor matching, radius matching, and kernel matching techniques to match Internet users with non-users who had similar propensity scores, thereby estimating the ATT. The IPW method was used to calculate weights for Internet users and non-users based on their propensity scores to balance the characteristics between them and estimate the ATT through weighted regression analysis. For the ESR method, household broadband access was used as an instrumental variable, and maximum likelihood estimation was employed to predict the counterfactual values of subjective age for both groups, thus enabling the estimation of ATT. Among these, PSM and IPW can correct for self-selection bias caused by observable factors; however, the former may exclude non-overlapping samples, while the latter does not lead to sample loss. ESR can overcome self-selection bias caused by both observable and unobservable factors. Panel C of Table 4 shows that the ATT obtained by different methods is significantly negative. After correcting for self-selection bias, the above conclusion still holds.

4.3.4 Boundary analysis

The previous analysis may be affected by unobservable factors that influence Internet use and subjective age simultaneously. Although the instrumental variable method can rule out this bias, we further assessed the impact on the estimation results using the boundary analysis approach. Boundary analysis is used to assess the severity of omitted variable bias by examining the stability of regression coefficients. This method requires two key pieces of information: (1) R_{max}, which represents the maximum R^2 obtained from a hypothetical regression including both observed and unobserved variables, and (2) δ, which represents the explanatory power of unobserved variables relative to observed factors. Boundary analysis can be conducted in two ways: by calculating the value of δ required to reduce the treatment effect to zero given a specified R_{max} (if $|\delta| > 1$, the test is considered passed); and by calculating the treatment effect under specified values of R_{max} and δ (if the effect remains significantly negative, the test is considered passed). Following the recommendations of Oster (49), this study set R_{max} to 1.3 times the R^2 from the baseline regression and assumed $\delta = 1$, implying that the impact of unobservable variables equals that of the observed factors. Panel D of Table 4 shows that the δ from the first test is −3.985, with $|\delta| > 1$, and the treatment effect obtained from the second test is significantly negative. Therefore, even in the presence of unobservable omitted variables, the baseline regression results remain valid.

4.4 Mechanism analysis

The above analyses suggest that Internet use can significantly reduce the subjective age of older adults. To shed light on these results, we attempted to test the potential mechanisms, guided by our theoretical framework. Specifically, we explored the set of possible channel outcomes: health status, self-efficacy, and social capital.

4.4.1 Health status

Figures 2A–E indicate that Internet use significantly negatively affects chronic diseases and depressive symptoms, significantly
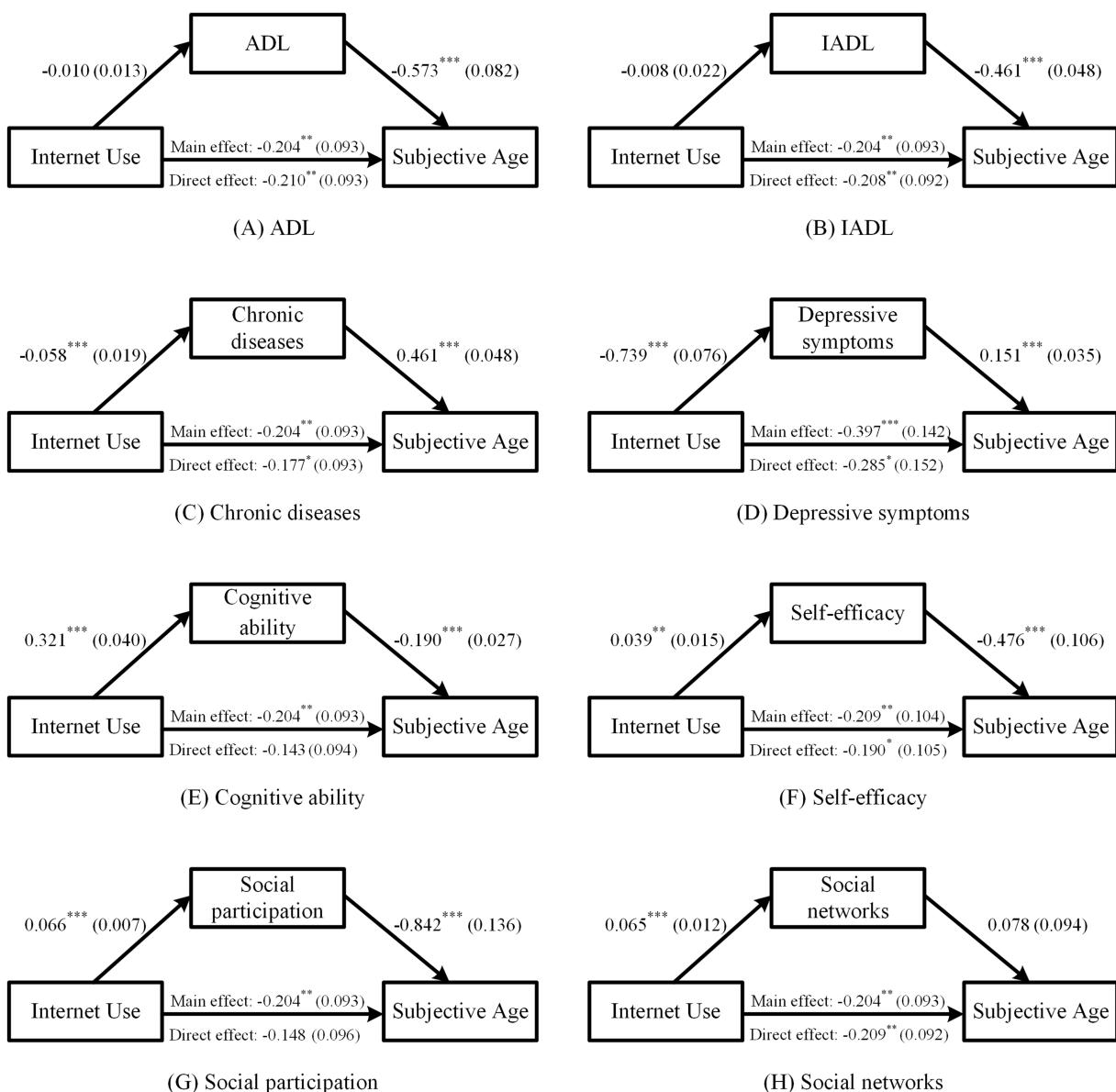
FIGURE 2
Mechanism analysis. Panels **(A)** to **(H)** present the mechanism analysis results for the following variables, respectively: ADL, IADL, chronic diseases, depressive symptoms, cognitive ability, self-efficacy, social participation, and social networks. The panels plot the results of the mechanism analysis for different mechanism variables, including the effect of Internet use on the mechanism variables, the effect of the mechanism variables on subjective age, and both the main and direct effects of Internet use on subjective age. Since the mechanism analysis models for depressive symptoms and self-efficacy used the IPAW method to correct for attrition bias, the main effect coefficients in Panels **(D)** and **(F)** differ from those in Panels **(A)**−**(C)**, **(E)**, **(G)**, and **(H)**.

positively affects cognitive ability, but has no significant effect on ADL and IADL. A possible explanation for this is that Internet use primarily improves older adults' health status by facilitating access to health information and medical services, enhancing social interaction, and providing cognitive stimulation. However, impairments in ADL and IADL are often the result of biological aging and accidental injuries, which are typically irreversible and difficult to recover from in the short term. Given that we rely on cross-sectional data with a limited observation window, Internet use may not have an immediate mitigating impact on functional impairments among older adults, resulting in non-significant effects on ADL and IADL. When chronic diseases, depressive symptoms, and cognitive ability are included in the model, the effect of Internet

use on subjective age weakens. However, the effect of Internet use on subjective age remains unchanged when ADL and IADL are included. Therefore, Internet use can reduce subjective age by lowering the incidence of chronic diseases, alleviating depressive symptoms, and enhancing cognitive ability, supporting hypothesis H2a.

4.4.2 Self-efficacy

Figure 2F demonstrates that Internet use significantly positively affects self-efficacy. After including self-efficacy in the model, the effect of Internet use on subjective age weakens. Therefore, Internet use can reduce subjective age by enhancing self-efficacy, supporting hypothesis H2b.

TABLE 5 Heterogeneity analysis.

Subgroups	Internet use	Control variables	Province fixed effects	N
Panel A. Age Heterogeneous Effects				
Young-old group, ages 60 to 69 years	−0.360*** (0.108)	Yes	Yes	4,327
Old-old, ≥70 years	0.055 (0.172)	Yes	Yes	5,204
Panel B. Hukou Type Heterogeneous Effects				
Agricultural hukou	−0.103 (0.128)	Yes	Yes	5,320
Non-agricultural hukou	−0.255* (0.137)	Yes	Yes	4,211
Panel C. Economic Condition Heterogeneous Effects				
Poorer	−0.538 (0.336)	Yes	Yes	1,056
Average	−0.064 (0.106)	Yes	Yes	6,778
Better	−0.494** (0.221)	Yes	Yes	1,697

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$; Robust standard errors in parentheses.

4.4.3 Social capital

Figures 2G,H show that Internet use significantly positively affects social participation and social networks. When social participation is included in the model, the effect of Internet use on subjective age weakens. However, when social networks are included, the effect of Internet use on subjective age remains unchanged, while the effect of social networks on subjective age is non-significant. This may be because the measurement of social networks was based on the Lubben Social Network Scale, which evaluates the friends and relatives older adults engage in daily interactions and discuss personal matters with, and receive assistance from. Social support obtained through social networks may enhance resource endowment, compensate for role loss, and reduce subjective age. However, it could also increase dependence on others, exacerbate feelings of uselessness, and elevate subjective age. The overall impact of social networks on subjective age is therefore non-significant. To summarize, Internet use can reduce subjective age by promoting social participation, supporting hypothesis H2c.

4.5 Heterogeneity analysis

Older adults represent a highly heterogeneous group, and the impact of Internet use on their subjective age may vary depending on individual characteristics. Accordingly, we employed the instrumental variable methods to further explore heterogeneous treatment effects across older adults, specifically across age, hukou type, and economic conditions.

4.5.1 Age heterogeneous effects

Panel A of Table 5 shows that Internet use significantly negatively affects the subjective age of the young-old group, but has no significant effect on the old-old group. This may be because the young-old group has better health status and fewer barriers to Internet use, making them more likely to benefit from it. In contrast, the health decline of the old-old group reduces their ability to use the Internet, making it difficult to utilize its benefits. Furthermore, the old-old group is more likely to fall victim to online fraud, increasing financial pressure and preventing Internet use from reducing subjective age (36). Additionally, compared with the old-old group, the young-old group perceives the Internet as being more useful (20), which may create an

age-conditioned positive selection, making Internet use more effective in reducing their subjective age.

4.5.2 Hukou type heterogeneous effects

Panel B of Table 5 shows that Internet use significantly negatively affects the subjective age of older adults with non-agricultural hukou but has no significant effect on those with agricultural hukou. This may be due to the relatively underdeveloped digital infrastructure in rural areas, with lower household broadband coverage and fewer fixed computers. Rural older adults typically access the Internet via mobile networks and smartphones, which are slower than fiber-optic and cable networks. Additionally, smartphones have lower performance compared to fixed computers (50), which limits the effective use of the Internet by rural older adults, preventing Internet-induced reductions in their subjective age. In contrast, urban older adults have earlier access to the Internet, more experience, and better digital skills, allowing them to utilize the Internet effectively. Thus, Internet use is more beneficial in reducing the subjective age of older adults with non-agricultural hukou.

4.5.3 Economic condition heterogeneous effects

Panel C of Table 5 shows that Internet use significantly negatively affects the subjective age of older adults with better economic conditions, but has no significant effect on those living in poorer or average economic conditions. These results can be explained by three factors: internet access devices, network infrastructure, and online services. First, older adults with better economic conditions can afford larger and better-equipped devices, which enhances the effectiveness of their use. Second, wealthier older adults typically reside in areas with better network infrastructure and can afford the costs of home broadband and data plans, allowing them to access more extensive online content and improve the quality of their Internet use. Third, the increasing trend toward paid Internet content creates disparities in the quality of online services accessed by different economic groups. Those with better economic conditions can afford high-quality paid content, while those living in poverty or average economic conditions tend to access homogeneous free content, exacerbating inequalities in the effectiveness of Internet use. Consequently, Internet use is more effective in reducing the subjective age of older adults living in better economic conditions.

4.6 Further analysis

According to research on the digital divide, there are three types of gaps in Internet use across different groups. The first-level digital divide, also known as the access gap, refers to disparities among different groups in terms of access to the Internet. The second-level digital divide, referred to as the usage gap, pertains to differences in Internet use motivation, content engagement, and preferences among different groups. The third-level digital divide, termed the utility gap, represents inequalities in the consequences of Internet use across different groups (51). The previous sections explored the main and heterogeneous effects of Internet use on the subjective age of older adults from the perspectives of the access and utility gaps. Here, we present an analysis of the effects of different Internet use patterns on subjective age, based on the concept of the usage gap, thereby clarifying the complex impact of the digital divide.

Following the approach of Pantelaki et al. (52), we constructed a latent class model to classify Internet use patterns using 11 types of online activities as observable variables. Table 6 shows that the AIC and SSABIC decrease, while the BIC first decreases and then increases, suggesting that the 5- and 6-class models fit the data well. The entropy for both the 5- and 6-class models is around 0.7, indicating that the classification accuracy is acceptable. The BLRT test for the 6-class

model is significant at the 0.1% level, but the LMR test is only significant at the 1% level. In the 5-class model, all class proportions are above 10%, whereas in the 6-class model, the probability of class 1 is below 5%, indicating that the classification is too detailed and lacks sufficient discrimination (53). Therefore, the 5-class model was selected as the optimal model.

Table 7 displays the response probabilities of observable variables for the 5-class model. In class 1, the response probabilities of all activities are relatively high, and it is labeled "comprehensive users." In class 2, the response probabilities of online chatting, information browsing, and leisure entertainment are higher than those of other activities, and it is labeled "social-information-entertainment users." In class 3, the response probabilities of online chatting and news watching are higher than those of other activities, and it is labeled "social-news users." In class 4, the response probabilities of online chatting, news watching, and media playback are higher than those of other activities, and it is labeled "social-news-audiovisual users." In class 5, the response probability of online chatting is significantly higher than that of other activities, and it is labeled "social users."

Then, we took non-Internet users as the reference group and household broadband access as the instrumental variable to construct a multinomial treatment effect model (MTEM) to examine the impact of Internet use patterns on subjective age. Table 8 shows that the

TABLE 6 Latent class models.

Latent class	AIC	BIC	SSABIC	Entropy	LMR	BLRT	Class proportions
2	28579.169	28718.203	28645.122	0.773	<0.001	<0.001	26.491%/73.509%
3	28097.412	28308.985	28197.775	0.697	<0.001	<0.001	38.775%/49.519%/11.706%
4	27892.774	28176.887	28027.548	0.728	<0.001	<0.001	39.609%/21.745%/ 25.529%/13.117%
5	27801.055	28157.707	27970.239	0.693	<0.001	<0.001	12.989%/24.792%/ 18.249%/29.570%/14.400%
6	27734.399	28163.591	27937.994	0.731	0.006	<0.001	4.362%/36.979%/19.917%/ 10.295%/8.499%/19.949%

TABLE 7 Response probabilities of observable variables in 5-class model.

Variables	Class 1	Class 2	Class 3	Class 4	Class 5
	Comprehensive users	Social-information-entertainment users	Social-news users	Social-news-audiovisual users	Social users
Voice and video chatting	0.981	1	0.981	0.749	1
Text chatting	0.979	0.886	0.984	0.122	0.243
Online shopping	0.872	0.266	0.253	0.076	0
Reading news	0.897	0.753	0.760	0.587	0.093
Browsing information	0.904	0.694	0.349	0.254	0
Playing music and video	0.891	1	0.215	0.520	0.248
Playing games	0.359	0.472	0.126	0.102	0.006
Transportation and travel	0.898	0.089	0.096	0.056	0
Health management	0.443	0.022	0.026	0.012	0
Financial management	0.264	0.004	0.058	0.010	0
Learning and training	0.077	0.004	0.001	0.006	0.001

TABLE 8 Multinomial treatment effect model.

Variables	(1)
Comprehensive users	−3.007*** (0.442)
Social-information-entertainment users	−0.231 (0.720)
Social-news users	−2.051** (0.964)
Social-news-audiovisual users	−1.114*** (0.426)
Social users	−0.719 (0.495)
Control variables	Yes
Province fixed effects	Yes
N	9,531

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; Robust standard errors in parentheses.

comprehensive, social-news, and social-news-audiovisual users significantly negatively affect subjective age, while the effects of the social-information-entertainment and social users are not significant. The possible reasons for these results are as follows: First, compared to other users, comprehensive users cover the broadest range of online activities, with higher response probabilities for instrumental uses such as transportation, health management, and financial management. This helps enrich their digital experiences, provides convenience in daily life, and enhances health and economic capital, thereby reducing subjective age. Second, social-news users include social interactions and information acquisition activities, allowing them to access high-quality health information, strengthen social connections with family and friends, and accumulate vicarious experiences (36). This improves health and self-efficacy, leading to a reduction in subjective age. However, the response probability of instrumental activities in this class is lower, making its effect on subjective age weaker than that of the comprehensive users. Third, social-news-audiovisual users also involve social interactions and information acquisition, but their entertainment activities are more time-consuming, making it difficult to achieve capital enhancement, thereby offsetting the effects of social and informational activities and weakening the impact on subjective age compared to social-news users. Fourth, social-information-entertainment users have the highest response probability for entertainment activities, which can lead to unhealthy behaviors such as prolonged screen time or sedentary lifestyles, triggering Internet dependency and harming users' physical and mental health, making a reduction in subjective age less likely. Finally, social users involve the fewest digital activities, almost entirely excluding information and instrumental uses, preventing them from fully benefiting from the Internet and thus failing to reduce subjective age.

5 Conclusion and policy implications

Using data from the China Longitudinal Aging Social Survey in 2020, this study empirically examined the effects and mechanisms of Internet use on the subjective age of older adults. The findings are as follows: First, Internet use significantly reduces the subjective age of older adults. Second, Internet use lowers subjective age by improving health status, self-efficacy, and social capital. Third, the impact of Internet use on reducing subjective age is more significant among individuals aged 60–69 (i.e., the young-old individuals), those with non-agricultural

hukou, and those with better economic conditions. Fourth, the impact of different Internet use patterns on subjective age varies. Specifically, comprehensive, social-news, and social-news-audiovisual significantly reduce their subjective age, while social-information-entertainment and social users do not exhibit significant effects.

Based on the above findings, the following policy recommendations are proposed to maximize the benefits of Internet use in delaying subjective aging among older adults.

First, Internet adoption among older adults should be expanded. The government should encourage businesses to develop age-friendly smart devices, increase the availability of Internet-enabled technologies, and enhance access to these devices among older individuals. Telecommunications companies should be guided to offer discounted broadband plans for seniors, lower the costs of home broadband and mobile data, and ease the financial barriers that hinder Internet access. Furthermore, the government should establish standardized digital skills training programs tailored for older adults, utilizing community centers, senior universities, and older adults care institutions to deliver training sessions. These initiatives would help close the access gap and contribute to lowering the subjective age of older adults.

Second, the effectiveness of Internet use among older adults should be enhanced. The government should optimize the provision of "Internet + public services" to improve access to social security, healthcare, and cultural engagement. ICT solution providers should be encouraged to develop health management applications, including health monitoring, telemedicine, and remote caregiving, to reduce healthcare costs for older adults. Additionally, society should foster a culture of filial piety by promoting "online family" platforms that facilitate intergenerational interaction and support. These efforts would strengthen the impact of Internet use on improving health status, self-efficacy, and social capital, thereby reducing subjective age among older adults.

Third, the utility gap among older adults should be bridged. The government should increase research and development subsidies to incentivize businesses to integrate cutting-edge technology into affordable commercial devices. Simultaneously, efforts should be made to improve digital infrastructure, accelerate the deployment of fiber-optic broadband and mid-to-high-frequency 5G networks, and enhance network transmission speeds. Additionally, content filtering technology should be utilized to identify and remove low-quality information, optimizing the digital experience for older users. These measures would help alleviate constraints to Internet use among rural and economically disadvantaged older individuals, narrowing the utility gap and lowering subjective age.

Fourth, the Internet use patterns among older adults should be optimized. The government should encourage Internet companies to promote diverse digital engagement among older users through non-coercive nudging strategies. Public awareness campaigns should also be strengthened to reshape perceptions of Internet use among older adults, encouraging participation in social, informational, and instrumental activities while reducing an overemphasis on entertainment-related usage. These efforts would help close the usage gap and further decrease subjective aging among older Internet users.

Finally, digital addiction among older adults should be prevented. While Internet use can help reduce older adults' subjective age and enhance their quality of life, it may also lead to digital addiction, which

can harm physical and mental health, increase feelings of loneliness, and ultimately diminish their overall well-being (54, 55). Therefore, alongside efforts to promote Internet use among older adults, it is essential to implement measures that prevent digital addiction in order to fully realize the benefits of the Internet. Existing studies have shown that digital addiction among older adults is influenced by several factors, including digital literacy, platform manipulation, and social support (56–58). In addition, the risk of digital addiction is likely to rise as the cost of Internet access continues to decrease (56). In response, the government should develop digital literacy training programs tailored to older adults, aiming to raise awareness of the potential harms of digital addiction and to encourage the formation of healthy Internet usage habits. Simultaneously, ICT solution providers should take into account the risks of digital addiction among older users by enhancing the age-friendliness of digital platforms and designing anti-addiction systems to help prevent irrational or excessive Internet use. Additionally, family members should increase their everyday interactions with older adults to reduce excessive reliance on the Internet. This can mitigate the risk of digital addiction among older adults, enabling a more balanced approach that maximizes the positive impacts of Internet use while minimizing its adverse effects, thereby improving the overall quality of life for older adults in the digital age.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: http://class.ruc.edu.cn/.

Author contributions

ZK: Conceptualization, Formal analysis, Funding acquisition, Methodology, Software, Writing – original draft, Writing – review & editing. AZ: Conceptualization, Formal analysis, Methodology, Software, Supervision, Writing – original draft, Writing – review & editing.

Funding

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.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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. Stephan Y, Sutin AR, Terracciano A. Subjective age and mortality in three longitudinal samples. *Psychosom Med*. (2018) 80:659–64. doi: 10.1097/PSY.0000000000000613

2. Debreczeni FA, Bailey PE. A systematic review and meta-analysis of subjective age and the association with cognition, subjective well-being, and depression. *J Gerontol B Psychol Sci Soc Sci*. (2021) 76:471–82. doi: 10.1093/geronb/gbaa069

3. Diehl M, Wahl HW, Brothers A, Miche M. Subjective aging and awareness of aging. *Annu Rev Gerontol Geriatr*. (2015) 35:1–28. doi: 10.1891/0198-8794.35.1

4. Nilsson K. Conceptualisation of ageing in relation to factors of importance for extending working life—a review. *Scand J Public Health*. (2016) 44:490–505. doi: 10.1177/1403494816636265

5. Jiang WK, Sun JJ. Life course, health status and subjective age of the elderly. *Popul Dev*. (2021) 27:85–95.

6. Kotter-Grühn D, Neupert SD, Stephan Y. Feeling old today? Daily health, stressors, and affect explain day-to-day variability in subjective age. *Psychol Health*. (2015) 30:1470–85. doi: 10.1080/08870446.2015.1061130

7. Rubin DC, Berntsen D. People over forty feel 20% younger than their age: subjective age across the lifespan. *Psychon Bull Rev*. (2006) 13:776–80. doi: 10.3758/BF03193996

8. Hubley AM, Russell LB. Prediction of subjective age, desired age, and age satisfaction in older adults: do some health dimensions contribute more than others? *Int J Behav Dev*. (2009) 33:12–21. doi: 10.1177/0165025408099486

9. Stephan Y, Sutin AR, Terracciano A. Physical activity and subjective age across adulthood in four samples. *Eur J Ageing*. (2020) 17:469–76. doi: 10.1007/s10433-019-00537-7

10. Stephan Y, Sutin AR, Terracciano A. How old do you feel? The role of age discrimination and biological aging in subjective age. *PLoS One*. (2015) 10:e0119293. doi: 10.1371/journal.pone.0119293

11. Schafer MH, Shippee TP. Age identity in context: stress and the subjective side of aging. *Soc Psychol Q*. (2010) 73:245–64. doi: 10.1177/0190272510379751

12. Infurna FJ, Gerstorf D, Robertson S, Berg S, Zarit SH. The nature and cross-domain correlates of subjective age in the oldest old: evidence from the OCTO study. *Psychol Aging*. (2010) 25:470–6. doi: 10.1037/a0017979

13. Bergland A, Nicolaisen M, Thorsen K. Predictors of subjective age in people aged 40–79 years: a five-year follow-up study. *Aging Ment Health*. (2014) 18:653–61. doi: 10.1080/13607863.2013.869545

14. Stephan Y, Sutin AR, Kornadt A, Canada B, Terracciano A. Personality and subjective age: evidence from six samples. *Psychol Aging*. (2022) 37:401–12. doi: 10.1037/pag0000678

15. Barrett AE. Socioeconomic status and age identity: the role of dimensions of health in the subjective construction of age. *J Gerontol B Psychol Sci Soc Sci*. (2003) 58:S101–9. doi: 10.1093/geronb/58.2.s101

16. Zhao MH, Yang F. Differences in the subjective age of Chinese older adults and its determinants. *Popul J*. (2020) 42:41–53. doi: 10.16405/j.cnki.1004-129X.2020.02.004

17. Rashid A, Azizah M, Rohana S. The attitudes to ageing and the influence of social support on it. *Br J Med Med Res*. (2014) 4:5462–73. doi: 10.9734/BJMMR/2014/10023

18. Hunsaker A, Hargittai E. A review of internet use among older adults. *New Media Soc*. (2018) 20:3937–54. doi: 10.1177/1461444818787348

19. Hargittai E, Piper AM, Morris MR. From internet access to internet skills: digital inequality among older adults. *Univ Access Inf Soc*. (2019) 18:881–90. doi: 10.1007/s10209-018-0617-5

20. Zhu Y, Zhou Y, Long C, Yi C. The relationship between internet use and health among older adults in China: the mediating role of social capital. *Health*. (2021) 9:559. doi: 10.3390/healthcare9050559

21. Yuan H. Internet use and mental health problems among older people in Shanghai, China: the moderating roles of chronic diseases and household income. *Aging Ment Health*. (2021) 25:657–63. doi: 10.1080/13607863.2020.1711858

22. Kamin ST, Lang FR. Internet use and cognitive functioning in late adulthood: longitudinal findings from the survey of health, ageing and retirement in Europe (SHARE). *J Gerontol B Psychol Sci Soc Sci*. (2020) 75:534–9. doi: 10.1093/geronb/gby123

23. Shapira N, Barak A, Gal I. Promoting older adults' well-being through internet training and use. *Aging Ment Health*. (2007) 11:477–84. doi: 10.1080/13607860601086546

24. Sum S, Mathews MR, Pourghasem M, Hughes I. Internet technology and social capital: how the internet affects seniors' social capital and wellbeing. *J Comput-Mediat Commun*. (2008) 14:202–20. doi: 10.1111/j.1083-6101.2008.01437.x

25. Cody MJ, Dunn D, Hoppin S, Wendt P. Silver surfers: training and evaluating internet use among older adult learners. *Commun Educ*. (1999) 48:269–86.

26. McGrath L. Achieving visibility: midlife and older women's literate practices on Instagram and blogs. *Lit Compos Stud*. (2018) 6:94–116. doi: 10.21623/1.6.2.7

27. Ng R, Indran N. Not too old for Tik Tok: how older adults are reframing aging. *J Gerontol B Psychol Sci Soc Sci*. (2022) 62:1207–16. doi: 10.1093/geront/gnac055

28. Diehl MK, Wahl HW. Awareness of age-related change: examination of a (mostly) unexplored concept. *J Gerontol B Psychol Sci Soc Sci*. (2010) 65B:340–50. doi: 10.1093/geronb/gbp110

29. Griffin B, Loh V, Hesketh B. A mental model of factors associated with subjective life expectancy. *Soc Sci Med*. (2013) 82:79–86. doi: 10.1016/j.socscimed.2013.01.026

30. Wan X, Lighthall NR, Paulson D. Subjective markers of successful aging and change in internet use among older adults: the distinctive role of subjective health. *Comput Hum Behav*. (2022) 127:107064. doi: 10.1016/j.chb.2021.107064

31. Shrauger JS, Schoeneman TJ. Symbolic interactionist view of self-concept: through the looking glass darkly. *Psychol Bull*. (1979) 86:549–73.

32. Wood JV. Theory and research concerning social comparisons of personal attributes. *Psychol Bull*. (1989) 106:231–48.

33. Weiss D, Freund AM. Still young at heart: negative age-related information motivates distancing from same-aged people. *Psychol Aging*. (2012) 27:173–80. doi: 10.1037/a0024819

34. Campbell DR. In defense of (some) online echo chambers. *Ethics Inf Technol*. (2023) 25:45. doi: 10.1007/s10676-023-09715-9

35. Hong YA, Cho J. Has the digital health divide widened? Trends of health-related internet use among older adults from 2003 to 2011. *J Gerontol B Psychol Sci Soc Sci*. (2017) 72:856–63. doi: 10.1093/geronb/gbw100

36. Leist AK. Social media use of older adults: a mini-review. *Gerontology*. (2013) 59:378–84. doi: 10.1159/000346818

37. Conger JA, Kanungo RN. The empowerment process: integrating theory and practice. *Acad Manag Rev*. (1988) 13:471–82.

38. Nguyen MH, Hunsaker A, Hargittai E. Older adults' online social engagement and social capital: the moderating role of internet skills. *Inf Commun Soc*. (2022) 25:942–58. doi: 10.1080/1369118X.2020.1804980

39. Pang H. How does time spent on WeChat bolster subjective well-being through social integration and social capital? *Telematics Inform*. (2018) 35:2147–56. doi: 10.1016/j.tele.2018.07.015

40. Ding BR, Wang YJ. Stress, resources, and the well-being of migrant older adults. *Jiangsu Soc Sci*. (2020) 6:33–43. doi: 10.13858/j.cnki.cn32-1312/c.2020.06.004

41. Mark G, Ganzach Y. Personality and internet usage: a large-scale representative study of young adults. *Comput Hum Behav*. (2014) 36:274–81. doi: 10.1016/j.chb.2014.03.060

42. Zhang Q, Li Z. The impact of internet use on the social networks of the elderly in China—the mediating effect of social participation. *Int J Environ Res Public Health*. (2022) 19:9576. doi: 10.3390/ijerph19159576

43. Ma X, Hu Q, He J, Wang W, Chen K, Qiao H. Association of Internet use and health service utilization with self-rated health in middle-aged and older adults: findings from a nationally representative longitudinal survey. *Front Public Health*. (2024) 12:1429983. doi: 10.3389/fpubh.2024.1429983

44. Zhang Y, Guo Y, Li M. The moderating effect of intergenerational relationships on the association between internet engagement and mental well-being. *Aging Ment Health*. (2023) 28:36–44. doi: 10.1080/13607863.2023.2207479

45. Chen Z, Ma C, Sinclair AJ. Banking on the Confucian clan: why China developed financial markets so late. *Econ J*. (2022) 132:1378–413. doi: 10.1093/ej/ueab082

46. Heckman J, Pinto R, Savelyev P. Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *Am Econ Rev*. (2013) 103:2052–86. doi: 10.1257/aer.103.6.2052

47. Lu H, Kandilov IT. Does mobile internet use affect the subjective well-being of older Chinese adults? An instrumental variable quantile analysis. *J Happiness Stud*. (2021) 22:3137–56. doi: 10.1007/s10902-021-00365-6

48. Falisse JB, Huysentruyt M, Olofsgård A. Incentivising textbooks for self-study: experimental evidence from the Democratic Republic of the Congo. *Econ J*. (2024) 134:3262–90. doi: 10.1093/ej/ueae039

49. Oster E. Unobservable selection and coefficient stability: theory and evidence. *J Bus Econ Stat*. (2019) 37:187–204. doi: 10.1080/07350015.2016.1227711

50. Napoli PM, Obar JA. The emerging mobile internet underclass: a critique of mobile internet access. *Inf Soc*. (2014) 30:323–34. doi: 10.1080/01972243.2014.944726

51. Li P, Li QH, Li X. The influence of three digital divide levels on financial advisor demand and engagement among Chinese residents: an investigation based on China. *J Innov Knowl*. (2024) 9:100488. doi: 10.1016/j.jik.2024.100488

52. Pantelaki E, Maggi E, Crotti D. Who is online? A latent class analysis of internet activities and determinant characteristics of older people. *Comput Hum Behav*. (2023) 147:107830. doi: 10.1016/j.chb.2023.107830

53. Weller BE, Bowen NK, Faubert SJ. Latent class analysis: a guide to best practice. *J Black Psychol*. (2020) 46:287–311. doi: 10.1177/0095798420930932

54. Demir OB, Bilgin A, Yilmaz FT. Smartphone addiction among elderly individuals: its relationship with physical activity, activities of daily living, and balance levels. *BMC Public Health*. (2025) 25:965. doi: 10.1186/s12889-025-22145-0

55. Tian H, Wang Y. Mobile phone addiction and sleep quality among older people: the mediating roles of depression and loneliness. *Behav Sci*. (2023) 13:153. doi: 10.3390/bs13020153

56. Jeong JH, Bae SM. The relationship between types of smartphone use, digital literacy, and smartphone addiction in the elderly. *Psychiatry Investig*. (2022) 19:832–9. doi: 10.30773/pi.2021.0400

57. Kozyreva A, Lewandowsky S, Hertwig R. Citizens versus the internet: confronting digital challenges with cognitive tools. *Psychol Sci Public Interest*. (2020) 21:103–56. doi: 10.1177/1529100620946707

58. Jia Y, Liu T, Yang Y. The relationship between real-life social support and internet addiction among the elderly in China. *Front Public Health*. (2022) 10:981307. doi: 10.3389/fpubh.2022.981307

The cumulative effect of various social activities and depression: a longitudinal study in Chinese older adults

Sixiang Tao[1,2], Ming Huo[3] and Hongzhao Wang[1]*

[1]Faculty of Physical Education, Huaian Normal University, Huainan, China, [2]Faculty of Education, National University of Malaysia, Bangi, Malaysia, [3]Faculty of Rehabilitation Engineering, University of Health and Rehabilitation Sciences, Qingdao, China

Objective: While depression is linked to social activities, few studies comprehensively examine the cumulative and diverse effects of social activity trajectories. Study investigates the long-term relationship between the progression of depression and the patterns of changes in social activity participation.

Method: This study adopted a follow-up research design and analyzed data from three periods of the China Health and Aged Care Tracking Survey (CHRLS) between 2015 and 2020. Data from 3,762 participants aged 60 and older who participated in CHARLS between 2015 and 2020 were included in the analysis. Depressive symptoms were measured by using the Epidemiological Studies Depression Scale (CES-D). A Kaplan−Meier survival analysis was performed, followed by a Cox regression analysis, to identify the interactions between depression and the trajectory of patterns of changes in social activity participation.

Results: In the baseline survey of the third wave study (2015), the prevalence of depression was 24.9%. This increased significantly at each subsequent follow-up, reaching 28.7% at the fourth wave and 32.7% at the fifth wave. Survival analyses showed a statistically significant protective effect of Internet use and leisure-oriented social activities on the prevention of depression after adjusting for confounders such as demographic characteristics, health status, and health behaviors.

Conclusion: Continued participation in recreational social activities and use of the Internet are strongly associated with effective resistance to depression.

KEYWORDS

social activity, participation, depression, older adults in China, longitudinal study

Introduction

As the aging trend intensifies, the policy framework of "Active Aging" has emerged. The "Active Aging" policy framework proposed by the WHO comprises three basic pillars, which offer three primary directions for active aging initiatives: health, participation, and security (1). This framework system focuses on both the physical and mental health and quality of life of older persons and highlights the critical role of social participation for the older population. Actively participating in social activities, giving play to the value of the older adult, and realizing social integration are important manifestations of active aging. According to behavior or activity theory,

when the older adults are separated from social groups and familiar work environments, encouraging their participation in social development within the bounds of their abilities can alleviate depression resulting from disconnection from societal progress and the disruption of their social roles (Human behavior and thinking are the result of interaction with the external environment, that is, the formation of stimulus–response connection. In this study, social activity is the stimulus and depression are the response) (2). Research data show that more than 95 million people have depression in China, and depression is a common but often neglected phenomenon among the older adult (3).

Depression has a significant impact on the health of older people, increasing their risk of cardiovascular disease, diabetes and cognitive impairment (4). Additionally, it may contribute to sleep disturbances, changes in appetite, and weight fluctuations. Depression, as a major public health problem, has far-reaching implications at both the individual and societal levels. It has been identified as a leading cause of disability globally and imposes a considerable burden on healthcare systems (5). Some studies have highlighted the global prevalence, burden, and treatment efficacy of depression, emphasizing its critical role as a public health issue (6, 7). Scholars have found that social activity participation plays a positive role in alleviating depressive symptoms, while depression also affects the level of social activity participation in the older adult (8, 9).

Social participation is an important channel for achieving active aging. Studies indicate that it is beneficial for promoting the physical health of the older adult and can effectively reduce their levels of depression (10).

Some authors have noted that social participation can be categorized into various forms, including formal, informal, productive, consumptive, interpersonal, virtual, face-to-face, and community/social/citizen participation, as well as community involvement and personal relationships. However, the most effective type of social participation for combating depression in older adults is not well documented (11, 12). Consequently, it is significant to recognize that different forms of social engagement can have varying impacts on health (13, 14). Furthermore, the relationship between social participation and health is influenced by factors such as socioeconomic status, social support, and individual health conditions (15). Building upon previous research findings, it is necessary to hypothesize that the impact of social activities on depression may vary. Given the multifaceted nature of social activities, evaluating a single indicator or conducting cross-sectional analysis is insufficient to fully capture the characteristics of population social activity. Such approaches also overlook the comprehensive coexistence and synergistic effects of social activities on the development of mental illness. Particularly for the outcome state of complex traits, further research is essential to fully understand the mechanisms by which social status influences depression. Additionally, there is a need to develop effective interventions aimed at reducing disparities in mental health outcomes associated with social activity status. In accordance with this, the present longitudinal study endeavors to examine the association between trajectories of change in social activity status and the evolution of depressive symptoms. It proposed that changes in the trajectory of social activity states may be related to the emergence or aggravation of depressive symptoms (Figure 1).

Subjects and methods

Study population

This investigation encompassed 3,762 older adult participants aged 60 and over, sourced from the CHARLS data survey ranging from 2015 (Wave 3) to 2020 (Wave 5).

Ethical considerations The CHARLS survey has been approved by the Biomedical Ethics Committee of Peking University for each cycle. The fieldwork plan for this phase of the household questionnaire survey has been approved, with the approval number: IRB00001052-11015. Throughout the field survey process, each individual who agrees to participate in the study must sign two copies of the informed consent form. One copy is retained by the participant, and the other is archived at the CHARLS office and filed in PDF scanned form. This study has followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.
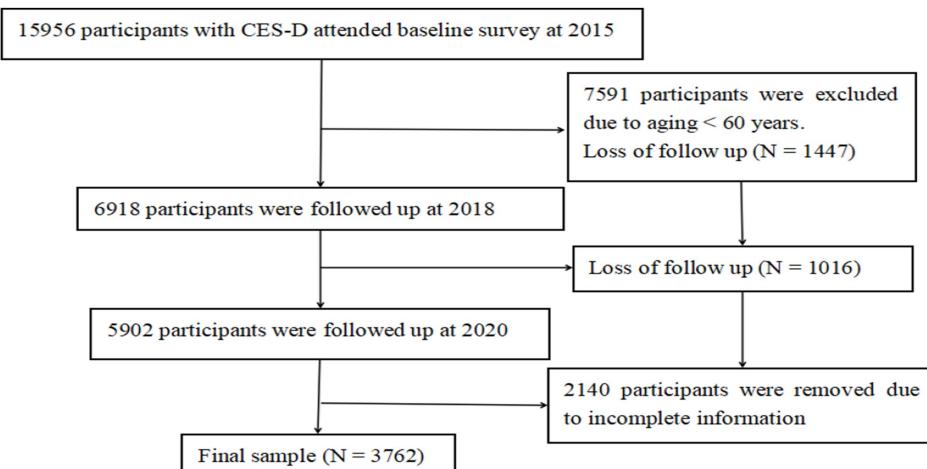
FIGURE 1
Flowchart of participant.

Data collection

Demographic variables were collected, including age, gender, marital, residence, and income at baseline.

The Epidemiological Studies Depression Scale (CES-D) was used to assess depression, which has been used to measure depressive symptoms in the older adult (16). The following 10 questions are about how you felt and behaved last week. Each question has the same set of answers, including rarely or never, not too much, sometimes, or half of the time, most of the time. Please choose the appropriate answer. The top 10 questions are listed: perplex, impaired concentration, dejection, exhaustion, expectation, fear, poor sleep, happiness, loneliness, and stagnation. The 7th and 8th items are reverse scoring. The scale options consisted of 4 levels and were assigned: "rarely or none of the time = 0," "some or few times = 1," "occasionally or moderate number of times = 2," "most or all of the time = 3"; The total score ranges from 0 to 30, with scores ≥ 12 were defined as having depressive symptoms (16, 17).

The evaluation of social activities (SAs) includes the following aspects: SA 1. interaction with friends; SA 2. participation in mahjong, chess, card games, or going to community clubs; SA 3. providing assistance for those who do not live together or are not paid; SA 4. participation in sports, social or other types of clubs; SA 5. participating in activities of community-related organizations; SA 6. volunteering, charity work, or caring for patients or disabled people who are not paid; SA 7. participation in education or training courses; SA 8. Internet activities: chatting, reading news, watching videos, playing games, fund management, mobile payment; SA 9. others. Questions regarding participation in social activities include: "Have you participated in the following social activities in the past month?" and "How often did you do the activities mentioned above over the past month?" Participants who answered "yes" to the question were defined as having some kind of social activity.

Assessment of health status began with self-report, covering respondents' self-assessment of their overall health, and questions about a range of pain, falls, physical disability, and chronic disease diagnoses raised by physicians. In addition, assessments of activities of daily living (ADLs), and instrumental activities of daily living (IADLs). Questions about physical dysfunction included "Do you have difficulties with activities such as dressing, bathing, eating, getting up, using the toilet, doing housework, cooking, shopping, making phone calls, taking medication, and managing finances due to health and memory reasons? (db001: Difficulty with Dressing; db003: Difficulty with Bathing or Showering; db005: Difficulty with Eating; db007: Difficulty with Getting into or out of Bed; db009: Difficulty with Using the Toilet; db011: Difficulty with Controlling Urination and Defecation; db012: Difficulty with Household Chores; db014: Difficulty with Preparing Hot Meals;db016: Difficulty with Shopping for Groceries; db018: Difficulty with Making Phone Calls; db020: Difficulty with Taking Medications; and db022: Difficulty with Managing Money.)." Participants who answered "yes" to the question were defined as having some kind of physical disability.

The health-related behaviors in this study include smoking, drinking, and physical exercise. The question about smoking was "Have you ever smoked? (Including cigarettes, pipes, hookahs, or chewing tobacco)." Participants who answered "yes" to the question were defined as having smoking behavior. Questions about drinking were "Did drink alcohol over the past year, including beer, wine, rice wine, yellow wine, white spirit, or medicinal liquor, etc.?" and "How

often did they drink?" Questions about physical exercises were "Is doing physical activity due to work needs, recreational activities, physical exercise, or something else? The respondent can choose one or multiple options from: 1. Work needs; 2. Entertainment; 3. Physical exercise; 4. Other.

Statistics analysis

Use Stata 18 and SPSS 25 for overall data statistics. Record data using frequency and percentage and use chi-square analysis for data comparison. The p value of the comparison between variables is less than 0.05, which is statistically significant. In survival analysis, use the Kaplan–Meier method to analyze the development of data trends during follow-up, and use Cox regression to analyze the cumulative risk ratio. In survival analysis, test data robustness by swapping dependent and independent variables in Cox regression.

Results

Characteristics of study participants at baseline

Table 1 presents the socio-demographic characteristics of depression and no-depression groups at the baseline of Wave 3. Slightly more than half of the participants were male (53.4%, $n = 2010$). The prevalence of depression was 24.9%. Depressive participants were not significantly older than non-depression groups ($p = 0.17$). Statistics showed a significant difference in the incidence of depression based on gender, marital, residence, and annual income (all p-values were <0.01). The incidence of smoking and drinking is significantly lower in the depression group compared to the non-depression group (all p-values were < 0.01), while there is no significant difference between the two groups in terms of physical exercise ($p = 0.3$). In terms of health status, physical functional disability, falls, pain, and chronic disease depression groups are all higher than the non-depression group (all p values were less than 0.05). However, cigarette smoking ($p < 0.01$) and alcohol consumption ($p = 0.00$) were significantly lower in the depressed group than in the non-depression group. In social activities, there is no significant difference between the depression group and the non-depression group in items SA 1, SA 3, SA 6, and SA 7 (1. Interacted with Friends; 3. Provided Help to Others Who Do Not Live with You or Did Not Pay You for Help; 6. Done Voluntary, Charity Work or Cared for A Sick or Disabled Adult Not Live with You or Did Not Pay You for Help; 7Attended An Educational or Training Course. All p-values were more than 0.05).

In the five-year follow-up after taking Wave 3 as the baseline, there were trends of increasing incidence of probability over time for depression (Wave 3 = 24.9%, Wave 4 = 28.7% and Wave 5 = 32.7%; X2 = 56.05, $p < 0.01$.) and SA8 with internet (Wave 3 = 3.0%, Wave 4 = 5.3 and Wave 5 = 18.4; X2 = 636.83, $p < 0.01$); and there were decreasing incidence of SA 1, SA 2, SA 4, and SA 6 (SA 1. Interacted with Friends: Wave 3 = 33.0, Wave 4 = 31.8, and Wave 5 = 29.5; X2 = 11.33, $p < 0.01$. SA 2. Played Ma-Jong, Played Chess, Played Cards, or Went to Community Club: Wave 3 = 20.8, Wave 4 = 18.3, and Wave 5 = 15.9; X2 = 29.69, $p < 0.01$. SA 4. Went to A Sport, Social, or Other Kind of Club: Wave 3 = 8.1, Wave 4 = 5.8, and Wave 5 = 5.2;

TABLE 1 Basic characteristics of participants in the non-depression group and the depression group at Wave 3 (N = 3,762).

Total (N = 3,762)	Non-depression group	Depression group	X2	p
	(n = 2,824, 75.1%)	(938, 24.9%)		
Demographic background				
Age	60–75 (3122)	74.6	25.4	1.85	0.17
	≥76 (640)	77.2	22.8		
Gender	Male (2010)	81.4	18.6	93.76	0
	Female (1752)	67.8	32.2		
Marital	Yes (2230)	77.8	22.2	21.9	0
	No (1532)	71.1	28.9		
Residence	City (445)	86.5	13.5	35.85	0
	Town (1516)	74.5	25.5		
	Village (1801)	72.8	27.2		
Income	0 (1496)	72.3	27.7	85.63	0
	1–2000 (1377)	70.6	29.4		
	≥2001 (889)	86.7	13.3		
Health status				
Development disabilities	Yes (1004)	61.5	38.5	135.58	0
	No (2758)	80	20		
Fall	Yes (736)	49.5	50.5	320.64	0
	No (3026)	81.3	18.7		
Pain	Yes (458)	63.1	36.9	39.9	0
	No (3304)	76.7	23.3		
Chronic diseases	Yes (2198)	73.7	26.3	5.61	0.02
	No (1564)	77	23		
Health-related behaviors				
Drinking	Yes (966)	80.1	19.9	17.64	0
	No (2796)	73.3	26.7		
Smoking	Yes (1150)	79.5	20.5	17.22	0
	No (2612)	73.1	26.9		
Physical exercises	Yes (713)	77.3	22.7	2.3	0.3
	No (3049)	74.5	24.5		
Social activities				
1	Yes (1241)	76.2	23.8	1.34	0.25
	No (2521)	74.5	25.5		
2	Yes (783)	82.1	17.9	26.29	0
	No (2979)	73.2	26.8		
3	Yes (523)	76.9	23.1	1.05	0.36
	No (3239)	74.8	25.2		
4	Yes (303)	81.5	18.5	7.33	0.01
	No (3459)	74.5	25.5		
5	Yes (114)	86.0	14.0	7.46	0.01
	No (3648)	74.7	25.3		

(Continued)

TABLE 1 (Continued)

Total (N = 3,762)	Non-depression group	Depression group	X2	p
	(n = 2,824, 75.1%)	(938, 24.9%)		
6	Yes (135)	77.8	22.2	0.55	0.46
	No (3627)	75.0	25.0		
7	Yes (16)	87.5	12.5	1.33	0.25
	No (3746)	75.0	25.0		
8	Yes (114)	90.4	9.6	14.67	0
	No (3648)	74.6	25.4		
9	Yes (42)	88.1	11.9	3.85	0.06
	No (3720)	74.9	25.1		

1: SA1 Interacted with friends.
2: SA2 Played Ma-Jong, played chess, played cards, or went to community club.
3: SA3 Provided help to others who do not live with you or did not pay you for help.
4: SA4 Went to a sport, social, or other kind of club.
5: SA5 Took part in a community-related organization.
6: SA6 Done voluntary, charity work or cared for a sick or disabled adult not live with you or did not pay you for help.
7: SA7 Attended an educational or training course.
8: SA8 Activities with internet: chatting; reading news; watching videos; playing games; money management; payment with mobile phone.
9: SA9 Others.
Disabilities: basic daily activity limitations and instrumental of daily activity limitations.

X2 = 28.53, $p < 0.01$. SA 6. Done Voluntary, Charity Work or Cared for A Sick or Disabled Adult Not Live with You or Did Not Pay You for Help: Wave 3 = 3.6, Wave 4 = 3.0, and Wave 5 = 1.8; X2 = 24.34, $p < 0.01$).

Five-year follow-up study on the cumulative effects of depressive symptoms and social activities

Through Kaplan–Meier univariate analysis, three insignificant variables of social activities (1, 3, and 6) were excluded, and then Cox proportional regression analysis was performed (Table 2). In this regression model, the depression variable was taken as the state variable, and the three follow-up visits from Wave 3 to Wave 5 were taken as the time variable. The demographic and sociological indicators, health indicators, and other behavioral indicators were taken as covariates to form this brief model. Social activities of SA 2 (Played Ma-Jong, Played Chess, Played Cards, or Went to Community Club, OR = 0.85, CI: 0.77–0.95, $p < 0.01$), SA 4 (Went to A Sport, Social, or Other Kind of Club, OR = 0.85, CI: 0.72–0.99, $p < 0.01$), SA 5 (Took Part in A Community-Related Organization, OR = 0.71, CI: 0.53–0.95, $p < 0.01$), SA 8 (Activities with Internet: Chatting; Reading News; Watching Videos; Playing Games; Money Management; Payment with Mobile Phone, OR = 0.49, CI: 0.42–0.56, $p < 0.01$), and SA 9 (Others, OR = 0.67, CI: 0.49–0.91, $p < 0.01$) are protective factors against depression, after adjusting for demographic factors in the model 1; Social activities of SA 2 (Played Ma-Jong, Played Chess, Played Cards, or Went to Community Club, OR = 0.86, CI: 0.78–0.95, $p < 0.01$), SA 5 (Took Part in A Community-Related Organization, OR = 0.73, CI: 0.58–0.99), SA 8 (Activities with Internet: Chatting;

TABLE 2 Cumulative interaction between depressive symptoms and social activity factors (N = 3,762).

Social activities	Model 1	95.0% CI for Exp (B)		Model 2	95.0% CI for Exp (B)		Model 3	95.0% CI for Exp (B)	
	Exp (B)	Lower	Upper	Exp (B)	Lower	Upper	Exp (B)	Lower	Upper
2	0.85	0.77	0.95	0.86	0.78	0.95	0.89	0.8	0.99
4	0.85	0.72	0.99	–	–	–	–	–	–
5	0.71	0.53	0.95	0.73	0.55	0.98	–	–	–
8	0.49	0.42	0.56	0.51	0.44	0.59	0.54	0.46	0.62
9	0.67	0.49	0.91	0.73	0.58	0.99	–	–	–

2: SA 2 Played Ma-Jong, played chess, played cards, or went to community club.
4: SA 4 Went to a sport, social, or other kind of club.
5: SA 5 Took part in a community-related organization.
8: SA 8 Activities with internet: chatting; reading news; watching videos; playing games; money management; payment with mobile phone.
9: SA 9 Others.
The model 1 is the result of controlling for demographic sociological factors.
The model 2 is the result of controlling for demographic sociological factors and health status.
The model 3 is the result of controlling for demographic sociological factors, health status and health-related behaviors.

Reading News; Watching Videos; Playing Games; Money Management; Payment with Mobile Phone, OR = 0.51, CI: 0.44–0.59, $p < 0.01$) and SA 9 (Others, OR = 0.73, CI: 0.58–0.99, $p < 0.01$) are protective factors against depression after adjusting demographic factors and health status in the model 2; and social activities of only SA 2 (Played Ma-Jong, Played Chess, Played Cards, or Went to Community Club, OR = 0.89, CI: 0.80–0.99, $p < 0.01$) and SA 8 (Activities with Internet: Chatting; Reading News; Watching Videos; Playing Games; Money Management; Payment with Mobile Phone, OR = 0.54, CI: 0.46–0.62, $p < 0.01$) are protective factors against depression, after adjusting for demographic factors, health status, and health-related behavior in model 3.

Discussion

This study scientifically demonstrates the impact of the diversity and trajectories of social participation on depression in older adults based on the CHARLS data and reveals that the risk of depression in older people gradually increases with age, according to the five-year follow-up. Although there is a relatively clear relationship between social activity participation and depression, there is relatively little evidence regarding the connection between trajectories of depression and social activity participation (18). This present study further demonstrates that ensuring recreational social interaction and adhering to the Internet may be protective against depression or associated with lower depression risk in older people. This result indicates that older adults with recreational social interaction and adhering to the Internet are not more likely to experience long-term high levels of depression. The analysis suggests that in the process of recreational social interaction, the older adult can effectively eliminate feelings of loneliness, depression, and other negative emotions by constructing and maintaining intimate relationships, thereby improving their health status (19). In our study, this might suggest that providing more opportunities for entertainment for the older adult and encouraging them to use the Internet correctly for social activities is a strong guarantee to improve the quality of life of the older adult. Many older adults lack adequate social support e. g. family support, friend interaction, and community services, which may contribute to worsening their depressive symptoms. These results are partially consistent with previous studies on related issues in China and abroad (8, 9, 16).
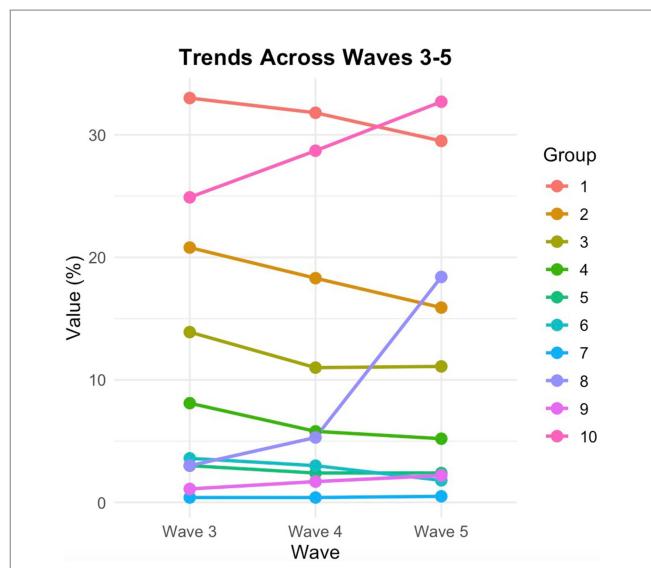
FIGURE 2
Trajectories in social activities and changes of depression in sequential follow-ups. 1: SA1 Interacted with friends. 2: SA2 Played Ma-Jong, played chess, played cards, or went to community club. 3: SA3 Provided help to others who do not live with you or did not pay you for help. 4: SA4 Went to a sport, social, or other kind of club. 5: SA5 Took part in a community-related organization. 6: SA6 Done voluntary, charity work or cared for a sick or disabled adult not live with you or did not pay you for help. 7: SA7 Attended an educational or training course. 8: SA8 Activities with internet: chatting; reading news; watching videos; playing games; money management; payment with mobile phone. 9: SA9 Others. 10: Depression. 1. $X2 = 11.33$, $p < 0.01$; 2. $X2 = 29.69$, $p < 0.01$; 3. $X2 = 19.60$, $p < 0.01$; 4. $X2 = 28.53$, $p < 0.01$.; 5. $X2 = 4.21$, $p = 1.22$; 6. $X2 = 24.34$, $p < 0.01$; 7. $X2 = 0.50$, $p = 0.78$; 8. $X2 = 636.83$, $p < 0.01$; 9. $X2 = 13.57$, $p < 0.01$; 10. depression, $X2 = 56.05$, $p < 0.01$.

Among other findings, two are particularly noteworthy. The firstly, social activity participation is considered to have a positive impact on preventing diseases, especially for the older adult. However, it is necessary to consider the diversity of social activity participation and the direct interactions between various factors. The data from this study show that the activities with internet increased from 3% in 2015 to 18.4% in 2020 over a five-year follow-up period, an increase of more than fivefold (Figure 2). Moreover, the Cox regression analysis indicates that increased activities with internet is the most significant and

effective factor in protecting older adults against depression, surpassing leisure and entertainment activities (Table 2). In this study, SA 8, the use of the internet includes: Chatting, Reading news, Watching videos, Playing games, Managing money, Making payments with a smart phone, Using WeChat, and Using WeChat moments, etc. This study did not further divide these contents but agreed to categorize them into one variable as the SA 8 (Tables 1, 2). Innovative construction of age-friendly social media from the perspective of active aging is an important measure to improve the quality of life for the older adult, such as: the service innovation of age-friendly social media, mainly expounding on the functional positioning and service function framework; furthermore, describing the interface innovation of age-friendly social media, mainly the principles of interface innovation and the innovation of interface layout, and so on. The secondly but not the last, the social activity participation of SA 7"Attended An Educational or Training Course" has seen almost no growth over the past 5 years after three follow-ups, and the initial level was already very low (2015: 0.4%; 2018: 0.4%; 2020: 0.5%) (Figure 2). To some extent, this longitudinal data also reflects the serious shortcomings of SA 7 in health education and training for the older adult in the context of active aging. Therefore, the health management department of the older adult should understand the satisfaction of the health education needs of the older adult and related influencing factors, to provide a basis for the formulation of more targeted intervention strategies. Although this study effectively verified the longitudinal association between various factors of social participation and depression, there are still some shortcomings. First, the panel data on social participation and depression in the CHARLS database used in this study contains too much missing data, which may lead to inconsistencies between the results and actual conditions. Second, this study only investigated data from the third round onwards, when individuals entered their older adult stage. Data from those who subsequently entered the older adult stage were not included in this study, inevitably leading to data gaps for these older adults, thus affecting the objectivity of the research results.

Social activity participations are important controllable factors related to depressive symptoms. Previous scholars' research on the relationship between social activity participation and depression has mostly been based on cross-sectional data, with fewer studies on developmental trajectories (19). This study examines the relationship between longitudinal trajectories of social activity participation and depressive symptoms, which helps us further understand the interplay between the two and assists professionals in formulating optimized health policies.

Conclusion

The effects of social activity participation on depression are varied, and older individuals often maintain the benefits of social and recreational activity, as well as active participation in social activities with internet, as effective alternatives to antidepressants. Engagement in recreational social activities and Internet use may serve as protective factors against depression in older adults. In the future, technical training programs or social activities should be supported to promote further randomized controlled trial (RCT) research and community intervention experimental research.

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 from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Funding

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.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

References

1. Ayoubi-Mahani S, Eghbali-Babadi M, Farajzadegan Z, Keshvari M, Farokhzadian J. Active aging needs from the perspectives of older adults and geriatric experts: a qualitative study. *Front Public Health*. (2023) 11:1121761. doi: 10.3389/fpubh.2023.1121761

2. Peng W, Bai X, Wu C, Zhang H, Li X, Lu J. Sociodemographic factors, leisure-time physical activity and mortality. *Am J Prev Med*. (2024) 66:598–608. doi: 10.1016/j.amepre.2023.11.007

3. Lu J, Xu X, Huang Y, Li T, Ma C, Xu G, et al. Prevalence of depressive disorders and treatment in China: a cross-sectional epidemiological study. *Lancet Psychiatry*. (2021) 8:981–90. doi: 10.1016/S2215-0366(21)00251-0

4. Zhao X, Duan X, Shen S, Wang J. Independent and combined associations of depression and cognitive impairment with frailty in oldest-old adults. *BMC Psychol*. (2024) 12:1–8. doi: 10.1186/s40359-024-02007-x

5. World Health Organization. (2022). Depression. World Health Organization. Available online at: https://www.who.int/news-room/fact-sheets/detail/depression (Accessed 31 March, 2023).

6. Park M, Sangha O, Gwathmey K, Ricci JF, Willmon R. RWD106 psychological burden in people living with myasthenia gravis: prevalence and associated risk factors of depression and anxiety from the MGFA global MG patient registry (MGFAPR) in the US (2017-2022). *Value Health*. (2024) 27:S378–8. doi: 10.1016/j.jval.2024.03.1760

7. Ferrari AJ, Somerville AJ, Baxter AJ, Norman R, Patten SB, Vos T, et al. Global variation in the prevalence and incidence of major depressive disorder: a systematic review of the epidemiological literature. *Psychol Med*. (2013) 43:471–81. doi: 10.1017/S0033291712001511

8. Gao Q. Social participation and subjective well-being. *Curr Psychol*. (2024) 43:20041–55. doi: 10.1007/s12144-024-05796-x

9. Liao Y, Duan W, Cheng X. The social convoy for depression among the older adults in rural China: a multilevel structural equation modeling analysis using a national sample. *Geriatr Nurs*. (2024) 60:570–9. doi: 10.1016/j.gerinurse.2024.10.012

10. Alfian SD, Kusuma CF, Wicaksono IA, Puspitasari IM, Wawruch M, Abdulah R. Social participation among individuals with depression is associated with the use of informal healthcare facilities: findings from the Indonesian family life survey-5. *Curr Psychol*. (2024) 43:21596–604. doi: 10.1007/s12144-024-05940-7

11. Levasseur M, Richard L, Gauvin L, Raymond É. Inventory and analysis of definitions of social participation found in the aging literature: proposed taxonomy of social activities. *Soc Sci Med*. (2010) 71:2141–9. doi: 10.1016/j.socscimed.2010.09.041

12. Shiho A, Noritoshi F, Hiroyuki K, Oka K, Takamiya T, Odagiri Y, et al. Types of social participation and psychological distress in Japanese older adults: a five-year cohort study. *PLoS One*. (2017) 12:e0175392. doi: 10.1371/journal.pone.0175392

13. Fancourt D, Baxter L. Differential participation in community cultural activities amongst those with poor mental health: analyses of the UK taking part survey. *Soc Sci Med*. (2020) 261:113221. doi: 10.1016/j.socscimed.2020.113221

14. Tran S, DiGiovanna B, Gamino D, Langarica AA, Motley J, Way S, et al. A – 86 perceived social support predicts everyday cognition for daily functioning beyond geriatric anxiety and depression. *Arch Clin Neuropsychol*. (2024) 39:1024. doi: 10.1093/arclin/acae067.100

15. Yang J, Lee SG. Association between retirement age and depressive symptoms among Korean retirees: results from Korean retirement and income panel study. *J Affect Disord*. (2024) 352:454–9. doi: 10.1016/j.jad.2024.02.082

16. Li X. Stability and transitions of depressive symptoms among Chinese older adults over a 5-year follow up. *Curr Psychol*. (2024) 43:15787–97. doi: 10.1007/s12144-023-05522-z

17. Choi Y, Park EC, Kim JH, Yoo KB, Choi JW, Lee KS. A change in social activity and depression among Koreans aged 45 years and more: analysis of the Korean longitudinal study of aging (2006-2010). *Int Psychogeriatr*. (2015) 27:629–37. doi: 10.1017/S1041610214002439

18. Mu Y, Yi M, Liu Q. Association of neighborhood recreational facilities and depressive symptoms among Chinese older adults. *BMC Geriatr*. (2023) 23:667. doi: 10.1186/s12877-023-04369-0

19. Choi NG, Dinitto DM. The digital divide among low-income homebound older adults: internet use patterns, eHealth literacy, and attitudes toward computer/internet use. *J Med Internet Res*. (2013) 15:e93. doi: 10.2196/jmir.2645

Digital interaction and active aging: the impact of social media use on physical activity behavior mediated by social capital and self-efficacy

Jian Liu[1], Chaoxin Wang[1], Zhanpeng Meng[2] and Chuanwen Yu[1]*

[1]College of Physical Education and Health, Heze University, Heze, China, [2]College of Physical Education, Shandong Normal University, Jinan, China

Background: Social media use has been linked to higher physical activity levels in older adults, but the mechanisms underlying this connection are not yet well understood. Emerging evidence suggests that social capital may act as a mediator, though little research has explored whether specific dimensions of social capital and self-efficacy mediate this relationship.

Objective: This study investigates how social media usage influences older adults' physical activity behavior, focusing on the mediating roles of social capital—structural, bonding, and bridging—and self-efficacy. The goal is to provide a foundation for strategies to promote physical activity in this population.

Methods: A cross-sectional survey was conducted between December 2023 and April 2024 involving 519 social media users (275 male and 244 female). Data were gathered using validated scales for social media usage intensity, physical activity levels (PARS-3), social capital, and self-efficacy. Structural equation modeling (SEM) was applied to examine the relationships between these variables and the mediating effects at play.

Results: Older adults who engaged more actively with social media exhibited higher physical activity behavior ($\beta = 0.179$, $p < 0.05$). Social capital, across its three dimensions—structural ($\beta = 0.254$), bonding ($\beta = 0.294$), and bridging ($\beta = 0.237$)—significantly mediated the link between social media usage and physical activity (all $p < 0.05$). Additionally, self-efficacy was a critical, independent mediator ($\beta = 0.242$, $p < 0.05$). A chain-mediating effect involving social capital dimensions and self-efficacy further strengthened this relationship ($p < 0.05$).

Conclusion: Social media use fosters physical activity in older adults by building social capital, mainly structural, bonding, and bridging types, and boosting self-efficacy. Enhancing the social media environment, developing social capital, and supporting self-efficacy are vital strategies for promoting physical activity in this group. The cross-sectional design of this study is a limitation, and future longitudinal research is needed to understand the causal relationships better.

Introduction

The rapid acceleration of global aging has highlighted the urgent need to promote healthy aging (Chen et al., 2022b). Research consistently shows that regular physical activity behavior enhances older adults' physical functions, mental well-being, and social adaptability (Xiong et al., 2021; Liu et al., 2024). However, due to declines in physical abilities and shrinking social networks, older adults often engage in less physical activity (Sun et al., 2024). Therefore, developing effective strategies to encourage this population's physical activity is critical.

Recent advancements in digital technology have created new opportunities to address these challenges. Social media, in particular, has allowed older adults to overcome barriers related to geography and physical limitations, thereby revitalizing their social networks (Liu and Zhao, 2023). It also serves as a platform for accessing health-related information, sharing experiences, and receiving social support (Tseng et al., 2022). While evidence suggests that social media positively influences health behaviors in older adults (Asiamah et al., 2021), research on its impact specifically on physical activity behavior remains limited (López-Carril et al., 2020; Wang and Xu, 2024).

The role of social media in improving life satisfaction (Zhao, 2021) and facilitating psychosocial outcomes such as social support and social capital (Liu and Yeo, 2022). While much of this research focuses on adolescents (Schemer et al., 2021), college students (Roberts and David, 2020), and general adult populations (Chen and Li, 2017), studies on older adults are still in the early stages. Social media use can enhance self-efficacy and social support, key factors in promoting physical activity (Steinhoff and Reiner, 2024). By enabling the formation of social support networks and providing access to health-related resources, social media has significant potential to encourage physical activity among older adults (Lin and Kishore, 2021; Yi et al., 2024). Moreover, the self-efficacy gained through online interactions may play a pivotal role in shaping exercise behavior among older adults (Sen et al., 2022; Long et al., 2024).

The theoretical basis for this model is grounded in Social Cognitive Theory (Bandura, 1989) and the Socioecological Model (Bronfenbrenner, 1979). Social Cognitive Theory emphasizes the role of observational learning, social support, and self-regulation in health behavior. At the same time, the Socioecological Model highlights the influence of multiple levels of social environments, including digital platforms, on individual behaviors. Social media serves as a tool for strengthening social networks (structural, bonding, and bridging social capital), providing emotional support and behavioral resources (Huang et al., 2024), and enhancing the motivation to engage in physical activity behavior. Additionally, through its interactive nature, social media boosts self-efficacy by reinforcing confidence in one's ability to participate in physical activity.

This study introduces several key innovations. First, it is the first to construct a chain mediation model that simultaneously incorporates three dimensions of social capital—structural, bonding, and bridging—along with self-efficacy to explore how social media use influences physical activity behavior among older adults. Unlike previous studies that often emphasize cognitive or linking social capital (Solano, 2025; Rahe et al., 2025; Zhang et al., 2025), this research strategically focuses on the three dimensions most directly related to health behaviors, thereby enhancing the explanatory power and practical relevance of the model. Second, by differentiating the

roles of bonding, bridging, and structural capital, the study clarifies the specific mechanisms through which social media platforms, such as WeChat, foster distinct social connections in later life, providing a more nuanced understanding of digital engagement. Third, the research reflects a localized innovation by embedding the analysis within the Chinese sociocultural context, where family-oriented networks and the widespread use of WeChat shape online interaction patterns. This approach highlights the unique function of WeChat in strengthening bonding capital and promoting physical activity among older adults. Finally, the study extends the theoretical framework of social capital and health behavior by introducing a complex, multi-level mediation structure, providing a novel direction for future empirical and intervention research.

Literature review

To further elaborate on the theoretical foundations and clarify the research gap identified in the introduction, this section reviews prior studies on social media use, social capital, and physical activity among older adults, setting the stage for the study's innovative framework. Regular social media use has been shown to help individuals build social capital and enhance their self-efficacy, which contributes to consistent exercise habits (Szwedo et al., 2024). The effects of social media on physical activity are often mediated by different dimensions of social capital, including bridging, bonding, and structural types (Gao et al., 2025). The conceptual framework is shown in Figure 1.

Social media use and physical activity behavior

Social media platforms enable users to share information, interact with others, and access content, which has helped overcome the limitations of traditional media (Jitsaeng et al., 2024). The rapid growth of social media has aligned with advancements in Web 2.0 technologies, facilitating greater communication and information dissemination (Guaya et al., 2025). Notably, social media use among older adults has significantly increased (Dahlberg et al., 2022), especially in China, where it has become a vital tool for information acquisition and socializing (Celik, 2023; Wei and Gao, 2017). Several studies have explored how digital tools can support physical activity behavior among older adults. For instance, Jansons et al. (2022) found that exercise programs delivered through the Amazon Echo Show effectively encourage older adults to be more active. Similarly, Ho and Merchant (2022) demonstrated the effectiveness of remote guidance in managing exercise routines during the COVID-19 pandemic.

Additionally, studies have highlighted how apps like Social Bike and live-streamed exercise sessions via Facebook have improved physical activity behavior outcomes for older adults (Arlati et al., 2019; Chang et al., 2021). However, while these studies underscore the potential of social media to encourage physical activity, they fail to examine how social media use directly influences elderly exercise behavior, particularly through the lens of social capital and self-efficacy. Therefore, this study hypothesizes:

> H1: Social Media Use is positively associated with Physical activity behavior among older adults.
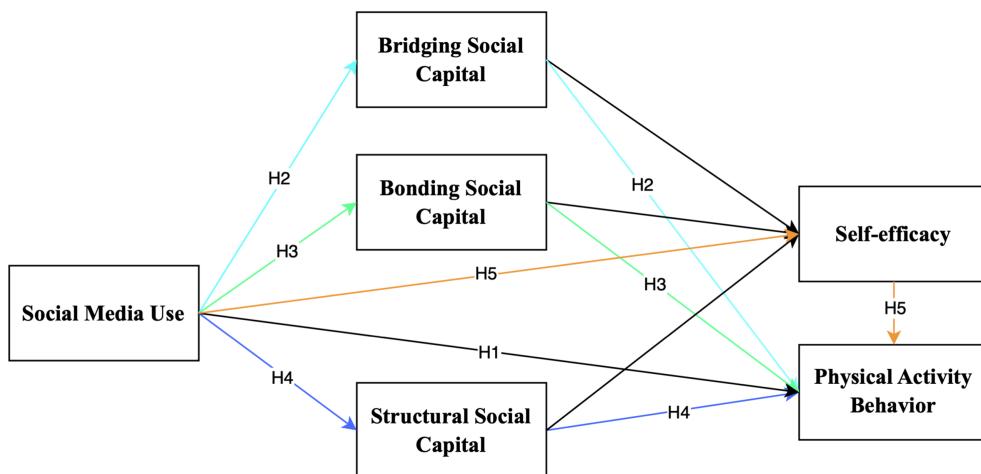
FIGURE 1
Conceptual framework illustrating the hypothesized relationships among social media use, social capital dimensions, self-efficacy, and physical activity behavior in older adults.

The mediation role of social capital and self-efficacy

The rise of digital media has transformed traditional communication patterns, replacing face-to-face interactions with online connections. Social media is a powerful platform for building social capital—the resources derived from social networks (Tuan et al., 2024). Unlike traditional social capital, which is grounded in physical interactions, digital social capital enables broader, more diverse connections, enhancing bonding and bridging social capital (Perez Fernandez et al., 2024). Structural social capital is the underlying framework that shapes these interactions (Nahapiet and Ghoshal, 1998). Social media has been shown to expand these forms of capital by lowering the costs of maintaining relationships, enabling the development of both strong ties within close-knit groups (bonding) and weak ties across different groups (bridging), both of which can promote physical activity (Kahai and Lei, 2019; Sachan et al., 2025). Social capital positively influences online and offline physical activity participation (Fan et al., 2023; Fu et al., 2018). Social capital facilitates the spread of health-related information, encouraging greater participation in exercise (Reid et al., 2016).

Additionally, increasing access to social media has expanded opportunities for exercise engagement among older adults (Zhong et al., 2022). These findings suggest that social media is pivotal in helping older adults develop the social networks and support systems necessary for sustained physical activity. Therefore, social media helps older adults expand their social networks, lengthen social capital, and serve as a key factor in increasing their engagement in physical activity behavior. The following hypotheses are proposed:

H2: Bridging social capital mediates the relationship between social media use and physical activity behavior among older adults.

H3: Bonding social capital mediates the relationship between social media use and physical activity behavior among older adults.

H4: Structural social capital mediates the relationship between social media use and physical activity behavior among older adults.

Social capital, self-efficacy, and social media use

Self-efficacy—the belief in one's ability to succeed in specific tasks—has been identified as a crucial determinant of physical activity in older adults (Fu et al., 2023). Research suggests that higher self-efficacy is associated with greater participation in moderate and high-intensity physical activities (Yu and Song, 2022). By providing access to health-related content and online communities, social media can enhance self-efficacy by offering emotional support and reinforcing positive health behaviors (Godfrey and Johnson, 2009; Guan, 2024). Studies have shown that older adults who engage with social networking sites exhibit higher levels of self-efficacy in physical activities, increasing their likelihood of participating in exercise (Chen et al., 2022a). Based on this, the following hypotheses are proposed:

H5: Self-efficacy significantly mediates the relationship between social media use and older adults' physical activity behavior.

The interaction between social capital and self-efficacy is also crucial. Social capital enhances self-efficacy by providing resources such as emotional support, social recognition, and encouragement, strengthening individuals' confidence in their ability to engage in physical activity (Kim et al., 2021; Patterson et al., 2022). The accumulation of structural and bridging social capital through social media can improve self-efficacy, as seen in studies that link Facebook-based exercise programs to better adherence and motivation for physical activity (Chang et al., 2021). Thus, this study incorporates both social capital and self-efficacy to propose the following hypotheses:

H6: Social media use influences older adults' physical activity behavior through the sequential mediating roles of structural social capital and self-efficacy.

H7: Social media use influences older adults' physical activity behavior through the sequential mediating roles of bonding social capital and self-efficacy.

Methods

Sample and procedure

This study investigates the impact of social media use, social capital, and self-efficacy on physical activity behavior among older adults. Shandong Province was selected as the research site due to its large population, high aging rate (21.5%, exceeding the national average of 18.8%), and relatively advanced economic and digital infrastructure. Participants were recruited from urban and rural communities across multiple regions of Shandong Province between December 1, 2023, and April 1, 2024. To enhance sample representativeness, a multi-stage stratified random sampling approach was employed. In the first stage, districts and counties were stratified by urban–rural classification and key socioeconomic indicators (e.g., average household income and educational attainment). In the second stage, specific communities were randomly selected within each stratum in collaboration with local civil affairs departments and community committees. Within the selected communities, community workers compiled rosters of eligible older adults. From these lists, participants were systematically sampled (e.g., every third name) and invited to participate. To ensure diversity across demographic variables, quotas were applied for age groups (60–69, 70–79, 80+), gender, and self-reported digital literacy levels. Participants were eligible to participate if they met the following criteria: (a) Aged 60 years or older; (b) In generally good physical health, as self-reported or verified by local health service records; (c) Capable of completing the questionnaire independently or with minimal assistance; (d) Reported at least occasional use of social media platforms (e.g., WeChat, QQ, Douyin), without restriction to a specific platform.

Technological proficiency may influence willingness and ability to participate, so measures were taken to reduce selection bias. Specifically, trained investigators conducted face-to-face interviews with older adults with limited formal education, low digital literacy, or difficulty reading. During these sessions, investigators read the questions aloud, explained items when necessary, and recorded responses verbatim, ensuring that individuals with lower levels of digital engagement were adequately represented. A total of 630 questionnaires were distributed. After eliminating incomplete or invalid responses, 519 valid questionnaires were obtained, yielding an effective response rate of 82.4%. The final sample encompassed a broad range of demographic characteristics (Table 1), enhancing the findings' generalizability and robustness.

Measures

The measurement scales used in this study were adapted and validated for the Chinese older adult population. Initially developed by Sánchez-Arrieta et al. (2021), the social media usage intensity scale was modified to reflect the context of older adults in China. This adaptation process involved forward and back translation to ensure clarity and cultural relevance. The scale was validated through expert review and pilot testing, which confirmed its suitability for the target population. The final version of the scale includes five items, assessing older adults' social media engagement

TABLE 1 Demographic characteristics of the participants.

Variables	Options	N	Percent (%)	Total
Gender	Male	275	53.00	519
	Female	244	47.00	
Age	60 ~ 69 years old	318	61.30	519
	70 ~ 79 years old	186	35.80	
	Over 80 years old	15	2.90	
Place of residence	Rural areas	240	46.20	519
	Urban areas	279	53.80	
Education	No formal education	34	6.60	519
	Primary school	154	29.70	
	Junior high school	162	31.20	
	Senior high school(including vocational school and technical school)	67	12.90	
	College or above (including associate degree, bachelor's degree, and postgraduate degree)	102	19.70	
Monthly income	Less than 1,000$	95	18.30	519
	1,001–1,500$	122	23.50	
	1,501–2000$	138	26.60	
	More than 2000$	164	31.60	

and dependency in daily life, with responses recorded on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). This study's scale demonstrated strong reliability, with a Cronbach's alpha of 0.902. We used the Physical Activity Rating Scale (PARS-3) to measure physical activity behavior, as revised by Xiong et al. (2023). This scale evaluates physical activity across three dimensions: exercise intensity, session duration, and frequency, each rated on a five-point scale. The two-week test–retest reliability was 0.85, and the internal consistency coefficient was 0.92, indicating strong reliability. Social capital was assessed through three dimensions: structural social capital, bonding social capital, and bridging social capital, using a five-point Likert scale adapted from Williams (2006) Internet Social Capital Scale. The adapted scale was translated and validated for the Chinese context. Self-efficacy was measured using the General Self-Efficacy Scale (GSES) developed by Kahai and Lei (2019), consisting of 10 items rated on a five-point Likert scale, with higher scores indicating greater self-efficacy. The GSES demonstrated excellent reliability in this study, with a Cronbach's alpha 0.950.

Data analysis

Data analysis was conducted using SPSS 22.0. Harman's single-factor test was employed to assess potential standard method bias, revealing six factors with eigenvalues greater than 1, which together explained a cumulative variance of 69.62%. The first factor accounted for 20.84% of the variance, well below the 40% threshold proposed by Podsakoff et al. (2003), indicating that common method bias was not a significant concern in this study. Although other methods for testing common method bias, such as the marker variable approach, exist, they were not employed here due to Harman's test's robustness and consistency with prior research findings.

Following the assessment of method bias, model fit was evaluated. The model demonstrated a strong fit, with CMIN/DF = 1.820 (<3), GFI = 0.914, AGFI = 0.899, NFI = 0.929, IFI = 0.921, TLI = 0.963, CFI = 0.969, and RMSEA = 0.040 (90% CI: 0.035–0.044). These values indicate a good fit for the data, meeting the criteria proposed by Kim (2005) and Hu and Bentler (1999).

Convergent validity was assessed to establish the psychometric soundness of the model further. The AVE values ranged from 0.603 to 0.651, and the CR values ranged from 0.864 to 0.951, which exceeded the recommended thresholds (Fornell and Larcker, 1981). Discriminant validity was evaluated using Fornell and Larcker's (1981) method. As shown in Table 2, the square root of the AVE for each

construct exceeded its correlations with other constructs, confirming that the scales effectively distinguished between different theoretical concepts. For example, the square root of the AVE for social media usage (0.78) was substantially greater than its correlation with physical activity behavior ($r = 0.32$), demonstrating successful construct differentiation.

Results

This study investigates the relationships between six latent variables: social media use, bridging social capital, bonding social capital, structural social capital, self-efficacy, and physical activity behavior. Specifically, social media use is treated as an exogenous latent variable. In contrast, the three dimensions of social capital (bridging, bonding, and structural), self-efficacy, and physical activity behavior are modeled as endogenous latent variables. A total of 31 observed variables were included in the analysis. Based on the proposed hypotheses, an SEM was constructed to examine the relationships between these variables and to explore how social media use influences physical activity behavior among older adults. The model structure is illustrated in Figure 2. Data analysis was conducted using AMOS 29.0 software, and the resulting fit indices are as follows: CMIN/DF = 1.820, GFI = 0.914, AGFI = 0.899, NFI = 0.929, IFI = 0.921, TLI = 0.963, CFI = 0.969, and RMSEA = 0.040, 90% CI [0.035–0.044]. All indices meet the recommended thresholds, indicating that the model adequately fits the data and demonstrates strong explanatory power regarding the impact of social media use on physical activity behavior among older adults. Furthermore, Table 3 presents the measurement model results, showing that all latent variables—social media use, bonding social capital, bridging social capital, structural social capital, and self-efficacy—passed the significance tests. The p-values for the path coefficients linking these latent variables to their respective observed variables are below 0.01, confirming the validity of the observed variables as indicators of the latent constructs.

As shown in Table 3, the path analysis supported all hypothesized relationships. Specifically, social media usage directly affected physical activity among older adults ($\beta = 0.241$, $p = 0.005$), confirming H1. It also significantly enhanced all three dimensions of social capital—bridging ($\beta = 0.473$), bonding ($\beta = 0.511$), and structural ($\beta = 0.557$)—as well as self-efficacy ($\beta = 0.203$), all at $p < 0.001$.

In turn, the three forms of social capital positively influenced self-efficacy ($\beta = 0.219$ for bridging, 0.439 for bonding, and 0.245 for structural), and both bridging and structural social capital were

TABLE 2 Pearson correlation analysis and AVE square root values.

Variable	SMU	BRI	STR	BON	SE	PAB
SMU	**0.807**					
BRI	0.438	**0.788**				
STR	0.498	0.192	**0.777**			
BON	0.461	0.016	0.344	**0.784**		
SE	0.634	0.361	0.529	0.594	**0.813**	
PAB	0.241	0.197	0.208	0.324	0.470	**0.757**

SMU, social media use; BRI, bridging social capital; STR, structural social capital; BON, bonding social capital; SE, self-efficacy; PAB, physical activity behavior. The bold value is the square root of AVE.
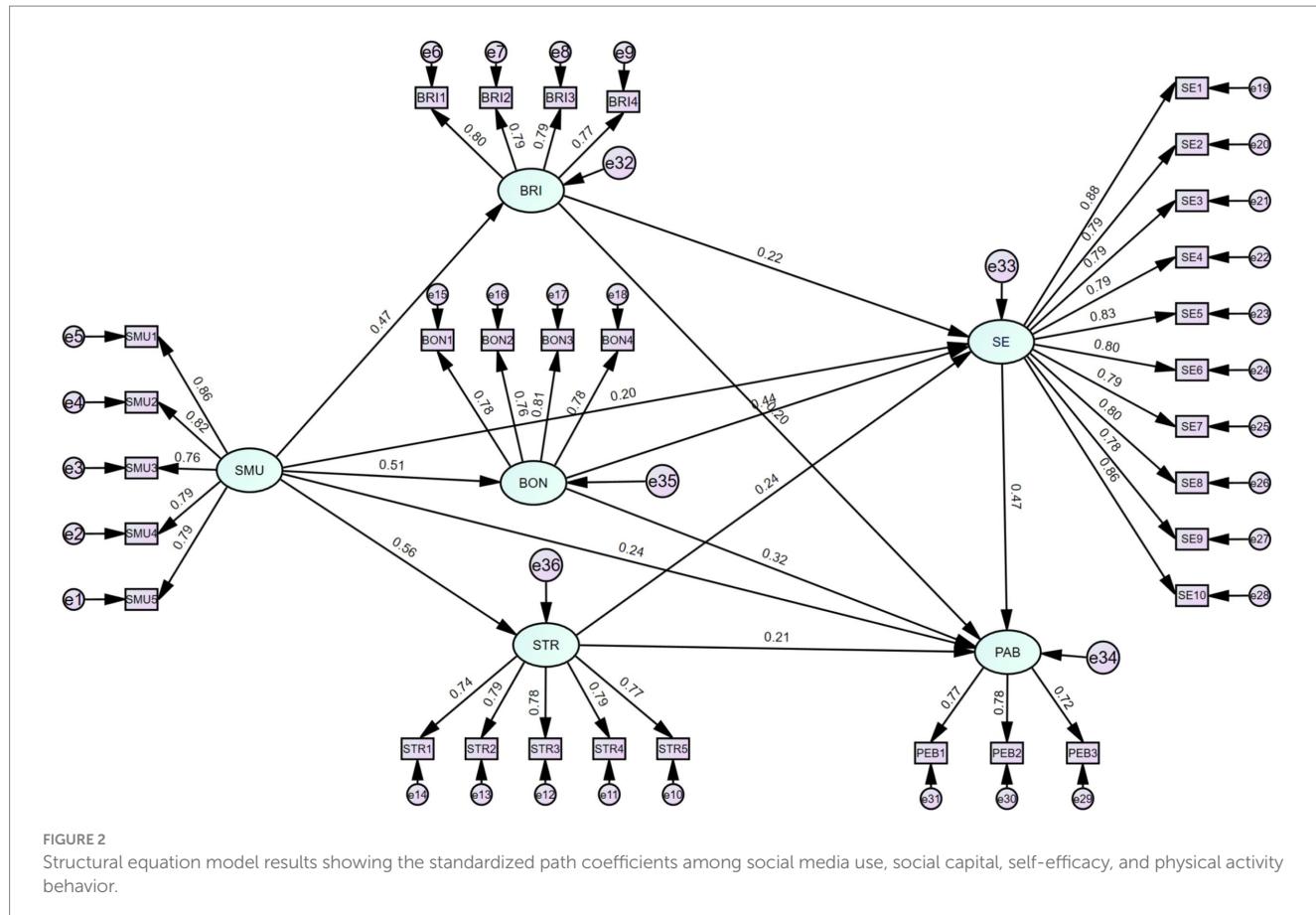
FIGURE 2
Structural equation model results showing the standardized path coefficients among social media use, social capital, self-efficacy, and physical activity behavior.

TABLE 3 Results of SEM path relationship test on factors influencing physical activity behavior of the elderly.

Path	Estimate	S. E.	C. R.	p
BRI ← SMU	0.473	0.05	9.509	***
BON ← SMU	0.511	0.049	10.153	***
STR ← SMU	0.557	0.048	11.082	***
SE ← SMU	0.203	0.056	4.182	***
SE ← BRI	0.219	0.043	5.911	***
SE ← BRI	0.439	0.049	10.532	***
SE ← STR	0.245	0.049	6.147	***
PAB ← BRI	0.197	0.013	2.893	0.004
PAB ← BON	0.324	0.017	3.695	***
PAB ← STR	0.208	0.015	2.862	0.004
H1: PAB ← SMU	0.241	0.016	2.820	0.005
PAB ← SE	0.470	0.018	4.232	***

***$p < 0.001$.

directly associated with higher physical activity ($\beta = 0.197$ and 0.208, respectively; $p = 0.004$). Finally, self-efficacy emerged as a strong predictor of physical activity ($\beta = 0.470$, $p < 0.001$).

Before testing the mediation paths, we verified the existence of multicollinearity among the mediators—structural social capital, bonding social capital, and bridging social capital. The results indicated that all mediators' variance inflation factors (VIFs) were significantly below the threshold of 5, suggesting that multicollinearity

is not a concern (Hair Jr et al., 2010). To further explore the mediation mechanisms, this study employed the Bootstrap method with 5,000 resamples to assess multiple mediation effects. Confidence intervals that do not contain zero were used as indicators of statistical significance. As shown in Table 4, structural social capital (total effect = 0.254, indirect effect = 0.074), bonding social capital (total effect = 0.294, indirect effect = 0.114), and bridging social capital (total effect = 0.237, indirect effect = 0.057) all partially mediate the

TABLE 4 Mediation analysis of the effects of social capital dimensions and self-efficacy on the relationship between social media use and physical activity behavior.

Path	Effect	Effect value	S. E.	95% C. I.
H2: SMU → BRI → PAB	Total effect	0.237	0.058	[0.120, 0.348]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.057	0.021	[0.018, 0.102]
H3: SMU → BON → PAB	Total effect	0.294	0.060	[0.178, 0.412]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.114	0.030	[0.058,0.178]
H4: SMU → STR → PAB	Total effect	0.254	0.059	[0.139, 0.370]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.074	0.027	[0.025, 0.130]
H5: SMU → SE → PAB	Total effect	0.242	0.065	[0.114, 0.371]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.063	0.020	[0.114, 0.371]
H6: SMU→ STR → SE → PAB	Total effect	0.359	0.056	[0.247, 0.470]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.180	0.031	[0.123, 0.243]
H7: SMU→ BON → SE → PAB	Total effect	0.715	0.106	[0.503, 0.922]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	0.536	0.051	[0.430, 0.633]
H8: SMU → BRI → SE → PAB	Total effect	1.487	0.203	[1.086, 1.886]
	Direct effect	0.179	0.065	[0.052, 0.305]
	Indirect effect	1.308	0.203	[1.021, 1.586]

relationship between social media use and physical activity behavior among older adults. These findings fully support Hypotheses H2, H3, and H4. When self-efficacy is considered a mediator, the total effect is 0.242 (direct effect = 0.179, indirect effect = 0.063), indicating partial mediation and fully supporting Hypothesis H5.

In addition, a chain mediation effect was identified: social media use indirectly influences physical activity behavior through the pathway, SMU → social capital (structural, bonding, and bridging social capital) → SE → PAB. Structural social capital (total effect = 0.359, indirect effect = 0.180), bonding social capital (total effect = 0.715, indirect effect = 0.536), and bridging social capital (total effect = 1.487, indirect effect = 1.308) all exhibit mediation effects with confidence intervals that exclude zero (at the 95% confidence level). Since all Bootstrap confidence intervals exclude zero, Hypotheses H6, H7, and H8 are fully supported.

Interpretation and implications of findings

This study investigates how social media use influences physical activity behaviors in older adults. In contrast to the study by Schlenk et al. (2021), which focused on the elderly population in the U.S., this research, based on a survey in Shandong Province, China, finds a significant positive direct relationship between social media use and physical activity behavior among older adults. Despite this, the findings are consistent with several earlier studies (Jiang et al., 2024), which highlight the mediating role of factors such as structural social

capital, bonding social capital, bridging social capital, and self-efficacy in the relationship between social media use and physical activity in older adults. This research expands on these findings by examining how social media use enhances physical activity behaviors through these mediating mechanisms. Building on prior studies, the results show that social media use positively influences physical activity through various mediators, including structural social capital, bonding social capital, bridging social capital, and self-efficacy.

In line with previous research on younger adults (Rutter et al., 2021; Durau et al., 2022), older adults who actively engage in social media for exercise are more likely to participate in physical activities. Specifically, various dimensions of social capital—such as structural social capital, bonding social capital, bridging social capital, and self-efficacy—act as important mediators in the relationship between social media usage and physical activity. This study highlights the essential role of social media in promoting physical activity among older adults, fostering social capital, and contributing to successful aging, thus adding to the growing body of literature in social media and communication studies. The results suggest that social media use can help older adults boost their physical activity levels and increase their self-efficacy by acquiring social capital, encouraging further physical activity. Given the risk factors older adults face—such as physical limitations, functional decline, and muscle loss—they are more likely to experience a decline in physical abilities. Therefore, social media helps older adults establish physical activity habits and offers more opportunities for physical exercise, effectively improving their levels of physical activity.

Notably, the mediating effect of bridging social capital, self-efficacy, and physical activity was substantially larger than the other indirect paths. This result suggests that bridging social capital, which represents loose ties with diverse social groups and access to non-redundant resources, may be particularly influential in promoting physical activity among older adults. Prior studies have suggested that such heterogeneous networks can provide broader informational support, favorable social comparisons, and new behavioral norms, all conducive to enhancing self-efficacy (Han and Zhai, 2024). However, the large effect size (1.308) may also indicate potential model sensitivity or overestimation related to measurement structure, especially in cross-sectional SEM.

Theoretical contributions

This study makes several significant theoretical contributions that are worth highlighting. First, while research on social media usage and its impact on physical activity has expanded over the past decade, studies examining the relationship between social media use and physical activity behavior in older adults remain relatively scarce. By focusing on the elderly population, this study explores how social media usage influences physical activity behavior, offering a fresh perspective. Furthermore, the study makes notable progress in the literature on healthy aging, particularly regarding how social media affects physical activity through various dimensions of social capital (structural, bonding, and bridging social capital) and self-efficacy as mediating factors. These elements have been shown to mediate physical activity behavior in older adults significantly. Specifically, the social connections fostered by social media and the enhancement of self-efficacy are key drivers of physical activity among older adults. The results provide preliminary support for this model, helping to explain variations in physical activity behavior among the elderly. However, this study offers only preliminary evidence regarding the role of social media in influencing older adults' physical activity, leaving several important questions to be explored further. For instance, older adults generally have less exposure to information and communication technology (ICT) and may lack the skills to use new technologies effectively, which worsens the digital divide. Thus, the research assumes that older adults can use social media equally without addressing factors like technological competence and self-efficacy that may impact the effectiveness of social media usage. Moreover, this study demonstrates the positive impact of social media on physical activity in older adults and highlights the chain-mediating effect of self-efficacy. This finding prompts further reflection on how individual differences may moderate the relationship between social media use and physical activity in older adults. For example, we discovered that older adults who are more comfortable with self-disclosure on social media experience a significant boost in self-efficacy when using WeChat. This mediating role of self-efficacy adds depth to the existing literature on how social media influences physical activity behavior differences among older adults.

Practical implications

This study has significant practical implications for both older adults and policymakers. The results indicate that social media use aids older adults in building social capital, which closely correlates with increased self-efficacy and greater physical activity. Social media provides a unique advantage in encouraging older adults to engage in physical activity, particularly for less active ones. Through social media, they can partake in physical activities with close family members and friends and establish new social connections with acquaintances or even strangers. Therefore, the government should continue to invest in enhancing ICT infrastructure, reducing broadband internet costs, and ensuring that older adults have equal internet and social media access, thereby increasing their usage. Additionally, when creating health promotion strategies for aging populations, policymakers should consider regional and educational disparities and design more tailored interventions. For instance, local community centers could motivate older adults to engage in physical activities by organizing a variety of options, such as dance, chess, hiking, and traditional martial arts, to help improve their fitness and overall health.

Limitations and future research directions

The findings of this study should be interpreted in light of several limitations. First, while the study focuses on social media and its direct and indirect effects on physical activity behavior in older adults, it may overlook how other patterns of social media use could influence physical activity. For instance, some older adults may primarily use social media for entertainment, such as watching live streams or political participation, which could affect physical activity differently. Therefore, future research should investigate how diverse social media usage patterns affect physical activity in older adults. Second, this study measures social media use using five specific items designed to capture various aspects of social media use. However, it does not consider certain important activities, such as watching fitness live streams on platforms like WeChat or Douyin and interacting with others. Future studies could expand the measurement of social media use to include a broader range of social media behaviors. To gain a deeper understanding of how different usage dimensions affect physical activity, researchers could analyze each aspect of social media use separately, particularly looking at how activities such as watching fitness streams and other forms of interaction impact older adults' overall use of social media. Third, this study uses cross-sectional data, which limits its ability to establish causal relationships. While we found a correlation between social media use and physical activity, we cannot determine the direction of causality. Future research should utilize longitudinal data or experimental designs to establish causal inferences better. Lastly, while this study shows a positive correlation between social media use and physical activity in older adults and examines the mediating roles of social capital and self-efficacy, it is unclear whether this framework applies to other economically developed regions or countries. Future research could include more diverse samples, such as stratified sampling, to include older adults with limited exposure to or familiarity with digital technologies to test this model's generalizability further.

Conclusion

With the advancement of ICT and the widespread use of smartphones, social media has become a key tool for promoting

home fitness, physical activity, and overall health. While research on the effects of social media use on physical health has increased in recent years, studies examining the link between social media use and physical activity behavior in older adults remain relatively scarce. This study's findings demonstrate a direct relationship between social media use and physical activity behavior in older adults. The research further identifies that social capital (including structural, bonding, and bridging social capital) and self-efficacy play important sequential mediating roles in the relationship between social media usage and physical activity behavior in the elderly. These results confirm the positive correlation between social media use and physical activity observed in previous studies. Additionally, the study highlights that understanding the patterns of social media use and its application in promoting physical activity can help older adults overcome the physical decline and health challenges that come with aging, thereby improving their overall health and quality of life.

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 Ethical Review Form for Studies at the School of Physical Education, SDNU. 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

JL: Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing. CW: Investigation, Methodology, Writing – original draft, Writing – review & editing. ZM: Investigation, Methodology, Writing – original draft, Writing – review & editing. CY: Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing.

Funding

Acknowledgments

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.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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

Arlati, S., Colombo, V., Spoladore, D., Greci, L., Pedroli, E., Serino, S., et al. (2019). A social virtual reality-based application for the physical and cognitive training of the elderly at home. *Sensors* 19:261. doi: 10.3390/s19020261

Asiamah, N., Conduah, A. K., and Eduafo, R. (2021). Social network moderators of the association between Ghanaian older adults' neighbourhood walkability and social activity. *Health Promot. Int.* 36, 1357–1367. doi: 10.1093/heapro/daaa156

Bandura, A. (1989). Human agency in social cognitive theory. *Am. Psychol.* 44:1175. doi: 10.1037/0003-066X.44.9.1175

Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Cambridge, Massachusetts, and London, England: Harvard University Press.

Celik, I. (2023). Exploring the determinants of artificial intelligence (AI) literacy: digital divide, computational thinking, cognitive absorption. *Telemat. Inform.* 83:102026. doi: 10.1016/j.tele.2023.102026

Chang, S. H., Wang, L. T., Chueh, T. Y., Hsueh, M. C., Hung, T. M., and Wang, Y. W. (2021). Effectiveness of facebook remote live-streaming-guided exercise for improving the functional fitness of community-dwelling older adults. *Front. Med.* 8:734812. doi: 10.3389/fmed.2021.734812

Chen, X., Giles, J., Yao, Y., Yip, W., Meng, Q., Berkman, L., et al. (2022b). The path to healthy ageing in China: a Peking University–lancet commission. *Lancet* 400, 1967–2006. doi: 10.1016/S0140-6736(22)01546-X

Chen, H.-T., and Li, X. (2017). The contribution of mobile social media to social capital and psychological well-being: examining the role of communicative use, friending and self-disclosure. *Comput. Human Behav.* 75, 958–965. doi: 10.1016/j.chb.2017.06.011

Chen, E., Wood, D., and Ysseldyk, R. (2022a). Online social networking and mental health among older adults: a scoping review. *Canad. J. Aging* 41, 26–39. doi: 10.1017/S0714980821000040

Dahlberg, L., McKee, K. J., Frank, A., and Naseer, M. (2022). A systematic review of longitudinal risk factors for loneliness in older adults. *Aging Ment. Health* 26, 225–249. doi: 10.1080/13607863.2021.1876638

Durau, J., Diehl, S., and Terlutter, R. (2022). Motivate me to exercise with you: the effects of social media fitness influencers on users' intentions to engage in physical activity and the role of user gender. *Digit. Health* 8:20552076221102769. doi: 10.1177/20552076221102769

Fan, J., Guo, X., Liu, X., and Xue, X. (2023). Research on users' exercise behaviors of online exercise community based on social capital theory. *Systems* 11:411. doi: 10.3390/systems11080411

Fornell, C., and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* 18, 39–50. doi: 10.1177/002224378101800104

Fu, W., Li, Y., Liu, Y., Li, D., Wang, G., Liu, Y., et al. (2023). The influence of different physical exercise amounts on learning burnout in adolescents: the mediating effect of self-efficacy. *Front. Psychol.* 14:1089570. doi: 10.3389/fpsyg.2023.1089570

Fu, C., Wang, C., Yang, F., Cui, D., Wang, Q., and Mao, Z. (2018). Association between social capital and physical activity among community-dwelling elderly in Wuhan, China. *Int. J. Gerontol.* 12, 155–159. doi: 10.1016/j.ijge.2017.10.001

Gao, Z., Chee, C. S., Omar Dev, R. D., Liu, Y., Gao, J., Li, R., et al. (2025). Social capital and physical activity: a literature review up to March 2024. *Front. Public Health* 13:1467571. doi: 10.3389/fpubh.2025.1467571

Godfrey, M., and Johnson, O. (2009). Digital circles of support: meeting the information needs of older people. *Comput. Human Behav.* 25, 633–642. doi: 10.1016/j.chb.2008.08.016

Guan, J. (2024) An intervention model to motivate older adults to participate in physical activity (doctoral dissertation, Loughborough University). Thesis. doi: 10.26174/thesis.lboro.27891156.v1

Guaya, D. E., Jaramillo-Fierro, X. V., Meneses, M. A., and Valarezo, E. (2025). Innovative chemical engineering education: social media-enhanced project-based learning approaches. *Emerg. Sci. J.* 8, 358–378. doi: 10.28991/ESJ-2024-SIED1-021

Hair, J. F. Jr., Black, W. C., Babin, B. J., and Anderson, R. E. (2010). Multivariate data analysis. In *Multivariate data analysis.* 7 ed. London: Prentice Hall, 785.

Han, G., and Zhai, Y. (2024). Temporary food insecurity, social capital, and mental health during the COVID-19 lockdowns in Shanghai. *J. Urban Aff.* 1, 1–17. doi: 10.1080/07352166.2024.2393840

Ho, V., and Merchant, R. A. (2022). The acceptability of digital technology and tele-exercise in the age of COVID-19: cross-sectional study. *JMIR aging* 5:e33165. doi: 10.2196/33165

Hu, L. T., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model. Multidiscip. J.* 6, 1–55. doi: 10.1080/10705519909540118

Huang, Y., Ma, Y., Ou, J., and Ma, J. (2024). Capital or burden? The impact of social networks on elderly care services consumption: evidence from China. *Int. Rev. Econ. Finance* 94:103416. doi: 10.1016/j.iref.2024.103416

Jansons, P., Fyfe, J., Via, J. D., Daly, R. M., Gvozdenko, E., and Scott, D. (2022). Barriers and enablers for older adults participating in a home-based pragmatic exercise program delivered and monitored by Amazon Alexa: a qualitative study. *BMC Geriatr.* 22:248. doi: 10.1186/s12877-022-02963-2

Jiang, M. M., Xiao, Y. W., and Liao, Z. L. (2024). Pathways of media contact to health literacy in middle-aged and older people: the chain mediation effect of perceived social support and self-efficacy. *J. Multidiscip. Healthc.* 17, 111–121. doi: 10.2147/JMDH.S448223

Jitsaeng, K., Chansanam, W., Kanyacome, S., Detthamrong, U., and Li, C. (2024). Factors influencing social media platform engagement among Thai students: a quantitative study. *Emerg. Sci. J.* 8, 539–556. doi: 10.28991/ESJ-2024-08-02-011

Kahai, S. S., and Lei, Y. (2019). Building social capital with Facebook: type of network, availability of other media, and social self-efficacy matter. *Int. J. Hum.-Comput. Stud.* 130, 113–129. doi: 10.1016/j.ijhcs.2019.05.013

Kim, K. H. (2005). The relation among fit indexes, power, and sample size in structural equation modeling. *Struct. Equ. Model.* 12, 368–390. doi: 10.1207/s15328007sem1203_2

Kim, A. C. H., Ryu, J., Lee, C., Kim, K. M., and Heo, J. (2021). Sport participation and happiness among older adults: a mediating role of social capital. *J. Happiness Stud.* 22, 1623–1641. doi: 10.1007/s10902-020-00288-8

Lin, X., and Kishore, R. (2021). Social media-enabled healthcare: a conceptual model of social media affordances, online social support, and health behaviors and outcomes. *Technol. Forecast. Soc. Change* 166:120574. doi: 10.1016/j.techfore.2021.120574

Liu, P. L., and Yeo, T. E. D. (2022). Weak ties matter: social network dynamics of mobile media multiplexity and their impact on the social support and psychological well-being experienced by migrant workers. *Mobile Media Commun.* 10, 76–96. doi: 10.1177/20501579211001106

Liu, J., Yin, C., and Sun, B. (2024). Associations between neighborhood environments and health status among Chinese older people during the pandemic: exploring mediation effects of physical activity. *J. Transp. Health* 35:101757. doi: 10.1016/j.jth.2024.101757

Liu, Q., and Zhao, D. (2023). A study of the impact of population aging on fiscal sustainability in China. *Sustain. For.* 15:5409. doi: 10.3390/su15065409

Long, K. M., Casey, K., Bhar, S., Al Mahmud, A., Curran, S., Hunter, K., et al. (2024). Understanding perspectives of older adults on the role of technology in the wider context of their social relationships. *Ageing Soc.* 44, 1453–1476. doi: 10.1017/S0144686X2200085X

López-Carril, S., Escamilla-Fajardo, P., González-Serrano, M. H., Ratten, V., and González-García, R. J. (2020). The rise of social media in sport: a bibliometric analysis. *Int. J. Innov. Technol. Manag.* 17:2050041. doi: 10.1142/s0219877020500418

Nahapiet, J., and Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Acad. Manag. Rev.* 23, 242–266. doi: 10.5465/amr.1998.533225

Patterson, M. S., Amo, C. E., Prochnow, T., and Heinrich, K. M. (2022). Exploring social networks relative to various types of exercise self-efficacy within CrossFit participants. *Int. J. Sport Exerc. Psychol.* 20, 1691–1710. doi: 10.1080/1612197X.2021.1987961

Perez Fernandez, H., Rodriguez Escudero, A. I., Martin Cruz, N., and Delgado Garcia, J. B. (2024). The impact of social capital on entrepreneurial intention and its antecedents: differences between social capital online and offline. *BRQ Bus. Res. Q.* 27, 365–388. doi: 10.1177/23409444211062228

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., and Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J. Appl. Psychol.* 88:879. doi: 10.1037/0021-9010.88.5.879

Rahe, M. L., Van Leuven, A. J., and Malone, T. (2025). Leveraging social ties to financial gains: exploring the impact of social capital in rural development. *J. Rural. Stud.* 114:103539. doi: 10.1016/j.jrurstud.2024.103539

Reid, J., Cormack, D., and Crowe, M. (2016). The significance of socially-assigned ethnicity for self-identified Māori accessing and engaging with primary healthcare in New Zealand. *Health* 20, 143–160. doi: 10.1177/1363459315568918

Roberts, J. A., and David, M. E. (2020). The social media party: fear of missing out (FoMO), social media intensity, connection, and well-being. *Int. J. Hum.-Comput. Interact.* 36, 386–392. doi: 10.1080/10447318.2019.1646517

Rutter, L. A., Thompson, H. M., Howard, J., Riley, T. N., De Jesús-Romero, R., and Lorenzo-Luaces, L. (2021). Social media use, physical activity, and internalizing symptoms in adolescence: cross-sectional analysis. *Jmir. Ment. Health* 8:e26134. doi: 10.2196/26134

Sachan, T., Chhabra, D., and Abraham, B. (2025). Social Capital in Online Gaming Communities: a systematic review examining the role of virtual identities. *Cyberpsychol. Behav. Soc. Netw.* 28, 147–161. doi: 10.1089/cyber.2024.0375

Sánchez-Arrieta, N., González, R. A., Cañabate, A., and Sabate, F. (2021). Social capital on social networking sites: a social network perspective. *Sustain. For.* 13:5147. doi: 10.3390/su13095147

Schemer, C., Masur, P. K., Geiß, S., Müller, P., and Schäfer, S. (2021). The impact of internet and social media use on well-being: a longitudinal analysis of adolescents across nine years. *J. Comput.-Mediat. Commun.* 26, 1–21. doi: 10.1093/jcmc/zmaa014

Schlenk, E. A., Sereika, S. M., Martire, L. M., and Shi, X. (2021). Older adults' social network and support and its association with physical activity. *Geriatr. Nurs.* 42, 517–523. doi: 10.1016/j.gerinurse.2020.09.006

Sen, K., Prybutok, G., and Prybutok, V. (2022). The use of digital technology for social wellbeing reduces social isolation in older adults: a systematic review. *SSM-Popul. Health* 17:101020. doi: 10.1016/j.ssmph.2021.101020

Solano, G. (2025). Negative social capital and requests for resources in a developing country: the case of rural–urban migrants in Kampala, Uganda. *Int. Migr.* 63:e13244. doi: 10.1111/imig.13244

Steinhoff, P., and Reiner, A. (2024). Physical activity and functional social support in community-dwelling older adults: a scoping review. *BMC Public Health* 24:1355. doi: 10.1186/s12889-024-18863-6

Sun, S., Wang, Y., Wang, L., Lu, J., Li, H., Zhu, J., et al. (2024). Social anxiety and loneliness among older adults: a moderated mediation model. *BMC Public Health* 24:483. doi: 10.1186/s12889-024-17795-5

Szwedo, D. E., Davis, A. A., Fowler, C., Mikami, A. Y., and Allen, J. P. (2024). Social media posts from friends during late adolescence as predictors of young adult physical health. *J. Youth Adolesc.* 53, 784–798. doi: 10.1007/s10964-024-01945-4

Tseng, H. T., Ibrahim, F., Hajli, N., Nisar, T. M., and Shabbir, H. (2022). Effect of privacy concerns and engagement on social support behaviour in online health community platforms. *Technol. Forecast. Soc. Change* 178:121592. doi: 10.1016/j.techfore.2022.121592

Tuan, T. A., Nghia, N. H., Dai An, T., and Loan, D. T. T. (2024). Exploring mental stress expressions in online communities: a subreddit analysis. *J. Human Earth Future* 5, 131–150. doi: 10.28991/HEF-2024-05-02-01

Wang, G., and Xu, J. (2024). The effect of social media forwarding on subjective well-being in Chinese older adults: a moderated mediation model. *Psychol. Res. Behav. Manag.* 17, 917–931. doi: 10.2147/prbm.S449852

Wei, L., and Gao, F. (2017). Social media, social integration and subjective well-being among new urban migrants in China. *Telemat. Informs* 34, 786–796. doi: 10.1016/j.tele.2016.05.017

Williams, D. (2006). On and off the'net: scales for social capital in an online era. *J. Comput.-Mediat. Commun.* 11, 593–628. doi: 10.1111/j.1083-6101.2006.00029.x

Xiong, G., Wang, C., and Ma, X. (2023). The relationship between physical activity and mental depression in older adults during the prevention and control of COVID-19: a mixed model with mediating and moderating effects. *Int. J. Environ. Res. Public Health* 20:3225. doi: 10.3390/ijerph20043225

Xiong, J., Ye, M., Wang, L., and Zheng, G. (2021). Effects of physical exercise on executive function in cognitively healthy older adults: a systematic review and meta-analysis of randomized controlled trials: physical exercise for executive function. *Int. J. Nurs. Stud.* 114:103810. doi: 10.1016/j.ijnurstu.2020.103810

Yi, J., Yoon, J. Y., Won, C. W., Kim, M., and Lee, K. S. (2024). The roles of health literacy and social support in the association between smartphone ownership and frailty in older adults: a moderated mediation model. *BMC Public Health* 24:1064. doi: 10.1186/s12889-024-18163-z

Yu, G., and Song, Y. (2022). What affects sports participation and life satisfaction among urban residents? The role of self-efficacy and motivation. *Front. Psychol.* 13:884953. doi: 10.3389/fpsyg.2022.884953

Zhang, J., Özpolat, K., Karamemis, G., and Schniederjans, D. (2025). To disclose or not? The impact of prosocial behavior disclosure on the attainment of social capital on social networking sites. *Decis. Support. Syst.* 192:114437. doi: 10.1016/j.dss.2025.114437

Zhao, L. (2021). The effects of mobile social media use on older migrants' social integration and life satisfaction: use types and self-esteem perspective. *Soc. Sci. Comput. Rev.* 41:08944393211042545. doi: 10.1177/08944393211042545

Zhong, H. M., Xu, H. B., Guo, E. K., Li, J., and Wang, Z. H. (2022). Can internet use change sport participation behavior among residents? Evidence from the 2017 Chinese general social survey. *Front. Public Health* 10:837911. doi: 10.3389/fpubh.2022.837911

The mediating effect of self-perceived aging on social capital and depression among Chinese community-dwelling older adult: a cross-sectional study

Yuguo Ye[1], Hui Liu[2], Ziming Wang[3], Qianwei Zhang[4], Shifan Yang[2] and Lian Yang[5]*

[1]Faculty of Public Health & Policy, London School of Hygiene & Tropical Medicine, London, United Kingdom, [2]Sichuan Development Centre for Healthy Aging, Chengdu, China, [3]China Center for Health Development Studies, Peking University, Beijing, China, [4]Department of Nutrition and Food Hygiene, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China, [5]HEOA Group, School of Public Health, Chengdu University of Traditional Chinese Medicine, Chengdu, China

Background: Amid an aging society, boosting older adult social capital is crucial to meet their growing health needs. This could be an effective way to alleviate the shortage of public health resources and improve the mental health of the older adult. However, the underlying mediation pathways of how social capital affects the mental health of the older adult are not yet clear. This study aims to explore whether social capital has an impact on the depression levels of community-dwelling older adult and whether self-perceived aging mediates the relationship between social capital and depression, while providing a theoretical basis for scientifically constructing mental health intervention programs for the older adult.

Method: A cross-sectional study was conducted from June to December 2022 in Chengdu, China. A stratified sampling survey of 1809 community-dwelling older adult individuals was conducted. Data on sociodemographic characteristics, social capital, self-perceived aging, and depression were collected. Univariate analysis was used to compare the depression differences among community-dwelling older adult with different sociodemographic characteristics. Pearson correlation analysis was used to explore the correlations between social capital, self-perceived aging, and depression. The SPSS PROCESS macro program was used to test the mediating effect of self-perceived aging between social capital and depression.

Results: The mean score of depression was 39.07 (SD 13.97). Univariate analysis showed that there were statistically significant differences in depression scores among community-dwelling older adult of different age, marital status, chronic disease, medical insurance, endowment insurance, and monthly income per capita ($p < 0.05$). Social capital is negatively correlated with self-perceived aging ($r = -0.418$, $p < 0.001$) and also negatively correlated with depression ($r = -0.263$, $p < 0.001$), while self-perceived aging is positively correlated with depression ($r = 0.324$, $p < 0.001$). Social capital was negatively correlated with depression ($\beta = -0.477$, $p < 0.001$), and self-perceived aging partially mediated the relationship between social capital and depression, with a mediating effect

of −0.180 (95% bootstrap CI −0.225 ~ −0.139), accounting for 37.7% of the total effect.

Conclusion: Self-perceived aging played a partial mediating role between social capital and depression. It is recommended that relevant management agencies, communities, and families take effective measures to enhance the social capital of the older adult, help them build a positive self-perceived aging, and thereby reduce the risk of depression.

KEYWORDS

social capital, depression, self-perceived aging, older adult, mediation analysis, cross-sectional study

1 Introduction

Aging in China is a particularly pressing issue, given that the country has already transitioned into an aging society. As this demographic trend persists, it will further intensify the burden on both family and public healthcare systems (1). The aging trend is sign significant with the population of individuals aged 60 and above exceeding 297 million, accounting for 21.1% of the total population (2). In the face of such a large older adult population, their mental health issues have become a focus of concern for the nation and society. Depression has become a common mental disorder affecting the older adult in China (3, 4). According to the fourth round of the China Health and Retirement Longitudinal Study (CHARLS) in 2018, approximately 50.6% of older adult individuals in both urban and rural areas exhibit symptoms of depression (5). This grim reality urgently demands that we identify and validate modifiable risk factors and effective intervention measures. In the last decade, the Chinese government has given high priority to the mental health and social integration of the older adult, actively enhancing relevant policies and services (6). Against this backdrop, social capital, as an important social resource, has gradually attracted widespread academic attention for its potential impact on the mental health of the older adult.

Social capital has been defined in diverse ways across the literature (7). Over time, scholarly discourse has extended its concept from an individual asset to a feature of communities and even nations (8). Robison et al. (9) argued that definitions of social capital should be limited to what social capital is, rather than including statements about its applications, such as where it resides or what is can be used to achieve. In our study, social capital is defined as a person's or group's sympathy toward another person or group that may produce a potential benefit, advantage, and preferential treatment for another person or group of persons beyond that expected in an exchange relationship (9).

Measurement is a critical topic for social capital research. There is no consensus on social capital measurements, and different constructs of social capital are usually overlapping (10, 11). This study identified two validated Chinese-language social capital scales that are widely cited in the literature (12, 13). Based on an international multidisciplinary literature review, Gui and Huang developed a Chinese-language multidimensional scale to measure community social capital, incorporating seven key dimensions: local networks, sentiment, cohesion, non-local sociability, volunteerism, reciprocity and general trust, and community trust. Their analysis of data from 50 communities demonstrated strong reliability and validity. Subsequent English-language cross-sectional social capital studies

have successfully applied and adapted this multidimensional scale (14, 15). Chen et al. (12) developed another validated social capital measurement index specifically for the Chinese context, also in Chinese language, employing a rigorous methodology that combined a literature review, expert panel discussions, and a two-round Delphi study involving 34 field experts to ensure robust reliability and validity. The eventually established index system included 5 first (including individual, family, community, workspace, and macro social capital), 23 s, and 50 third level indicators. Subsequent English-language cross-sectional studies adopted and adapted this multi-level social capital scale (16, 17).

Research shows that social capital not only provides individuals with emotional support, information exchange, and practical assistance but also promotes community cohesion, thereby helping to combat psychological distress, including depressive mood (18). Social capital is particularly important in the role of depression because it is directly related to an individual's sense of social integration and belonging (19), which are crucial cornerstones of mental health. When individuals possess greater social capital, they are more likely to receive emotional support from friends and family, a vital resource in alleviating stress and combating depression (20, 21). However, despite studies indicating a positive correlation between social capital and mental health in the older adult (22–25), there is still a lack of in-depth discussion on how it specifically affects older adult depression, especially from the perspective of self-perceived aging (SPA).

Self-perceived aging, which refers to an individual's subjective feelings and cognition about their own aging process (26, 27), is one of the key factors affecting the mental health of the older adult. Individuals with high SPA often hold more negative attitudes towards aging, and this negative cognition may exacerbate feelings of loneliness and helplessness, thereby increasing the risk of depression (28, 29).

Research indicates that social capital shapes SPA through multiple levels of influence. At the individual, family, and community social capital levels, Li et al. (30) found that marital status, frequency of children's visits, and self-reported health indirectly affect SPA by reducing loneliness, while time spent outdoors indirectly influences SPA through improvements in daily living activities and social connectedness. According to Liu et al. (31), individuals more involved in grandchild care reported feeling older at younger ages. Additionally, workplace social capital also plays a critical role, as Tybjerg-Jeppesen et al. (32) demonstrated that a positive intergenerational work climate enhances SPA, increases work engagement, and reduces turnover intention. Liu et al. (31) found

that individuals involved in political or community activities reported stronger perceptions of aging than their non-participating counterparts. At the society social capital level, Xiao et al. (33) identified the forms of healthcare and harmonious social environment as key determinants of SPA among older adults. Therefore, we hypothesize that self-perceived aging may be an important mediating variable between social capital and older adult depression. This hypothesis is supported by the study which indicates that SPA can significantly impact the mental health outcomes of the older adult (34). Ultimately, our study's hypothesis is grounded in the following logical framework: individuals or groups with greater social capital (i.e., those who enjoy exchanges of relational goods and have rich sympathy toward another person or group that may produce a potential benefit, advantage, and preferential treatment for another person or group of persons beyond that expected in in exchange relationships across individual, family, community, association, and society levels) are more likely to form a more positive SPA, thereby reducing the risk of depression. SPA is not only a core variable influencing the mental health of older adults, directly related to their sense of happiness and satisfaction in later life, but also a malleable factor that can be significantly improved through psychological interventions and social support. Therefore, by exploring the mediating role of SPA in the relationship between social capital and older adult depression, we can not only gain a deeper understanding of the causes of older adult depression but also provide a scientific basis for developing more precise and effective mental health intervention strategies.

Communities, as the primary venues for the lives and social interactions of the older adult, offer unique advantages for mental health interventions (35), such as easy access, feasibility of implementation, and cost-effectiveness (36). However, community-dwelling older adult individuals not only face the gradual decline of physical functions (37), but also bear multiple pressures such as changes in social roles and family structures, all of which may affect their mental health status (38). Moreover, the failure to correctly distinguish between depression and normal aging, insufficient societal attention to the mental health of the older adult, and social prejudice against individuals with depression lead to low recognition and inadequate treatment of older adult depression (39, 40). As the aging population intensifies, these issues will become more pronounced.

In this context, this study centers on community-dwelling older adult in China, aiming to explore the relationship between social capital and depression of older adults and factors that mediate the association. By delving into these relationships, we hope to provide a scientific basis for developing more precise and effective mental health intervention strategies for the older adult. We developed the following priori hypotheses (Figure 1): (1) Social capital will be negatively correlated with depression; (2) Self-perceived aging will mediate the relationship between social capital and depression.

2 Methods

2.1 Study population and data collection

This is a cross-sectional study conducted in the main urban districts of Chengdu City, Sichuan Province, China, from June to December 2022. Chengdu was chosen as the research location not only because of its leading economic position in Western China, high urbanization rate, and strong population appeal, but also due to its higher aging population proportion compared to the national average. This characteristic makes Chengdu an ideal place to study aging-related issues. A multi-stage cluster (stratified) random sampling method was employed. Firstly, based on the administrative division of Chengdu City, five central urban districts comprising only urban streets and communities were sampled. Secondly, two communities were randomly selected from each of the five urban districts, resulting in a total of 10 communities being chosen as the study's sampling points. Finally, older adult individuals, in the selected communities with singular number of units and singular number of houses, who met the inclusion criteria were recruited to participate in a questionnaire survey.

Ten medical graduate students were recruited as interviewers and given them 1-week standardized training before data collection. The training covered research purposes, interview strategies and coding methods. The completed questionnaire and the coded entry process of the questionnaire were reviewed by two researchers daily during the survey period to ensure completeness of investigation and correctness of entry. The older adult filled out the questionnaire by themselves through face-to-face survey; for those who had difficulty in reading and writing, investigators would read questions for them and filled out
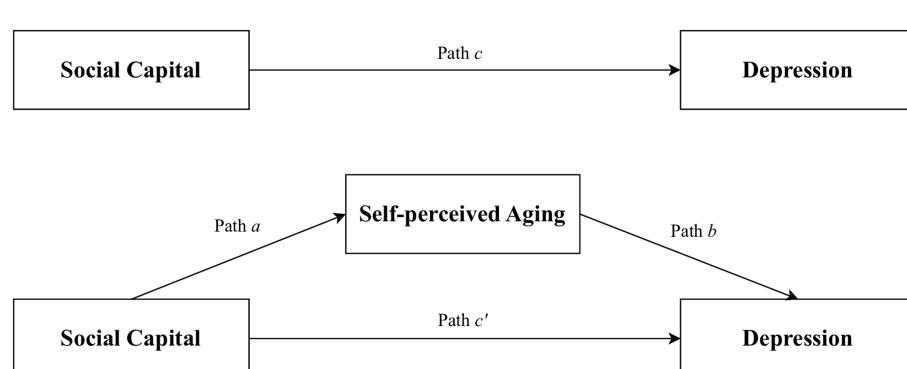

FIGURE 1
Proposed models that investigate mediated effects in the association between social capital and depression.

questionnaires based on the answers of the older adult. Inclusion criteria: Permanent residents in main urban areas aged ≥ 60 years in Chengdu. Consciousness and able to express their current situation clearly. Exclusion criteria: Severe chronic non-infectious diseases based on International Classification of Diseases-10 (ICD-10), such as serious mental diseases, heart failure, renal failure, liver failure, malignant tumors. Severe mental diseases according the diagnostic and statistical manual of mental disorders-5(DSM-5), such as Schizophrenia, Bipolar disorder.

Sample size calculation was based on the formula: $n = \dfrac{\mu_{\alpha/2}^2 \pi (1-\pi)}{\delta^2}$. δ represents the margin of error, taken as 2.5%, $\alpha = 0.05$, and $\mu_{\alpha/2} = 1.96$. Literature indicates that the prevalence of depressive symptoms among individuals aged 60 and above in China is 50.4%, hence $\pi = 50.4\%$. The calculation yielded a required sample size of 1,537 for this study. Considering design effects, missing data, and non-response, to ensure a sufficient number of participants, the adjusted sample size was taken as 1.2 times the calculated sample size, resulting in a final sample size of approximately 1844 individuals. In the end, 1809 respondents completed the questionnaire, of which 1706 questionnaires were completed and valid, with an effective rate of 94.3%. This study was ethically approved by the Medical Ethics Committee of the Affiliated Hospital of Chengdu University of Chinese Medicine (approval no. 2023KL-011). The investigation was conducted in accordance with the Declaration of Helsinki.

2.2 Sociodemographic variables

The sociodemographic questionnaire was developed by the researchers, and the information included gender, age (60–69, 70–79 and ≥80 years), marital status (married and divorce/separate/widowed), education level (primary school or below, junior high school, senior high school, college or above), whether have chronic disease, whether have medical insurance, whether have endowment insurance and monthly income per capita (<1,000, 1,000–1,999, 2,000–2,999 and >3,000). Chronic diseases include hypertension, cardiovascular disease and diabetes mellitus. Endowment insurance also calls old age insurance, it is to point to national legislation compulsory collection of social insurance premium, and the formation of pension fund, pension is paid when the laborer retires, in order to ensure the social security system that its basic life needs (Supplementary Table S1).

2.3 Measurement of social capital

We adapted Chen et al.'s validated Chinese health-related social capital scale to develop our study-specific questionnaire (12). Due to the abstract nature of social capital as a construct (41), we operationalized it through proxy indicators reflecting its functional levels. We adapted a first-level indicator from "workplace" to "association" to more accurately capture retirees' organizational engagements. Corresponding secondary indicators were also refined to align with our study purpose. The social capital scale in this study has 15 items, which are divided into five levels: individual, family, association, community, and society. The first level was individual social capital with 3 variables, measuring individual's social network

(e.g., you have lots of close relationship in your life). The second level was family social capital with 4 variables, measuring the relationship with family members and available support from family (e.g., your family is always around you). The third level was association dimension with 2 variables, including participation in organization activities (e.g., in the past year, you have usually participated in organization activities). The forth level was community social capital with 3 variables, including trust neighborhood and sense of belonging (e.g., if I have to move out of my present place, you will feel reluctant to do so). The last level was society dimension with 3 variables, concerning trust and equity (e.g., you have a lot of trust in medical institutions like hospitals and CDC). The answers consisted of 5-point Likert scales. The response categories were: 1 = strongly disagree to 5 = strongly agree. The total score was 15–75 points. The higher the score of each dimension and the overall total score, the higher the level of social capital. The Cronbach's α value of the health-related social capital scale was 0.711 (Supplementary Table S2).

2.4 Measurement of self-perceived aging

The B-APQ (Brief Aging Perceptions Questionnaire), developed by Sexton et al. (42) based on the Leventhal self-adjustment theory model, measured SPA (42, 43). This questionnaire comprises 21 items across five dimensions: timeline-chronic, consequences positive, consequences and control negative, control positive, and emotional representations. Responses are recorded using a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. These five dimensions can be categorized into two broader aspects: negative SPA and positive SPA (44). Negative SPA encompasses the dimensions of timeline-chronic, consequences and control negative, and emotional representations. In contrast, positive SPA is constituted by consequences positive and control positive. It is important to note that the scoring for positive SPA (consequences positive and control positive) is reversed. The total score was 21–105 points. The higher the score of each dimension and total score of SPA, the more negative the SPA. The reliability of the B-APQ scale is supported by a Cronbach's α value of 0.821 (Supplementary Table S3).

2.5 Measurement of depression

In this study, the Self-rating Depression Scale (SDS) was utilized to assess the depressive symptoms among the community-dwelling older adult population. The SDS, developed by Zung et al. (45), consists of 20 items scored using a 4-point Likert scale (46, 47). Ten of these items, specifically 2, 5, 6, 11, 12, 14, 16, 17, 18, and 20, are reverse-scored. A lower score indicates a better mental state. For ease of comprehension and comparison, the raw SDS score is multiplied by 1.25 to obtain the standard score. The total score was 25–100 points. The Cronbach's α value for the SDS scale is 0.963.

2.6 Statistical analysis

The purpose of this study was to explore the pathway of SPA and social capital' effects on depression in the older adult. Therefore, the mediating effect of SPA was the main objective of data analysis in this

study. Data analysis was conducted using SPSS 23.0 software. Continuous variables that were normally distributed, such as social capital, SPA, and depression, were expressed as mean ± standard deviation (SD). Categorical variables (such as age, gender, education, etc.) were presented as N (%). Independent samples t-tests and one-way ANOVA were employed to assess differences in SDS score (depression) among community-dwelling older adult with varying sociodemographic characteristics. Pearson correlation analysis was utilized to investigate the correlations between social capital, SPA, and depression.

The hypothesized mediation model (Figure 1) was tested using the PROCESS macro in SPSS, a widely recognized tool for examining mediating effects in current research. Social capital was designated as the prediction variable, SPA as the mediator, and depression as the outcome variable. Sociodemographic factors including age, marital status, chronic disease, medical insurance, endowment insurance, and monthly income per capita were included as covariates to control for potential confounding effects. The coefficient c' represented the direct effect of social capital on depression. The indirect influence of social capital on depression through SPA was captured by the product of coefficients a and b (a × b). The total effect of social capital on depression was indicated by coefficient c, which is the sum of c' and a × b. Point estimates were derived from 5,000 bootstrap samples, and 95% confidence intervals (CI) were calculated. An indirect effect was considered significant if the 95% CI did not include zero. All statistical tests were two-tailed, and the significance level for all analyses was set at 0.05. In addition, Cronbach's alpha, ranging from 0 to 1, was used to assess the reliability of social capital scales. A Cronbach's alpha of 0.6 or greater was considered acceptable (48).

3 Results

3.1 Sociodemographic characteristics and SDS score of samples

A total of 1706 community-dwelling older adult people over 65 years old were included in this study, with an average age of 73.75 ± 7.25. Most of them were female (56%), married (74.3%), had no chronic diseases (62.6%), had medical insurance (94.7%) and had endowment insurance (90.7%). Among all participants, the mean score of SDS was 39.07 (SD 13.97). The results of univariate analysis indicated that there were statistically significant differences in SDS score among older adults with different age, marital status, chronic disease, medical insurance, endowment insurance and monthly income per capita ($p < 0.05$). 80 years old and above, married, with chronic disease, with medical insurance, with endowment insurance, monthly income per capita 3,000 yuan and over, are the characteristics older adults with which have a lower level of SDS compared with other groups (Table 1).

3.2 Correlations between social capital, self-perceived aging and depression

Pearson's r correlation analysis was conducted. The results indicated that social capital was significantly negatively correlated with depression (r = −0.263, $p < 0.001$) and SPA (r = −0.418,

$p < 0.001$). Meanwhile, SPA was significantly positively correlated with depression (r = 0.324, $p < 0.001$) (Table 2). The significant correlation among the three variables indicates that their relationship can be further examined and elucidated through the development of a regression analysis model.

3.3 Mediation test for self-perceived aging

Tables 3, 4 and Figure 2 presented the results of the mediation analysis conducted using the PROCESS macro. After adjusting for sociodemographic factors, the total effect of social capital on depression was significant (c = −0.477, $p < 0.001$). When SPA was introduced as a mediator, the direct predictive effect of social capital on depression persisted (c' = −0.297, $p < 0.001$). In addition, social capital had a significant predictive effect on SPA (a = −0.566, $p < 0.001$), and the predictive effect of SPA on depression was also significant (b = 0.318, $p < 0.001$). Bootstrapping analysis with 5,000 samples confirmed a significant indirect effect (a × b = −0.180, 95% CI: −0.225 to −0.139), indicating that SPA acted as a mediator in the relationship between social capital and depression. Overall, the model explained 15.2% of the variance in depression.

4 Discussion

Against the backdrop of aging, this study takes the Chinese community-dwelling older adult as an example to explore and confirm the impact of social capital on depression in the older adult and the mediating role of SPA in the relationship between the two. This has important reference value for future theoretical and practical research aimed at improving depression among the older adult. Our study innovatively introduces SPA as a mediating mechanism, which has not been systematically examined in previous studies on social capital and depression among the older adult (23, 49). While prior research has emphasized the role of life satisfaction or social networks in mediating this relationship (50), our findings highlight the unique contribution of SPA in explaining how social capital shapes mental health outcomes.

Our study results show that there are significant differences in the SDS scores of the older adult in terms of age, marital status, chronic disease conditions, whether they have medical insurance, whether they have endowment insurance, and monthly income per capita, which is consistent with previous research findings (51–53). These identified non-modifiable factors can be used to determine which individuals are at risk of depression and to identify vulnerable groups that health professionals need to target. In health education, we should pay close attention to those aged 80 and above, who are divorced/separated/widowed, suffer from chronic diseases, without medical insurance, without endowment insurance, and have a monthly income per capita below 1,000 yuan, and provide more health intervention measures to improve their depressive symptoms.

This study found that social capital is negatively correlated with depressive symptoms among community-dwelling older adult individuals, confirming Hypothesis 1. A possible explanation for this correlation lies in the multifaceted nature of social capital, which encompasses trust, mutual aid, participation, and social connections. These elements of social capital serve as protective factors against

TABLE 1 The status of SDS by different sociodemographic characteristics (*N* = 1706).

Variable	n (%)	SDS			
		Mean ± SD	t or F	p value	Post hoc
Age (years)			16.807	<0.001	
60–69[a]	597 (35.0)	37.00 ± 13.05			a < b,c
70–79[b]	691 (40.5)	39.01 ± 13.81			b < c
≥80[c]	418 (24.5)	42.11 ± 14.94			
Gender			0.352	0.725	
Male	751 (44.0)	38.93 ± 13.92			
Female	955 (56.0)	39.17 ± 14.01			
Marital status			4.108	<0.001	
Married	1,268 (74.3)	38.24 ± 13.81			
Divorce/Separate/Widowed	438 (25.7)	41.45 ± 15.16			
Education			1.925	0.124	
Primary school or below[a]	586 (34.3)	39.63 ± 14.41			
Junior high school[b]	596 (34.9)	39.45 ± 13.57			
Senior high school[c]	454 (26.6)	38.27 ± 14.13			
College or above[d]	70 (4.1)	36.23 ± 12.02			
Chronic disease			7.403	<0.001	
With	637 (37.3)	42.26 ± 14.84			
Without	1,069 (62.7)	37.16 ± 13.06			
Medical insurance			2.210	0.029	
With	1,616 (94.7)	38.89 ± 13.96			
Without	90 (5.3)	42.19 ± 13.76			
Endowment insurance			2.086	0.037	
With	1,548 (90.7)	38.84 ± 13.93			
Without	158 (9.3)	41.27 ± 14.23			
Monthly income per capita (RMB)			8.532	<0.001	
<1,000	265 (15.5)	41.27 ± 14.05			a > c,d
1,000–1,999	803 (47.1)	39.73 ± 14.31			b > c,d
2,000–2,999	497 (29.1)	38.09 ± 13.66			c > d
≥3,000	141 (8.3)	34.60 ± 11.62			

The lowercase a, b,c, and d represent different groups of the characteristics of different age, education and monthly income per capita.

TABLE 2 Pearson correlation matrix of the variables of interest.

Variable	r			Mean ± SD
	1.	2.	3.	
1. Social capital	1	−0.418***	−0.263***	47.07 ± 6.72
2. Self-perceived aging	-	1	0.324***	45.33 ± 9.88
3. Depression	-	-	-	39.07 ± 13.97

*** *p*-value<0.001.

depression by providing emotional support, information exchange, and practical assistance, which are crucial in alleviating stress and enhancing well-being (20, 54). The presence of a robust social network can act as a buffer against the negative impacts of stress and isolation, which are common among the older adult. When older adult individuals are embedded in supportive social networks, they are more likely to receive encouragement and validation, which can boost their self-esteem and sense of self-worth. This, in turn, can lead to a reduced likelihood of experiencing depressive symptoms. Furthermore, social capital can facilitate access to resources that are essential for maintaining mental health, such as healthcare services and community programs designed to promote well-being. Another aspect of social capital that may contribute to the observed negative correlation is the sense of belonging and community engagement. Active participation in community activities can provide a sense of purpose and belonging, which are known to be protective against depression (55). Older adult individuals who are actively engaged in their communities are more likely to experience positive social interactions, which can foster a sense of happiness and satisfaction with life, further mitigating the risk of depression (56, 57). Additionally, social capital can influence health behaviors and lifestyles (58, 59). Older adult individuals with higher social capital

TABLE 3 Multivariate linear regression analysis for the association among social capital, self-perceived aging and depression ($N = 1706$).

Variable	Model 1 (depression)			Model 2 (self-perceived aging)			Model 3 (depression)		
	B (SE)	t	p value	B (SE)	t	p value	B (SE)	t	p value
Age	0.184 (0.049)	3.769	<0.001	0.169 (0.033)	5.194	<0.001	0.130 (0.048)	2.707	0.007
Marital status	0.650 (0.806)	0.807	0.420	0.521 (0.538)	0.969	0.333	0.485 (0.788)	0.615	0.539
Chronic disease	4.345 (0.676)	6.424	<0.001	2.007 (0.451)	4.447	<0.001	3.706 (0.665)	5.574	<0.001
Medical insurance	−2.517 (1.828)	−1.377	0.169	0.648 (1.219)	0.532	0.595	−2.723 (1.787)	−1.524	0.128
Endowment insurance	1.004 (1.456)	0.689	0.491	−1.601 (0.972)	−1.648	0.010	1.513 (1.425)	1.062	0.288
Monthly income per capita	−1.988 (0.418)	−4.753	<0.001	−1.267 (0.279)	−4.543	<0.001	−1.585 (0.411)	−3.853	<0.001
Social capital	−0.477 (0.049)	−9.691	<0.001	−0.566 (0.033)	−17.227	<0.001	−0.297 (0.052)	−5.696	<0.001
Self-perceived aging							0.318 (0.036)	8.946	<0.001
R^2	0.112			0.210			0.152		
F	30.540 ($p < 0.001$)			64.342 ($p < 0.001$)			37.969 ($p < 0.001$)		

TABLE 4 Mediation analyses of self-perceived aging in the association between social capital and depression.

|	Effect	95% bootstrap CI	Bootstrap SE
Total effect (c)	−0.477	(−0.573, −0.380)	0.049
Direct effect (c')	−0.297	(−0.399, −0.195)	0.052
Indirect effect (a × b)	−0.180	(−0.225, −0.139)	0.022
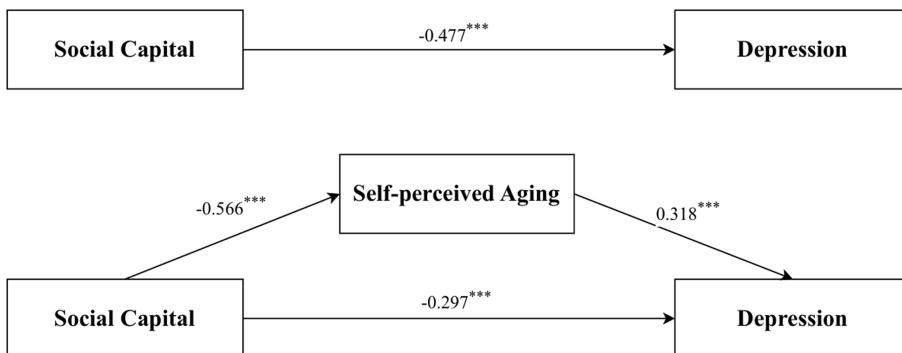
FIGURE 2
Self-perceived aging mediated the association of social capital and depression. ***$p < 0.001$.

may be more likely to adopt healthy behaviors, such as regular physical activity and a balanced diet, which are known to have positive effects on mental health. They may also be more likely to seek help when needed, reducing the duration and severity of depressive episodes.

This study also found that SPA partially mediates the relationship between social capital and depression among community-dwelling older adult individuals, preliminarily clarifying the association mediation pathway between social capital and depression, and confirming Hypothesis 2. The mediating effect is mainly divided into two stages: (1) social capital has a negative impact on SPA, and (2) SPA has a positive impact on depression. The mediating effect of SPA in the relationship between social capital and depression can be explained in the following ways.

Notably, this mediation pathway extends prior work by identifying SPA as a critical psychological mechanism. While previous studies have linked social capital to depression through life satisfaction (49)

or social networks (23), our findings suggest that social capital not only provides structural support but also shapes how individuals perceive their own aging process, which in turn affects mental health. This aligns with theoretical frameworks emphasizing the role of self-perception in aging outcomes (60).

Firstly, individuals with abundant social capital often receive more social support and positive social feedback, which helps them form a more positive SPA. Research has shown that social capital is associated with the mental health status and emotional depressive symptoms of the older adult. Positive social interactions and community participation can enhance the older adult's sense of self-worth and social belonging, thereby reducing their negative perception of their own aging process (61). Secondly, a positive SPA can reduce the older adult's feelings of loneliness and helplessness, which are important predictive factors for depressive symptoms (62). When older adult individuals hold a positive attitude towards their own aging, they are

more likely to adopt a healthy lifestyle and participate in social activities, both of which help alleviate depressive symptoms.

Furthermore, the mediating role of SPA is also reflected in its ability to modulate the impact of social capital on depression. Specifically, individuals with higher social capital may receive more positive feedback due to stronger social connections and more frequent social interactions, which helps them to have a more positive view of aging (63). This positive view can reduce the occurrence of depressive emotions because it can enhance individuals' coping abilities and life satisfaction. Conversely, individuals with lower social capital may have a more negative view of aging due to insufficient social support, which may increase their risk of depression.

Therefore, SPA, as a mediating variable, reveals the potential mediation pathway by which social capital may reduce the risk of depression by influencing older adult individuals' perceptions of their own aging process. This finding provides important theoretical basis for the development of targeted mental health intervention measures in the future, especially in designing intervention projects aimed at increasing the social capital of the older adult and improving their positive views on aging. Through such interventions, we can expect to reduce the risk of depression in the older adult and improve their quality of life.

Moreover, our study contributes to the literature by providing empirical evidence from a rapidly aging society (China), where the older adult population has unique sociocultural contexts (e.g., family structures, healthcare access) compared to Western populations (64). This expands the generalizability of social capital theories in non-Western settings.

This study has some limitations. (1) First of all, this study is a cross-sectional study. Thus, we were unable to examine the causal relationship between social capital, SPA, and depression. For example, mental health status is also considered an important resource in later life. Older adults with good mental health can not only be more socially active, but they can also be more optimistic about their lives and tend to positively evaluate their social relationships and social resources. Future longitudinal studies with larger sample sizes and more variables are needed to address this important question. (2) The SDS Scale is a measure of self-reported depressive symptoms within the recent past week, which may lead to recall bias or be influenced by the current environment. (3) The study's sample of community-dwelling older adult was drawn from a limited number of randomly selected communities within a single city, which could potentially introduce sampling bias and restrict the generalizability of the findings. Therefore, it is essential that future studies engage with community-dwelling older adult populations across various regions to enhance the applicability and breadth of the research outcomes.

5 Conclusion

Our research has identified a negative correlation between social capital and depression, with SPA acting as a partial mediator in this relationship. This suggests that enhancing social capital and fostering a positive SPA could be instrumental in preventing depression among older adults. This insight not only broadens the scope of social capital research but also offers a novel approach to addressing depression among Chinese community-dwelling older adult. It is recommended that relevant management agencies, communities,

and families take effective measures to enhance the social capital of the older adult. Tailoring to their characteristics, strategies such as senior university programs, square dance clubs, senior chorus groups, and community sports events should be employed to motivate the older adult in building robust social networks. Additionally, fostering a positive outlook on aging is advised to improve their self-image and attitude towards the aging process.

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 Medical Ethics Committee of the Affiliated Hospital of Chengdu University of Chinese Medicine (approval no. 2023KL-011). 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

YY: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization. HL: Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – review & editing. ZW: Data curation, Formal analysis, Investigation, Project administration, Writing – review & editing. QZ: Data curation, Formal analysis, Project administration, Writing – review & editing. SY: Data curation, Investigation, Methodology, Writing – review & editing. LY: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

Funding

Acknowledgments

collaborators across the local network for their significant efforts in study design and implementation.

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.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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.2025.1571977/full#supplementary-material

References

1. Fang EF, Xie C, Schenkel JA, Wu C, Long Q, Cui H, et al. A research agenda for ageing in China in the 21st century (2nd edition): focusing on basic and translational research, long-term care, policy and social networks. *Ageing Res Rev*. (2020) 64:101174. doi: 10.1016/j.arr.2020.101174

2. National Bureau of Statistics. (2024). Wang Pingping: Total population has declined, and high-quality population development has been effective [WWW document]. Available online at: https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html (accessed 11.12.24).

3. Fan X, Guo X, Ren Z, Li X, He M, Shi H, et al. The prevalence of depressive symptoms and associated factors in middle-aged and elderly Chinese people. *J Affect Disord*. (2021) 293:222–8. doi: 10.1016/j.jad.2021.06.044

4. Shao M, Chen J, Ma C. Research on the relationship between Chinese elderly health status, social security, and depression. *Int J Environ Res Public Health*. (2022) 19:7496. doi: 10.3390/ijerph19127496

5. Yan Y, Du Y, Li X, Ping W, Chang Y. Physical function, ADL, and depressive symptoms in Chinese elderly: evidence from the CHARLS. *Front Public Health*. (2023) 11:1017689. doi: 10.3389/fpubh.2023.1017689

6. Liang D, Mays VM, Hwang W-C. Integrated mental health services in China: challenges and planning for the future. *Health Policy Plan*. (2018) 33:107–22. doi: 10.1093/heapol/czx137

7. Ozgun AH, Tarim M, Delen D, Zaim S. Social capital and organizational performance: the mediating role of innovation activities and intellectual capital. *Healthc Anal*. (2022) 2:100046. doi: 10.1016/j.health.2022.100046

8. Scott A, Nash K, Smith AM eds. New critical writings in political sociology In: Power, state and inequality, vol. *1*. Abingdon, Oxon: Routledge (2016)

9. Robison LJ, Schmid AA, Siles ME. Is social capital really capital? *Rev Soc Econ*. (2002) 60:1–21. doi: 10.1080/00346760110127074

10. Jeong SW, Ha S, Lee K-H. How to measure social capital in an online brand community? A comparison of three social capital scales. *J Bus Res*. (2021) 131:652–63. doi: 10.1016/j.jbusres.2020.07.051

11. Lochner K. Social capital: a guide to its measurement. *Health Place*. (1999) 5:259–70. doi: 10.1016/S1353-8292(99)00016-7

12. Chen R, Hu X, Gao B. Establishment of an index system for evaluation on health-related social capital for new urban immigrants in China. *Chin J Public Health*. (2020) 36:1055–7.

13. Gui Y, Huang R. Measuring community social capital: an empirical study. *Sociol Stud*. (2008) 3:122–42. doi: 10.19934/j.cnki.shxyj.2008.03.006

14. Gao B, Yang S, Liu X, Ren X, Liu D, Li N. Association between social capital and quality of life among urban residents in less developed cities of western China: a cross-sectional study. *Medicine (Baltimore)*. (2018) 97:e9656. doi: 10.1097/MD.0000000000009656

15. Yang S, Gao B, Gu J, Gong Y, Yu B, Han J, et al. Relationship between social capital and heroin use behaviors among patients in methadone maintenance treatment in Sichuan Province, China: a cross-sectional study. *Medicine (Baltimore)*. (2020) 99:e19963. doi: 10.1097/MD.0000000000019963

16. Han J, Jia P, Huang Y, Gao B, Yu B, Yang S, et al. Association between social capital and mental health among older people living with HIV: the Sichuan older HIV-infected cohort study (SOHICS). *BMC Public Health*. (2020) 20:581. doi: 10.1186/s12889-020-08705-6

17. Yu B, Luo M, Liu M, Zhou J, Yang S, Jia P. Social capital changes after COVID-19 lockdown among youths in China: COVID-19 impact on lifestyle change survey (COINLICS). *Front Public Health*. (2021) 9:697068. doi: 10.3389/fpubh.2021.697068

18. Cramm JM, Nieboer AP. Social cohesion and belonging predict the well-being of community-dwelling older people. *BMC Geriatr*. (2015) 15:30. doi: 10.1186/s12877-015-0027-y

19. Allen K-A, Kern ML, Rozek CS, McInerney DM, Slavich GM. Belonging: a review of conceptual issues, an integrative framework, and directions for future research. *Aust J Psychol*. (2021) 73:87–102. doi: 10.1080/00049530.2021.1883409

20. Bassett E, Moore S. Social capital and depressive symptoms: the association of psychosocial and network dimensions of social capital with depressive symptoms in Montreal, Canada. *Soc Sci Med*. (2013) 86:96–102. doi: 10.1016/j.socscimed.2013.03.005

21. Domènech-Abella J, Lara E, Rubio-Valera M, Olaya B, Moneta MV, Rico-Uribe LA, et al. Loneliness and depression in the elderly: the role of social network. *Soc Psychiatry Psychiatr Epidemiol*. (2017) 52:381–90. doi: 10.1007/s00127-017-1339-3

22. Almedom AM. Social capital and mental health: an interdisciplinary review of primary evidence. *Soc Sci Med*. (2005) 61:943–64. doi: 10.1016/j.socscimed.2004.12.025

23. Cao W, Li L, Zhou X, Zhou C. Social capital and depression: evidence from urban elderly in China. *Aging Ment Health*. (2015) 19:418–29. doi: 10.1080/13607863.2014.948805

24. Dai X, Gu N. The impact of social capital on mental health: evidence from the China family panel survey. *Int J Environ Res Public Health*. (2021) 19:190. doi: 10.3390/ijerph19010190

25. Sun Q, Lu N. Social capital and mental health among older adults living in urban China in the context of COVID-19 pandemic. *Int J Environ Res Public Health*. (2020) 17:7947. doi: 10.3390/ijerph17217947

26. Rippon I, Steptoe A. Feeling old vs being old: associations between self-perceived age and mortality. *JAMA Intern Med*. (2015) 175:307. doi: 10.1001/jamainternmed.2014.6580

27. Robertson DA, Savva GM, King-Kallimanis BL, Kenny RA. Negative perceptions of aging and decline in walking speed: a self-fulfilling prophecy. *PLoS One*. (2015) 10:e0123260. doi: 10.1371/journal.pone.0123260

28. Brothers A, Kornadt AE, Nehrkorn-Bailey A, Wahl H-W, Diehl M. The effects of age stereotypes on physical and mental health are mediated by self-perceptions of aging. *J Gerontol B Psychol Sci Soc Sci*. (2021) 76:845–57. doi: 10.1093/geronb/gbaa176

29. Freeman AT, Santini ZI, Tyrovolas S, Rummel-Kluge C, Haro JM, Koyanagi A. Negative perceptions of ageing predict the onset and persistence of depression and anxiety: findings from a prospective analysis of the Irish longitudinal study on ageing (TILDA). *J Affect Disord*. (2016) 199:132–8. doi: 10.1016/j.jad.2016.03.042

30. Li S, Dong Y, Li X. Influencing factors of self-perceived aging among empty nesters: a cross-sectional study. *Rev Cuid*. (2024) 15:e3500. doi: 10.15649/cuidarte.3500

31. Liu H, Wu B, Feng Z. Social participation and self-perception of being old in China. *Int J Aging Hum Dev*. (2020) 91:219–34. doi: 10.1177/0091415019875456

32. Tybjerg-Jeppesen A, Conway PM, Ladegaard Y, Jensen CG. Is a positive intergenerational workplace climate associated with better self-perceived aging and workplace outcomes? A cross-sectional study of a representative sample of the Danish working population. *J Appl Gerontol*. (2023) 42:1212–22. doi: 10.1177/07334648231162616

33. Xiao Z, Yin J, Chen D, Peng J, Tang S. Analysis of the status quo of self-perception and its influencing factors in Changsha elderly. *Chin J Pract Nurs*. (2022) 38:801–6. doi: 10.3760/cma.j.cn211501-20211020-02915

34. Sun J, Zhou N, Zhang H, Wu H, Wang F, Luo Y. Longitudinal analysis of the mediating role of self-perception of aging in the relationship between frailty and intrinsic capacity: a cross-lagged mediation model. *Arch Gerontol Geriatr*. (2024) 120:105336. doi: 10.1016/j.archger.2024.105336

35. World Health Organization ed. Guidance on community mental health services: Promoting person-centred and rights-based approaches. *1st* ed. Geneva: World Health Organization (2021).

36. Le LK-D, Esturas AC, Mihalopoulos C, Chiotelis O, Bucholc J, Chatterton ML, et al. Cost-effectiveness evidence of mental health prevention and promotion interventions: a systematic review of economic evaluations. *PLoS Med*. (2021) 18:e1003606. doi: 10.1371/journal.pmed.1003606

37. Beydoun MA, Popkin BM. The impact of socio-economic factors on functional status decline among community-dwelling older adults in China. *Soc Sci Med*. (2005) 60:2045–57. doi: 10.1016/j.socscimed.2004.08.063

38. Abbas S, Alvi AS, Tarar MG. Social isolation and well-being among community dwelling elderly. *J Manag Pract Humanit Soc Sci*. (2021) 5:50–59. doi: 10.33152/jmphss-5.2.6

39. Nair P, Bhanu C, Frost R, Buszewicz M, Walters KR. A systematic review of older adults' attitudes towards depression and its treatment. *The Gerontologist*. (2019) 60:e93–e104. doi: 10.1093/geront/gnz048

40. Rodda J, Walker Z, Carter J. Depression in older adults. *BMJ*. (2011) 343:d5219–9. doi: 10.1136/bmj.d5219

41. Gannon B, Roberts J. Social capital: exploring the theory and empirical divide. *Empir Econ*. (2020) 58:899–919. doi: 10.1007/s00181-018-1556-y

42. Sexton E, King-Kallimanis BL, Morgan K, McGee H. Development of the brief ageing perceptions questionnaire (B-APQ): a confirmatory factor analysis approach to item reduction. *BMC Geriatr*. (2014) 14:44. doi: 10.1186/1471-2318-14-44

43. Barker M, O'Hanlon A, McGee HM, Hickey A, Conroy RM. Cross-sectional validation of the aging perceptions questionnaire: a multidimensional instrument for assessing self-perceptions of aging. *BMC Geriatr*. (2007) 7. doi: 10.1186/1471-2318-7-9

44. Velaithan V, Tan M-M, Yu T-F, Liem A, Teh P-L, Su TT. The Association of Self-Perception of aging and quality of life in older adults: a systematic review. *The Gerontologist*. (2024) 64:gnad041. doi: 10.1093/geront/gnad041

45. Biggs JT, Wylie LT, Ziegler VE. Validity of the Zung self-rating depression scale. *Br J Psychiatry*. (1978) 132:381–5. doi: 10.1192/bjp.132.4.381

46. Sepehry AA. Self-rating depression scale (SDS) In: F Maggino, editor. Encyclopedia of quality of life and well-being research. Cham: Springer International Publishing (2023). 6269–76.

47. Zung WWK. A self-rating depression scale. *Arch Gen Psychiatry*. (1965) 12:63. doi: 10.1001/archpsyc.1965.01720310065008

48. Hinkle DE, Wiersma W, Jurs SG. Applied statistics for the behavioral sciences. *5. Aufl*. ed. Boston: Houghton Mifflin Company (2003).

49. Sun J, Xiao T, Lyu S, Zhao R. The relationship between social capital and depressive symptoms among the elderly in China: the mediating role of life satisfaction. *Risk Manag Healthc Policy*. (2020) 13:205–13. doi: 10.2147/RMHP.S247355

50. Bai Z, Xu Z, Xu X, Qin X, Hu W, Hu Z. Association between social capital and depression among older people: evidence from Anhui Province, China. *BMC Public Health*. (2020) 20:1560. doi: 10.1186/s12889-020-09657-7

51. Cui Y, Gong Q, Huang C, Guo F, Li W, Wang Y, et al. The relationship between sunlight exposure duration and depressive symptoms: a cross-sectional study on elderly Chinese women. *PLoS One*. (2021) 16:e0254856. doi: 10.1371/journal.pone.0254856

52. Kaneko Y, Motohashi Y, Sasaki H, Yamaji M. Prevalence of depressive symptoms and related risk factors for depressive symptoms among elderly persons living in a rural Japanese community: a cross-sectional study. *Community Ment Health J*. (2007) 43:583–90. doi: 10.1007/s10597-007-9096-5

53. Lin H, Jin M, Liu Q, Du Y, Fu J, Sun C, et al. Gender-specific prevalence and influencing factors of depression in elderly in rural China: a cross-sectional study. *J Affect Disord*. (2021) 288:99–106. doi: 10.1016/j.jad.2021.03.078

54. Haines VA, Beggs JJ, Hurlbert JS. Neighborhood disadvantage, network social capital, and depressive symptoms. *J Health Soc Behav*. (2011) 52:58–73. doi: 10.1177/0022146510394951

55. Ahn MY, Davis HH. Sense of belonging as an indicator of social capital. *Int J Sociol Soc Policy*. (2020) 40:627–42. doi: 10.1108/IJSSP-12-2019-0258

56. Arampatzi E, Burger MJ, Novik N. Social network sites, individual social capital and happiness. *J Happiness Stud*. (2018) 19:99–122. doi: 10.1007/s10902-016-9808-z

57. Rodríguez-Pose A, Von Berlepsch V. Social capital and individual happiness in Europe. *J Happiness Stud*. (2014) 15:357–86. doi: 10.1007/s10902-013-9426-y

58. Chuang Y-C, Huang Y-L, Tseng K-C, Yen C-H, Yang L. Social capital and health-protective behavior intentions in an influenza pandemic. *PLoS One*. (2015) 10:e0122970. doi: 10.1371/journal.pone.0122970

59. Nieminen T, Prättälä R, Martelin T, Härkänen T, Hyyppä MT, Alanen E, et al. Social capital, health behaviours and health: a population-based associational study. *BMC Public Health*. (2013) 13:613. doi: 10.1186/1471-2458-13-613

60. Xu Z, Zhang W, Zhang X, Wang Y, Chen Q, Gao B, et al. Multi-level social capital and subjective wellbeing among the elderly: understanding the effect of family, workplace, community, and society social capital. *Front Public Health*. (2022) 10:772601. doi: 10.3389/fpubh.2022.772601

61. Zorrilla-Muñoz V, Agulló-Tomás MS, Rodríguez-Blázquez C, Ayala A, Fernandez-Mayoralas G, Forjaz MJ. Ageing perception as a key predictor of self-rated health by rural older people—a study with gender and inclusive perspectives. *Land*. (2022) 11:323. doi: 10.3390/land11030323

62. Wang T, Feng S, Wang J, Li H, Song Y, Han D, et al. Negative emotions are associated with older self-perceived age: a cross-section study from the UK biobank. *Int J Health Policy Manag*. (2024) 13:8060. doi: 10.34172/ijhpm.8060

63. Wu F, Sheng Y. Social support network, social support, self-efficacy, health-promoting behavior and healthy aging among older adults: a pathway analysis. *Arch Gerontol Geriatr*. (2019) 85:103934. doi: 10.1016/j.archger.2019.103934

64. Su H, Zhou Y, Wang H, Xing L. Social support, self-worth, and subjective well-being in older adults of rural China: a cross-sectional study. *Psychol Health Med*. (2022) 27:1602–8. doi: 10.1080/13548506.2021.1905861

Frontiers in Psychology

Paving the way for a greater understanding of human behavior

The most cited journal in its field, exploring psychological sciences - from clinical research to cognitive science, from imaging studies to human factors, and from animal cognition to social psychology.

Discover the latest Research Topics

See more →

frontiers | Frontiers in Psychology