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Public health promotion and medical education reform, volume III

Edited by
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Public health promotion and medical education reform, volume III

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Editorial: Public health promotion and medical education reform, volume III

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Editorial on the Research Topic
Public health promotion and medical education reform, volume III

1 Introduction

Since the outbreak of the COVID-19 pandemic, governments and local authorities have addressed this global crisis by increasing investment, making public policies, enhancing individual health awareness, and improving public health facilities and services (1). Indisputably, the coronavirus pandemic has not only contributed to considerable progress in the field of public health and medical education, but also exposed a host of issues within the public health system. After years of public health system reform, disseminating health knowledge, optimizing basic health service delivery, cultivating medical talents, and reforming medical education still need continuous exploration.

2 Health promotion and health education

Health promotion refers to activities that enable individuals and communities to improve their health and overall wellbeing. A fundamental and integral component of health promotion is health education. Specifically, individuals and communities health outcomes are determined by the interplay of social, economic, and cultural factors, which can be positively shaped by effective health education (2).

Over the past decades, the significance of health education and prevention has been increasingly recognized. However, existing health education systems face multiple limitations, including inequalities between developed and developing countries as well as between urban and rural areas. For example, despite substantial improvement in the availability of prevention tools and effective treatment, responses to the sexual and reproductive health remain suboptimal, particularly in some regions of Africa (3). An institution-based cross-sectional study demonstrated that the pre-exposure prophylaxis (PrEP) remains under-utilized among female sex workers in Addis Ababa, Ethiopia. This is attributed to their limited knowledge of PrEP, lack of targeted education, and restricted access to PrEP services (Berhe et al.). Furthermore, it is striking that even medical students in Pereira, Colombia, exhibited a high prevalence of risky sexual behaviors, with only one

third expressing willingness to undergo sexually transmitted infections (STI) screening (Loaiza-Guevara, et al.). Beyond sexually transmitted infections, maternal mortality and severe morbidity are also prominent women's health issues. In developing countries, the maternal mortality rates are even 15 times higher than those in developed nations (4). Derbew et al. demonstrated that husbands' limited knowledge of obstetric danger signs in Ethiopia may contribute to the delays in recognizing the danger signs and seeking timely health care.

In addition, health education interventions have been shown to play a major role in the prevention and treatment of chronic diseases including cancer. Currently, cancer screening services are offered by medical institutions at all levels. However, due to insufficient education and limited awareness of cancer, only a minority of the urban residents are willing to undergo cancer screening, with the majority opting for county-level or lower-level medical institutions (Chai et al.).

Visual impairment (VI) is another global health concern, ranking behind only cardiovascular disease, cancer, and diabetes. Although VI can be prevented or slowed with timely intervention, eye care has been neglected over the years (5). A report from the developed country U.S. puts forward suggestions that healthcare workers provide relevant education to individuals experiencing visual change, thereby effectively preventing VI within communities, neighborhoods, and broader society (Powers et al.).

Collectively, the above findings indicate that health education level is one of the key factors in improving health outcomes. Then, how can health education be effectively promoted on a broader scale? It is well-accepted that due to the strong learning abilities, college students play a crucial role in the dissemination of health knowledge. In China, a separate study assessed the current knowledge, attitudes, and practices (KAP) among college students regarding foodborne diseases, an important public health issue. Contrary to expectations, these students had insufficient level of knowledge, moderate level of practices, but positive attitudes toward foodborne diseases (Ma et al.). Similar results have been observed in two additional large-scale KAP surveys on physical activity-related injuries (PARI) and bystander cardiopulmonary resuscitation (CPR) training. Results showed that students' attitudes toward PARI and CPR were, respectively, neutral and positive, which may be explained by varying levels of understanding (Kong, Zhu et al.; Qin et al.). However, most students still revealed low knowledge levels, highlighting the urgent need to implement public health educational interventions and allocate relevant resources in university environments. To address this challenge, Central South University innovatively applied the Delphi method to construct PARI-focused public health education programs for undergraduates. This initiative advances the development of health literacy and the establishment of proactive health management among young adults (Kong, Xu et al.).

Currently, the primary sources of health education encompass healthcare professionals, mass media, educational materials and school education (6). Among these, the media play an outstanding role in sharing healt-related information. In China, short-video platforms (e.g., TikTok, Bilibili, and Kwai) are experiencing rapid growth, owing to the sociality, interactivity, vividness and originality of short videos. Nevertheless, a cross-sectional study on the information quality of *H. pylori*-related videos across three platforms revealed that the content and quality of the videos were suboptimal (Lai et al.). Short videos produced by health professionals tend to offer more accurate, high-quality, and reliable guidance on disease prevention and treatment. In the future, short-video platforms should be refined to prevent the propagation of misinformation through online social networks. Furthermore, more professionals should be encouraged to release authoritative and credible short videos.

3 Public policy and health services

As the COVID-19 pandemic comes to an end, countries worldwide have shifted their public health policies from confronting the pandemic to enhancing the health of the entire population. Moreover, the onset of COVID-19 substantially accelerated the formulation and implementation of evidence-informed health policy regarding primary health care provision and community-based interventions.

With the support of relevant public policies, the National Institutes of Health (NIH) launched the Community Engagement Alliance (CEAL) during the early stages of the pandemic. In this program, communities serve as core components to facilitate collaboration between clinical researchers and social scientists (7). Through dynamic exchanges between community and academic experts, CEAL initiative has successfully fostered trust in science, countered misinformation, and advanced health equity in communities (Pons-Calvo et al.).

Consequently, the primary public health system has relatively improved in some countries. However, the majority of developing countries continue to encounter challenges in providing access to essential primary health services for economically disadvantaged and/or low-educated populations, especially in resource-limited settings. For example, Iraq's healthcare landscape has shifted from a hospital-centered model to a community clinic-centered service model. Nevertheless, significant inequalities in health-seeking behavior (HSB) impede individuals' access to high-quality primary healthcare (Mkhailef Hawi Al-Tameemi et al.). Similarly, evidence from Ethiopia shows that low maternal income and limited educational achievement hinder mothers' acceptance of healthcare professionals' recommendations, leading them to prefer receiving care from traditional healers at home rather than seeking more specialized medical services (Fenta Abebe et al.). As a result, when maternal referral is required, up to half of the referral practices prove unsatisfactory due to the lack of professional medical services, poor transportation access, and long travel time. Therefore, the government and public health officials can reduce health service disparities by designing more targeted and effective interventions to address economic and educational gaps, coupled with efforts to enhance individuals' health awareness.

4 Medical education reform

It has been widely acknowledged that the primary goal of medical education is to train qualified healthcare professionals who will improve the public health. However, medical education currently confronts a series of challenges such as insufficient training of emergency response ability, inadequate integration of interdisciplinary knowledge, and a lack of humanistic education (8). Accordingly, a growing number of medical education institutions have been carrying out reforms in higher medical education system.

4.1 Educational system reform

Prior to the pandemic outbreak in 2019, Chinese government proposed an important strategic plan "Healthy China 2030" aiming to improve national health literacy, reduce mortality, and extend healthy life expectancy. Within the framework of "Healthy China 2030" strategy, medical education is undergoing diverse reforms (Han and Wu).

Above all, the most crucial step is to shift orientation at new educational concepts, to secure the strong collaboration between public health and medical education. A growing body of research demonstrates the significance of incorporating public health into medical education. A meta-analysis of Ethiopian college students' understanding of COVID-19 underscores the need to implement targeted interventions to strengthen health education curricula and initiatives among students, thereby facilitating self-management of health and effective responses to pandemics (Chereka et al.). Consistent with these findings, a qualitative study on South African medical students indicates that incorporation of primary health care (PHC) re-engineering plan into undergraduate training helps to equip students with knowledge and skills in the field of PHC (Mabuza et al.).

In addition, the cultivation of humanistic qualities is recognized as an essential part of medical education, yet it has been neglected for a considerable period of time. To strengthen humanistic education for medical students, colleges have incorporated humanistic courses into the curriculum system. Furthermore, the implementation of labor education has been shown to help students establish a correct outlook in labor and develop a social consciousness of saving (Wang, Zhou et al.).

4.2 Teaching reforms

Following confirmation of the role of public health education in enhancing awareness and capacity for disease prevention, there is a need to seek effective strategies to integrate public health content into medical curricula. The University of Dundee Medical School has launched a medical curriculum reform by incorporating public health into the wider curriculum. The Bigger Picture provides context for professional development by replacing didactic sessions on healthcare with lectures, tutorials and workshops, and providing additional teaching materials in elective components within the course. Meanwhile, the Dundee Doctor serves as a framework for scrutinizing new proposals regarding teaching content and assessing learning outcomes (Hothersall).

As a cooperative learning strategy, the Jigsaw teaching method emphasizes group work and full engagement in learning activities. In contrast, the Self-Regulated Learning cycle encourages students' independent learning and self-monitoring. Notably, the combination of these two approaches can boost the interplay of personal, behavioral, and environmental factors, thereby more effectively improving students' self-regulated learning ability and commitment (Chen et al.).

Educational digitalization is a pivotal element of teaching reform. By utilizing modern information technologies such as human-computer interaction, cloud computing and big data analytics, the curriculum teaching can deliver intelligent learning guidance, a high-quality learning environment, and favorable learning conditions (9). For example, the application of virtual Reality (VR) technology in classroom settings can simulate real clinical scenarios, and offer personalized learning paths and resources. Consequently, this technology not only enhances students' learning motivation and practical skills, but also strengthens their self-confidence and professional competencies. Therefore, clinical nurse educators from a tertiary hospital in Wuhan city exhibit a strong willingness to adopt VR technology (Mengying et al.).

4.3 Reform of talent training and assessment

High-quality medical talents are the foundation for delivering satisfactory medical and health services. However, as public healthcare systems grow increasingly complex, the demands on medical talents have become more stringent in the new era. Beyond professional knowledge and skills, good humanistic literacy and self-learning ability, a qualified medical student should also possess innovative spirits and strong emotional regulation ability (10).

Against the backdrop of the pandemic, public health educators and practitioners have recognized that medicine is an evolving discipline. Only medical students equipped with innovative capabilities can actively explore optimal medical processes, introduce new technologies and methods, and improve treatment efficacy (11). Indeed, Chinese medical institutions have come to focus their attention on cultivation of high-quality public health talents with innovative capabilities. Moreover, Wang, Geng et al. constructed a nomogram to predict and evaluate the academic innovation level of public health students, thereby supporting more accurate and efficient training.

To meet patients' healthcare needs, medical students must devote greater effort to acquiring professional knowledge and skills, along with increased mental stress in their future clinical practice. Hence, mental health has emerged as an important health concern for medical students worldwide, especially in Asia where students are prone to mental health issues. An analysis of happiness perception among Korean medical

students revealed that enhancing students' happiness is mainly dependent on social support, self-management, and quality of life (Lee et al.). In light of these findings, medical schools should foster students' wellbeing by providing opportunities for emotion regulation training, physical activities, and career guidance services.

Numerous universities have introduced the Health Promoting Universities (HPUs) initiative to create an environment that integrates health (physical and mental) into institutional culture, policies, and activities (12). In the context of HPUs, all members (students, teachers and staff) have a high level of participation in the decision-making processes regarding health that influence their learning, working and living. Nevertheless, the successful adaptation of HPUs to local culture is essential for the effective implementation of HPU initiatives (Boncheva et al.).

Last but not least, the reliable and valid assessment is of considerable importance to comprehensive education reform, helping to determine whether a reform is working and how to implement improvements. At present, assessment methods have shifted from summative to formative assessment (13). Formative assessment is used to monitor students' progress to provide ongoing feedback that supports the continuous development of their comprehensive qualities and abilities. A cross-sectional study shows that the perceived formative assessment can directly boost psychological empowerment, further foster positive academic emotions, and ultimately promote medical students' learning autonomy (Wang, Zhang et al.).

In summary, the explosive growth of health education has contributed to significant advancements in public health as manifested by improved public health awareness, enhanced public health outcomes, and strengthened public health system. However, we must clearly recognize that the growth in public health lags behind the growth in demand, which has been well-substantiated by the COVID-19 pandemic.

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The status quo of short videos as a health information source of *Helicobacter pylori*: a cross-sectional study

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Background: Health education about *Helicobacter pylori (H. pylori)* is one of the most effective methods to prevent *H. pylori* infection and standardize *H. pylori* eradication treatment. Short videos enable people to absorb and remember information more easily and are an important source of health education. This study aimed to assess the information quality of *H. pylori*-related videos on Chinese short video-sharing platforms.

Methods: A total of 242 *H. pylori*-related videos from three Chinese short video-sharing platforms with the most users, TikTok, Bilibili, and Kwai, were retrieved. The Global Quality Score (GQS) and the modified DISCERN tool were used to assess the quality and content of videos, respectively. Additionally, comparative analyzes of videos based on different sources and common *H. pylori* issues were also conducted.

Results: The median GQS score and DISCERN score was 2 for *H. pylori*-related videos analyzed in this study. Non-gastroenterologists posted the most *H. pylori*-related videos (136/242, 56.2%). Videos from gastroenterologists (51/242, 21.0%) had the highest GQS and DISCERN scores, with a median of 3. Few videos had content on family-based *H. pylori* infection control and management (5.8%), whether all *H. pylori*-positive patients need to undergo eradication treatment (27.7%), and the adverse effects of *H. pylori* eradication therapy (16.1%).

Conclusion: Generally, the content and quality of the information in *H. pylori*-related videos were unsatisfactory, and the quality of the video correlated with the source of the video. Videos from gastroenterologists provided more correct guidance with higher-quality information on the prevention and treatment of *H. pylori* infection.

KEYWORDS

***Helicobacter pylori*, short video, health information, quality, reliability**

Highlights

- **What is already known on this topic**—*H. pylori* infection is the main cause of gastric cancer, but most people do not know about *H. pylori*. The short video platform is favored by the majority of users because it can spread health information through vivid graphics and videos.
- **What this study adds**—This study evaluated the information quality of *H. pylori*-related videos on short video platforms in China, hoping to provide some suggestions for improving short video content on *H. pylori*.
- **How this study might affect research, practice or policy**—Overall, the content and quality of the information in *H. pylori*-related videos were unsatisfactory, and the quality of the video correlated with the source of the video. Short video platforms should be encouraged to strengthen management to prevent the spread of misinformation through the Internet. In addition, more professionals should be advocated to release authoritative videos.

Introduction

Helicobacter pylori (H. pylori) is a microaerophilic gram-negative helical-shaped bacterium that has infected almost half of the world population (1). Usually transmitted during childhood through oral-oral or fecal-oral routes, *H. pylori* secretes a series of virulence factors after colonizing the stomach epithelium and may lead to a range of gastrointestinal and extra-gastrointestinal diseases, including chronic gastritis, peptic ulcers, gastric adenocarcinoma, iron-deficiency anemia, and mucosa-associated lymphoid tissue lymphoma, which cause heavy economic and healthcare burden (2–5). Early in 1994, *H. pylori* was recognized as a Class I (highest class) carcinogen for gastric cancer by the World Health Organization (WHO), and in 2014, WHO called for the worldwide eradication of *H. pylori* as an important strategy for preventing gastric cancer (6). The 15th edition of the US Report on Carcinogens published in 2021 classified *H. pylori* as a definite carcinogen (7). Therefore, eradicating *H. pylori* is of great importance for maintaining human health and reducing economic burden.

There is growing public awareness that *H. pylori* infection is the primary cause of gastric cancer and curing the infection can reduce the incidence or prevent the development of gastric cancer (8). However, there is a lack of knowledge on how to prevent *H. pylori* infection and standardize the eradication treatment of *H. pylori*. Additionally, there is also a certain level of fear and anxiety about *H. pylori* among people. There are concerns about how to detect *H. pylori*, which method is the gold standard for *H. pylori* eradication, and whether all positive tests indicate *H. pylori* infection. Furthermore, the treatment of *H. pylori* infection requires the long-term use of two antibiotics in large quantities. However, irregular medication, lack of knowledge about the adverse effects of treatment regimens, and unauthorized discontinuation of drugs lead to eradication failure. Moreover, whether *H. pylori* eradication is required for all age groups and whether eradication should be done at the family level impact the success or failure of *H. pylori* eradication. Therefore, understanding *H. pylori* and standardized treatment of *H. pylori* infection are important to increase the *H. pylori* eradication rate.

Emerging technologies are developing improved methods of health communication between doctors and patients, empowering patients to get disease-related information (9). Short video platforms, such as TikTok, Kwai, and Bilibili, are replacing traditional textual information formats with more acceptable graphic video information allowing patients to absorb and remember information more easily (10–12). According to recent evidence, active use of social media to obtain disease-related information is associated with a good prognosis for patients, which empowers patients regarding self-disease management and helps to reduce the financial burden of health care (13, 14). Besides, with the increasing number of short video users in China, 934 million by 2021, short videos are certainly an efficient format to standardize testing and treatment of *H. pylori* in the population (14).

However, despite the promising potential of short videos, there are certain accompanying problems that cannot be ignored. Among them, the information quality of short videos deserves our attention the most. The abundance of short videos has increased the possibility of faulty health information, which may lead patients to make incorrect judgments about disease management (15, 16). Moreover, low-quality video health content can put patients through a more convoluted disease treatment process and can add more financial burden to patients (17). Therefore, examining the quality of short videos as a health information source and providing patients guidance about the standardized treatment of *H. pylori* infection are important for *H. pylori* eradication.

The quality of *H. pylori* information on video-based social media platforms has not been fully assessed. This study aims to examine the information quality of *H. pylori* videos on short video platforms in China, hoping to provide some suggestions for improving short video content on *H. pylori*.

Methods

Search strategy and data processing

This was an observational retrospective study based on videos collected from TikTok, Bilibili, and Kwai, the three most popular short video platforms in China. Using search keywords "幽门螺杆菌" or "幽门螺旋杆菌" ("*H. pylori*" in Chinese), this study retrieved the first 100 Chinese language videos each from TikTok, Bilibili, and Kwai. The entire search process was conducted and completed during March 10–15, 2023. The exclusion criteria were as follows: (1) videos with duplicate content; (2) videos with incomplete data; (3) videos with no sound/poor sound quality; (4) videos irrelevant to the topic. Videos for advertisement or commercial purposes were also excluded. The videos were independently reviewed and categorized by two qualified physicians (Lai YK and Liao FQ), who worked in the department of gastroenterology in a tertiary hospital and had extensive experience in managing patients with *H. pylori* infection, and discrepancies, if any, were resolved by consensus.

Basic information, including publication date, name and type of the uploader, physician title and department, video duration (seconds), and the number of likes, favorites, and shares, was extracted from each video and recorded in Excel (Microsoft Corporation). Patients or the public WERE NOT involved in the design, or conduct, or reporting, or dissemination plans of our research.

Evaluation methodologies and procedure

The content and information quality of the videos were evaluated using the modified DISCERN tool and the Global Quality Score (GQS), respectively. DISCERN, first proposed by Goobie et al., is a widely validated and applied tool to help consumers and health professionals assess the quality of health-related content in videos (10, 18, 19). The tool assesses videos primarily through five questions (see Supplementary Table S1), which are scored either "1" or "0" according to whether the answer is "yes" or "no," with a minimum score of 0 out of 5. The GQS is another widely used tool for assessing the quality of health information in videos, with response selection based on a 5-point scale from 1 (poor quality) to 5 (good quality) (10, 20, 21). Details of this tool are presented in Supplementary Table S2. In addition, we used another video scoring tool from Goobie et al. that scores six main aspects of video content: definition of the disease, its signs and symptoms, risk factors, assessment, management, and outcomes. The scoring was divided into three main sections: no content (0 points), some content (1 point), and a lot of content (2 points).

All settings and history on a smartphone were deleted before conducting the search to avoid potential pre-buffered cache-induced targeted video recommendations, and none of the videos were downloaded, reposted, liked, or commented on to avoid impacting the data. The video evaluation process was as follows: Firstly, we recorded video information including the publication date; video duration; the number of likes, favorites, and shares; as well as publisher information including account name, self-description, and authentication status. The uploaders were classified into two main types (health professionals and non-health professionals) and identified by their account name and authentication status. The videos were also examined for whether they addressed common current *H. pylori*-related issues, such as *H. pylori* testing, whether all patients with *H. pylori* infection need to be treated, whether patients with *H. pylori* should be treated as a family unit, and the adverse reactions during *H. pylori* treatment. Finally, two independent raters assessed the content, reliability, and quality of the videos based on the DISCERN and GQS scoring systems. Before the evaluation, the two raters reviewed the official descriptions of these aforementioned tools and discussed the best way to evaluate video content using these tools, making any necessary adjustments.

Results

Short video characteristics

A total of 242 short videos retrieved from the three platforms were included for data analysis (Figure 1). The videos came mainly from two types of sources: health professionals and non-health professionals. In this study, most *H. pylori*-related videos were posted by health professionals (187/242, 77.3%). We further divided health professionals into gastroenterologists (51/242, 21.0%) and non-gastroenterologists (136/242, 56.2%). As for non-health professionals (55/242, 22.7), we categorized them into four types, including news agencies, nonprofit organizations, science bloggers, and patients, where science bloggers posted the most videos (26/242, 10.7%), followed by patients (13/242, 5.4%), news agencies (10/242, 4.1%), and nonprofit organizations (6/242, 2.5%) (Table 1).

The overall video length ranged from 92 to 2,280 s, with a median length of 198.5 s. The median number of likes received by the videos was 968 (interquartile range [IQR]: 178–5,620), and the median number of favorites and shares was 294 (IQR: 58–1,050) and 44.5 (IQR: 0–1,306), respectively (Table 2). Compared with health professionals, videos contributed by non-health professionals were longer (median: 217.5 vs. 184.5, $p = 0.586$) and shared more (median: 82 vs. 41, $p = 0.248$), but had fewer likes (median: 597 vs. 1093.5, $p = 0.164$) and favorites (median: 244.5 vs. 294, $p = 0.225$) (Supplementary Table S3). We further compared characteristics of videos contributed by gastroenterologists and non-gastroenterologists (Supplementary Table S4) and found that the median length (median: 231 vs. 182, $p = 0.489$) and number of shares (median: 43 vs. 38, $p = 0.744$) of videos provided by gastroenterologists were greater than those posted by non-gastroenterologists, but the differences were not statistically significant. In contrast, the median number of likes (median: 1320 vs. 565, $p = 0.019$) and favorites (median: 454 vs. 131, $p = 0.007$) of videos posted by non-gastroenterologists was significantly more than that of videos contributed by gastroenterologists.

Short video content analysis

The content comprehensiveness of each video was evaluated according to the six main aspects and common current *H. pylori* issues described in the Methods section, and the results showed that very few videos provided extensive content about *H. pylori*. As shown in Table 3, 73.2% of the videos contained little or no content on *H. pylori* definition, and the risk factors for *H. pylori* infection were rarely or not at all addressed in 68.3% of videos. Moreover, there were few videos (13.2%) describing *H. pylori* testing methods in detail. Treatment or management of *H. pylori* infection was the most common topic, with 63.6% of videos providing information on the management of *H. pylori*.

Figure 2 shows comparisons in the video content of different subgroups. Overall, videos posted by healthcare professionals provide more information about the symptoms and treatment of *H. pylori*, while non-healthcare professionals focus on the definition, detection, outcomes, and risk factors of *H. pylori*. Among healthcare professionals, gastroenterologists' videos have higher content coverage in all six aspects, especially in the treatment and detection of *H. pylori*. However, both types of videos lack substantial content coverage in the definition of *H. pylori*. Further subgroup analysis based on professional titles, including residents, attending physicians, associate chief physicians, and chief physicians, showed no substantial differences in the content coverage of videos related to *H. pylori* definition, symptoms, screening, and outcomes among different healthcare professionals. However, videos from attending physicians are more likely to address risk factors for *H. pylori* infection, while videos from chief physicians focus more on *H. pylori* treatment. As for non-healthcare professionals, videos from news agencies provide more comprehensive information about *H. pylori*, while videos from patients are limited in covering all six aspects of *H. pylori* information.

Furthermore, we assessed whether these videos addressed current topics related to *H. pylori*. As shown in Figure 3, most videos did not mention whether all *H. pylori*-positive patients need eradication

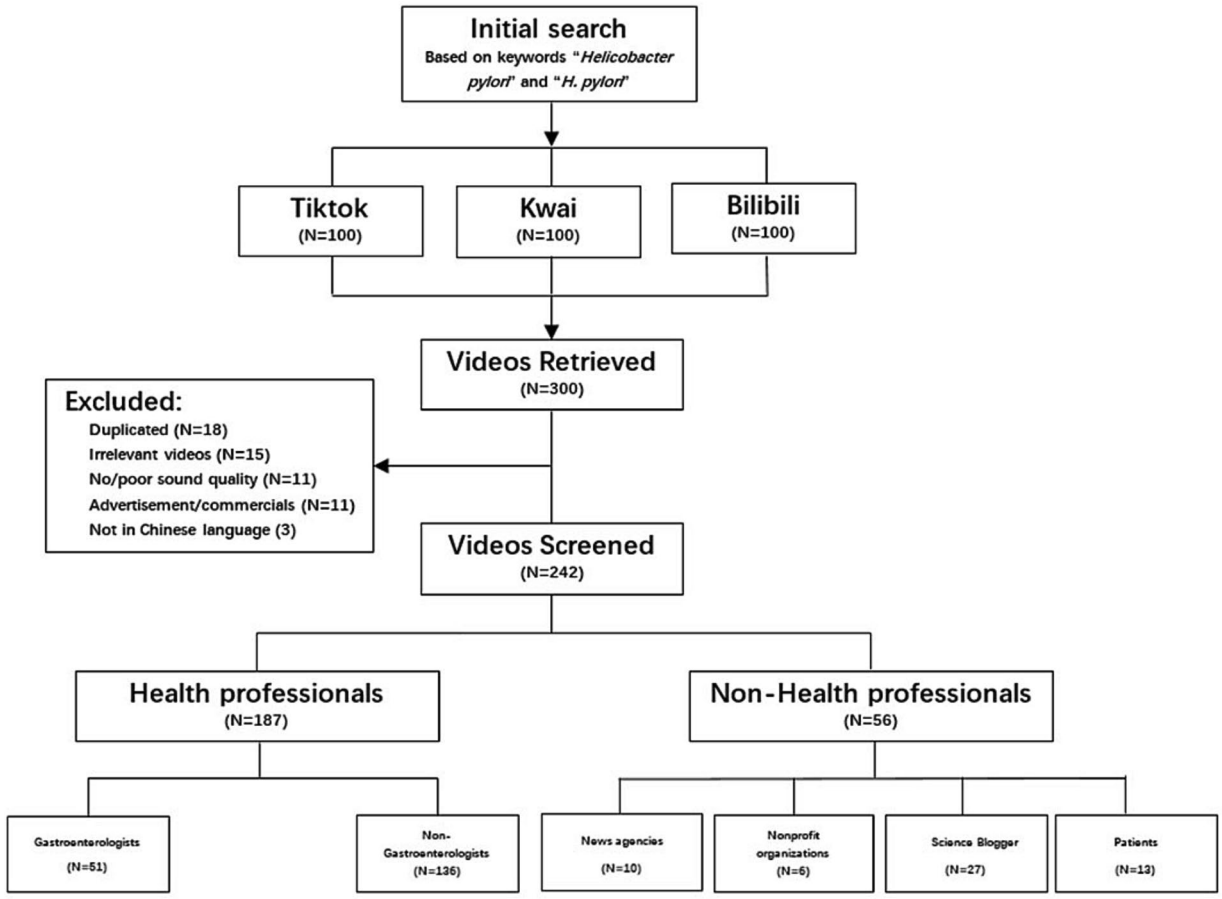


FIGURE 1
Flowchart of *H. pylori*-related videos included in the present study.

treatment (175/242, 72.3%), whether *H. pylori* should be eradicated at the family level (228/242, 94.2%), and whether *H. pylori* eradication treatment has any adverse effects (203/242, 83.9%). Further subgroup analysis revealed that videos from health professionals are more likely to be associated with family-based *H. pylori* eradication (6.5% vs. 0) and the need for eradication in all positive patients (23.7% vs. 12.5%) (Supplementary Table S3). Regarding health professionals, gastroenterologists' videos are more likely to address these three questions, as shown in Supplementary Table S4.

Short video information assessment

As shown in Table 2, overall video content quality was low, with a median GQS score of 3 (IQR: 2–3). There was no significant difference in video quality between health professionals and non-health professionals. Among health professionals, videos from gastroenterologists had significantly higher quality than videos from non-gastroenterologists, with no association between physician title and video quality. Among non-health professionals, news agencies posted the best quality videos. We also evaluated video reliability, which was low overall, while the subgroup analysis showed no difference between the reliability of videos posted by health and non-health professionals. Video reliability was significantly higher for gastroenterologists than for non-gastroenterologists, and physician title was not associated with video reliability. The lowest reliability videos were posted by patients among non-health professionals (Figure 4).

Discussion

High-quality health education is an important factor in *Helicobacter pylori* eradication

Gastric cancer has one of the highest incidence and mortality rates among gastrointestinal cancers worldwide, especially in East Asia, and *H. pylori* infection is the major risk factor associated with gastric cancer (22–24). Although significant progress has been made in understanding the relationship between *H. pylori* infection and gastric cancer, the clinical success rate of *H. pylori* eradication remains unsatisfactory (25, 26). Patient awareness of the disease is a crucial factor affecting the eradication and recurrence rate of *H. pylori* (27–29). Improved knowledge of *H. pylori*, its detection methods, infection risk factors, and management not only can reduce patient fear of *H. pylori* and help patients gain or maintain the skills they need to best manage their lives to reduce the spread of *H. pylori*, but also can

TABLE 1 Characteristics of the sources of *Helicobacter pylori*–related videos (*N* = 242).

Source	Description	Videos. n (%)
		Total
Health professionals		
Gastroenterologists	Certified physician or nurse practitioner specializing in gastroenterology	51 (21.1)
Non-gastroenterologists	Certified physician or nurse practitioner specializing in in other medical fields except gastroenterology	136 (56.2)
Overall		187 (76.9)
Non-Health professionals		
News agencies	News agencies and the press	10 (4.1)
Nonprofit organizations	Organizations and public hospitals that operate in the collective, public or social interest	6 (2.5)
Science Blogger	Individuals engaged in the dissemination of scientific knowledge	26 (10.7)
Patients	Patients who have undergone *H. pylori* testing or treatment	13 (5.4)
Overall		56 (23.1)

TABLE 2 Characteristics of *Helicobacter pylori*–related videos.

Characteristics	*n* = 242
Video duration (seconds), median, IQR	198.5 (92–2,280)
Number of likes, median, IQR	968 (178–5,620)
Number of favorites, median, IQR	294 (58–1,050)
Number of shares, median, IQR	44.5 (0–1,306)
DISCERN score, median, IQR	2 (1–3)
GQS score, median, IQR	2 (2–3)
Family-based H. pylori infection control and management (n, %)	
Not mentioned	228 (94.2)
Recommend	12 (5)
Not recommended	2 (0.8)
Treat all H. pylori-positive patients with no eradication of treatment-resistant factors (n, %)	
Not mentioned	175 (72.3)
Recommend	51 (21.1)
Not recommended	16 (6.6)
Adverse effects (n, %)	
Not mentioned	203 (83.9)
Mentioned	39 (16.1)

increase the compliance of patients, improving the eradication rate of *H. pylori* (26). Several previous studies have shown that high-quality education about *H. pylori* is effective in improving the *H. pylori* eradication rate (26, 30, 31).

Short video plays an important role in health education

According to the 49th Statistical Report on Internet Development in China, the number of mobile phone users in China has reached 1.643 billion, and the coverage of short videos among Chinese netizens has reached 90.5%, which means that nearly everyone in China can get or receive information through short videos on mobile phones (32). Through short videos, people can obtain health information more conveniently, and compared with traditional textual information platforms, this readily accessible platform provides people with graphical video information, which makes it easier for users to absorb and remember information (10). For example, during the coronavirus pandemic, there were 93.1 billion views of pandemic-related videos on TikTok by July 2020 (33). The results of Song et al. also showed that short health videos on TikTok had received approximately 1.7 million likes and 176,000 comments since they were published (18). The 242 short videos analyzed in this study had received approximately 6.2 million likes and were shared 1.2 million times, which suggests that short videos about *H. pylori* are widely viewed and disseminated. Therefore, health education for patients through short videos is an important tool that is effective as well as inexpensive. However, the quality of videos varies, and some videos even spread erroneous health information, which can cost patients more effort in treating *H. pylori*. Therefore, it is important for health practitioners to review the content of videos and screen the videos for high-quality information, ensuring their effectiveness in health education and disease self-management of patients.

Principal findings

Currently, several studies have evaluated the quality of *H. pylori*-related videos on short video platforms (34–36). Ergenç et al. (34) assessed *H. pylori*-related videos on YouTube, while Tan et al. and Du et al. evaluated the quality of such videos on TikTok and Bilibili (35, 36). Although they all concluded that the quality of videos on short video platforms is unsatisfactory, their studies still suffer from limitations such as small sample sizes and a single-platform evaluation. Besides, these studies did not make further differentiations among healthcare workers when categorizing video sources. In reality, videos posted by doctors from specialized departments in disease research tend to have significantly higher quality than those from doctors in other departments (10, 37). This may be a reason for the inaccurate conclusion drawn by these studies that non-profit organization videos have higher quality than doctor-generated videos. Additionally, these studies did not address topics of significant interest to people, such as whether all *H. pylori*-positive patients need eradication and whether testing for *H. pylori* eradication should be done on a family basis. Therefore, there is still a need for a larger-sample, multi-platform, and more comprehensive study.

TABLE 3 Completeness of video content.

Video content	Definition, *n* (%)	Signs/ symptoms, *n* (%)	Risk factors, *n* (%)	Test, *n* (%)	Treatment/ Management, *n* (%)	Outcomes, *n* (%)
No content (0 points)	164 (67.8)	134 (55.4)	158 (65.3)	152 (62.8)	84 (34.7)	109 (45)
Little content (0.5 points)	13 (5.4)	7 (2.9)	8 (3.3)	12 (5)	4 (1.7)	9 (3.7)
Some content (1 point)	36 (14.9)	50 (20.7)	45 (18.6)	46 (19)	99 (40.9)	90 (37.2)
Most content (1.5 points)	5 (2.1)	6 (2.5)	10 (4.1)	8 (3.3)	6 (2.5)	15 (6.2)
Extensive content (2 points)	24 (9.9)	45 (18.6)	21 (8.7)	24 (9.9)	49 (20.2)	19 (7.9)

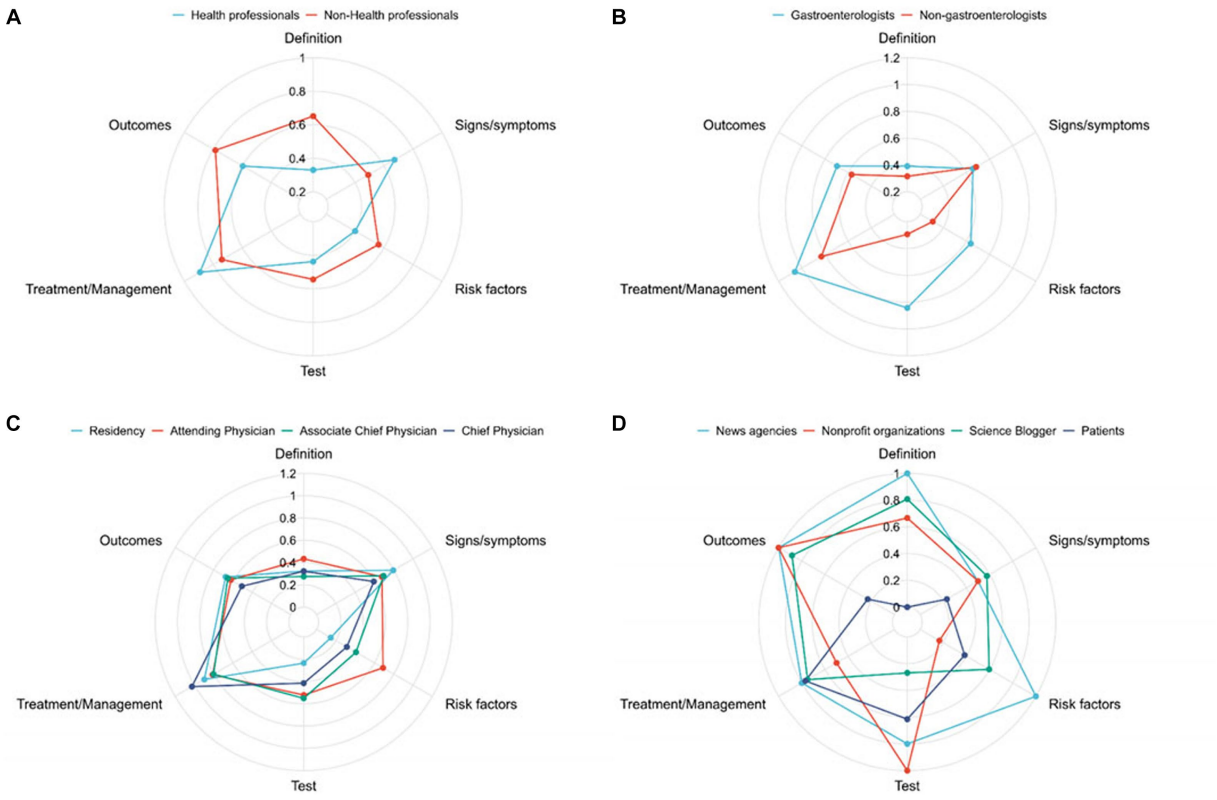


FIGURE 2
Comparisons of content comprehensiveness **(A)** between health professionals and non-health professionals; **(B)** between gastroenterologists and non-gastroenterologists; **(C)** among residents, attending physicians, associate chief physicians, and chief physicians; **(D)** among news agencies, nonprofit organizations, science bloggers, and patients.

In this study, we evaluated the content, quality, and reliability of health education videos about *H. pylori* on TikTok, Kwai, and Bilibili. Overall, the quality of videos in our sample was poor, with few videos comprehensively addressing the six aspects of *H. pylori* infection: definition, symptoms, risk factors, detection, treatment, and outcomes, making the video content potentially less helpful to patients, which may be related to the fact that the videos were not regulated and monitored before releasing.

Overall, videos from health professionals and news media provide accurate information on antibiotic-based triple or quadruple therapy for *H. pylori* treatment. In terms of preventive measures, videos from health professionals and news media sources correctly emphasize preventive actions such as using public chopsticks and reducing dining out to prevent transmission. There was no significant difference in the quality and reliability of videos posted by health professionals and non-health professionals. A subgroup analysis of health

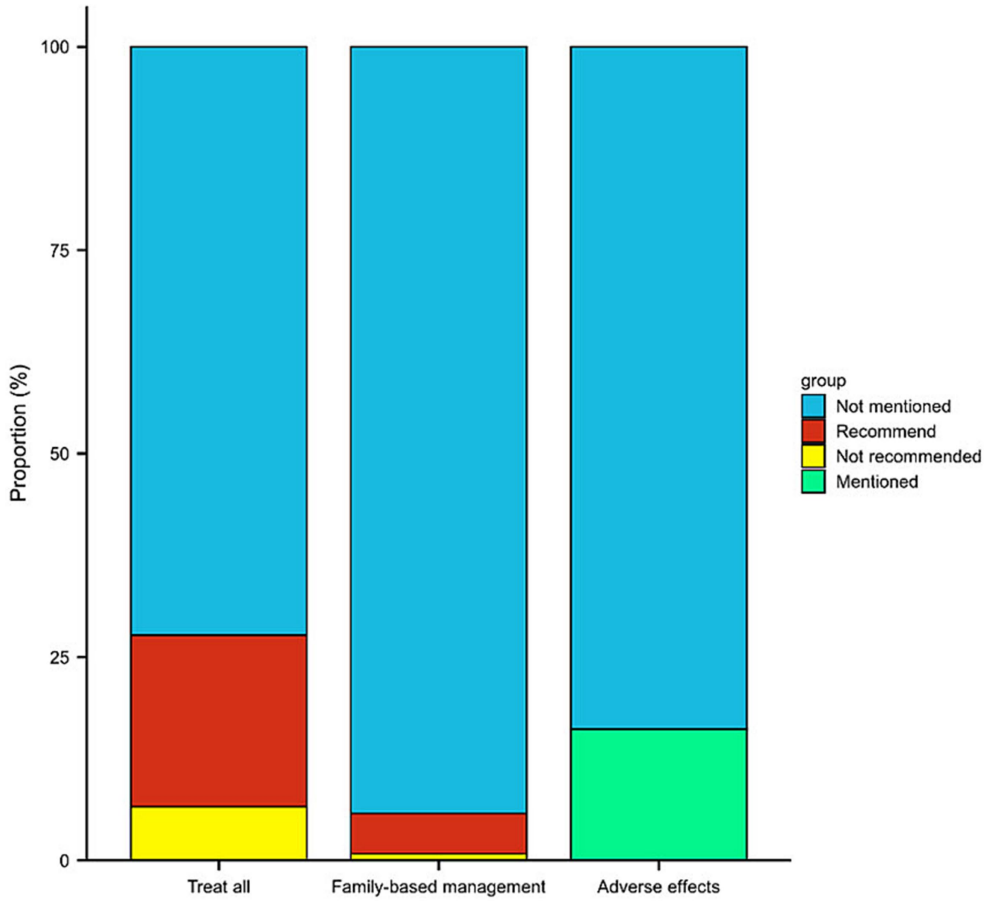


FIGURE 3
Percentage of short videos with common *H. pylori* questions (whether all positive patients should be eradicated, whether testing and treatment based on family, whether adverse effects of eradication are mentioned).

professionals showed that non-gastroenterologists posted the greatest number of videos, which may be the reason for the low quality of videos posted by health professionals. As we watched the videos, we found that there were still many errors and biases in the understanding of *H. pylori* among non-gastroenterologists, which may be related to their different areas of expertise and lack of professional training, leading to an incomplete understanding of *H. pylori*. For example, professionals from the Department of Traditional Chinese Medicine disregarded the standard eradication protocols proposed by the global eradication guidelines and even advocated for uncertified Chinese herbal medicine for *H. pylori* eradication in the videos, resulting in misconceptions that may not only lead to the failure of *H. pylori* eradication but also affect patients' subsequent eradication treatment. In videos posted by non-professionals, especially those from patient sources, there was an excessive exaggeration or minimization of the harm caused by *H. pylori*. Moreover, these videos even suggested incorrect treatment methods such as dietary therapy for the treatment of *H. pylori*.

We also conducted a subgroup analysis of professionals based on their titles and found no association between title and video quality. This may be because chief physicians in gastroenterology posted less video content, while chief physicians in other specialties with less knowledge about *H. pylori* posted more videos. Furthermore, most of the video content did not address current issues concerning *H. pylori*. For example, there are guidelines that *H. pylori*-positive patients need to undergo eradication therapy if there are no contraindications to eradication (3, 28, 29, 38), but most videos in this study did not mention this information, and some videos even suggested the opposite, which can create confusion about the treatment process and is not conducive for the successful eradication of *H. pylori*. Moreover, according to a previous study, *H. pylori* has a family infection rate of 71.21% in China (39), and family-based *H. pylori* testing, treatment, and guidelines are recommended for *H. pylori* eradication (3). Yet, there were essentially no videos on this aspect of *H. pylori*, which is important in improving the eradication rate and reducing the recurrence rate of *H. pylori*.

Future directions and limitations

Short videos can make complex health information more understandable and impressive (40–42). However, incorrect health information in short videos can make self-management of disease extremely difficult. Therefore, it is important to improve the information quality of short videos to maintain patients' health and reduce their financial burden. To this end, we propose the following recommendations to make short videos a truly important tool for health education in the future. Firstly, the

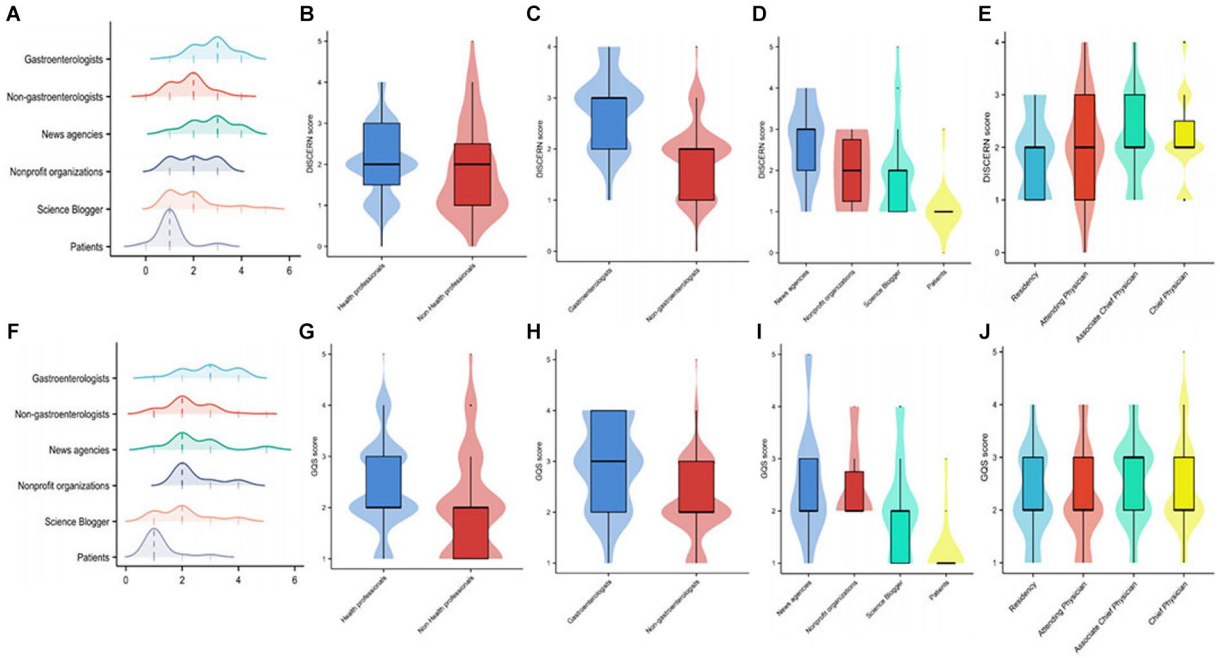


FIGURE 4
Comparison between DISCERN scores and Global Quality Scores (GQS) across video sources. **(A)** The distribution of DISCERN scores among different sources displayed by the ridge plot. **(B–E)** Comparisons of DISCERN scores in videos from different sources displayed by violin plots. **(F)** The distribution of GQS scores among different sources displayed by the ridge plot. **(G–J)** Comparisons of GQS scores in videos from different sources displayed by violin plots; $*p < 0.05$; $**p < 0.01$; ns: non-significant.

relevant departments should carefully review the content of health promotion videos before they are released to prevent the dissemination of wrong information through the Internet. Secondly, we should advocate for more authoritative videos from relevant professionals, and if necessary, the government or authoritative institutions should invite chief physicians of relevant professions to give detailed and easy-to-understand explanations on self-management of diseases and answer common questions of patients. Finally, the video platforms should keep the authenticated authoritative videos on top, so that patients can view them first when searching for related content and avoid being misled by other misinformation.

In the future, videos related to *H. pylori* should provide more detailed explanations in terms of definition, symptoms, detection, treatment, risk factors, and outcomes. At the same time, content that concerns patients, such as whether all *H. pylori*-positive patients need eradication treatment, whether *H. pylori* should be eradicated at the family level, and adverse reactions after *H. pylori* treatment, should be explained in dedicated videos by authoritative gastroenterology experts and promoted through official accounts to avoid patients receiving misinformation in these areas.

There are still some limitations in this study. Firstly, only Chinese videos were included for analysis; therefore, the results of this study may not be applicable to short video platforms in other languages. Secondly, since videos are constantly uploaded and deleted, this study only evaluated and analyzed videos posted within a specific period.

Third, due to privacy concerns, we did not obtain the accurate number of views of the videos. However, based on the number of likes, shares, and bookmarks, we can still conclude that these videos have a considerable viewership on Chinese short video platforms, with a broad audience. Besides, in this study, a detailed subgroup analysis of video sources was conducted, and a relevant evaluation was made regarding whether the videos addressed common *H. pylori* issues. Thus, the findings of this study provide important guidelines for both patient selection of short videos and subsequent management of content on short video platforms.

Conclusion

A total of 242 *H. pylori*-related short videos from three short video platforms (TikTok, Kwai, and Bilibili) were analyzed in this study. Overall, the content and information quality of the videos were not very satisfactory and video quality was correlated with the source of the videos, with the highest quality of videos posted by gastroenterologists. Although most of the videos mentioned the relationship between *H. pylori* infection and gastric cancer and advocated the need for *H. pylori* eradication, the videos did not address topics of current concern, such as whether all *H. pylori*-positive patients need to undergo eradication treatment, whether family-based testing and eradication should be performed, and the adverse effects of eradication treatment. In the future, *H.*

pylori-related short videos need to be further improved to more accurately disseminate *H. pylori*-related knowledge to patients, thereby increasing the success rate of *H. pylori* eradication.

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.

Author contributions

YL: Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. FL: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft. ZH: Investigation, Methodology, Project administration, Validation, Writing – original draft. WL: Formal analysis, Investigation, Project administration, Supervision, Writing – review & editing. CZ: Formal analysis, Investigation, Project administration, Resources, Writing – original draft. YD: Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. ZL: Investigation, Project administration, Supervision, Validation, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1344212/full#supplementary-material

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Examining students' level of understanding toward COVID-19 and its associated factors in Ethiopia: a systematic review and meta-analysis

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Background: This systematic review and meta-analysis aim to investigate students' understanding of COVID-19 in Ethiopia and identify associated factors. The primary goal is to pinpoint key contributors shaping students' perception and comprehension of the virus. The study aims to offer valuable insights for developing targeted educational interventions, ultimately enhancing students' overall knowledge and awareness of the pandemic in the specific context of Ethiopia.

Methods: The study adhered rigorously to PRISMA criteria, ensuring a standardized methodology. Data from reputable databases like Google Scholar and PubMed were systematically collected. Ten relevant articles were meticulously analyzed using STATA version 11, with heterogeneity assessed by the I2 test. A funnel plot and Egger's test were used to check for publication bias. The determination of the pooled effect size utilized a random-effect model meta-analysis, offering a robust 95% confidence interval.

Results: This meta-analysis, based on 10 articles, reveals an overall prevalence of 61.58% (95% CI: 47.26–75.89). Significant contributors to students' comprehension include Social media users (AOR) = 2.38, urban residence AOR = 3.31, news media followers AOR = 2.51, fathers' educational status AOR = 2.35, watching television AOR = 4.71, and health science students AOR = 4.21. These findings underscore crucial elements shaping students' understanding of COVID-19 in Ethiopia.

Conclusion: Our analysis indicates that 61.58% of Ethiopian students possess a good understanding of COVID-19. Factors such as active social media engagement, geographic location, frequency of news consumption, father's level of education, television viewing habits, and enrollment in health science programs significantly influence their comprehension. These findings underscore the importance of implementing targeted interventions to enhance

health literacy and education among students, thereby facilitating a more effective response to pandemics.

KEYWORDS

COVID-19, coronavirus, knowledge, understanding, awareness, students, Ethiopia

1 Background

Coronavirus Disease 2019 (COVID-19) is a highly contagious viral illness caused by the SARS-CoV-2 virus (1). First identified in late 2019 in Wuhan, China, it rapidly spread globally, leading the World Health Organization (WHO) to declare it a pandemic in March 2020 (2, 3). The virus primarily spreads through respiratory droplets, which are released during activities such as coughing, sneezing, or talking. Common symptoms include fever, cough, shortness of breath, and loss of taste or smell (4–6).

The COVID-19 pandemic has touched every aspect of human life worldwide, impacting business, research, education, health, economy, sports, transportation, worship, social interactions, politics, governance, and entertainment (7, 8). This influence affects patients, healthcare workers, communities, and students, spanning all populations (8, 9). The high rate of transmission of COVID-19 makes it challenging to manage its progression (8, 10).

To control the spread of the pandemic globally, various restrictive measures were implemented, such as contact tracing, quarantine, mask-wearing, hand hygiene, stay-at-home orders, lockdowns, and social and physical distancing (10). These measures resulted in the closure of facilities and services, bringing about significant changes to societal norms (11).

As of October 2023, globally, over 698.5 million individuals have been affected by COVID-19, including in Africa and Ethiopia (12). In Africa, the impact extends to more than 12.8 million people (13). In Ethiopia, specifically in October 2023, there were over 501,060 reported cases of COVID-19 (14). The consequences of COVID-19 are profound, affecting healthcare systems, economies, job markets, and education, and causing social and psychological impacts (10). These consequences underscore the contagious and severe nature of the virus (15, 16). This indicates the contagion and severity of the virus for human beings (8).

In March 2020, Ethiopia declared COVID-19 and implemented measures such as social distancing and lockdowns to control the virus's spread. However, the impact has been profound, straining healthcare systems, disrupting economies, causing job losses, affecting education, and inducing social and psychological impacts (17). Despite the Ethiopian government's active engagement in testing, contact tracing, treatment, and vaccination campaigns, challenges persist due to limited resources (10, 18).

The global disruption in the education sector caused by the COVID-19 pandemic underscores the importance of understanding how students perceive and interpret the ongoing situation (19). This systematic review and meta-analysis in Ethiopia are specifically designed to delve into students' knowledge and awareness, while also scrutinizing the factors that shape their perspectives (12). Ethiopia's unique socio-cultural dynamics contribute a distinctive layer to this investigation, enhancing our understanding of the variations in students' knowledge levels and consolidating existing knowledge (20).

In light of transformative changes in education, acquiring a nuanced understanding of students' perspectives is crucial. However, this practice is not widely employed in resource-limited settings (21). Previous studies conducted in Ethiopia have indicated a varying degree of poor knowledge or understanding of COVID-19 among students, with reported outcomes ranging from 23.5 to 86.3% (22–31). This variability could be attributed to factors such as the student's level of education, attitudes, perceptions, awareness, university or college status, exposure to mass media, place of residence, sources of information, family educational status, and internet and computer accessibility for seeking coronavirus information, among other relevant considerations (21, 22, 25–27, 30, 31).

Despite several studies being conducted on the level of understanding of COVID-19 among Ethiopian students, a systematic review and meta-analysis dedicated specifically to focusing on the students were limited. As a result, this study addresses this limitation, serving as a crucial foundation for informed policymaking, the development of effective public health strategies, and the implementation of targeted educational interventions. The primary objective is to offer valuable insights that contribute to a comprehensive understanding of the impact of the COVID-19 pandemic on Ethiopian students. Ultimately, this study aims to enhance resilience and adaptability among students in the face of persistent challenges.

2 Methods

2.1 Searching strategy

The systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (32). Between October 1 and November 10, 2023, we conducted a thorough data search across various platforms, including PubMed, the Cochrane Library, Google, Google Scholar, and the Embase database. This search encompassed both Medical Subject Headings (MeSH) and free-text terms, employing a detailed search strategy.

To enhance the search precision, the systematic review employed both "AND" and "OR" in the search strategy. In addition to the mainstream sources, the Master's thesis or Dissertation was explored through the Ethiopian university's research repository online library. Furthermore, a manual search of the reference lists in the included studies was conducted to ensure a comprehensive coverage of evidence.

To comprehensively examine the level of understanding among students regarding COVID-19 and the influencing factors in Ethiopia, we employed a thorough search strategy. Utilizing snowballing

techniques, we explored various search phrases, including keywords and free-text queries.

We utilized a systematic approach to search relevant literature across multiple electronic databases including PubMed, Web of Science, Scopus, and Google Scholar. The search terms were carefully selected to capture all relevant studies related to students' understanding of COVID-19 and its associated factors in Ethiopia.

Specifically, our search strategy included keywords such as "COVID-19," "students," "knowledge," "awareness," "Ethiopia," and variations thereof. Boolean operators (e.g., AND, OR) were utilized to combine these keywords effectively. Additionally, Medical Subject Headings (MeSH) terms were employed where applicable to ensure a comprehensive search strategy.

2.2 Inclusion and exclusion criteria

The inclusion criteria for this systematic review encompassed freely accessible full-text articles conducted in Ethiopia between 2019 and 2023 and written in English. We included studies that underwent peer review for publication in journals or were discovered in gray literature. Eligible studies covered all observational study designs (cross-sectional, case–control, and cohort) involving human subjects and reporting on knowledge, understanding, and awareness of COVID-19 in their full articles. To ensure inclusivity, we adopted a comprehensive approach, welcoming a diverse range of observational study designs and sources. These criteria were established *a priori* to ensure the selection of studies that met the objectives of our systematic review. Studies were included if they met the following criteria: (1) conducted in Ethiopia, (2) focused on assessing students' understanding or knowledge of COVID-19, (3) published in peer-reviewed journals, and (4) written in English.

However, studies without freely accessible full texts after applying the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols search strategies were excluded. Furthermore, studies not quantitatively reporting specific proportions of good knowledge, understanding, and awareness regarding COVID-19 were also excluded from this systematic review and meta-analysis. This stringent approach aimed to concentrate on studies offering detailed and quantitative insights into the specified aspects of COVID-19 awareness and understanding in the Ethiopian context. Studies were excluded if they were duplicates, conference abstracts, editorials, or opinion pieces.

2.3 Outcome measures

The primary goal of this systematic review and meta-analysis was to estimate the combined level of students' knowledge, understanding, or awareness regarding COVID-19 in Ethiopia. We categorized students' knowledge into either good or poor responses during the assessment process.

2.4 Data extraction

Following the selection criteria, two authors independently reviewed titles and abstracts. Selected titles and abstracts underwent further scrutiny, and data extraction was carried out using an organized Microsoft Excel Spreadsheet. Studies approved by both authors during this selection process were included in the review. In case of disagreements among data extractors, discussions were held to reach a consensus.

For each study, comprehensive information was collected, including the initial author, publication year, study years, participant count, background details, study area, sample size, data collection techniques, response rate, study design, and prevalence. The status of Ethiopian students' knowledge and associated factors was also extracted, along with 95% confidence intervals. Any identified issues were discussed with the corresponding author for resolution.

2.5 Quality appraisal of selected literature

The quality appraisal of the selected literature involved a thorough assessment to ensure the reliability and validity of the studies included in the systematic review. The evaluation process considered various criteria such as study design, methodology, sample size, data collection techniques, and the overall rigor of each study.

Using a standardized tool (a modified version of the Newcastle-Ottawa Scale (NOS)), that categorizes bias potential and can help to explain variations in the results of included research, Each study's quality was assessed, and the authors additionally examined at each publication's methodology and other features (33). We concluded that works with a modified NOS component score of 7 or higher were relevant after analyzing a range of publications (see: Table 1) (34). Additionally, three authors independently conducted a quality control assessment.

2.6 Data processing and analysis

The data processing and analysis employed a systematic approach to extract meaningful insights. Initially, data was meticulously organized in Microsoft Excel and then imported into STATA version 11, for further analysis. In the analytical phase, a random-effects model of meta-analysis estimated both the pooled and individual study effects, accompanied by 95% confidence intervals (CI) for a nuanced understanding. The visual representation used forest plots, providing a clear overview of the pooled impact size and weight, complemented by 95% CI for each selected study.

Ensuring result validity involved assessing heterogeneity among studies using I2 statistics (35), considering variations in participants, locations, and measurement methods. A random-effects model was chosen for flexibility in handling identified heterogeneity. A meticulous check for publication bias was conducted using funnel plots and Egger's test to enhance credibility by addressing potential bias in the published literature (34). In essence, this methodology aimed to deliver a comprehensive, reliable, and unbiased evaluation of Ethiopian students' knowledge levels concerning COVID-19.

3 Patient and public involvement

No patients were involved in developing the research question, determining outcome measures, designing the study, recruiting

TABLE 1 Characteristics of individual studies conducted on the level of understanding towards COVID-19 among students in Ethiopia, 2024.

Authors	Regions	Year of the study	Year of publication	Study design	Sample size	Prevalence	Quality score
Aklil, M. and Temesgan, W.	Amhara	2021	2022	Cross-sectional	634	46.8	9
Aynalem, Y. et al.	Amhara	2020	2021	Cross-sectional	634	73.8	8
Feleke, A. et al.	Amhara	2021	2022	Cross-sectional	417	98.8	9
Getawa, S. et al.	Amhara	2021	2022	Cross-sectional	395	93.6	8
Yesuf, M. and Abdu, M.	SNNP	2021	2022	Cross-sectional	422	81.8	7
Berihun, G. et al.	Amhara	2020	2021	Cross-sectional	422	75.9	9
Handebo, S. et al.	Amhara	2020	2021	Cross-sectional	403	23.5	7
Larebo, M. and Abame, E.	SNNP	2021	2021	Cross-sectional	800	29.2	8
Angelo, T. et al.	SNNP	2020	2021	Cross-sectional	422	47	8
Tadesse, W. et al.	Amhara	2020	2020	Cross-sectional	422	69.6	8

participants, analyzing data, interpreting results, or implementing the research. Furthermore, the study design did not directly engage the general public, and there is no intention to share the findings with patients.

3.1 Ethical consideration

As part of this systematic review, we applied the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria to evaluate the literature. To address potential conflicts of interest, as well as voice and representation issues, we systematically reviewed and acknowledged the included research in the manuscript. Therefore, the dates of participant recruitment and/or medical record access are not relevant, and ethics approval is not applicable.

4 Results

4.1 The selection process of the articles

In the process of conducting a comprehensive literature review, various online search engines, including Google, Google Scholar, and other databases such as Medline, Pub Med, Scopus, Cochrane, EMBASE, African Journal Online (AJOL), HINARI, and Science Direct, were utilized. This extensive search yielded a total of 18,300 papers across all databases. To ensure quality and relevance, a meticulous screening process unfolded. Initially, 4,500 duplicate papers were removed. Subsequently, 8,327 papers were disqualified based on a detailed review of abstracts and titles, considering factors like study focus and subject matter.

Refinement continued with the exclusion of 183 publications due to quality and full-text availability issues. Subsequently, 5,280 full-text papers were excluded based on study area and subject matter, refining the focus. The research specifically centered on Ethiopia, involving a meticulous meta-analysis and systematic review of 10 carefully chosen full-text papers. This thorough process ensures a robust and meaningful analysis, providing valuable insights into the study's specific context (see Figure 1).

4.2 Characteristics of the included articles in the review

This study, encompassing 10 articles and involving 5,003 study participants, aimed to assess the collective understanding of students regarding COVID-19 in Ethiopian educational sectors. The majority of the studies, analyzed through a systematic review and meta-analysis, were conducted in the Amhara region, with study participants varying from 403 to 634 (25–27, 29–31). Additionally, three articles focused on the South nation nationality people, involving study participants ranging from 422 to 800. The inclusion of diverse regions provided a comprehensive perspective on students' comprehension of COVID-19 in the Ethiopian educational context (23, 24, 28).

The variability in students' understanding of COVID-19 in Ethiopia was substantial, ranging from 23.5 to 86.3% across the included articles. Importantly, all reviewed studies met a specified quality threshold of seven and above on a modified version of the Newcastle-Ottawa Scale (NOS). This comprehensive analysis provides valuable insights into the diverse perspectives and comprehension levels among students in different regions of Ethiopia, offering crucial information for the formulation of effective educational and public health strategies (see Table 1).

4.3 The pooled prevalence of Ethiopian students' level of understanding of COVID-19

According to the reviewed articles, the level of understanding among students in the Ethiopian educational sector regarding COVID-19 was found to be insufficient. The meta-data analysis revealed that the pooled prevalence of students with a good level of

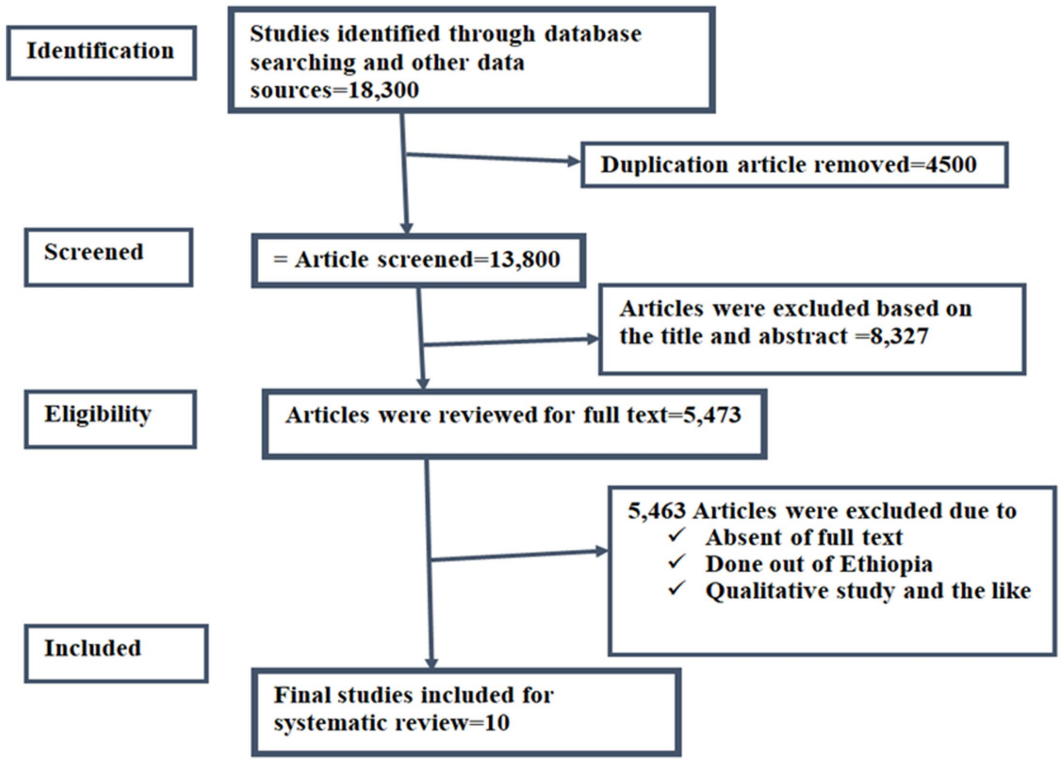


FIGURE 1
PRISMA flowcharts showing the selection process of the articles.

understanding of COVID-19 in Ethiopia was 61.58% (95% CI, 47.26–75.89). However, a random-effects model showed a statistically significant level of heterogeneity (I2 = 70.8%; $p = 0.000$), indicating substantial variation among the primary studies.

Consequently, the conclusion drawn from this significant heterogeneity was that further investigation through subgroup analysis is warranted. This suggests that there may be underlying factors contributing to the diversity in students' understanding of COVID-19 in Ethiopia, and exploring specific subgroups or factors could provide valuable insights for addressing these variations (see Figure 2).

4.4 Publication bias

In this meta-analysis, both Egger's regression test and funnel plots were employed to assess the presence of publication bias. Unfortunately, the results from the funnel plots indicated evidence of publication bias, as the observed asymmetry contradicted the expected symmetrical distribution. It's crucial to note that each point in the funnel plot represents a visual representation of study results rather than individual studies. Despite the anticipation of symmetry, the observed asymmetry raised concerns about potential biases in the included studies.

Furthermore, Egger's regression test, evaluating the statistical significance of publication bias, yielded a result of $p = 0.042$. This p-value, being less than the conventional significance level (e.g., 0.05), indicates that Egger's test for the absence of publication bias was not statistically significant. In summary, both the visual inspection of the funnel plot and the statistical test collectively suggest the presence of publication bias in this meta-analysis (see Figure 3).

4.5 Univariate meta-regression of factors related to the heterogeneity of students' level of understanding toward COVID-19 in Ethiopia

In our study, we initially conducted a univariate meta-analysis, focusing on response rate and the year of publication, to investigate potential causes of heterogeneity among the collected data. Surprisingly, this analysis did not reveal a significant link between either response rate or publication year and the observed heterogeneity.

To delve deeper into understanding the sources of variation, we proceeded with a subgroup analysis. This involved considering additional factors such as the study's area, sample size, years of publication, and the specific year of the study. Despite this thorough exploration, none of these factors emerged as a potential cause of the observed heterogeneity.

In essence, our thorough examination did not pinpoint response rate or year of publication, nor did it reveal any other specific factors considered in the subgroup analysis, as significant contributors to the heterogeneity observed in the studies. This suggests that further exploration or the consideration of other factors may be necessary to understand the sources of variability in the meta-analysis (see Table 2).

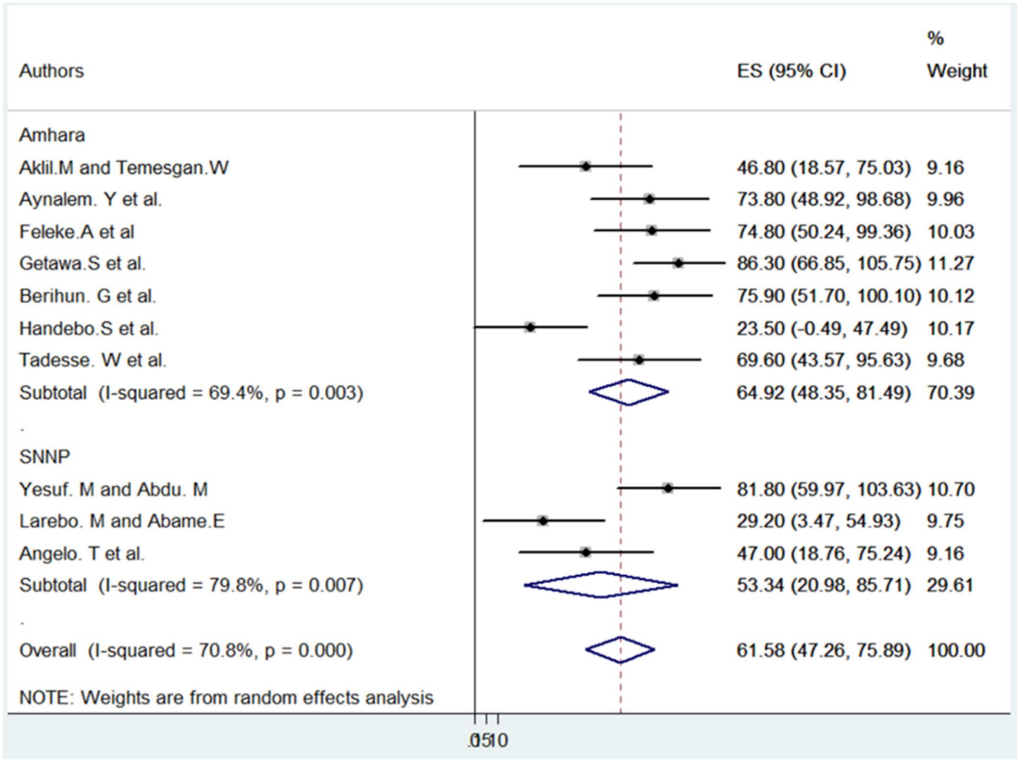


FIGURE 2
The pooled prevalence of good levels of understanding towards COVID-19 among students in Ethiopia, 2024.

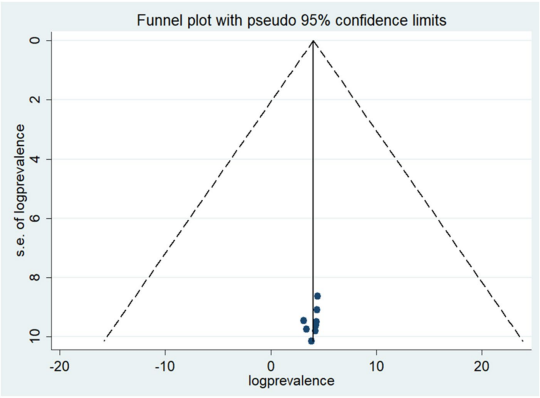


FIGURE 3
Funnel plot to shows publication bias among the included articles of a good level of understanding towards COVID-19 a systematic review and meta-analysis, Ethiopia.

TABLE 2 Univariate Meta-regression of factors related to heterogeneity level of understanding towards COVID-19, systematic review and meta-analysis, Ethiopia, 2024.

Factors	Coefficient	*p*-value
Response rate	0.1372339	0.874
Year of publication	10.553313	0.427

4.6 Subgroup analysis

In our systematic review and meta-analysis, we encountered significant variability among the articles included. To better understand and address this heterogeneity, we conducted a subgroup analysis, considering key factors such as the study region, sample size, study area, year of publication, and year of the study.

Upon analyzing these subgroups, we found that the primary source of heterogeneity was studies conducted in secondary schools ($I^2 = 83.7\%$, $p = 0.003$). The second most significant source of heterogeneity was attributed to studies conducted in the Amhara region ($I^2 = 79.8\%$, $p = 0.007$), while the third major source was studies conducted after the year 2021 ($I^2 = 75.2\%$, p = 0.003).

It's noteworthy that all other variables considered in the subgroup analysis also contributed to the overall heterogeneity. This comprehensive examination provides valuable insights into the specific factors influencing the variability observed in our meta-analysis, with a clear hierarchy of influence identified (see: Table 3 and Figure 4).

4.7 Factors associated with Ethiopian student's level of understanding of COVID-19

This study, based on an analysis of 10 articles, aimed to uncover the factors influencing students' understanding of COVID-19 in Ethiopia. Six key factors were identified. Firstly, students active on social media showed a higher understanding (AOR = 2.38). Additionally, residents of specific locations demonstrated significantly

TABLE 3 Sub-group meta-analysis of factors relating to the heterogeneity of students' level of understanding towards COVID-19.

Variables	Category	Included study	Sample size	Prevalence	I^2	*p*-value
Study area	University	4	2,278	56.92	66.8%	0.029
	College	2	1,056	58.88	26.2%	0.245
	Secondary school	4	1,669	67.03	83.7%	0.000
Sample size	Large sample size	3	2068	50.17	67.0%	0.048
	Small sample size	7	2,935	66.58	71.4%	0.002
Year of study	After 2021	5	2,700	64.91	75.2%	0.003
	Before 2021	5	2,303	57.98	69.1%	0.000

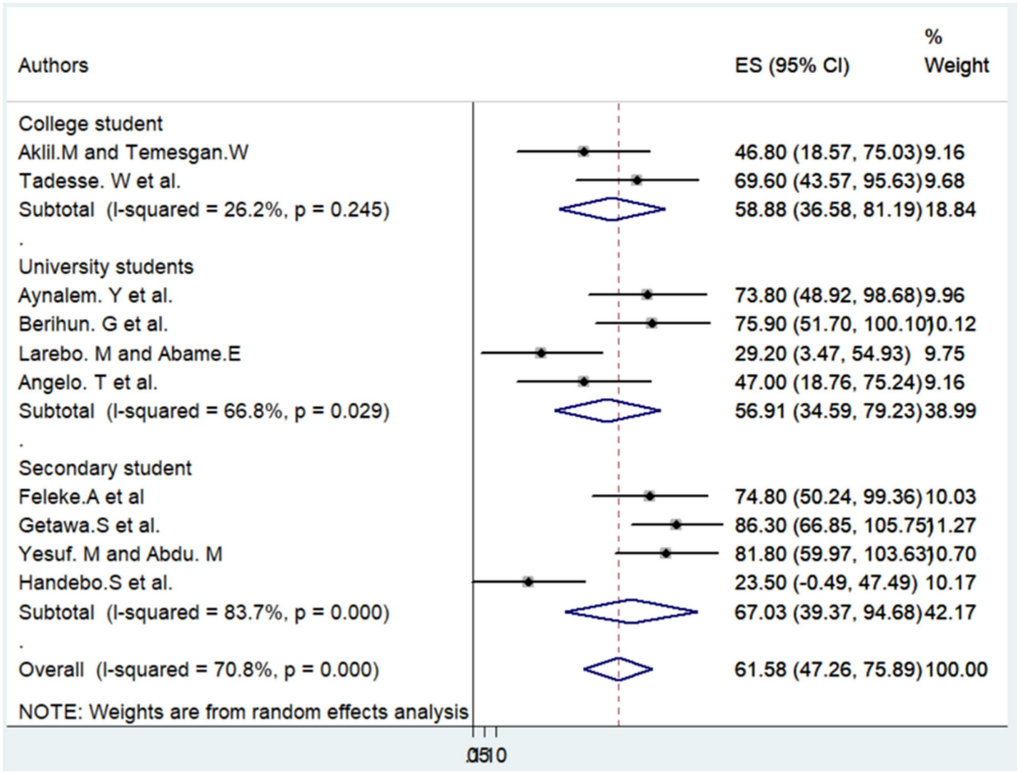


FIGURE 4
Subgroup analysis based on study area.

better comprehension (AOR = 3.31). Those who followed news media also exhibited a stronger grasp of COVID-19-related information (AOR = 2.51). The educational status of fathers was linked to students' understanding (AOR = 2.35), and those who engaged in television watching showed notably higher comprehension (AOR = 4.71). Lastly, health science students demonstrated a greater understanding (AOR = 4.21). In conclusion, the study underscores the diverse factors influencing students' COVID-19 understanding in Ethiopia, spanning media engagement, family background, academic discipline, and personal circumstances.

In total, four studies were accessed to assess the correlation between students' level of understanding regarding COVID-19 and their residence. Another set of three studies investigated the relationship between students' comprehension of COVID-19 and factors such as being social media users, followers of news media, and respondents who watch television. Additionally, these studies explored the understanding of students majoring in health science departments in college and university study areas. Finally, two studies delved into the impact of marital status and fathers' educational status on students' level of understanding of COVID-19. Collectively, these studies provide a comprehensive analysis of various factors influencing students' understanding of the pandemic, contributing valuable insights across different dimensions of their lives and academic pursuits (see Figure 5).

5 Discussion

This systematic review and meta-analysis of students' understanding of COVID-19 in Ethiopia revealed a pooled prevalence of 61.58% (95% CI: 47.26–75.89). This indicates that a substantial majority of students possess a reasonable level of comprehension. The

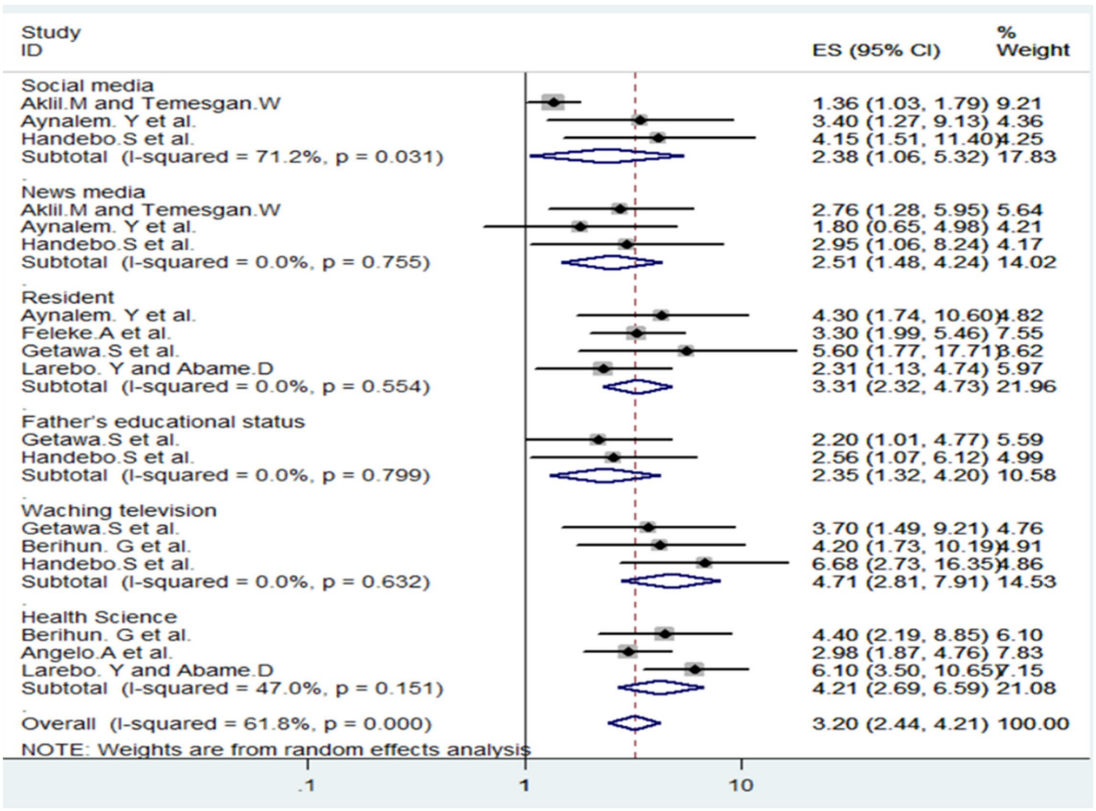


FIGURE 5
Factors Associated with Ethiopian Student's Level of Understanding towards COVID-19.

study emphasizes the importance of targeted interventions considering diverse factors influencing understanding, providing valuable insights for educational strategies in the context of the ongoing pandemic.

Our study aligns with previous research conducted in Ethiopia among pregnant women, reporting a prevalence of 60.24% (36), and in the overall population, including healthcare professionals and students, with a prevalence of 61.78% (37). However, it notes a lower prevalence compared to similar studies conducted among healthcare professionals in Ethiopia, where the prevalence was 79.4% (38), and in the general population, including nearly 75% of healthcare professionals, with a prevalence of 70.25% (39).

This variation may be explained by the fact that healthcare professionals benefit from their educational backgrounds and continuous exposure to professional training, specialized resources, and ongoing updates within the healthcare environment. This heightened access contributes to a more comprehensive understanding of COVID-19 among this group.

Based on the associated factors analysis, six significant factors influence students' understanding of COVID-19 in Ethiopia. Among these, regular television watching emerged as the most significant factor. Students who engage in this activity are 4.71 times more likely to grasp information compared to those who do not watch regularly. Television, serving as a common source of information, aids students by providing accessible and comprehensive details about the virus. This was supported by studies done (22, 25, 30). One possible justification is that students who utilize television as a source of information regarding COVID-19 play a vital role in expanding their understanding of the pandemic. Television's widespread accessibility ensures that a diverse range of students, including those from various socioeconomic backgrounds, can access timely and relevant information. Moreover, the visual and auditory presentation offered by television facilitates comprehension and retention of complex topics like COVID-19 through news broadcasts, documentaries, and expert interviews. Visual aids such as charts and graphs further enhance understanding. Additionally, many students trust established television networks for accurate information, as these networks often feature dedicated health segments and special coverage on COVID-19, including updates from reputable sources like the World Health Organization and the Centers for Disease Control and Prevention. The consistency and routine of regular television watching also contribute to students' knowledge acquisition, as it establishes a habit of seeking out information on the pandemic. Research demonstrates that the frequency of television watching correlates with the depth of understanding; students who watch television regularly are 4.71 times more likely to grasp information about COVID-19 compared to those who do not. In conclusion, students who rely on television for COVID-19 updates significantly enhance their knowledge base, benefiting from television's accessibility, presentation style, trusted networks, consistency, and frequency of exposure.

The second most significant factor influencing students' understanding of the pandemic is enrollment in health science departments. Students in these departments are 4.21 times more likely to have a deep understanding compared to those outside health science departments. This is attributed to the focus on health-related

subjects within these departments, providing students with more in-depth knowledge about COVID-19. This is in line with studies done (25).

Living in urban areas also emerged as a significant factor, with students in cities being 3.31 times more likely to possess a thorough understanding compared to students living in rural areas, this could be attributed to urban settings offering increased access to information, and healthcare facilities, and generally providing a higher educational environment. This is in line with the study done (36).

Active engagement with news media significantly influences students' understanding of the pandemic, with a 2.51 times higher likelihood for those who actively follow news media to have a solid understanding. This highlights the importance of regularly exposing oneself to trustworthy news sources, as it plays a crucial role in making students more informed about COVID-19. Regular and reliable information from news media contributes significantly to students' knowledge and comprehension of the ongoing pandemic (38).

Active engagement in social media plays a significant role in shaping students' understanding of COVID-19. Those who actively participate in social media are 2.38 times more likely to comprehend the situation compared to those who do not engage in social media. The swift dissemination of information through social media offers diverse perspectives and real-time updates, contributing to a more comprehensive awareness among students (38).

Lastly, the educational background of fathers emerged as a significant factor, suggesting that students with fathers having higher education are 2.35 times more likely to understand COVID-19 comprehensively. This highlights the important role of family educational environments in shaping students' knowledge, emphasizing the interplay of familial factors in educational outcomes. In summary, these factors collectively play a crucial role in shaping how well students understand COVID-19 in Ethiopia. This is in line with the study done (36).

5.1 Strengths and limitations of the study

The strength of our study lies in its comprehensive examination of students' understanding of COVID-19 in Ethiopia through a systematic review and meta-analysis. By synthesizing data from various sources, we obtained a broad perspective on this crucial subject, contributing to a nuanced understanding of the factors influencing students' comprehension. Our meticulous approach to screening, excluding duplicates, and assessing study quality enhances the reliability of our findings, ensuring a robust foundation for analysis.

However, it's important to acknowledge certain limitations. The primary weakness arises from the inherent constraints of the available literature. Variability in study designs, data reporting, and regional differences posed challenges in standardizing the analysis. Additionally, the exclusion of studies in languages other than English may introduce a language bias. Moreover, the evolving nature of the pandemic may render some data outdated, affecting the timeliness of our conclusions. Despite these limitations, our study provides valuable insights into students' understanding of COVID-19 in Ethiopia, offering a foundation for targeted educational interventions and avenues for further research.

6 Conclusion and recommendations

This systematic review and meta-analysis on students' understanding of COVID-19 in Ethiopia identified several significant factors, including social media usage, urban residence, news media followership, fathers' educational status, television watching, and enrollment in health science programs. This comprehensive understanding underscores the complex interplay of various factors shaping students' knowledge of COVID-19 in Ethiopia.

In light of the significant factors identified in this study, policymakers, educators, and public health authorities in Ethiopia must adopt a multifaceted approach to enhance students' knowledge and awareness of COVID-19. Given the complexity of factors influencing students' understanding, interventions should be tailored to address the diverse socio-demographic characteristics and media consumption patterns observed among students.

6.1 Targeted educational campaigns

Develop targeted educational campaigns aimed at increasing awareness and knowledge of COVID-19 among students, particularly those residing in urban areas and enrolled in health science programs. These campaigns should leverage various communication channels, including social media, television, and news media, to disseminate accurate and up-to-date information about COVID-19 prevention, transmission, and mitigation strategies.

6.2 Engagement with social media platforms

Collaborate with social media platforms to promote reliable sources of information and combat misinformation surrounding COVID-19. Encourage students to critically evaluate the information they encounter on social media and provide resources for fact-checking and verifying the accuracy of COVID-19-related content.

6.3 Incorporation into curriculum

Integrate COVID-19 education into the curriculum of health science programs and other relevant disciplines. Incorporate evidence-based teaching materials and case studies that highlight the socio-economic determinants of COVID-19 knowledge and its implications for public health practice in Ethiopia.

6.4 Community engagement

Foster community engagement initiatives that involve students, parents, teachers, and local leaders in discussions about

COVID-19 awareness and prevention. Encourage open dialog and collaboration to address misconceptions, cultural beliefs, and barriers to accessing accurate information about the pandemic.

6.5 Capacity building

Invest in capacity-building initiatives to empower students with the skills and knowledge needed to become advocates for COVID-19 prevention and health promotion within their communities. Provide training opportunities on effective communication strategies, health literacy, and community outreach techniques.

Data availability statement

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

Author contributions

AC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration. AD: Conceptualization, Data curation, Supervision, Validation, Writing – original draft, Writing – review & editing. FB: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Visualization, Writing – original draft, Writing – review & editing. AS: Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. CG: Conceptualization, Data curation, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. DA: Conceptualization, Validation, Visualization, Writing – original draft, Writing – review & editing. WL: Data curation, Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. AF: Conceptualization, Investigation, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. MT: Conceptualization, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. GK: Conceptualization, Investigation, Methodology, Data curation, Formal analysis, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1369738/full#supplementary-material

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Analysis of factors influencing college students' food waste behavior and evaluation of labor education intervention

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Background: Food waste remains a major problem for the world and food security. Despite the fact that consumers are significant producers of food waste, little research attention has been paid to college students. The present study aimed to assess food waste and the influence factors among college students. Additionally, the goal was to improve college students' food waste attitudes and behaviors through labor education.

Methods: Through an online questionnaire survey, 407 college students from three universities were asked about food waste; 27 students of them were randomly selected as the research object, and labor practice was carried out in groups in the student cafeteria. Mann–Whitney U test was performed to show food waste behavior of college students and logistical regression analysis was used to analyze the factors affecting food waste behavior.

Results: The results indicated that the food waste is more serious among college students in East China, senior or female students, BMI plays a positive role in food waste among college students, while monthly consumption and peers waste play a negative role in food waste. After participating in the labor education, the students' views and practices toward their peer's food waste have improved.

Conclusion: The implementation of labor education in college canteens is conducive to the establishment of a correct outlook on labor as well as saving consciousness among college students, and to the formation of a social consciousness of saving.

KEYWORDS

food waste, labor education, college students, survey, interventions

1 Introduction

There's an old Chinese saying, "Food is the God of the people." Food is a basic necessity for everyone as it provides them with survival and health. Meanwhile, it has an irreplaceable basic position in the development of the national economy. Food production and supply, therefore, is a major world-class topic. However, due to wars, diseases, extreme weather and other factors, access to food is still partially or significantly limited in many regions of the world, which threatens the well-being of societies. It was estimated in 2020 that from 720 to 811 million people worldwide experienced hunger, which is as much as 161 million people more than the year before considering the upper end of this range (1). However, China is a large agricultural country with 1.4 billion people and 800 million farmers, the issue of food security is particularly important.

On the other hand, however, food waste is a global problem. According to (2), "food waste refers to food fit for human consumption that is discarded, whether or not it is stored beyond its expiry data or left to spoil. This is often due to food going bad, but can also be due to other reasons such as oversupply in markets of individual consumer shopping/eating habits." According to the 2011 report of the Food and Agriculture Organization of the United Nations (3), global food waste generation is estimated at roughly 1.3 billion tons of still edible food is wasted every year, one third of food suitable for eating by humans was wasted every year in the first decade of the 21st century, with a 44% predicted increase between 2005 and 2025 (4). In China, with the improvement of the living standard of the population and the rise in consumption capacity, the phenomenon of food waste is also becoming increasingly serious. According to the report made by the Institute of Science and Technology Strategic Consulting of the Chinese Academy of Sciences in 2020, China's annual food waste is approximately 67.5 million kg (5).

Food waste is said to occur at all stages of the food chain, 28% of waste occurs at the consumer level (6). Despite the fact that consumers are significant producers of food waste, little research attention has been paid to college students. China has a large number of college students, and some researchers have found that up to 74% of college students have food waste behavior, *per capita* food leftover weight reached 61.03 g/meal, the average food waste rate per person per meal is 12.13% (7).

Labor education in the new era, as an important way to implement the fundamental task of establishing moral education, is an important motivation to inspire college students to aspire to success. Therefore, colleges should increase student' social practice experience, cultivate students' ideology of respect for labor, organize students to go out of the classroom and carry out a wide range of practical experience activities.

If the citizens of this country do not pay enough attention to food waste, it is likely that food waste will grow gradually as people's living standards are improving year after year. In addition to the environmental and pollution problems caused by food waste, it may also lead to a series of social problems. Therefore, this study aims to study the current situation of food waste behavior of college students and the analysis of influencing factors, so as to reduce food waste behavior of college students by participating in the practice of labor education and improve their consumption concept, which is contribute to the development of China's society, economy, culture and ecology.

2 Materials and methods

2.1 Methodical approach

An online survey was conducted to collect sample for this research work to obtain the current situation of food waste behavior among college students, which was showed in Table 1. The idea of food waste was clearly explained to the respondents at initial stage of the survey, so they clearly understand what was and was not. The questions in the questionnaire included socio-demographic aspects, aspects of family trait, dining characteristics, as well as environmental characteristics. The questionnaire was adopted from an earlier research paper (8), with a slight modification based on this research requirement. According to the latest statistics of the Ministry of Education of the People's Republic of China on number of students of formal education by type and level, there are currently more than 19.65 million undergraduate students enrolled in colleges, including 1.29 million medical students. The participants were randomly selected from students at Changzhi Medical College in North China, Harbin Medical University in Northeast China, and Xuzhou Medical University in East China. The online survey was conducted from 9 to 16 October 2023. In all, 407 students took part in the survey from different universities in China, accounting for 0.03% of all medical students.

2.2 Model logit

While analyzing the influence of food waste in different college students (the dependent variable), a logit model (a qualitative model) was used, in which the dependent variable (Y) was "Level of food waste per meal" or "Frequency of food waste per week." Variable Y in the logit model took the following values:

$Y_1 = 1$—Food waste per meal.

$Y_1 = 0$—No food waste per meal.

$Y_2 = 1$—Weekly food waste.

$Y_2 = 0$—No weekly food waste.

The results of the logit model estimation were interpreted based on: (a) the log odds ratio (LOR), (b) the odds ratio (OR) for each independent variable, through which the change in the odds of occurrence of the selected value is expressed ($Y = 1$) when the independent variable grows by 1 unit (*ceteris paribus*).

The quality of matching the model of the variable "Food waste" was evaluated on the basis of the determination coefficient (R^2). The values of this coefficient fall within the range (0–1), and the higher the value, the better the matching of the model.

2.3 Labor education implementation

Using whole cluster random sampling, it is due to resource limitations, one natural class (27 students) of preventive medicine was identified as the research subjects to participate in this labor education activity. The subjects were randomly divided into three groups, namely, plate recycling group, table hygiene group and serving free soup group, and the understanding and requirements were unified before the activity. Among them, the plate recycling group was mainly responsible for dumping college students'

TABLE 1 Variable assignment of factors influencing college students' food waste.

Type	Name	Variable assignment
Dependent variable 1	Level of food waste per meal ⊥	1 = Yes; 2 = No
Dependent variable 2	Frequency of food waste per week ▲	1 = Yes; 2 = No
Personality characteristics	Region of the University	1 = North China; 2 = Northeast; 3 = East China
	Gender	1 = Male; 2 = Female
	BMI#	1 = Underweight; 2 = Normal weight;3 = Overweight; 4 = Obese
	Grade	1 = First year; 2 = Second year; 3 = Third year or more
	Scholarship	1 = Yes; 2 = No
	Hunger experience	1 = Yes; 2 = No
	Agricultural labor experience	1 = Yes; 2 = No
	Average monthly consumption (yuan)	1 = Less than 800; 2 = 800–1,500; 3 = 1,500-2,000; 4 = More than 2,000
	Attitude toward "Clean your plate campaign"	1 = Strongly disapprove, waste of time; 2 = Disagree, do not think it's very effective; 3 = It does not matter, follow the crowd; 4 = Strongly support it and think it makes sense
Family trait	Household registration	1 = Urban; 2 = Rural
	An only child	1 = Yes; 2 = No
	Parental accompaniment	1 = Yes; 2 = No
	Family farming	1 = Yes; 2 = No
	Parental education	1 = Junior high school and below; 2 = Senior high school; 3 = Specialty; 4 = Undergraduate college; 5 = Postgraduate
Dining characteristics	Dining place	1 = Cafeteria; 2 = Dormitory; 3 = Dining out
	Number of people eating together	1 = Dining alone; 2 = 1 person sharing a meal; 3 = Shared meals for more than 2 people
	Peers waste	1 = Never; 2 = Once in a while; 3 = Often; 4 = Always
Environmental characteristics	Cafeteria vegetable quantity	1 = Very dissatisfied; 2 = Unsatisfactory; 3 = General; 4 = Relatively satisfied; 5 = Very satisfied
	Cafeteria meal quantity	1 = Very dissatisfied; 2 = Unsatisfactory; 3 = General; 4 = Relatively satisfied; 5 = Very satisfied

⊥Level of food waste per meal. Yes = Waste a little or more per meal; No = Almost no waste per meal.
▲Frequency of food waste per week. Yes = Waste food more than 1 time per week; No = Waste food less than 1 time per week.
#BMI, body mass index. According to the Chinese Public Health Standards, as follows: underweight, BMI < 18.5 kg/m^2; normal weight, 18.5 ≤ BMI < 24.0 kg/m^2; overweight, 24 ≤ BMI < 28.0 kg/m^2; and obese, BMI ≥ 28.0 kg/m^2.

leftovers into a special food waste bin and classifying other garbage, the table hygiene group was a mobile operation mainly responsible for cleaning up the desktop hygiene after college students' meals and the free soup group was mainly responsible for serving free soup to students in need. The students who participated in the labor education activity wore uniforms, hats, masks and gloves, and the work was stationed in the student cafeteria and carried out labor experience in their respective positions during the peak eating hours (Lunch: 11:30 ~ 12:30; Diner: 17:30 ~ 18:30) for a period of 3 days.

In order to further investigate the effectiveness of the labor education implementation, we repeated the survey on food waste behaviors with the 27 students mentioned above, with questions about changes in awareness of cafeteria waste, personal food waste behaviors, and attitudes toward food waste, and returned the online questionnaire within 1 day after the labor education implementation was completed.

2.4 Statistic methods applied

SPSS 19.0 statistical software was used to rationalize the differences in food waste behavior. Qualitative data were expressed as composition ratio (%). Comparison of differences in the current status of food waste among college students and the effectiveness of the implementation of labor education were tested using the

TABLE 2 Summary of the socio-demographic data about the participating students (China, 2023, $n = 407$).

Variable	Description	Frequency (%, *n*)
Region of the University	North China	29.0 (118)
	Northeast	35.1 (143)
	East China	35.9 (146)
Age (years)	18-	82.6 (336)
	20-	14.5 (59)
	22-	2.9 (12)
Grade	First year	52.3 (213)
	Second year	30.2 (123)
	Third year or more	17.4 (71)
Gender	Male	34.9 (142)
	Female	65.1 (265)
BMI (kg/m^2)[#]	Underweight	11.1 (45)
	Normal weight	67.3 (274)
	Overweight	13.5 (55)
	Obese	8.1 (33)

[#]BMI, body mass index. According to the Chinese Public Health Standards, as follows: underweight, BMI < 18.5 kg/m^2; normal weight, 18.5 ≤ BMI < 24.0 kg/m^2; overweight, 24 ≤ BMI < 28.0 kg/m^2; and obese, BMI ≥ 28.0 kg/m^2. The results were shown as frequency.

nonparametric rank sum test (Mann–Whitney U test, $u = \frac{U - n_1 n_2 / 2}{\sqrt{\frac{n_1 n_2 (N+1)}{12}\left(1 - \frac{\sum (t_j^3 - t_j)}{N^3 - N}\right)}}$). Logistics multivariate regression analysis was used to analyze the factors affecting food waste behavior of college students, which were used to analyze the odds ratio (OR) and 95% confidence intervals (CIs), and differences were considered statistically significant at $p < 0.05$.

3 Results

3.1 Characteristics of respondents

In this survey, 407 valid questionnaires were collected, balanced among students from three districts. Students between the ages of 18 and 25 participated in the study. More than half of the students who participated in the survey were freshmen, meaning that there was a higher level of participation from underclassmen. A larger percentage of respondents were female. Of the students who participated in the survey, 67.3% of them were normal weight, 11.1% were underweight, and the remaining 21.6% were overweight or obese (Table 2).

3.2 The current situation of food waste among college students

The composition ratios of food waste per meal or the frequency of food waste per week varied among students in different schools. About half of the students in the three regions wasted hardly any food per meal and wasted food less than once a week. In North China, Northeast China and East China, the proportion of students who wasted less than 10% of food per meal was 94.1, 93, and 79.5%, respectively (Table 3). The proportion of food wasted less than 3 times per week was 96.6, 93.7, and 89.8%, respectively (Table 3). It can be seen that food waste among college students in East China is more serious than in the previous two regions.

Food waste varies among college students in different grades. 50% of students do not waste any of their meals. As many as 95.3% of first year students waste less than 10%. 20% of second year and above students waste 10% or more per meal (Table 3). The level of food waste per meal and the frequency of food waste per week varied among college students of different genders. The majority of female students (56.2%) wasted different levels of food per meal, and 43.8% wasted food more than twice a week. Most male students (71.8%) wasted little at each meal, and 83.1% of male students wasted food less than once a week (Table 3).

In summary, food waste is more serious among college students in East China, senior or female student.

3.3 Analysis of the influencing factors of college students' food waste

The results of the multilevel analysis of the factors affecting food waste among college students are shown in Table 4. The null model (referent) with no exploratory variable revealed a significant variation in food waste between college students in the multilevel linear regression models. The logistic model assessed the relationship between personality characteristics, family trait, dining characteristics and environmental characteristics with food waste. The results showed that students with higher levels of BMI were less likely to have food waste [OR (95% *CI*), 0.680 (0.497, 0.930), $p = 0.016$], students with higher levels of monthly consumption were more likely to have food waste [OR (95% *CI*), 1.438 (1.050, 1.968), $p = 0.024$], and peer waste exacerbated the waste of students who dined with them, either per meal [OR (95% *CI*), 1.924 (1.224, 3.022), $p = 0.005$] or weekly [OR (95% *CI*), 1.617 (1.021, 2.561), $p = 0.040$] of food waste.

3.4 Effectiveness of labor education

We compared the changes in dining attitudes and behaviors of males and females after participating in labor education, and the results are shown in Table 5. Before labor education, there was no difference between male and female perceptions of cafeteria waste, but after the practice of labor education, female students were more likely to believe that cafeteria waste was still more serious ($Z = -2.050$, $p = 0.040$, Table 5, Q1). On the other hand, before and after labor education, there was a difference in food wastage among both males and females, both of which showed more serious wastage among female students. However, the improvement of students' wasteful behavior was not obvious after labor education (Table 5, Q2 and Q3).

Before labor education, males and females had different attitudes toward food waste, and females were more likely to show indifference ($Z = -2.185$, $p = 0.029$, Table 5, Q4), and the difference in attitudes between males and females was not significant and did not improve after labor education. After labor education, students were less likely

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TABLE 3 The current situation of food waste among college students (China, 2023, $n = 407$).

			Level of food waste per meal					Frequency of food waste per week			
		N	Almost no waste *n* (%)	Waste a little (<10%) *n* (%)	Less waste (10–30%) *n* (%)	Comparatively large amount of waste (30–50%) *n* (%)	Large amount of waste (>50%) *n* (%)	0–1 time per week *n* (%)	2–3 times per week *n* (%)	4–5 times per week *n* (%)	More than 5 times per week *n* (%)
		407	218 (53.6)	142 (34.9)	42 (10.3)	4 (1.0)	1 (0.2)	267 (65.6)	112 (27.5)	16 (3.9)	12 (3.0)
Region of the University	North China	118	71 (60.2)	40 (33.9)	5 (4.2)	1 (0.8)	1 (0.8)	87 (73.7)	27 (22.9)	1 (0.8)	3 (2.5)
	Northeast	143	78 (54.5)	55 (38.5)	10 (7.0)	0 (0)	0 (0)	98 (68.5)	36 (25.2)	4 (2.8)	5 (3.5)
	East China	146	69 (47.3)	47 (32.2)	27 (18.5)	3 (2.1)	0 (0)	82 (56.2)	49 (33.6)	11 (7.5)	4 (2.7)
	χ^2		119.96					10.41			
	P		<0.001*					0.005*			
Grade	First year	213	124 (58.2)	79 (37.1)	10 (4.7)	0 (0)	0 (0)	148 (69.5)	58 (27.2)	4 (1.9)	3 (1.4)
	Second year	123	56 (45.5)	44 (35.8)	19 (15.4)	3 (2.4)	1 (0.8)	79 (64.2)	28 (22.8)	8 (6.5)	8 (6.5)
	Third year or more	71	38 (53.5)	19 (26.8)	13 (18.3)	1 (1.4)	0 (0)	40 (56.3)	26 (36.6)	4 (5.6)	1 (1.4)
	χ^2		155.79					5.023			
	P		<0.001*					0.081			
Gender	Male	142	102 (71.8)	35 (24.6)	5 (3.5)	0 (0)	0 (0)	118 (83.1)	20 (14.1)	3 (2.1)	1 (0.7)
	Female	265	116 (43.8)	107 (40.4)	37 (14.0)	4 (1.5)	1 (0.4)	149 (56.2)	92 (34.7)	13 (4.9)	11 (4.2)
	Z		−14.90					−5.43			
	P		<0.001*					<0.001*			

The results were shown as frequency. Statistical analysis was conducted using the Mann–Whitney U test. *$p < 0.05$ compared to the control group.

to be indifferent to their peers' waste ($\chi^2 = 13.831$, $p = 0.008$, Table 5, Q5). Most of the students thought that the cafeteria slogans were still useful in warning about food waste. After labor education, the proportion of students who thought that the food-saving slogans posted in the cafeteria had "no effect at all" decreased from 18.52% (5/27) to 0, and the proportion of those who thought that they had "some effect" increased (81.48% vs. 100%, Table 5, Q6). The percentage of those who thought that "it is very useful" increased to 48.15% (13/27), and in general, after labor education, students thought that posting food-saving slogans in the cafeteria had "some good effects" ($Z = -2.274$, $p = 0.023$, Table 5, Q6).

In conclusion, after participating in the practical activities of labor education, the students' views and practices toward their peers' food waste have improved.

4 Discussion

Food is an essential human requirement. Food waste is a significant global problem. The majority of average consumers consider food waste to be a problem of social focus rather than as an environmental or economic problem (9). Environmental damage is not only caused by production but also by food waste since part of this waste is related to various environmental aspects such as the emission of greenhouse gases (10, 11), in turn, the prevention of food waste depends on consumer behavior. Therefore, food waste is presently gaining extra attention due to wastage itself leads to serious economic, environmental, moral, and social consequences (12). According to the United Nations International Children's Emergency Fund (UNICEF) 2011 report, approximately 21,000 people perish daily due to hunger-related problem. On the other hand, nearly one third of all food produced is sent to landfills (13). Food waste has been identified as one of the major factors that constitute numerous anthropogenic activities, especially in developing countries (14). Reducing food waste is an important element of a sustainable environment and is the responsibility of every country and every individual.

For college students, their primary activities occur at school, and school cafeterias worldwide offer an opportune microcosm in which to educate on food and nutrition knowledge and change related behavior (15). Nevertheless, young adult college and university students, who have proven to be more wasteful (16). Therefore, this study focuses on observing cafeteria food waste among college students. In order to increase the representativeness, we selected college students in three regions to conduct a food waste survey. The results

TABLE 4 Factors affecting food waste among college students (China, 2023, $n = 407$).

Variable	Level of food waste per meal		Frequency of food waste per week	
	OR (95% *CI*)	*p*	OR (95% *CI*)	*p*
Region of the University	0.944 (0.697, 1.279)	0.709	1.029 (0.754, 1.405)	0.857
Gender	0.842 (0.516, 1.373)	0.491	0.999 (0.605, 1.649)	0.997
BMI[#]	0.680 (0.497, 0.930)	0.016*	0.620 (0.443, 0.869)	0.005*
Grade	1.030 (0.834, 1.271)	0.784	1.085 (0.875, 1.346)	0.457
Scholarship	0.635 (0.336, 1.201)	0.162	0.582 (0.306, 1.110)	0.100
Hunger experience	0.847 (0.510, 1.407)	0.522	1.151 (0.680, 1.951)	0.600
Agricultural labor experience	1.008 (0.620, 1.638)	0.975	1.070 (0.647, 1.770)	0.793
Average monthly consumption (yuan)	1.438 (1.050, 1.968)	0.024*	1.216 (0.883, 1.676)	0.232
Attitude toward "Clean your plate campaign"	1.234 (0.773, 1.971)	0.379	1.298 (0.778, 2.163)	0.318
Household registration	1.693 (0.946, 3.032)	0.076	1.184 (0.656, 2.140)	0.575
An only child	1.416 (0.855, 2.347)	0.177	1.002 (0.597, 1.681)	0.995
Parental accompaniment	1.257 (0.567, 2.790)	0.573	1.014 (0.451, 2.281)	0.973
Family farming	1.035 (0.589, 1.821)	0.904	1.145 (0.638, 2.058)	0.650
Parental education	1.088 (0.872, 1.357)	0.454	0.973 (0.774, 1.223)	0.815
Dining place	1.062 (0.696, 1.622)	0.779	1.075 (0.693, 1.667)	0.748
Number of people eating together	0.962 (0.746, 1.242)	0.768	0.873 (0.672, 1.135)	0.310
Peers waste	1.924 (1.224, 3.022)	0.005*	1.617 (1.021, 2.561)	0.040*
Cafeteria vegetable quantity	1.287 (0.874, 1.895)	0.201	1.416 (0.935, 2.144)	0.101
Cafeteria meal quantity	1.348 (0.917, 1.981)	0.128	0.979 (0.654, 1.466)	0.919

[#]BMI, body mass index. According to the Chinese Public Health Standards, as follows: underweight, BMI < 18.5 kg/m^2; normal weight, 18.5 ≤ BMI < 24.0 kg/m^2; overweight, 24 ≤ BMI < 28.0 kg/m^2; and obese, BMI ≥ 28.0 kg/m^2. The results were shown as OR (95% CI). Statistical analysis was conducted using the Logistics multivariate regression analysis. *$p < 0.05$ compared to the control group.

showed that food waste of college students varies in different regions, and East China is more serious. It may be related to the fact that the economy of this region is more developed, and college students generally have better family conditions, and they have a weak sense of thrift and frugality since childhood, and have not developed the habit of saving food. In addition, this part of the students' purchasing and choice of food is on the high side, and these may lead to a greater tendency to food waste. This is similar to previous studies that found people with higher income families waste more than households with a lower income (17, 18).

Experimental evidence suggests that age and sex are important factors for food consumption and hence the generation of food waste (19). Our study found that compared with the lower grades students, the upper grades students have a higher level of food waste, considering that it may be because the lower grades students have a lower level of consumption and have just been separated from their families for a short of time, and they still show more rustic living habits. On the other hand, there is still a certain degree of freshness to the cafeteria, therefore, there is no obvious food waste shown. Correspondingly, the majority of the upper grades students have a higher level of living expenses, and those who have a higher level of living expenses tend to consume snacks with a higher frequency. We found that compared with male, female's food waste is more serious, which may be related to the fact that females have to maintain a pretty figure, the previous study showed that females tend to improve their appearance image with the help of dietary adjustment (20), and individuals with appearance anxiety are more likely to suffer from anorexia nervosa and thus tend to waste food (21). On the other hand, females consume more snacks, which leads to a certain degree of decline in the amount of meals to the cafeteria, and the vast majority of students do not have the habit of packing leftover meals. However, it was observed that although female waste more than male (22), they are more predisposed to reduce food waste when compared to the latter (23).

Previous studies have suggested that food waste is shaped by multiple individual and social environmental factors (24, 25). Niaki et al. (24) has suggested that around 78% of respondents believed that students engaging more in socializing than in focusing on eating was the reason for food waste on the school campus (24). On the other hand, the most common reasons for throwing away food were exceeding the expiration data, storing food for too long, not having enough time to use up stored ingredients, and preparing too-large portions of meals (26, 27). Research has generally concluded that both low and high BMI can have an impact on emotion (28), this in turn affects the choice of food type and quantity.

This study suggested that food waste occurs less frequently among heavier college students. That is to say, fat college students can only consume large amounts to satisfy their normal metabolism, and thus are not prone to food waste. As the largest developing country in the world, China has seen a remarkable change in its social environment, which may influence the eating behaviors of college students. Compared to children and adolescents, college students may have greater access to their own money and much more freedom to make decisions about their eating (29). This study showed that the higher the monthly consumption, the more serious the food waste among college students. This is also an indirect indication that college students with better economic status are indifferent to food conservation. Recent research also suggests that other environmental

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TABLE 5 Evaluation of the implementation effect of labor education for college students (China, 2023, $n = 27$).

Question		Before		After		Before vs. After
		Male	Female	Male	Female	
	n	12	15	12	15	–
Q1 Do you feel there is a lot of waste in the cafeteria?	Not serious	2	1	4	1	–
	A little serious, but acceptable	6	12	7	9	–
	More serious and requires measures	4	2	1	5	–
	It does not matter	0	0	0	0	–
	Z	−0.528		−2.050		−0.423
	P	0.598		0.040*		0.672
Q2 What is your level of food waste per meal?	Almost no waste	9	2	7	2	–
	Waste a little (<10%)	1	8	3	8	–
	Less waste (10–30%)	2	3	2	4	–
	Comparatively large amount of waste (30–50%)	0	2	0	1	–
	Large amount of waste (>50%)	0	0	0	0	
	Z	−2.690		−2.126		−0.303
	P	0.007*		0.034*		0.762
Q3 How often do you waste food each week?	0–1 time per week	11	4	11	5	–
	2–3 times per week	1	5	1	6	–
	4–5 times per week	0	4	0	3	–
	More than 5 times per week	0	2	0	1	–
	Z	−3.324		−3.023		−0.456
	P	0.001*		0.003*		0.648
Q4 Do you feel self-conscious about the waste caused by leftovers?	Regularly	7	3	8	7	–
	Occasionally	5	10	4	7	–
	Not usually	0	2	0	1	–
	Not at all	0	0	0	0	–
	Z	−2.185		−1.118		−1.363
	P	0.029*		0.264		0.173
Q5 What is your attitude toward your classmates wasting food?	Stop it now	1	2	4	4	–
	I do not like it, but I'm too embarrassed to stop it	4	3	6	5	–
	It does not matter. It's normal	2	3	0	0	–
	It's someone else's business	5	4	0	3	–
	I'll tell the student privately	0	3	2	3	–
	χ^2	4.621		4.117		13.831
	P	0.328		0.249		0.008*
Q6 Do you think the signs posted on the cafeteria about saving food work for you?	It does not work at all	2	3	0	0	–
	It works a little bit	2	4	1	6	–
	Sometimes it works	4	7	5	2	–
	Serve a valuable purpose	4	1	6	7	–
	Z	−1.177		−0.897		−2.274
	P	0.239		0.370		0.023*

The results were shown as frequency. Statistical analysis was conducted using the Mann–Whitney U test. *$p < 0.05$ compared to the control group.

factors, such as interpersonal relationships (30), might shape individuals' food waste behavior. The results implied that college students are more likely to have food waste if their peers food waste. Because this peer effect is twofold. That is why group educational interventions are necessary for college students.

Wasted food, an indicator of systemic food system issues, is pervasive and must be addressed holistically. Educational programming, is one important tool among others for decreasing food waste and improving the footprint and overall justice of the global food system (31), among many other things, is an essential aspect of improving food-related behaviors (15). Educational institutions worldwide have recognized their ability to encourage food waste reduction and improve their own measures of institutional sustainability through campus food diversion programming (32). In the context of the new era, universities shoulder the important responsibility of cultivating talents for the country, and it is even more necessary to deploy labor education as an important task. The value of labor education is fully realized through students' personal participation in labor practice. This study combined college students' food waste and its influencing factors to carry out labor education, and the results show that after the labor education, college students' attitudes toward their peers' wastefulness have changed, and they resolutely resist this food waste situation. But we know that it takes time to change any behavior or habit. That's why we are considering labor education on a larger scale and for a longer period of time.

Food waste is a significant global problem and young people need to be activated to change their behavior. This study can guide educational efforts and contribute to further research in this area. Therefore, education among students regarding food waste and its consequences should be considered (15, 33, 34). Of course, reducing food waste is a complex and long-term process and requires a shared responsibility between the state, society and even the family. In order to promote sustainable social development, China enacted "The Law of the People's Republic of China Against Food Waste" in 2021, implying that the public will face penalties for food waste behavior. Therefore, based on the results of this research, government and college should constantly expand high-quality educational resources, it is possible to root the awareness of caring for the environment and saving resources in students' instincts, and thus reduce food waste behavior. Furthermore, the government should launch a campaign on the theme of food conservation every year, so that awareness of environmental protection can cover all groups, and further guide the general public to develop the concept of honor in conservation and the habit of diligence and thrift among individuals.

However, this study also has several limitations. First, bigger sample sizes could give us a better insight into the student population. Furthermore, the sample will be more representative by adopting whole cluster random sampling. In addition, the number of students who participated in the labor education practice was small and the time was too short to clearly observe the change of labor education on college students' food waste behavior in a short term.

5 Conclusion

Studying the phenomenon of food waste in colleges is conducive to the formulation of public policies to regulate the behavior of college students, and labor education is conducive to the establishment of a correct outlook on labor and a sense of conservation among college students.

Data availability statement

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

Author contributions

DW: Methodology, Writing – original draft, Writing – review & editing. KZ: Investigation, Writing – review & editing. XL: Investigation, Writing – review & editing. LX: Investigation, Writing – review & editing. ZY: Investigation, Writing – review & editing. PL: Funding acquisition, Supervision, Writing – review & editing.

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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.

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Risk factors affecting the utilization of eye care services evaluated by the CDC's behavior risk factor surveillance system from 2018 to 2021

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When thinking about major health concerns in the U.S. and around the world, eye care ranks lower compared to cardiovascular disease, cancer, and diabetes. However, people do not think about the direct connection between diabetes and eye health. Untreated diabetes can lead to visual impairments such as blindness or difficulty seeing. Studies have found that eye health associated with nutrition, occupational exposure, diabetes, high blood pressure, and heart disease are some of the known risk factors. This study aimed to identify the potential risk factors that are associated with visual impairment (VI). The data used for this analysis were obtained from the Centers for Disease Control and Prevention (CDC) - Behavioral Risk Factor Surveillance System (BRFSS) from 2018 to 2021. We found important characteristics, such as the U.S. region, general health perception, employment status, income status, age, and health insurance source, that are associated with VI. Our study confirmed that the common demographical factors including age, race/ethnicity, the U.S. region, and gender are associated with VI. The study also highlights associations with additional risk factors such as health insurance source, general health perceptions, employment status, and income status. Using this information, we can reach out to communities with large numbers of individuals experiencing vision challenges and help educate them on prevention and treatment protocols, thereby effectively addressing VI and blindness challenges within our communities, neighborhoods, and finally, the broader society.

KEYWORDS

diabetic retinopathy, glaucoma, eye care utilization, quality of life, health disparities, risk factors

Introduction

Visual impairment (VI) is a worldwide issue that greatly impacts the quality of life and decreases life expectancy in the aging population (1). According to Assi et al. (2), a billion people worldwide struggle with VI and blindness although these conditions can be prevented or slowed with treatment. If we educate the public on the conditions that can make a person more susceptible to vision loss and the treatments that can prevent or slow their progression, this may result in blindness and decreasing rates of VI (3). The risk factors involved in influencing VI or blindness can be socioeconomic, biological, or demographic (4).

This study focuses on ophthalmological health and the utilization of eye health care. Eye care has been neglected as a routine health procedure over the years. People neither understand nor are educated on the importance of an annual eye examination, especially when they have diseases, such as diabetes, which can greatly affect vision. According to Besagar et al. (5), "visual impairment is one of the most common disabilities in the U.S., with ∼32 million U.S. adults exhibiting blindness or other difficulty seeing despite use of glasses or contact lenses." VI is becoming more prevalent, yet this trend has largely been ignored. The risk factors that can lead to VI include socioeconomic status (SES), genetics, accessibility to health care, and other diseases/comorbidities. When someone becomes visually impaired, their everyday life is greatly affected. They may lose their independence and a sense of purpose, leading to a decrease in their overall mental and physical health (5). Previous studies have shown that those who are in low SES have a substantially higher disease burden (6). Individuals with low SES are characterized by having low levels of education, income, and occupational status. These attributes are commonly found among marginalized groups. Being part of the low SES class also entails limited access to healthcare and a lack of knowledge regarding health-related issues. Since these individuals rely on state insurance, their options for doctors and medical care are restricted. Additionally, due to financial constraints, they often cannot afford to consult a doctor or purchase medication when they fall ill. In contrast, individuals in high SES groups have a greater awareness of the importance of eye health (3). These findings demonstrate that health disparities play a huge role in the level of health literacy and overall understanding of health care. In a recent study conducted by the American Academy of Ophthalmology (AAO), a mere 19% of respondents could name the three main causes of blindness, which are diabetic retinopathy, glaucoma, and age-related macular degeneration (3). Social determinants of health (SDOH) encompass various factors, such as economic stability, educational access and quality, access to quality healthcare, a safe neighborhood and built environment, and the overall social community, which have also shown a relationship with overall health. These determinants disproportionately impact individuals from lower SES and marginalized groups, who often face multiple challenges in these areas. The impact of SDOH can vary across states, with some states being more affected than others based on the level of government support in implementing beneficial programs. Individuals with a low SES face challenges in accessing adequate healthcare due to a lack of insurance or being underinsured. Consequently, they are more vulnerable to experiencing advanced stages and complications of diseases such as diabetes and glaucoma. A synopsis of the three main causes of blindness will be described in the following paragraph.

Diabetic retinopathy (DR) affects a third of those who have been diagnosed with diabetes, and the prevalence of DR continues to grow as the duration of diabetes lengthens (7). DR affects about 8 million Americans yet only 50% of people with diabetes receive the necessary annual eye examination (8). Two major risk factors for the development of DR are hyperglycemia and hypertension (7). DR is asymptomatic in its early stage and can be detected via eye dilation and retinal evaluation during an annual eye examination (9), which helps diagnose DR at the early stage and decreases the number of people who become blind by 94% (8). In the working-age population, 75% of people with type 1 diabetes and 50% of people with type 2 diabetes will develop DR (9). In the aging population, retinal changes, such as a decrease in blood flow, retinal thinning, and microglial changes, can make them more vulnerable to severe retinal damage from oxidative and ischemia changes (9). The prevalence of DR in adults with diabetes in the U.S. is 29% (7). In the U.S., the 10-year incidence of retinopathy is 74% at the baseline, 64% develop severe retinopathy, and 17% develop proliferative DR (7). Fairless et al. indicated that ethnicity and sociodemographic elements play a significant role in developing diabetic retinopathy.

Glaucoma is a chronic progressive optic neuropathy that causes damage to the optic nerve head (ONH) and the retinal nerve fiber layer (RNFL) (10). The damage is caused by increased pressure in the eye leading to VI and blindness. Approximately 3 million people in the U.S. have glaucoma, making it a major cause of irreversible vision loss in the U.S. (10). Many people have a very general idea of what glaucoma is but are not aware of its causes. Genetics, immune system disorders (sarcoidosis, rheumatoid arthritis, and lupus), certain infectious diseases (herpes and toxoplasmosis), endocrine disorders (diabetes), steroids, and low blood pressure are all factors contributing to the development or progression of glaucoma (10). Glaucoma can be treated, and its progression can be restricted when detected early. Annual eye examinations can facilitate the early detection of glaucoma. During eye exams, the IOP is measured, gonioscopy is performed, and perimetry and other testing are conducted to further monitor the disease (10). A previous study found that in 2017, 3,973,400 people were diagnosed with glaucoma; of this, 16,200 people were between the ages of 18–39 years; 235,100 were between the ages of 40–64 years; 3,000,300 were between the ages of 65–84 years; and 721,900 were 85 years and older (11). The crude annual prevalences of glaucoma diagnosis by race/ethnicity were as follows: 29.76% black non-Hispanics, 22.74% Asians, 19.80% Hispanics, 18.04% North American Natives, and 17.50% white non-Hispanics (11). The literature also noted the glaucoma prevalence in blacks was 6.1% compared to 2.8% in whites (12).

Age-related macular degeneration (ARMD) is a major cause of irreversible VI in older adult people; in the early stages, it is asymptomatic, while in later stages, severe vision loss frequently occurs (13). The prevalence of early ARMD to progress late ARMD is 5% over a 5-year period with an increase of 15% over a 15-year period (13). ARMD has multiple risk factors such as age, ocular dysfunction, systemic diseases, diet, smoking, genetics, and environmental factors (13). Advanced ARMD is considered rare before the age of 55 years and is more common in those who are 75 years and older (14).

Both glaucoma and diabetic retinopathy are eye diseases that can be prevented and/or successfully treated when detected early, thereby reducing the amount of vision loss in patients. There are many barriers to people seeking necessary health care and most do not seek care until their health starts to decline and changes become alarming For most diseases/illnesses, precautionary screening is not attainable or is not sought due to factors such as cost, insurance status, poor patient-physician communication, lack of trust, absence of symptoms, and no perceived need for



FIGURE 1
United States regions: the Northeast, Midwest, South, and West. Puerto Rico and Guam were also included.

examination (8). These factors are among the various barriers that interfere with people seeking care. Fairless and Nwanyanwu (8) categorized these barriers into seven categories: vision status (noticeable changes in vision before the person seeks an eye exam), competing concerns (employment schedule, childcare, and other health issues), emotional context (fear of negative news or procedures), resource availability (insurance coverage, cost, and transportation), in-clinic experiences (patient-physician interactions), cues to action (primary care referrals to other health providers and appointment reminders), and knowledge-creating experiences (information about diseases/illnesses from doctor, family, and friends, as well as misinformation). In 2020–2021, another barrier was the COVID-19 pandemic, which impacted the availability and delivery of healthcare (15). Ophthalmologic diagnosis relies heavily on physical examinations and imaging that cannot be performed via telemedicine which has become the new way of seeking health care during the pandemic (15). These barriers significantly contribute to the steady increase in several illnesses and diseases being experienced today.

The purpose of this study was to examine the potential risk factors of those who are VI using the BRFSS web analysis tool from 2018 to 2021. The BRFSS is a health-related telephone survey that collects data about U.S. residents regarding their health-related risk behaviors, chronic health conditions, and the use of prevention services. It collects data from all 50 states including the District of Columbia and the three U.S. territories (16). We will examine demographics, socioeconomic status, a personal reflection on health, insurance status, and several other characteristic traits. Other studies have suggested that these characteristics need to be further examined to observe which factors are more associated with visual impairment. Learning about these characteristics helps in the tailoring of interventions and education-based learning for patients and physicians.

Methods

The data used for this study were obtained from CDC's BRFSS web-enabled analysis tool from 2018 to 2021. This database is a health-related telephone survey that collects data about U.S. residents (approximately 400,000 random interviews in a year). A list of all U.S. telephone numbers, both landlines and cellular lines, is placed into a system that randomly picks a phone number to call (17). The phone interviews lasted for about 25 min per call. It collects data from U.S. residents related to health-related risk behaviors, chronic health conditions, and the use of preventive services (17). The full protocol for the BRFSS can be found on the CDC's website which will explain each step they took to develop the data used in this study (17). From the phone interview questionnaire, we specified variables of interest in the categories of demographic information, socioeconomic status, eye care health, and diabetic information after going through all the questions asked in the questionnaire. This includes variables such as "sex," "race/ethnicity," "[in the] past year needed to see a doctor but could not because of cost," "how long has it been since you visited a doctor for a routine checkup," "level of education," "employment status," "annual income," "type of insurance coverage," "ten-level age category," "three-categories of body mass index," "language identifier," "region," and "region classification." These variables were chosen based on the literature review and previous knowledge of the topic. From this, we identified the variables that previous studies have found significant and then chose other variables that may also be associated with eye care utilization.

We then had to do some variable modifications and group the variables to allow for clear analysis. All modifications were made with scientific proof of validity. For example, the states were listed by name. We classified them into four regions, namely, Northeast, Midwest, South, and West as shown in Figure 1. This classification enabled us to determine whether the geographical location is associated with VI and can later aid in targeting these areas for intervention and prevention strategies. Once all variables were ready for analysis, descriptive analysis was performed.

Descriptive analysis included 27 variables as follows: "region," "sex," "private residency," "general health," "physical health," "health care coverage," "personal doctor," "medical cost," "checkups," "blood pressure medication," "diabetes," "education level," "housing status," "employment," "income level," "blindness," "high blood pressure/

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TABLE 1 The variables are chosen for the analysis with their assigned codes for analysis purposes.

Variable	Question	Categories in dataset	Categories desired for analysis
State/region	State federal information processing standard (fip) code	States listed with #: 1, 2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47, 48, 49, 50, 51, 53, 54, 55, 56, 66, 72, 78	1 = Northeast (9, 23, 25, 33, 34, 36, 42, 44, 50) 2 = Midwest (17, 18, 19, 20, 26, 27, 29, 31, 38, 39, 46, 55) 3= south (1, 5, 10, 11, 12, 13, 21, 22, 24, 28, 37, 40, 45, 47, 48, 51, 54) 4 = west (2, 4, 6, 8, 15, 16, 30, 32, 35, 41, 49, 53, 56) 0 = guam, puerto rico, and virgin islands (66,72,78)
Sex	What is your sex?	1 = male 2 = female 3 = other 7 = do not know/ not sure 9 = refused	1 = male 0 = female
General health	Would you say that in general, your health is	1 - excellent 2 - very good 3 - good 4 - fair 5 - poor 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = excellent, very good 2 = good health 0 = fair, poor
Health care coverage	Do you have any kind of health care coverage, including health insurance, prepaid plans, such as Health Maintenance Organization (hmos), or government plans, such as Medicare and Medicaid, or Indian Health Services?	1 - yes 2 - no 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes 0 = no
Personal doctor	Do you have one person you think of as your personal doctor or health care provider?	1 - yes, only one 2 - more than one 3 - no 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes, one or more doctors 0 = no
Medical cost	Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?	1 - yes 2 - no 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes 0 = no
Checkups	About how long has it been since you visited a doctor for a routine checkup?	1 - within the past year 2 - within the past 2 years 3 - within the past 5 years 4 - 5+ years ago 7 – do not know/not sure 8 - never 9 - refused Blank - not asked/missing	1 = past month/year 0 = past 5 or more years
Hypertension	Are you currently taking medication for high blood pressure?	1 - yes 2 - no 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes 0 = no
Diabetes	(Ever told) you have diabetes	1 - yes 2 - yes, but the female said that during pregnancy 3 - no 4 - no, prediabetes or borderline diabetes 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes 0 = no

(Continued)

TABLE 1 (Continued)

Variable	Question	Categories in dataset	Categories desired for analysis
Education level	What is the highest grade or year of school you completed?	1 - never attended or only kindergarten 2 - grades 1 through 8 3 - grades 9 through 11 4 - grade 12 or GED 5 - college 1 year through 3 years 6 - college 4 years or more 9 - refused Blank - not asked/missing	1 = less than high school 2 = graduated high school 3 = attended college 4 = graduated college
Employment	Are you currently..?	1 - employed for wages 2 - self-employed 3 - out of work for 1 year or more 4 - out of work for less than 1 year 5 - a homemaker 6 - a student 7 - retired 8 - unable to work 9 - refused Blank - not asked/missing	1 = employed 2 = unemployed 3 = homemaker 4 = student 5 = retired 6 = unable to work
Income levels	Is your annual household income from all sources:	1 - < USD 10,000 2 - <USD 15,000 3 - <USD 20,000 4 - <USD 25,000 5 - <USD 35,000 6 - <USD 50,000 7 - <USD 75,000 8 - USD 75,000 or more 77 – do not know/ not sure 99 - refused Blank - not asked/missing	1 = <USD 35,000 2 = USD 35,000–74,999 3 = more than USD 75,000
Blindness	Are you blind or do you have serious difficulty seeing, even when wearing glasses?	1 - yes 2 - no 7 – do not know/not sure 9 - refused Blank - not asked/missing	1 = yes 0 = no
Type of insurance coverage	What is the primary source of your health care coverage? Is it…	1 - plan through employer/union 2 - plan that you or another family member buys 3 - medicare 4 - medicaid or other state programs 5 - TRICARE, Veterans Affairs, and military 6 - Alaskan Native, Indian health service, and tribal health services 7 - some other source 8 - none 77 – do not know/not sure 99 - refused Blank - not asked/missing	1 = through employer 2 = personal plan 3 = state program 4 = military 5 = other
Race/ ethnicity	Imputed race/ethnicity value	1 - white, non-Hispanic 2 - black, non-Hispanic 3 - Asian, non-Hispanic 4 - American Indian/Alaskan Native, non-Hispanic 5 - Hispanic 6 - other races, non-Hispanic	1 = white, non-Hispanic 2 = black, non-Hispanic 3 = Hispanic 0 = other
Age	14-level age categories	1 - aged from 18 to 24 2 - aged from 25 to 29 3 - aged from 30 to 34 4 - aged from 35 to 39 5 - aged from 40 to 44 6 - aged from 45 to 49 7 - aged from 50 to 54 8 - aged from 55 to 59 9 - aged from 60 to 64 10 - aged from 65 to 69 11 - aged from 70 to 74 12 - aged from 75 to 79	1 = 40–44 years old 2 = 45–49 years old 3 = 50–54 years old 4 = 55–59 years old 5 = 60–64 years old 6 = 65–69 years old 7 = 70–74 years old 8= 75–79 years old 9 = 80+ years old 0 = <40 years old

(Continued)

TABLE 1 (Continued)

Variable	Question	Categories in dataset	Categories desired for analysis
		13 - aged 80 or older 14 – do not know/ refused/missing	
BMI	Four categories of body mass index	1 – underweight (BMI < 5th percentile) 2 - normal weight (5th percentile <= BMI <85th percentile) 3 - overweight (85th percentile <= BMI <95th percentile) 4 – obese (BMI >= 95th percentile) Blank- do not know/ refused/ missing	1 = underweight 2 = normal weight 3 = overweight/obese
Language	Language identifier	1 = English 2 = Spanish 3–99 = other	1 = English 0 = Spanish
Region classification	Region	1 = urban 2= rural	1 = urban 0 = rural

The BMI categories are based on the CDC's categorization that is age and gender-specific.

diabetes testing," "diabetes/retinopathy," "pre-diabetic," "visit diabetes doctor," "type of insurance coverage," "race/ethnicity," "provider of majority of care," "age," "BMI," "language," and "region classification" for each year from 2018 to 2021. These 27 variables were selected as variables of interest for further analysis to find an association with VI.

Next, we performed a weighted bivariate analysis to examine the association between the response variable (Blindness "are you blind or have serious difficulties seeing, even when wearing glasses?") and the selected 17 explanatory variables from the 27 variables of the descriptive analysis: "region," "sex," "general health," "personal doctor," "medical cost," "checkups," "blood pressure medication," "diabetes," "education level," "employment," "income level," "type of insurance coverage," "race/ethnicity," "age," "BMI," "language," and "region classification." These variables were selected based on significance levels and confidence intervals. There was a weighted total of 6,269,897 individuals who responded "yes" that they are blind or have severe difficulties seeing over the 4 years. The final step of this study was a multiple logistic regression analysis using PROC SURVEYLOGISTIC. In this step, reference groups were chosen for each explanatory variable. This was accomplished by taking the response/category with the lowest total percentage from each explanatory variable and assigning it as the reference group. This multiple logistic regression analysis was used to study the association between the occurrence of the disease (responding "yes" to the blindness variable) and the demographic and clinical risk factors (explanatory variables). The significance level was set at 0.05. All analyses were implemented with SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

Variables responses were classified into specific categories per variable for analysis purposes. Recoding was performed to reduce the varied responses into general response categories (Table 1). This enables a more accurate analysis of each explanatory variable. The responses that were missing (".") or classified as "do not know/ not sure," "refused," or "blank" were not used in the analysis. All data were weighted to account for these missing responses.

The main insurance plans are defined as HMOs, PPOs, Medicare, and Medicaid. HMOs provide care through an approved network of doctors and require referrals for specialist doctors. They provide cheaper care with co-pays. However, the only downside is that out-of-network care will not be covered and everything will have to be paid out of pocket. In a PPO, you can see doctors who are in-network or out-of-network, and referrals are not needed. The downside is the cost of coverage which is more expensive than HMO plans. Medicare plans are federal health insurance for anyone over 65 years of age and those who are under 65 years with disabilities and certain conditions. Medicaid is a joint federal and state program that provides some health coverage to those who have low income and limited resources. Income qualifications depend on the number of people in the household and the state you reside in.

An analysis of the yearly data revealed that the highest percentage of those with VI had the following characteristics: they were from the South, female, lived in a private residence, reported their health as excellent or very good, had health insurance, had a primary care physician and had routinely visited them, were white non-Hispanic, were <40 years, had hypertension, etc. The results of the descriptive analysis are shown in Table 2. This gives an overview of the general characteristics of the surveyed population for each year.

After running a univariate analysis to pick the most significant variables, we performed a bivariate analysis of the response variable (blindness) and each of the 17 explanatory variables. From this analysis, it can be seen that the major characteristics of people who are blind/have difficulty seeing are those that are from the South, their general health is fair/poor, have had checkups in the past 2 years, have never been told that they have diabetes, graduated high school, make <USD 35,000 a year, have state health insurance, are white/non-Hispanic, are overweight/obese, speak English, and live in an urban area. These results are shown in Table 3.

In Figure 2, six explanatory variables were chosen to illustrate the importance of looking at the characteristics of those who are VI. From this analysis, we can infer which groups are more likely

TABLE 2 Univariate analysis of 27 selected variables from the yearly BRFSS datasets.

Descriptive analysis of each variable									
		Year 2018		Year 2019		Year 2020		Year 2021	
Variable		Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent
Region	Guam and Puerto Rico	932,151	2.66	874,602	3.08	982,698	2.76	904,930	3.72
	Northeast	5,020,880	14.31	3,662,703	12.92	5,390,689	15.12	3,628,617	14.91
	Midwest	8,180,076	23.31	6,548,514	23.09	7,160,230	20.08	5,133,029	21.09
	South	12,681,643	36.14	10,204,953	35.99	11,643,231	32.65	7,327,319	30.1
	West	8,271,581	23.57	7,066,440	24.92	10,487,563	29.41	7,347,019	30.18
Sex	Male	16,688,903	47.67	13,485,224	47.55	17,043,091	47.79	11,707,118	48.1
	Female	18,322,938	52.33	14,871,987	52.45	18,621,321	52.21	12,633,795	51.9
Private residency	Yes	26,934,038	99.45	22,231,612	99.56	28,648,872	99.58	19,964,549	99.58
	No	148,186	0.55	97,582	0.44	120,015	0.417	84,237	0.42
General health	Excellent/ very good	17440893	49.83	13887471	49.09	20115955	56.52	12,684,965	52.23
	Good	11,057,040	31.59	9,000,998	31.81	10,329,572	29.02	7,614,492	31.36
	Fair/poor	6,505,269	18.58	5,403,937	19.1	5,146,077	14.46	3,985,216	16.41
Physical health	One or more days of physically unhealthy	12,643,464	36.04	10,387,049	36.63	9,866,516	27.66	7,705,310	31.66
	No. days of physically unhealthy	22,442,867	63.96	17,970,162	63.37	25,797,896	72.34	16,635,603	68.34
Health care coverage	Yes	31,412,808	89.94	25,214,888	89.34	31,982,797	90.11	21,858,242	93.12
	No	3,512,524	10.57	3,007,296	10.66	3,509,580	9.89	1615760	6.88
Personal doctor	Yes, one or more providers	27,846,983	79.86	22,525,029	79.81	28,192,581	79.46	20,605,467	85.39
	No providers	7,024,489	20.14	5,697,952	20.19	7,285,537	20.54	3,526,172	14.61

(Continued)

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TABLE 2 (Continued)

Descriptive analysis of each variable									
		Year 2018		Year 2019		Year 2020		Year 2021	
Variable		Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent
Medical cost	Yes, the cost stopped me from seeing a doctor	4,183,786	11.98	3,494,096	12.35	3,428,567	9.64	2,143,989	8.83
	No cost has not stopped me	30,747,952	88.02	24,787,186	87.65	32,149,947	90.36	22,126,009	91.17
Checkups	Within the past 2 year	30,784,216	89.4	24,963,834	89.57	31,410,602	89.59	21,293,014	89.14
	Within the past 5+ years or never	3,649,613	10.6	2,905,854	10.43	3,649,868	10.41	2,593,966	10.86
Blood pressure meds	Yes			8,158,078	79.58			6,978,901	80.52
	No			2,093,590	20.42			1,688,434	19.48
Diabetes	Yes, I have diabetes	4,705,499	13.44	3,783,200	13.37	4,478,324	12.58	3,216,587	13.24
	No, I do not have diabetes	30,316,423	86.56	24,517,615	86.63	31,113,520	87.42	21,072,074	86.76
Education level	Less than high school	1,119,418	3.2	1,011,138	3.58	1,053,100	2.97	84,4407	3.49
	Graduated high school	10,457,595	29.92	8,276,293	29.32	9,957,358	28.06	6,628,012	27.38
	Attended college	9,455,757	27.05	7,599,214	26.92	9,382,514	26.44	6,213,126	25.67
	Graduated college	13,918,884	39.82	11,342,942	40.18	15,090,952	42.53	10,518,491	43.46
Housing status	Rent	22,273,809	63.95	18,061,579	64.23	22,157,251	62.71	15,305,106	63.56
	Own	10,524,532	30.22	8,441,570	30.02	11,085,940	31.38	7,399,526	30.73
	Other arrangements	2,029,281	5.83	1,619,059	5.76	2,089,760	5.91	1,376,583	5.72

(Continued)

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TABLE 2 (Continued)

Descriptive analysis of each variable									
		Year 2018		Year 2019		Year 2020		Year 2021	
Variable		Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent
Employment	Employed	19,343,930	55.83	15,312,412	54.95	19,309,900	55.2	13,291,520	55.63
	Unemployed	1,522,535	4.39	1,269,260	4.55	2,516,488	7.19	1,463,896	6.13
	Homemaker	1,901,781	5.49	1,521,438	5.46	1,668,754	4.77	1,165,173	4.88
	Student	1,296,619	3.74	1,046,187	3.75	1,285,713	3.68	80,8341	3.38
	Retired	8,152,453	23.53	6,802,932	24.41	8,107,913	23.8	5,770,455	24.15
	Unable to work	2,433,459	7.02	1,914,816	6.87	2,091,086	5.98	1,393,952	5.83
Income level	<USD 35,000	10,136,312	34.72	8,016,867	34.55	9,171,928	31.78	5,882,478	30.41
	Between USD 35,000–75,000	8,278,722	28.36	6,440,716	27.76	7,974,662	27.63	5,454,622	28.2
	> USD 75,000	10,775,406	36.91	8,746,480	37.69	11,715,830	40.59	8,005,611	41.39
Blindness	Yes, I am blind or have serious difficulty seeing	1,837,021	5.39	1,493,232	5.46	1,701,068	4.96	1,238,576	5.3
	No	32,222,873	94.61	25,875,330	94.54	32,564,365	95.04	22,140,320	94.7
High blood pressure/ diabetes testing	Yes, I have tested in the past 3 years	8,466,257	60.83	5,934,190	60.25	8,814,629	56.63	3,336,624	57.52
	No	5,452,393	39.17	3,914,326	39.75	6,751,186	43.37	2,464,414	42.48
Diabetes/ retinopathy	Yes, diabetes has affected my eyes	267,222	21.46	282,539	17.73	152,080	18.62	223,363	19.19
	No	978,174	78.54	1,311,371	82.27	664,664	81.38	940,416	80.81
Pre-diabetic	Yes, I have been told I am	1,942,238	13.52	1,337,154	13.06	2,367,021	14.68	848,396	14.04
	No	12,420,575	86.48	8,903,543	86.94	13,760,137	85.32	5,196,482	85.97
Visit diabetes doctor	More than one time in the past year	34,914,139	99.63	28,146,737	99.44	35,550,973	99.74	24,186,956	99.52
	None	131,151	0.37	157,861	0.558	93,067	0.261	115,459	0.475
Type of insurance coverage	Through employer	1,141,875	45.17	3,182,005	42.05	3,285,970	47.93	9,866,517	42.03

(Continued)

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TABLE 2 (Continued)

Descriptive analysis of each variable									
Variable		Year 2018		Year 2019		Year 2020		Year 2021	
		Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent
	Personal plan	266,208	10.53	716,526	9.47	641,013	9.35	2,152,566	9.17
	State programs (Medicare, Medicaid, etc.)	920,660	36.42	2,899,253	38.31	2,510,187	36.62	8,386,268	35.73
	Military (TRICARE, Veterans Affairs, etc.)	110,076	4.35	217,368	2.87	220,172	3.21	779,777	3.32
	Other sources	80,337	3.18	239,336	3.16	180,342	2.63	673,114	2.87
	None	9,070	0.36	313,127	4.14	17,663	0.26	1,615,760	6.88
Race/ ethnicity	White, non-Hispanic	23,735,633	67.65	19,072,793	67.26	23,519,706	65.95	15,670,625	64.38
	Black, non-Hispanic	3,363,827	9.59	2,582,056	9.12	3,225,033	9.04	2,213,461	9.09
	Hispanic	5269328	15.02	4613885	16.27	5819462	16.32	4301606	17.67
	Other	2717543	7.75	2088476	7.36	3100211	8.69	2155222	8.85
Provider of the majority of healthcare	Family/General practitioner	189065	70.94	4577	60.67	602278	72.26	164480	67.07
	Other doctors	77450	29.06	2967	39.33	231167	27.74	80766	32.93
Age	40–44 years old	2424126	7.04	1910183	6.85	2574128	7.37	1860148	7.8
	45–49 years old	2627926	7.63	2001118	7.17	2596337	7.3	1730210	7.26
	50–54 years old	3007716	8.73	2353621	8.44	2986363	8.55	2057093	8.63
	55–59 years old	3328569	9.66	2671280	9.57	3199981	9.16	2151936	9.03
	60–64 years old	3464441	10.06	2812436	10.08	3391643	9.71	2312949	9.7

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TABLE 2 (Continued)

Descriptive analysis of each variable									
Variable		Year 2018		Year 2019		Year 2020		Year 2021	
		Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent	Weighted frequency	Percent
	65–69 years old	3231215	9.38	2657507	9.52	3115639	8.92	2220841	9.32
	70–74 years old	2659004	7.72	2290467	8.21	2686768	7.69	1945745	8.16
	75–79 years old	1715634	4.98	1497458	5.37	1783988	5.12	1255081	5.27
	80+ years old	1796204	5.21	1542881	5.53	1797977	5.15	1293010	5.42
	Less than 40 years old	10198099	29.6	8164636	29.26	10795602	30.91	7010107	29.41
BMI	Underweight	516140	1.6	441618	1.71	543820	1.71	357223	1.64
	Normal weight	10074172	31.32	7919495	30.68	9996356	31.36	6572615	30.2
	Overweight/ obese	21575912	67.08	17453601	67.61	21339730	66.94	14830673	68.15
Language	English	32562297	92.82	25928166	91.99	33065885	92.71	22130234	90.92
	Spanish	2517165	7.18	2256398	8.01	2598510	7.29	2210679	9.08
Region classification	Urban	31,641,154	92.64	25404464	92.44	32449140	93.56	21881326	93.37
	Rural	2,513,026	7.36	2,078,146	7.56	2,232,573	6.44	1,554,658	6.63

Of the 27 selected variables, they include explanatory and the response variable (blindness).

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TABLE 3 The bivariate survey logistic regression of the response variable (blindness) and each explanatory variable by year.

Variable		2018 (n = 1,837,021)			2019 (n = 1,493,232)			2020 (n = 1,701,068)			2021 (n = 1,238,576)		
		Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)
Region	Northeast	5,020,880	205,247	4.09	3,66,2703	151,542	4.14	5,390,689	200,357	3.72	3,628,617	162,550	4.48
	Midwest	8,180,076	358,940	4.39	6,54,8514	260,361	3.98	7,160,230	283,926	3.97	5,133,029	192,884	3.76
	South	12,681,643	736,326	5.81	10,204,953	612,774	6.01	11,643,231	642,359	5.52	7,327,319	415,130	5.67
	West	8,271,581	361,638	4.37	7,066,440	312,940	4.43	10,487,563	383,641	3.66	7,347,019	319,179	4.34
	Guam, Puerto Rico	932,151	174,871	18.76	874,602	155,815	17.82	982,698	190,784	19.41	904,930	148,833	16.45
Sex	Male	16,688,903	774,348	4.64	13,485,224	617,137	4.58	17,043,091	725,643	4.26	11,707,118	525,104	4.49
	Female	18,322,938	1,056,216	5.76	14,871,987	876,095	5.89	18,621,321	975,424	5.24	12,633,795	713,471	5.65
General Health	Excellent, very good	17,440,893	370,813	2.13	13,887,471	318,017	2.29	20,115,955	444,342	2.21	12,684,965	299201	2.36
	Good	11,057,040	519,708	4.7	9,000,998	408,404	4.54	10,329,572	530,075	5.13	7,614,492	370,348	4.86
	Fair, poor	6,505,269	936,912	14.4	5,403,937	759,253	14.05	5,146,077	7,18,830	13.97	3,985,216	563,261	14.13
Personal Doctor	Yes, I have 1+doctors providing health care	27,846,983	1,489,260	5.35	22,525,029	1,203,107	5.34	28,192,581	1,386,580	4.92	20,605,467	1,064,774	5.17
	No	7,024,489	335,665	4.78	5,697,952	2,79,015	4.9	7,285,537	3,04,073	4.17	3,526,172	161,823	4.59
Medical cost	Yes, I have not seen a doctor due to cost	4,183,786	456,735	10.92	3,494,096	3,84,976	11.02	3,428,567	3,25,276	9.49	2,143,989	2,35,897	11
	No	30,747,952	1,369,047	4.45	24,787,186	1,099,010	4.43	32,149,947	1,365,252	4.25	22,126,009	997,532	4.51

(Continued)

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TABLE 3 (Continued)

Variable		2018 (n = 1,837,021)			2019 (n = 1,493,232)			2020 (n = 1,701,068)			2021 (n = 1,238,576)		
		Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)
Checkups	I had a checkup within the past 2 years	30,784,216	1,628,862	5.29	24,963,834	1,318,747	5.28	31,410,602	1,506,219	4.8	21,293,014	1,101,697	5.17
	Has been more than 5+years or never had one	3,649,613	1,68,275	4.61	2,905,854	146,302	5.03	3,649,868	158,399	4.34	2,593,966	110,287	4.25
Hypertension Medication	Yes, I take high blood pressure medication	N/A	N/A	N/A	8,15,8078	654,071	8.02	N/A	N/A	N/A	6,978,901	5,72,720	8.21
	No	N/A	N/A	N/A	2,093,590	139,573	6.67	N/A	N/A	N/A	1,688,434	103,697	6.14
Diabetes	Yes, I have been told I have diabetes	4,705,499	5,00,496	10.64	3,783,200	4,06,507	10.75	4,478,324	459,463	10.26	3,216,587	351,384	10.92
	No, I have never been told	30,316,423	1,328,665	4.38	24,517,615	1,080,080	4.41	31,113,520	1,234,702	3.97	21,072,074	881,129	4.18
Education	Less than high school	1,119,418	157,215	14.04	1,011,138	149,352	14.77	1,053,100	147,636	14.02	844,407	123,183	14.59
	Graduated high school	10,457,595	814,219	7.79	8,276,293	621,869	7.51	9,957,358	702,851	7.06	6,628,012	486,261	7.34
	Attended college	9,455,757	495,974	5.25	7,599,214	4,08,666	5.38	9,382,514	480,327	5.12	6,213,126	348,596	5.61
	Graduated college	13,918,884	362,718	2.61	11,342,942	3,071,79	2.71	15,090,952	362,504	2.4	10,518,491	274,667	2.61

(Continued)

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TABLE 3 (Continued)

Variable		2018 (n = 1,837,021)			2019 (n = 1,493,232)			2020 (n = 1,701,068)			2021 (n = 1,238,576)		
		Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)
Employment status	Employed	19,343,930	526,058	2.72	15,312,412	455,058	2.97	19,309,900	518,455	2.68	13,291,520	361,075	2.72
	Unemployed	1,522,535	12,6048	8.28	1,269,260	101,758	8.02	2,516,488	152,839	6.07	1,463,896	109,467	7.48
	Homemaker	1,901,781	129,196	6.79	1,521,438	110,268	7.25	1,668,754	102,610	6.15	1,165,173	87,788	7.53
	Student	1,296,619	33,454	2.58	1,046,187	29,516	2.82	1,285,713	38,228	2.97	8,08,341	22,423	2.77
	Retired	8,152,453	509,399	6.25	6,802,932	418,411	6.15	8,107,913	516,609	6.37	5,770,455	374,880	6.5
	Unable to work	2,433,459	499,197	20.51	1,914,816	363,053	18.96	2,091,086	357,561	17.1	1,393,952	270,484	19.4
Income status	Less than USD 35,000	10,136,312	1,020,618	10.07	8,016,867	812,126	10.13	9,171,928	865,259	9.43	5,882,478	620,092	10.54
	Between USD 35,000 and 74,999	8,278,722	2,93,927	3.55	6,440,716	239,456	3.72	7,974,662	278,323	3.49	5,454,622	222,072	4.07
	Greater than USD 75,000	10,775,406	1,79,954	1.67	8,746,480	153,433	1.75	11,715,830	190,220	1.62	8,005,611	139,523	1.74
Primary source of health insurance	Through employer	1,141,875	27,203	2.38	3,182,005	60,162	1.89	3,285,970	62,764	1.91	9,866,517	205,076	2.08
	Personal plan	266,208	13,087	4.92	7,16,526	28,398	3.96	641,013	16,484	2.57	2152566	84212	3.91
	State programs (Medicare and Medicaid.)	9,20,660	93,326	10.14	2,899,253	230,353	7.95	2,510,187	185,905	7.41	8,386,268	710713	8.47
	Military (TRICARE, Veterans Affairs, etc.)	110,076	5,488	4.99	217,368	10,591	4.87	220,172	13,498	6.13	779,777	45,358	5.82

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TABLE 3 (Continued)

Variable		2018 (n = 1,837,021)			2019 (n = 1,493,232)			2020 (n = 1,701,068)			2021 (n = 1,238,576)		
		Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)
	Other sources	80,337	8,205	10.21	239,336	14,074	5.88	180,342	11,229	6.23	673,114	42,174	6.27
	None	9,070	1,308	14.42	313,127	18,971	6.06	17,663	402.05	2.28	1,615,760	104,683	6.48
Race/ Ethnicity	White, non-Hispanic	23,735,633	9,79,986	4.13	19,072,793	7,75,201	4.06	23,519,706	863,478	3.67	15,670,625	620,051	3.96
	Black, non-Hispanic	3,363,827	2,33,987	6.96	2,582,056	1,91,609	7.42	3,225,033	205,162	6.36	2,213,461	144,538	6.53
	Hispanic	5,269,328	4,67,032	8.86	4,613,885	4,16,080	9.02	5,819,462	497,451	8.55	4,301,606	375738	8.73
	Other	2,717,543	156,017	5.74	2,088,476	110,343	5.28	3,100,211	134,977	4.35	2,155,222	98248	4.56
Age	40–44 years old	2,424,126	86,463	3.57	1,910,183	65,394	3.42	2,574,128	83,031	3.23	1,860,148	68308	3.67
	45–49 years old	2,627,926	134,505	5.12	2,001,118	109,376	5.47	2,596,337	123,268	4.75	1,730,210	8,6292	4.99
	50–54 years old	3,007,716	2,01,948	6.71	2,353,621	144,881	6.16	2,986,363	174,494	5.84	2,057,093	119,646	5.82
	55–59 years old	3,328,569	2,28,505	6.86	2,671,280	1,85,775	6.95	3,199,981	181,124	5.66	2,151,936	135,743	6.31
	60–64 years old	3,464,441	223,269	6.44	2,812,436	174,490	6.2	3,391,643	196,528	5.79	2,312,949	148,958	6.44
	65–69 years old	3,231,215	196,726	6.09	2,657,507	154,210	5.8	3,115,639	163,771	5.26	2,220,841	139,522	6.28
	70–74 years old	2,659,004	1,64,890	6.2	2,290,467	133,231	5.82	2,686,768	162,475	6.05	1,945,745	113,403	5.83
	75–79 years old	1,715,634	121,241	7.07	1,497,458	106,571	7.12	1,783,988	113,081	6.34	1,255,081	84,878	6.76
	80+ years old	1,796,204	165,189	9.2	1,542,881	145,716	9.44	1,797,977	182,235	10.14	1,293,010	138,708	10.73

(Continued)

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TABLE 3 (Continued)

Variable		2018 (n = 1,837,021)			2019 (n = 1,493,232)			2020 (n = 1,701,068)			2021 (n = 1,238,576)		
		Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)	Total people from the survey	# of those who answered yes to blind variable	Proportion of blind people (%)
	18–39 years old	10,198,099	2,92,749	2.87	8,164,636	259,544	3.18	1,079,5602	300,381	2.78	7,010,107	189,487	2.7
BMI	Underweight	516,140	41,081	7.96	441,618	34,674	7.85	543,820	38,119	7.01	357,223	23,986	6.71
	Normal weight	10,074,172	4,78,934	4.75	7,919,495	375,465	4.74	9,996,356	419,133	4.19	6,572,615	296,284	4.51
	Overweight/ obese	21,575,912	1,198,227	5.55	17,453,601	989,140	5.67	21,339,730	1,122,217	5.26	14,830,673	825,193	5.56
Language	English	32,562,297	1,520,078	4.67	25,928,166	1,198,654	4.62	33,065,885	1,367,991	4.14	22,130,234	967,473	4.37
	Spanish	2,517,165	316,701	12.58	2,256,398	283,668	12.57	2,598,510	333,077	12.82	2,210,679	271,103	12.26
Urban/ Rural Class	Urban	31,641,154	1,502,207	4.75	25,404,464	1,212,152	4.77	32,449,140	1,378,723	4.25	21,881,326	995,761	4.55
	Rural	2,513,026	159,943	6.36	2,078,146	125,465	6.04	2,232,573	131,561	5.89	1,554,658	93,982	6.05

This includes the total number of people in the survey who answered the survey question, followed by the number of people who answered "yes" to the blind variable ("are you blind or do you have serious difficulty seeing, even when wearing glasses?"). The final column is the proportion, in percentage, of those who responded yes from the total number of people who answered that survey question.

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TABLE 4 Multiple logistic regression analysis of explanatory variables in association with the response variable (blindness).

Comparison	Point estimate	95% Confidence interval	*P*-Value
State: Midwest vs. Northeast	1.03	0.826–1.284	0.793
State: South vs. Northeast	1.611	1.324–1.960	<0.0001*
State: West vs. Northeast	1.155	0.932–1.432	0.189
Sex: female vs. male	1.099	0.981–1.232	0.105
General Health: fair/ poor vs. excellent/ very good	2.923	2.475–3.452	<0.0001
General Health: good vs. excellent/very good	1.521	1.297–1.784	<0.0001
Personal doctor: yes, one or more vs. no provider	0.791	0.664–0.941	0.008
Medical cost: no vs. yes	0.592	0.512–0.685	<0.0001
Checkups: within past 2 years vs. never/5+ years	0.936	0.730–1.201	0.604
Diabetes: no vs. yes	0.842	0.739–0.959	0.010
Education level: graduated high school vs. less than high school	0.928	0.724–1.189	0.555
Education level: attended college vs. less than high school	0.833	0.642–1.081	0.170
Education level: graduated college vs. less than high school	0.645	0.489–0.850	0.002
Employment status: employed vs. student	1.507	0.916–2.480	0.107
Employment status: unemployed vs. student	2.86	1.662–4.919	0.0001
Employment status: homemaker vs. student	1.854	1.076–3.197	0.026
Employment status: retired vs. student	1.774	1.048–3.003	0.033
Employment status: unable to work vs. student	3.641	2.156–6.148	<0.0001
Income status: < USD 35,000 vs. > USD 75,000	1.683	1.347–2.102	<0.0001
Income status: Between USD 35,000–75,000 vs. > USD 75,000	1.157	0.930–1.439	0.190
Type of health insurance: no plan vs. military plan	2.517	1.288–4.920	0.007
Type of health insurance: through employer vs. military plan	0.86	0.648–1.142	0.299
Type of health insurance: personal plan vs. military plan	1.092	0.800–1.492	0.579
Type of health insurance: state program vs. military plan	1.409	1.089–1.822	0.009
Type of health insurance: another source vs. military plan	1.638	1.160–2.313	0.005
Race/ethnicity: Other vs. Black	1.154	0.900–1.481	0.259
Race/ethnicity: White vs. Black	0.833	0.714–0.971	0.020
Race/ethnicity: Hispanic vs. Black	1.167	0.893–1.526	0.258
Age: less than 40 years vs. 40–44 years	1.126	0.801–1.583	0.495
Age: 45–49 years vs. 40–44 years	2.069	1.460–2.934	<0.0001
Age: 50–54 years vs. 40–44 years	2.318	1.644–3.269	<0.0001
Age: 55–59 years vs. 40–44 years	1.971	1.414–2.747	<0.0001
Age: 60–64 years vs. 40–44 years	1.701	1.214–2.383	0.002
Age: 65–69 years vs. 40–44 years	1.833	1.290–2.604	0.001
Age: 70–74 years vs. 40–44 years	1.752	1.224–2.507	0.002
Age: 75–79 years vs. 40–44 years	2.186	1.501–3.183	<0.0001
Age: 80+ years vs. 40–44 years	3.604	2.514–5.167	<0.0001
BMI: normal weight vs. underweight	1	0.678–1.474	0.999
BMI: overweight/obese vs. underweight	0.912	0.623–1.334	0.634
Language: English vs. Spanish	0.7	0.465–1.055	0.088
Region classification: urban vs. rural	0.87	0.756–1.002	0.053

This includes point estimates (odds ratios), 95% confidence intervals, and p-values.

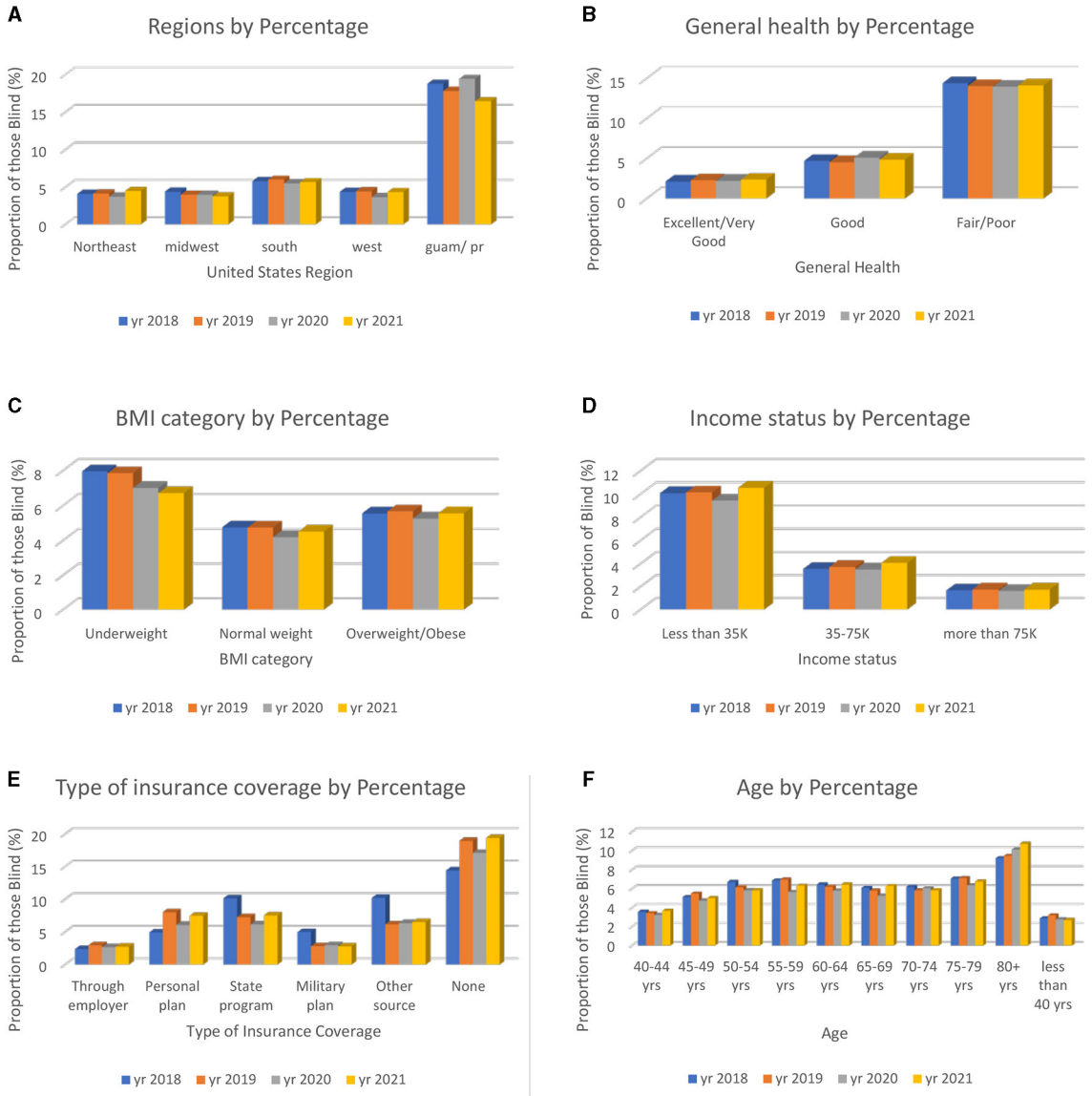


FIGURE 2
Six explanatory variables chosen from the bivariate analysis to show the characteristics of those who answered "yes" to blindness or having serious difficulty seeing, even with glasses. The total percentages of the combined data (2018–2021) are presented. **(A)** Total percentage of those who are VI based on geographic location state. **(B)** Total percentage of those who are VI based on personal health rating. **(C)** Total percentage of those who are VI based on BMI categories. **(D)** Total percentage of those who are VI based on income status. **(E)** Total percentage of those who are VI based on insurance source type. **(F)** Total percentage of those who are VI based on age.

to have VI based on those who answered the Centers for Disease Control and Prevention BRFSS. The variables selected were "state," "general health," "BMI," "income status," "type of insurance," and "age".

For the multiple logistic regression analysis (Table 4), the reference group for each explanatory variable was as follows: "state": Northeast, "sex": male, "general health": excellent/very good, "personal doctor": no, "medical cost": yes, "checkups": never/within past 5+ years, "diabetes": yes, "education level": less than high school, "employment": student, "income level": >75,000 a year, "type of insurance coverage": military, "race/ethnicity": Black, "age": <40 years old, "BMI": underweight, "language": Spanish, and "region classification": rural. This analysis included point estimates, 95% confidence intervals, and *p*-values to show the association between the explanatory variables and the response variables based on the various levels in the explanatory variables. The significance level of $p < 0.05$ was used to determine significance in this study.

The factors listed above have an association with blindness or having serious difficulty seeing based on their odds ratio. When the odds ratio is higher than 1, that factor is considered a risk factor. The descriptive and bivariate and multivariate regression analyses provide a key understanding of the characteristics of someone who is blind or has serious difficulty seeing, even when wearing glasses. We gathered the frequencies, percentages, confidence intervals, point estimates, and *p*-values to gain a full understanding of the socioeconomic status, demographics, and health status of individuals who answered "yes" to the question "are you blind or do you have serious difficulties seeing, even when wearing glasses?"

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Discussion

There have been studies on eye health and the factors affecting the utilization of eye care services. The evidence from previous studies suggests that VI is associated with a low quality of life and compromised physical, emotional, and social wellbeing (1, 2, 11). Another study found that ophthalmic health is associated with SDOHs and that VI is associated with many disparities in eye care (education, genetics, etc.) and barriers to health care access (transportation, reliable doctors, and income) (5). These studies show that social determinants (race, income, geographic location, sex, employment, and healthcare coverage source) have a large impact on the quality of eye care services and the access to eye care services and health as they all have found a significant relationship to VI. Groups including racial and ethnic minorities, low SES individuals, and uninsured individuals receive ophthalmic screening, preventative care, and treatments at lower rates and lower standards (5). Race and ethnicity play a huge role in the type of health care one may receive, yet minorities and marginalized individuals are more susceptible to diseases that can, in turn, impact their eye health if left untreated. Halawa et al. (6) discussed the barriers to access to health care for racial minorities which are low levels of health insurance coverage, geographic locations, access to high quality care, and systemic racial differences in care. People who access proper care encounter other barriers such as high treatment costs, the need for regular follow-ups, and interactions with other health sectors (financial, pharmaceutical, providers, and counseling), all of which reduce overall patient cooperation and compliance (attending follow-ups and taking medication properly) (1).

We must find a way to create better treatment options and make follow-up care accessible. To treat those with VI, it is important to do so at the early stages to reduce the severity of vision loss. Comprehensive eye care (CEC) is a holistic new approach that encompasses treatment, prevention, promotion, and rehabilitation for blindness (1). CEC is a way to decrease the number of people who are diagnosed with an eye disease causing blindness or progressive vision loss. To this end, we need to educate patients and physicians on the comorbidities, groups who have higher chances of developing eye diseases, and available interventions depending on the disease such as cataract surgery, corrective lenses, and anti-VEGF therapy, which have been shown to improve the quality of life for 150 million people worldwide (2). To implement these interventions, we must encourage people to undergo annual screenings regardless of whether or not experiencing visual changes. More financial support should be spent on education for the public. The U.S. spends most of its funds on pharmaceuticals, high-volume/high-margin procedures, CT and MRI imaging, and administration costs that makeup two-thirds of the difference in healthcare costs between the U.S. and other developed countries (18). If the spending was minimized in these four areas, we could then create a more preventative initiative, such as pop-up clinics, to allow minorities and those in the low SES to obtain free and easily accessible eye screenings, which could decrease the rate of vision loss in the U.S. and make us a healthier nation.

It is critical to prevent the occurrence of diseases that can impact eye health by ensuring that all social groups are equally

TABLE 5 The explanatory variables are significantly associated with VI.

Variables that were found to be associated with VI	
Variable	The odds ratios of VI
U.S. Region	
Northeast (ref)	1.00
Midwest	1.03
South	1.61
West	1.1
General health perception	
Excellent/very good (ref)	1.00
Good	1.52
Fair/poor	2.92
Employment status	
Student (ref)	1.00
Employed	1.51
Unemployed	2.86
Homemaker	1.85
Retired	1.77
Unable to work	3.64
Income status	
<35,000 USD	1.68
35–75,000 USD	1.16
>75,000 USD (ref)	1.00
Age (years)	
40–44 (ref)	1.00
45–49	2.07
50–54	2.31
55–59	1.97
60–64	1.70
65–69	1.83
70–74	1.75
75–79	2.19
80+	3.60
<40	1.13
Health insurance source	
Military (ref)	1.00
No plan	2.52
Through employer	0.86
Personal plan	1.09
State program	1.41
Other sources	1.64

The reference groups are marked and have an odds ratio of 1.

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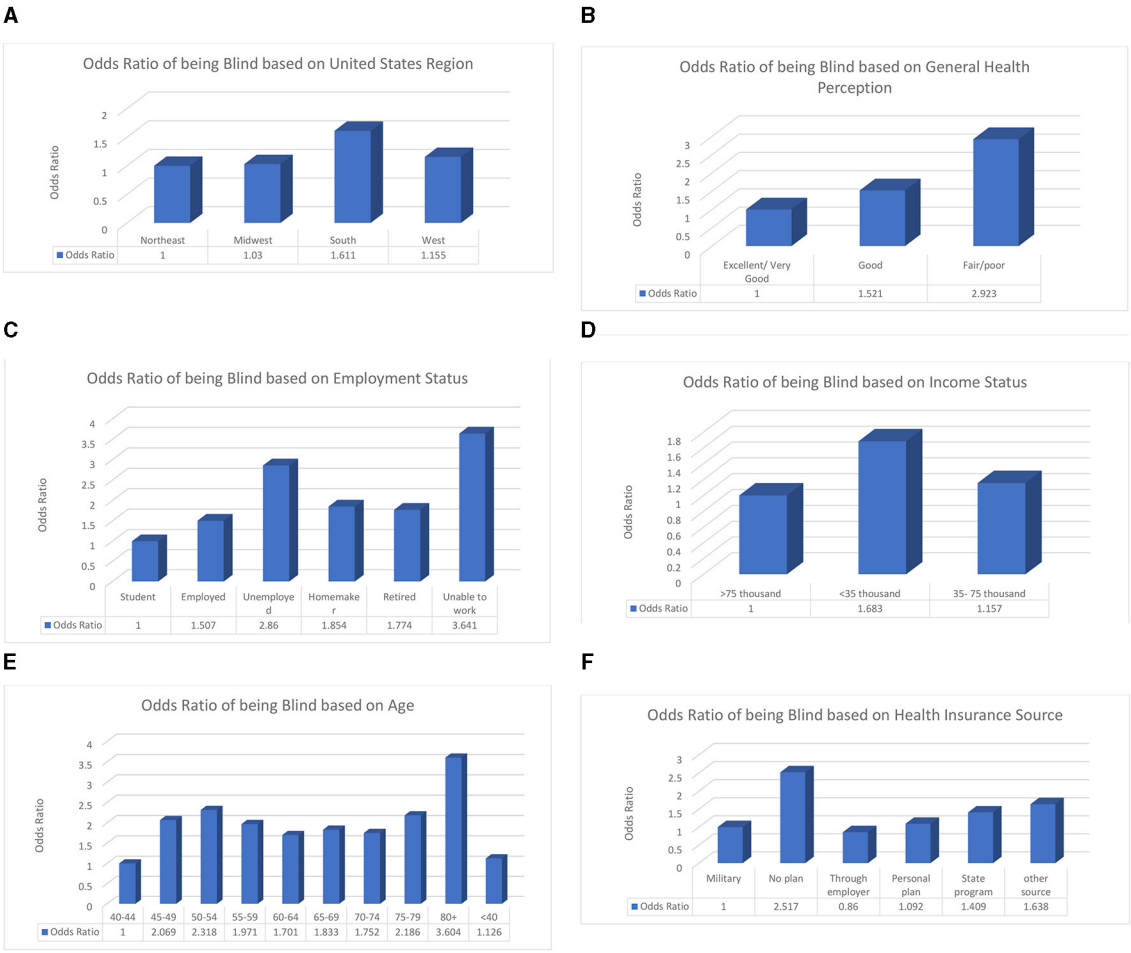


FIGURE 3
The explanatory variables are significantly associated with having difficulty seeing or being blind. The reference groups are shown as the first bar in each graph and have an odds ratio of 1. **(A)** Odds ratio of having visual impairments based on geographic location. **(B)** Odds ratio of having visual impairments based on general health perception. **(C)** Odds ratio of having visual impairments based on employment status. **(D)** Odds ratio of having visual impairments based on income status. **(E)** Odds ratio of having visual impairments based on age. **(F)** Odds ratio of having visual impairments based on health insurance source.

educated about them. This can be one of the only ways to truly decrease the number of people who lose vision due to health issues that could have been prevented by increasing the level of health literacy. All social groups should be equally educated about diseases they have that can affect the health of the eyes, as well as the characteristics/factors that can increase the risk of developing eye diseases. Health literacy is delivered in many forms including print literacy (written information), oral literacy (verbally informed), and numeracy (statistical data) (3). Multiple forms need to be available to reach every person in a way that can be informative. For example, a blind individual cannot read information unless it is braille so they must be able to listen to it, or someone who is deaf needs to be able to read the information. In the U.S. 76% of adults have an education level less than a high school degree and 59% of older adult (65+ years old) are below or at the base level (3). We must make efforts to reach all individuals so there are no disparities in health education based on race, education level, age, and geographic location. It has been found that "low health literacy is associated with increased hospitalizations, increased emergency care use, lower rates of mammography and influenza vaccination, decreased ability to take medications appropriately, decreased ability to understand labels, and higher mortality among older adult" (3) patients and physicians. We can address these issues and foster a healthier and more knowledgeable society.

The multiple logistic regression analysis identified some risk factors that have a significant effect on the occurrence of the disease: coming from a Southern state (OR 1.611 $p < 0.0001$ CI 1.324–1.960), general health classified as fair/poor (OR 2.923 $p < 0.0001$ CI 2.475–3.452), employment status of unable to work (OR 1.683 $p < 0.0001$ CI 1.347–2.102), income status of less than USD 35,000 a year (OR 1.683 $p < 0.0001$ CI 1.347–2.102), no insurance coverage (OR 2.517 p 0.0069 CI 1.288–4.920), and between the ages of 50–54 years old (OR 2.318 $p < 0.0001$ CI 1.644–3.269), the data are shown in Table 5. From this analysis, we identified six variables that are known to be relevant in those who are blind/have difficulty seeing. The odds ratios were not only <1 but the p-values were significant as α was >0.05 and the confidence intervals did not include 1. We found significant variables that define the high-risk population and

indicate the characteristic traits of those who are more vulnerable to suffering from vision loss.

BRFSS is not without limitations. Sampling bias, stemming from non-response and under coverage of certain population groups, alongside reliance on self-reported data, introduces potential sources of error. Furthermore, the cross-sectional nature of the survey restricts its ability to elucidate temporal trends or establish causal relationships. Additionally, the survey's scope may not fully capture all determinants of health outcomes, necessitating caution in interpretation. Acknowledging these limitations highlights the importance of complementing BRFSS data with other research methodologies and data sources to obtain a more nuanced understanding of public health dynamics.

Conclusion

In this study, geographical location, perceived health status, employment status, income status, source of health insurance, and age of the individual were associated with blindness or having serious difficulties seeing. Those who live in Southern states, with no insurance, have an income level below poverty, and are of retirement age have the highest odds of suffering from VI. The factors listed above have an association with blindness or having serious difficulty seeing based on their odds ratio. When the odds ratio is higher than 1, that factor is considered a risk factor. The odds ratios are shown in Figure 3. We must study these factors further to learn the exact causal pathways that can influence whether a person becomes blind or has serious difficulty seeing so that we can reduce the number of people who suffer from visual impairment. These risk factors can guide the future development of interventions by ensuring that the individuals in risk groups are targeted along with the rest of the population.

These odds ratios show that certain groups are at a higher risk of visual impairment due to socioeconomic, biological, or demographic factors, as well as other factors that need to be examined. Future studies should delve more in depth into how medical costs, education status, and body mass index vary among at-risk populations based on different levels. Another important direction is investigating the coverage provided by the main insurance companies regarding eye care in terms of examinations, procedures, medications, regulations, and deductibles. This study showed that patients using government insurance have a greater chance of blindness than those who have private insurance.

Data availability statement

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

Author contributions

AP: Writing—review & editing, Investigation, Software. KA: Writing—review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology. DP: Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Writing—review & editing. MD: Formal analysis, Software, Validation, Writing—review & editing. CF: Data curation, Formal analysis, Investigation, Software, Supervision, Writing—review & editing.

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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.

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Construction of PARI public health education programs for Chinese undergraduates: a Delphi study

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Objectives: The objective of this study is to develop a consensus among experts on a comprehensive and scientifically sound physical activity-related injuries (PARI) public health education program specifically tailored for undergraduates.

Methods: This study designed three rounds of expert consultation by using a Delphi method. A panel of 30 experts from the fields of public health education, sports medicine, anesthesia pain, emergency medicine, and emergency nursing participated in the study.

Results: This study successfully established a consensus among experts on the goals, content, teaching methods, and time allocation for the PARI Public Health Education Program for undergraduates. The program encompasses 10 objectives divided into 2 main categories: professional knowledge and skill goals. In terms of content, it includes 5 primary indicators, 22 secondary indicators, and 56 detailed tertiary indicators. Six teaching methods were identified as suitable. Additionally, a typical 60-min educational session was segmented into eight parts, with a proposed time arrangement for each, ensuring comprehensive coverage of all topics.

Conclusion: The consensus achieved in this study on the PARI Public Health Education Program for undergraduates lays a crucial foundation for the advancement of health literacy and proactive health management within this demographic. We presented a comprehensive framework for PARI public health education, integrating diverse learning methods and content areas. This systematic approach not only enriched the resources available for undergraduate health education, especially of PARI but also had the potential to significantly impact the implementation and effectiveness of health promotion strategies.

KEYWORDS

PARI, construction, public health education, undergraduates, Delphi

1 Introduction

In recent years, the focus on health and fitness has surged significantly, keeping pace with the growing realization of the benefits of sports and physical activities (1). However, this surge in participation has led to a notable rise in the number of physical activity-related injuries (PARI). As of 2022, 67.5% of the Chinese population aged 7 and older engaged in physical

exercises at least once a week, marking an 18.5% increase from 2014 (2). The rate of PARI in China stands at approximately 10–20% and continues to climb. The growing popularity of marathons and other running events has drawn more people into running, but this trend has also led to an escalation in PARI (3, 4).

The PARI refer to sudden bodily injuries that occur during sports or exercise, such as bruises, strains, sprains, and fractures. These injuries often result from accidental or sudden physical impacts, improper exercise techniques, misuse of equipment, or unsafe sports environments (5, 6). Regular cumulative sports injuries, in contrast, develop gradually due to repetitive stress or overuse of specific body parts, typically involving overstrained muscles, tendons, and joints. An example is knee arthritis from long-term running. Unlike cumulative injuries, PARI usually require timely and accurate medical assessment and intervention to prevent further damage and aid recovery. If not addressed promptly, PARI can be life-threatening or leave long-term physical complications for the patient (7–10).

Internationally, the preventive measures for PARI are well-developed, resulting in a high level of awareness and knowledge about PARI prevention among active populations (11). Countries like the United States, United Kingdom, Canada, and Australia have published relevant documents educating the public on methods to prevent PARI. For example, researchers have evaluated the effects of preventive interventions on sports injuries in children and adolescents, concluding that such measures are very effective (12). Consistent recommendations for reducing injury risk include having properly trained staff and sessions that include a warm-up, cool-down and skills progression (through the session) appropriate to the level of the participants to teach the public about exercise methods (13).

In China, the general public's understanding of PARI is not high. As university students are among the more knowledgeable groups in the public, they should have a better understanding of PARI. However, the articles cited point out that the overall risk of injury for sampled Chinese university students are 0.34 and 0.27 injuries/students/year respectively, indicating a high risk associated with PARI (14, 15). Currently, China has developed a relatively comprehensive pre-hospital emergency care system for PARI, with doctors and emergency personnel possessing a high level of knowledge in PARI prevention and treatment (16–18). However, to date, there has been no research focusing on public awareness or education regarding the prevention and treatment of PARI, leaving the public's understanding in this area unknown. For the Chinese public, PARI poses a significant threat to their physical health, especially for university students who frequently engage in sports activities, thus facing substantial risks. Therefore, we target university students first in launching a science popularization program on PARI.

The Delphi technique is a structured approach that employs a series of questionnaires to collect information (19). This process continues through multiple rounds until a group consensus is achieved. One of the key reasons for the Delphi technique's popularity is its ability to include a large number of participants from diverse locations and areas of expertise anonymously (20). This prevents any single expert or small group of experts from dominating the consensus process.

Therefore, this study plans to use the Delphi method to construct and implement an public health educational program for the prevention and treatment of PARI, aiming to ensure the life safety and physical health of the public when affected by PARI.

Compared to the numerous training programs targeting doctors and emergency personnel for emergency care skills, this research is the first in China to focus on educating the public about PARI prevention and treatment. Innovatively applying the Delphi method in developing public educational programs, this study aims to create a more scientific and systematic approach, thereby ensuring the life safety and physical health of the Chinese population following PARI incidents.

2 Materials and methods

In this study, the Delphi method is the primary approach utilized. Commonly employed in fields such as education and health, this method leverages expert knowledge to develop and refine new research topics. The Delphi technique is particularly apt for this study's aims.

2.1 Study design

Firstly, this study included experts from the fields of public health education, sports medicine, anesthesia pain, emergency medicine, and emergency nursing sourced from the CNKI database. Experts who met the inclusion criteria used to conduct in-depth research and publish articles in their respective fields. Subsequently, we draft the first round of expert questionnaires and sent them to the experts. Based on the results of the first round of responses from the expert panel, we revised the objectives and contents of the PARI public health education program and modified it to form the second round of expert questionnaires, which were then sent out. After that, we conducted a third round of inquiries and finalized the PARI public health education program.

2.2 Ethic approval

Ethical approval regarding human subject research was obtained from the Ethics Committee on Third Xiangya Hospital of Central South University (approval number: Fast24084). Informed consent was obtained from each participant offline by placing a question about their agreement to participate in the study at the beginning of the survey. Participants were assured of the confidentiality and anonymity of this study and their rights to exit at any time. We declare that the data were collected for academic use only.

2.3 Expert selection

Experts in the fields of public health education, sports medicine, anesthesia pain, emergency medicine, and emergency nursing from the CNKI database were included in this study. CNKI is a major academic online library launched in 1996 by Tsinghua University and Tsinghua Tongfang Company. It's the largest repository of Chinese academic resources, offering access to journals, dissertations, conference proceedings, and more. Primarily used in China, CNKI supports research, education, and learning by providing extensive scholarly materials predominantly in Chinese.

Inclusion criteria were as follows: (1) master's degree or higher; (2) intermediate or higher title; (3) more than 5 years of work experience.

Exclusion criteria were as follows: (1) experts who could not participate in this study due to personal reasons; (2) experts whose contact information was unknown; (3) experts who had no practical experience in geriatric work.

The experts who met the inclusion criteria had conducted in-depth research and published articles in the relevant fields. Therefore, email addresses and some phone numbers could be obtained from the database. The experts were then invited to participate in the survey by e-mail, telephone or SMS, and they were given a detailed description of the content, purpose and significance of the study.

A total of 30 experts agreed to participate in this Delphi study and a follow-up questionnaire was sent to them and then sent back by e-mail.

2.4 Questionnaire design

The questionnaire for the first round for experts consists of five parts: (1) experts' personal socio-demographic information such as unit and department, sex, age, years of working in first aid science, professional field and so on; (2) self-assessment of the degree of understanding of the consultation; (3) expert views on the degree of impact of the main basis (theoretical analysis, practical analysis, peer understanding and intuition) for judging the content of the consultation; (4) expert evaluation form for the PARI public health education program's goals; (5) expert evaluation form for the PARI public health education program's contents, where the fourth and fifth parts are the main body of assessment in the expert questionnaire.

By retrieving related popular science book, we decided to at least include both specialized knowledge popularization and technical ability popularization to form the science popularization program for PARI prevention and management. In this study, through literature reading and group discussion, we proposed the contents of the first draft of the scientific program for the prevention and management of acute sports injuries based on the "Interpretation of the National Fitness Guidelines" and the "Expert Consensus on Exercise Prescribing (2023)," in which there were 15 first-level, 24 s-level, and 67 third-level indexes and the importance of each part was assessed by experts with scores.

A 5-point Likert scale method was employed to measure importance from 5 points to 1 point as "very important"–"very unimportant," in descending order of importance. Considering the limited duration of the public health education program and the effectiveness of it, the inclusion of items needed to take time and teaching methods factors into account. Therefore, the questionnaire for the second round added items related to teaching time and teaching methods.

Additionally, an item regarding approval rate was included. There were no changes in the third round.

2.5 Questionnaire procedures

In this study, three rounds of questionnaires were distributed to the panel of experts, who met face-to-face with the researcher offline. There was no communication between the experts during this process. The first round of the survey summarized two primary and several secondary objectives, as well as primary, secondary and tertiary structures. In addition to scoring and evaluating the importance of each element, the experts were able to provide their own professional opinions and suggestions for modifying, deleting, and adding other relevant elements to enrich the PARI Preventive and Management Sciences curriculum.

Based on the results of the first round of questioning by the expert group, the objectives and contents of the PARI public health education program were revised. Meanwhile, in order to make the study more practical, the PARI Public Health Education Program Teaching Methods and Timing Scale was added to the second round of questionnaires. Feasibility was also measured using a 5-point Likert scale method, with a score of 5 to 1 being "feasible" – "infeasible," and "feasible" – "infeasible" in descending order.

The four sections of the questionnaire were deleted and supplemented based on the comments from the second round of the survey and the objectives of the study. Eventually, an expert assessment form for the third round of the survey was developed, and experts' comments and feedback were collected and analyzed.

Particularly worth mentioning is the addition of an overall evaluation scale for the public health education program at the end of each questionnaire, so that experts could evaluate the program's scientific and operability as well as the clarity of the subject matter and help us improve the study.

2.6 Data analysis

The returned data were analyzed using R 4.3.2. Experts' concern for this study was reflected in the positive coefficient of the expert panel, i.e., the rate of return of a questionnaire (21). It is generally believed that the positive coefficient above 85% indicates good feedback of the survey from the expert panel.

The representativeness of the experts in this research were presented as expert authority coefficient (21). Generally, an authority coefficient over 0.70 indicates that the expert opinions are reliable and the experts are authoritative.

The inclusion criteria for items in this study were as follows: (1) the average importance score of each item evaluated by the expert panel >4.00; (2) the coefficient of variation <0.20; (3) the approval rate >80% (if applicable) (22).

The exclusion criteria for items in this study were as follows: (1) the average importance score of each item evaluated by the expert panel is less than or equal to 4; (2) The coefficient of variation is greater than or equal to 20%; (3) the approval rate is less than or equal to 80% (if applicable); (4) the item is suggested for deletion by 6 or more experts; (5) the item is suggested for deletion by 6 or fewer experts, but its average score in the next round is greater than 0; (6) when a second-level item is deleted, and if its subordinate third-level items are suggested for deletion by 6 or more experts in the next round, then those third-level items are deleted; otherwise, they are moved under another second-level item; (7) when a first-level item is deleted, if all third-level items under a second-level item are deleted, then the second-level item is deleted.

Similarly, if all second-level items under a first-level item are deleted, then the first-level item is deleted. Furthermore, based on some written opinions of the experts with literature retrieval, the proposed contents were discussed among the research team and

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improved by means of deletion, modification, supplementation, and merger.

3 Results

3.1 Expert sociodemographic information

This study initially involved a diverse panel of 30 experts from five distinct fields: public health education, sports medicine, anesthesia pain, emergency medicine, and emergency nursing. The experts' professional experience ranges from 5 to 30 years, and 70% have over two decades of experience in their respective fields. All experts have prior experience in conducting public health education activities. The sociodemographic details of these experts are documented in Table 1.

The present study involved three rounds of questionnaires to the expert panel. In three rounds of Delphi, 30 experts returned questionnaires in time. In general, the response rate of the experts is 100%, and the authority coefficient is 0.9159 (>0.80), indicating the authority of the experts and the credibility of the Delphi results. Experts were interested in the study through their comments. The main purpose of each round of questionnaires, the number of questionnaire items to be evaluated by experts, item revisions and expert opinions were presented in Table 2.

3.2 Evaluation of goals

In the first Delphi round, the panel evaluated the PARI Public Health Education Program's objectives. Items under 'Knowledge goals' and 'Skill goals' were assessed. High mean scores close to 5.00 with minimal standard deviation (SD) indicated a strong consensus for items (see Supplementary Table S1). The second round showed a convergence of opinions, with all items achieving a mean score of 5.00, except for 'Understanding the importance of fitness testing' and 'Conducting fitness tests' which retained a mean of 4.97 but had reached 100% agreement rate (AR) (see Supplementary Table S2). By the third round all items sustained a perfect mean score of 5.00 and the 100% AR (see Supplementary Table S3).

TABLE 1 The socio-demographic information of the experts.

Groups	Classification	Number of first-round	Percentage	Number of second-round	Percentage	Number of third-round	Percentage
Gender	Male	19	0.63	19	0.63	19	0.63
	Female	11	0.37	11	0.37	11	0.37
Age	30 ~ 39	12	0.40	12	0.40	12	0.40
	40 ~ 49	18	0.60	18	0.60	18	0.60
Years of working	5 ~ 9 years	2	0.07	2	0.07	2	0.07
	10 ~ 19 years	19	0.63	19	0.63	19	0.63
	20 ~ 29 years	9	0.30	9	0.30	9	0.30
Highest education	Master	12	0.40	12	0.40	12	0.40
	Doctor	18	0.60	18	0.60	18	0.60
Professional positions	Intermediate certificate	10	0.33	10	0.33	10	0.33
	Senior position	20	0.67	20	0.67	20	0.67
Supervisor	Doctor supervisor	8	0.27	8	0.27	8	0.27
	Master supervisor	13	0.43	13	0.43	13	0.43
	No	9	0.30	9	0.30	9	0.30
Specialist areas	Popular Science (Internal Medicine, Chronic Disease)	7	0.23	7	0.23	7	0.23
	Popular Science (Surgery)	2	0.07	2	0.07	2	0.07
	Popular Science (Critical Care Direction)	5	0.17	5	0.17	5	0.17
	Sports Medicine	4	0.13	4	0.13	4	0.13
	Anesthesia Pain	1	0.03	1	0.03	1	0.03
	Emergency Medicine	8	0.27	8	0.27	8	0.27
	Nursing (Emergency Care Direction)	3	0.1	3	0.10	3	0.10

Screening of entries in Delphi's three rounds is shown in Figure 1.

3.3 Evaluation of contents

During the initial Delphi round for the PARI Public Health Education Program Contents, varied items across multiple health and fitness domains were scrutinized. While 'Risk Indicators in Sports' and 'Physical Activity Levels' received moderate scores with means of 4.73 and 4.37 respectively, certain third-level items like 'Definitions and Importance' and 'Recommended Criteria' under 'Physical Activity Levels' were marked for modification due to their lower means and higher coefficients of variation (CV). Conversely, some items like 'Recognizing Signs and Symptoms' related to 'kidney disease' scored significantly lower, leading to their proposed deletion (see Supplementary Table S4).

TABLE 2 The process of items revision.

Round	Response rate	Authority coefficient	Purpose	Total number of items
The first round	100.00	0.9159	Exploration	106
The second round	100.00		Clarification	118
The third round	100.00		Confirmation	107

Round	Number of modified items	Number of deleted items	Number of added items	Number of experts' suggestions
The first round	4	8	20	64
The second round	1	9	0	70
The third round	0	0	0	3

Moving into the second Delphi round, there was a noticeable improvement in consensus as indicated by the higher means, lower SDs, and CVs, and increased agreement rates (AR) across most items (see Supplementary Table S5).

In the final round, the expert panel reached full consensus on many key items, signifying a strong expert consensus on the importance and definitions of these concepts within the PARI program (see Supplementary Table S6).

Screening of entries in Delphi's three rounds is shown in Figures 2–4.

3.4 Evaluation of teaching methods

From the second round of the Delphi process, various pedagogical strategies for the PARI Public Health Education Program were additionally evaluated. Techniques such as 'Role Play' and 'Interactive Questionnaire' showed a divergence in expert opinions, as reflected by higher standard deviations and the decision to delete certain methods based on recommendations. Conversely, 'Experiential Learning' was unanimously endorsed with a perfect mean score, indicating a strong consensus on its effectiveness (see Supplementary Table S7).

By the third round, after deleting six items, the consensus among the experts had strengthened, with 'Sports Injury Prevention Workshop,' 'Video Analysis and Discussion,' and 'Online courses and resources' receiving near-perfect mean scores and full agreement. The inclusion of 'Infographics and Visual Aids,' and 'Reflections and journal entries' also demonstrated high mean scores (see Supplementary Table S8).

Screening of entries in Delphi's two rounds is shown in Figures 5, 6.

3.5 Evaluation of time arrangement

In the second round of the Delphi process, experts were engaged to estimate the time needed for various components of the PARI Public Health Education Program. The results yielded mean times with standard deviations, allowing for a nuanced understanding of the expected duration for each activity (see Table 3).

By the third round, the experts reached a full consensus (100% agreement rate) on the importance of each program component. The time arrangements made in the previous round were not just approved, but strongly endorsed (see Table 4).

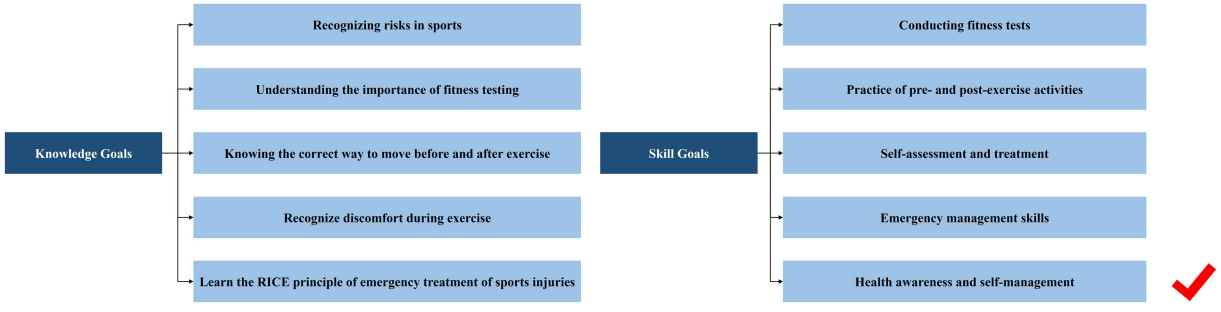


FIGURE 1
Screening of entries in Delphi's three rounds of Goals.

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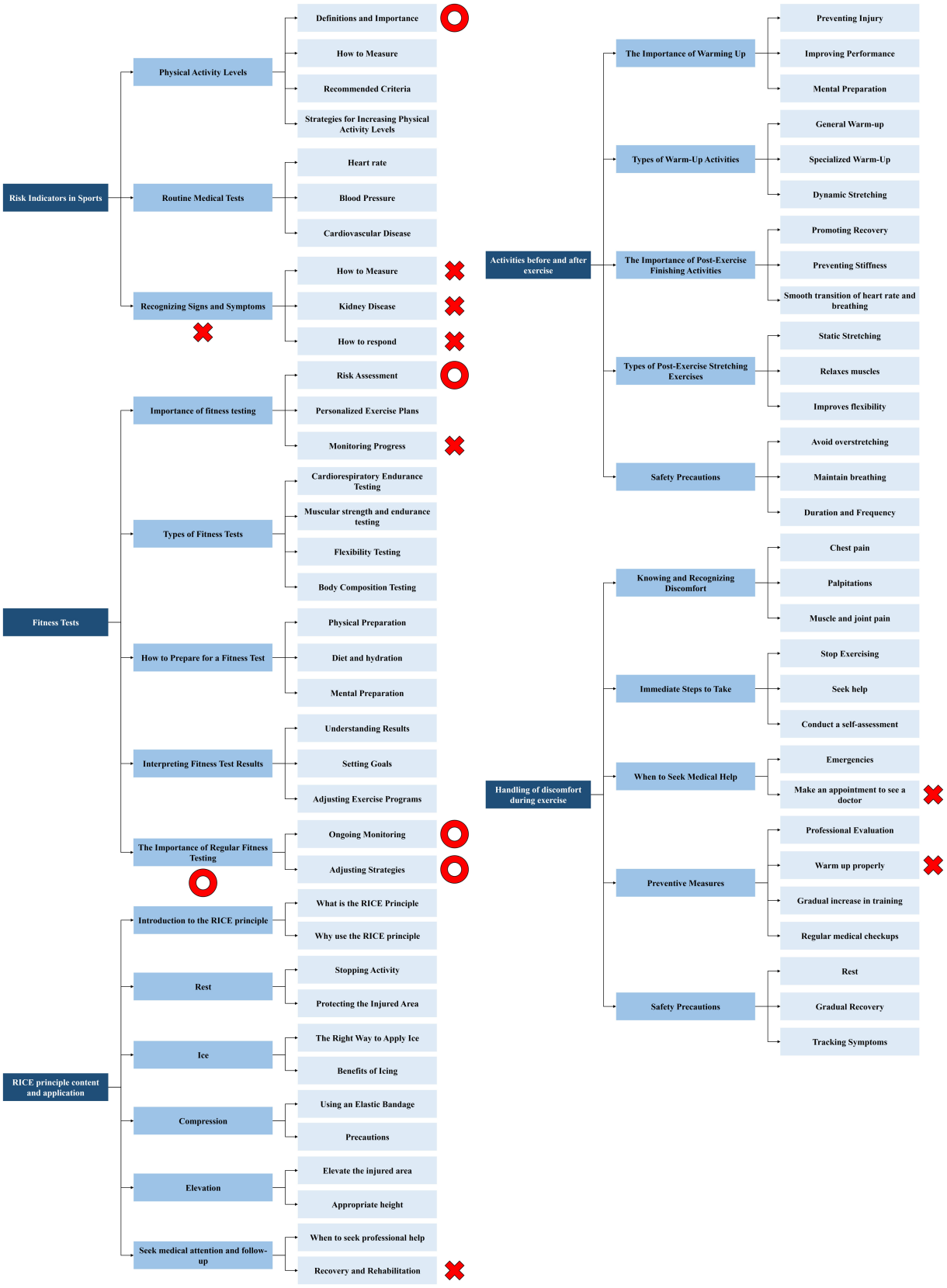


FIGURE 2
Screening of entries in Delphi's first rounds of Contents.

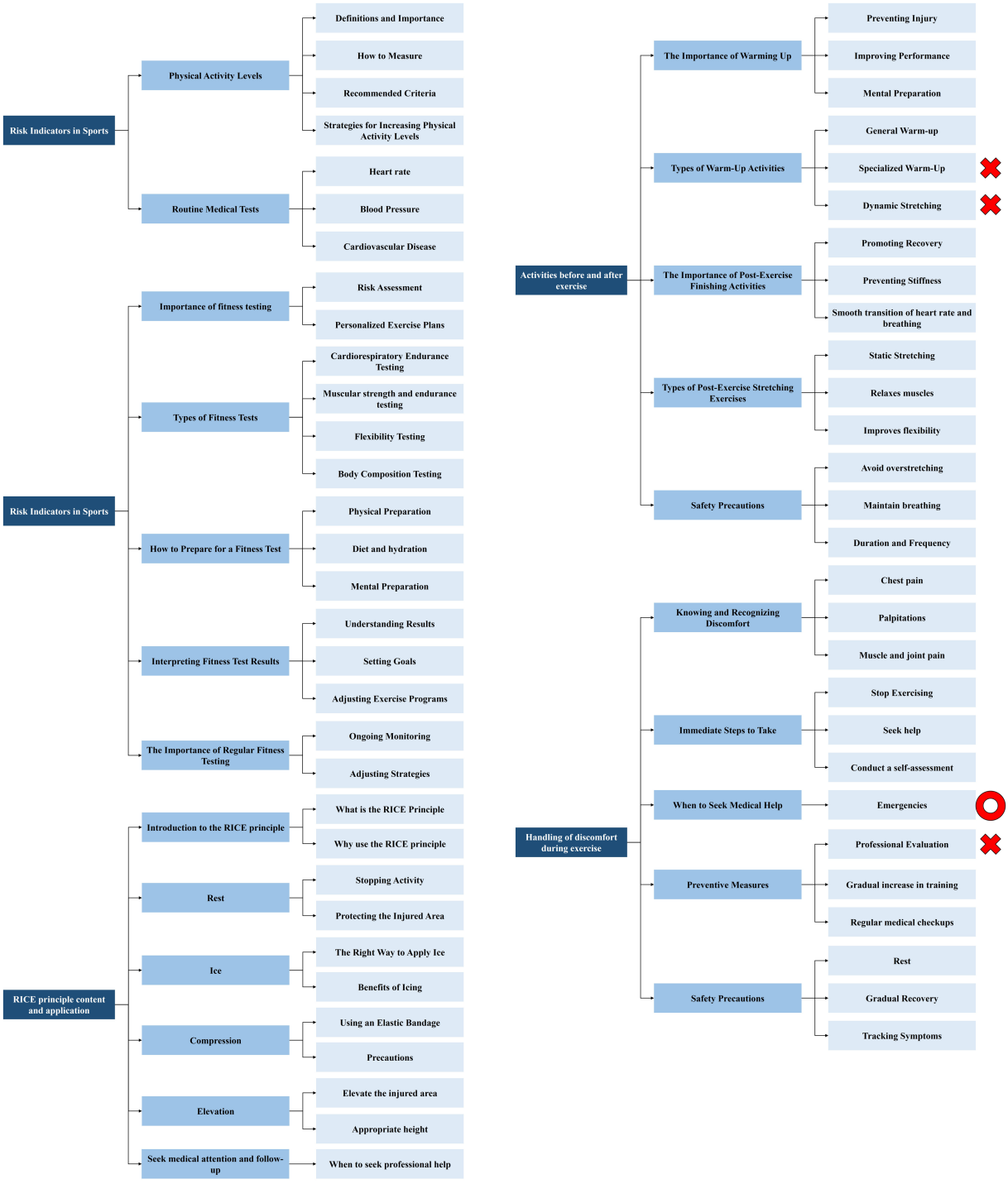


FIGURE 3
Screening of entries in Delphi's second rounds of Contents.

3.6 General evaluation

Throughout the evaluation of the overall effectiveness of the science popularization program, there was a clear trend of increasing consensus among the experts across all three rounds. Initially, there was considerable variability in the experts' ratings of the program's scientific nature and operationalization, as indicated by the higher standard deviations and coefficients of variation. By the second round, these measures began to decrease, reflecting a narrowing of expert opinions. In the final round, the experts reached a near-unanimous consensus on the clarity of the program's theme, operationalization, and scientific nature, with the mean scores approaching or reaching 5.00 and the variability significantly reduced, demonstrating a strong endorsement of the program's design and content (see Table 5).

4 Discussion

With the increasing prevalence of sports injuries among young people, particularly in the physically active college student population,



FIGURE 4
Screening of entries in Delphi's third rounds of Contents.

it becomes necessary to implement effective measures to enhance their self-protection awareness (13, 14). In the rapidly evolving modern society, education plays multiple roles in cultural screening, transmission, transformation, critique, innovation, and reshaping (23). It is not merely a transmitter of knowledge, but also a shaper of ideas and values. Thus, preventive health education is particularly important. The PARI (Prevention, Awareness, Response, and Information) educational program aims to impart knowledge about sports injury prevention to college students. It not only enhances their understanding of sports safety but also helps them develop a positive attitude toward health and make appropriate responses when necessary.

Based on this, the study aims to design a PARI science popularization education plan for the college student population.

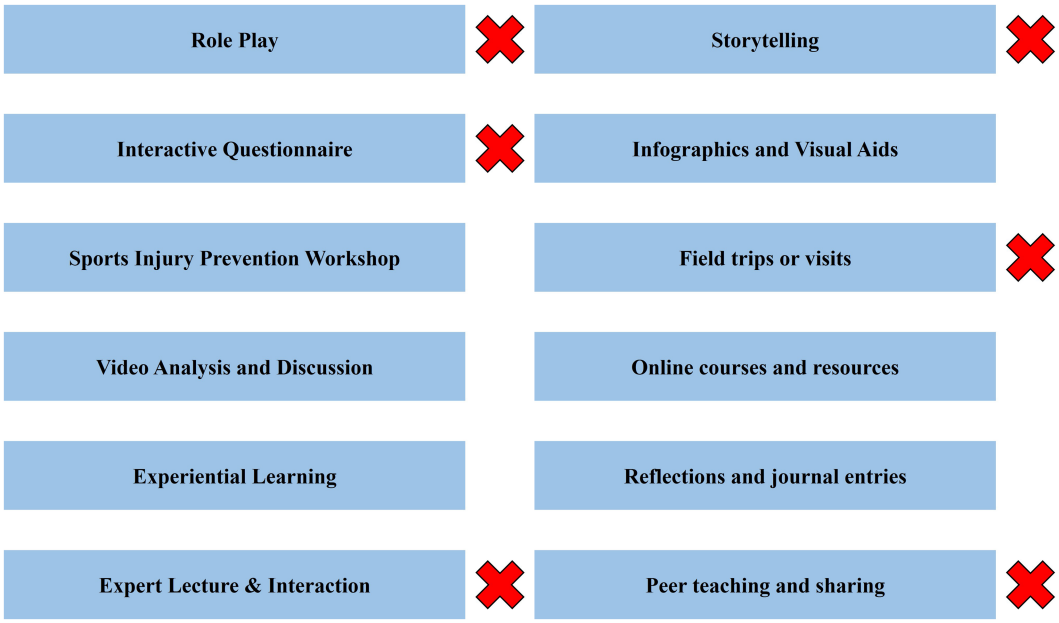


FIGURE 5
Screening of entries in Delphi's second rounds of Teaching Methods.



FIGURE 6
Screening of entries in Delphi's third rounds of Teaching Methods.

We believe that through systematic educational intervention, it is possible to reduce the physical pain and economic burden caused by sports injuries. Additionally, it can promote students' initiative in health management, help them establish scientific concepts of exercise, master the skills of preventing, identifying, and responding to sports injuries, and ultimately promote a healthy lifestyle among college students, laying a solid foundation for their long-term health and well-being.

4.1 Goals of programs

When designing a science popularization program aimed at enhancing college students' knowledge and skills in preventing sports injuries, it is crucial to ensure the precision and relevance of the educational objectives. After three rounds of expert consultation using the Delphi method, our science popularization objectives were unanimously approved by the experts, with no objections. These objectives encompass the necessary professional knowledge and practical skills to ensure students not only understand the potential risks in sports but also are able to assess and respond when necessary.

The knowledge objectives focus on helping students understand potential risks in sports and recognize the role of regular health tests in maintaining good physical condition and preventing injuries. These objectives aim to ensure students can take the right actions before and after sports to reduce the risk of injury and recognize discomfort during activities, which is crucial for taking necessary preventive measures. Through this knowledge transfer, students will be better able to protect themselves and reduce unnecessary injuries caused by sports. In terms of skill objectives, we focus on teaching practical skills, such as the RICE principle in emergency situations – Rest, Ice, Compression, Elevation – which are crucial in handling sports injuries. Additionally, we emphasize the practice of health tests by students, and the importance of activities before and after exercise. These are key skills to help students self-manage and reduce the risk of injuries in daily sports. Thus, our science popularization program ensures that students not only theoretically understand the principles of preventing sports injuries but also apply the learned knowledge and skills in practice (24, 25).

TABLE 3 Time arrangement of PARI public health education program after expert consultation (second-round).

Item	Mean	*SD*	CV	Time arrangement	Notes
Activity opening and introduction	4.87	0.35	7.19	9.80 ± 1.85	
Risk of cardiovascular events during exercise and its indicators	4.87	0.35	7.19	19.97 ± 1.87	
Fitness testing and risk reduction	4.90	0.31	6.33	14.63 ± 1.60	
Preparation and recovery activities before and after exercise	4.87	0.35	7.19	15.03 ± 1.74	
Symptoms and emergency treatment during exercise	5.00	0.00	0.00	19.90 ± 1.66	
RICE principle	5.00	0.00	0.00	15.17 ± 2.05	
Interactive Q&A and summary	4.97	0.18	3.62	19.97 ± 1.96	
End of the program and thank you	4.90	0.40	8.16	5.53 ± 1.65	

TABLE 4 Time arrangement of PARI public health education program after expert consultation (third-round).

Item	Mean	*SD*	CV	AR	Notes
Activity opening and introduction	5.00	0.00	0.00	100.00	
Risk of cardiovascular events during exercise and its indicators	5.00	0.00	0.00	100.00	
Fitness testing and risk reduction	5.00	0.00	0.00	100.00	
Preparation and recovery activities before and after exercise	5.00	0.00	0.00	100.00	
Symptoms and emergency treatment during exercise	5.00	0.00	0.00	100.00	
RICE principle	5.00	0.00	0.00	100.00	
Interactive Q&A and summary	5.00	0.00	0.00	100.00	
End of the program and thank you	5.00	0.00	0.00	100.00	

4.2 Contents of programs

In content development, after three rounds of Delphi query, experts' high recognition of certain items reflects a common understanding of their educational value and practicality. For instance, the monitoring of 'heart rate,' 'blood pressure,' and 'cardiovascular diseases' received unanimous emphasis, not only due to their concreteness and measurability but also their proven role in preventing cardiovascular-related diseases (26). These objective indicators are ideal for public health education, being easy to teach and convenient for students to grasp and apply. The retention of certain indicators in physical fitness tests, such as 'cardiopulmonary endurance tests' and 'muscle strength and endurance tests,' is because these tests help students understand their physical condition better, thus better guiding individual preventive PARI methods (27). These tests are seen as key tools in promoting self-health management and improving life quality, aligning with the current educational goal of enhancing individual health responsibility.

However, some items, such as 'recognizing symptoms in physical activities' and 'monitoring kidney diseases,' were removed due to their potential lack of direct relevance or practical application scenarios. For example, 'recognizing symptoms in physical activities' is too broad and difficult to operationalize, involving many subjective judgment factors, contrary to the clarity and empiricism sought in science popularization education. 'Monitoring kidney diseases' might be too specialized, challenging for non-professionals to understand and operate, limiting its practicality in popular education. Similarly, items like 'dynamic stretching' and 'professional warm-up,' suggested for removal in the second round, may be due to their limited general applicability and practicality for regular students, though beneficial for professional athletes (28). The purpose of science popularization education is to disseminate knowledge and improve the public's overall health level, so content selection should lean toward those beneficial and easy to understand and implement for most people.

In conclusion, when constructing the PARI science popularization education program, content with a clear scientific basis, easy to popularize, and capable of enhancing students' self-health management abilities should be chosen. At the same time, we need to consider the universality and practicality of the projects, avoiding those that may cause confusion or implementation difficulties. Thus, an effective PARI science popularization content is constructed.

4.3 Teaching methods of programs

In selecting teaching methods, we rigorously refined through the Delphi process. Initially considered methods included role-playing, interactive surveys, expert lectures, storytelling, field trips, and peer teaching. However, these were excluded in the second round as they

TABLE 5 General evaluation of PARI public health education program after expert consultation of each round.

	The first round			The second round			The third round		
	Mean	*SD*	CV	Mean	*SD*	CV	Mean	*SD*	CV
Scientific nature of PARI public health education program	4.47	0.82	18.34	4.77	0.50	10.48	4.93	0.25	5.07
Operationalization of PARI public health education program	4.40	0.81	18.41	4.83	0.46	9.52	4.97	0.18	3.62
Clarity of the theme of PARI public health education program	4.83	0.46	9.52	4.93	0.25	5.07	5.00	0.00	0.00

were not quite aligned with the objectives of the program for undergraduates. Role-playing and storytelling, while interactive, might not fully cover the depth of the program's content (29, 30). Surveys and lectures might render students' passive participants, and field trips and peer teaching posed logistical challenges and lacked standardization (31, 32). Instead, the group unanimously agreed to adopt methods such as workshops, video analysis, and experiential learning, which encourage active student participation and are more conducive to undergraduate learning. These methods were unanimously affirmed in the third round, reflecting their suitability for the PARI program's educational objectives.

Workshops provide a practical, collaborative environment where students can engage with materials in a real-world context, applying and reinforcing knowledge immediately. Video analysis and discussion allow participants to visually dissect and discuss various scenarios, deepening their understanding of the nuances in sports injuries and prevention (33). Experiential learning is vital as it transcends traditional didactic teaching, enabling students to consolidate knowledge through direct experience and reflection (34). Infographics and visual aids cater to different learning preferences, distilling complex information into digestible, visually appealing formats, thus enhancing memory and understanding (35). The inclusion of online courses and resources reflects the current state of modern education, providing flexible, convenient learning opportunities, aligning with undergraduates' digital fluency (36). Lastly, reflection and journals serve as tools for self-assessment and continuous learning, encouraging students to articulate their understanding and issues encountered during the learning process (37).

In summary, the teaching methods chosen for the PARI project align with contemporary educational principles, prioritizing active learning, student engagement, and diverse modes of knowledge acquisition.

4.4 Time arrangement of programs

In terms of time allocation for science popularization activities, a meticulous evaluation using the Delphi method led to a carefully designed distribution of time for each part of the PARI program, which ultimately received unanimous approval in the third round. The time allocation for sections like 'Activity Opening and Introduction,' 'Risk and Indicators of Cardiovascular Events in Sports,' and 'Physical Fitness Testing and Risk Reduction' reflects a reasonable balance between comprehensive coverage and focused learning. Experts allocated ample time to key parts such as 'Symptoms and Emergency Handling in Sports' and 'Risk and Indicators of Cardiovascular Events During Sports' because it is essential for students to fully grasp and practice these lifesaving procedures. In contrast, less time was allocated to sections like 'Participant Questions' and 'Key Points Summary,' recognizing their auxiliary role in reinforcing the main content. This rational time arrangement also considers the cognitive load theory, ensuring students are not overwhelmed by information in a single session (38). By reasonably allocating time across different teaching activities, the program facilitates better mastery and understanding of knowledge among students. Additionally, the time allocated for 'Interactive Q&A and Summary' is sufficient for students to engage in active discussions, clarify doubts, and consolidate understanding, which is crucial for adult learners who benefit immensely from interactive and reflective learning stages.

5 Conclusion

The consensus reached through this Delphi study on the structure of public health education programs for undergraduates lays a crucial foundation for the development of informed and effective health promotion strategies within this demographic. It contributes significantly to the cultivation of health literacy and the establishment of proactive wellness practices among young adults. Additionally, the outcomes of this research can aid educational institutions in tailoring their health education curricula to better suit the needs and dynamics of undergraduate populations.

This study designed a highly comprehensive PARI science popularization education program for Chinese undergraduates, thereby gradually enhancing the health literacy and self-protection capabilities of Chinese youth against physical injuries, as well as safeguarding their physical health. Moreover, this research lays a foundation for similar future science popularization programs and serves as a model for similar science popularization programs abroad.

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 Ethics Committee on Third Xiangya Hospital of Central South 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

YK: Formal analysis, Funding acquisition, Validation, Visualization, Writing – original draft, Writing – review & editing. HX: Writing – original draft. CL: Data curation, Formal analysis, Methodology, Writing – original draft. YY: Investigation, Methodology, Writing – original draft. XZ: Investigation, Writing – original draft. YZ: Project administration, Supervision, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1390011/full#supplementary-material

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What are the experiences of medical students and their trainers regarding undergraduate training in primary health care at four South African medical schools? A qualitative study

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Background: In 1978, the World Health Organization (WHO) adopted primary health care (PHC) as the most effective strategy to meet the healthcare needs of communities. This raises the question as to the extent and nature of the training that undergraduate (UG) medical students receive in medical schools regarding PHC, following this statement.

Aim: The study aim was to explore the experiences of UG medical students and their trainers regarding training in PHC in their institutions.

Methods: A qualitative study was conducted among UG medical students (MBChB 4-6) and their trainers at four conveniently selected South African medical schools. A total of 16 focus group discussions (FGDs) and 27 in-depth interviews were conducted among students and their trainers, respectively. The MAXQDA 2020 (Analytics Pro) software program was used to arrange the data, resulting in 2,179 data segments, from which categories, sub-themes and themes were derived.

Results: Both the UG medical students and their trainers regarded PHC as mainly an approach to health rather than a level of care. Students were trained by specialists and generalists, received training in the undifferentiated patient, coordinated, comprehensive and continuity of care. The training in tertiary centers, conducted mainly by specialists, the implicitness of the training and the inadequacy of trainers at the PHC settings presented challenges.

Conclusion: Students and their trainers experienced UG student training in PHC in line with the internationally recognized principles on the subject. The view by students and their trainers that PHC is an approach rather than a level of care enhanced its training across disciplines. The implicitness of the training and the tertiary learning platforms were the main challenges experienced. For optimum PHC training, more time should be dedicated to distributed training platforms with supportive specialist outreach programs in the South African medical schools.

KEYWORDS

primary health care, training experiences, UG medical students, student trainers, generalists, specialists

Background

In 1978, the World Health Organisation (WHO) adopted primary health care (PHC) as the most effective strategy to meet the health care needs of communities (1). Furthermore, in 2018 the WHO advanced a vision for PHC in the 21st century, which states that "Primary Health Care is the whole-of-society approach in health, aimed at providing equitable health and well-being to individuals, families and communities, as early as possible in the continuum of health, namely health promotion, disease prevention, curative, rehabilitative and palliative care, as close as feasible to people's day-to-day environments" (2). Literature indicates that PHC is generally described in terms similar to the WHO definition of PHC, as "taking the whole society into consideration" (3, 4); "providing health and well-being" (3); "addressing the whole spectrum of ailments" (3); and "accessibility to communities" (3, 5).

Since the dawn of democracy in South Africa in 1994, the government has achieved several successes in the implementation of PHC. The 14 health administrations of the Bantustans were consolidated into one national department comprising nine provincial health departments. Health facilities were de-segregated and PHC, delivered via a district health system, has been made the cornerstone of the country's health policy (6). Furthermore, the South African government introduced the PHC re-engineering plan in 2010, a three-stream approach to PHC comprising: ward-based PHC outreach teams, strengthening school health services and district-based clinical specialist teams with a focus on improving maternal and child health (7). Logically, the implementation of the PHC re-engineering plan would require its incorporation in the training of the South African medical students. There is already an explicit social accountability imperative for medical schools in the country to produce undergraduates who are equipped to function effectively at PHC, regardless of who trains them (8, 9). A conference statement released by the Eighth Primary Care and Family Medicine Education (PRIMAFAMED) conference held in Nairobi in 2016, attended by 18 African universities, acknowledged that PHC training in the African region is only centered at post-graduate level whereas it "should begin during undergraduate training" (10).

Barbara Starfield proposed four pillars of PHC, namely first contact care, continuity of care, comprehensiveness, and coordination of care (5). Emanating from these pillars, the principles of PHC are generally understood as (a) the main entry point and interface of the population and the health system (11), whereby PHC plays the gatekeeping and access functions; (b) a broad-based healthcare incorporating health promotion, disease prevention, curative, rehabilitative and palliative care throughout the life of a patient (2); and (c) interprofessional collaborative patient care provided at all levels of care addressing patients' social determinants of health (including their social, economic, environmental and educational situations) (12); and (d) building relationships with the patient for patient-centered care (13). In the current study, the researchers factored in the four pillars of PHC in their exploration of the experiences of students and their trainers in PHC training, and the challenges encountered in the process.

The current study was nested in the multicenter collaborative study named "Transformation in Medical Education" (TiME), in which four universities collaborated: University of KwaZulu-Natal (UKZN), Sefako Makgatho Health Sciences university (SMU), University of the Witwatersrand (WITS) and Walter Sisulu University (WSU). The objective of this umbrella study was to investigate the balance between specialist and generalist training platforms with particular emphasis on medical students' training in the South African medical schools (14).

Literature indicates the importance of training medical students in PHC, equipping them with knowledge and skills for the field of practice (15). At the time when the current study was conducted, the main focus in South Africa had been on exposure of UG medical students to PHC through distributed training platforms (16). Recently, literature exploring the understanding of students and their trainers regarding PHC has been published (17). However, the experiences of students and their trainers in PHC training has not been explored. Since the training of students in PHC is conducted by both generalists and specialists in South African medical schools, there is need for both to work collaborately and assume a common approach for the task. In answering the research question of the current study which is on the "experiences in PHC training," the position of the specialists and generalists may be ascertained, opening a window of opportunity to address shortfall and discrepancies among them. The findings of this study could add another dimension to the body of knowledge on the subject.

Materials and methods

Study context

This paper is part of the principal researcher's PhD project which explores the training of UG medical students in "generalist medical practice" and "primary health care." He has produced four manuscripts each addressing a specific objective of the project focusing on the medical students and their trainers' (a) understanding of "generalist medical practice," (b) experiences in the training in "generalist medical practice," (c) understanding of "primary health care" and, lastly (d) experiences of the training in "primary health care." The current study addresses objective (d).

Researcher's positionality

As a family physician at the time of the study, the principal researcher was a trainer of UG and postgraduate students in the discipline of Family Medicine. He was based at SMU, one of the four settings where the study was conducted. It became important for him to declare this position to both students and fellow trainers at the beginning of each interview. This was followed by the explanation of the study, including its aim and objectives. Specifically for students, they were requested to respond with honesty as there were no right or wrong responses. They were also informed that they were free to express their views, even those they would have thought would go against the interviewer. They were assured that no response would be found unacceptable to the interviewer. Furthermore, the interviewer adopted a reflexive approach (maintaining self-consciousness) during data collection, analysis and interpretation—as recommended in literature (18).

TABLE 1 The interview guide used in data collection.

	Section A: Students (FGDs)	Section B: Trainers (in-depth interviews)
Exploratory question	"As undergraduate medical students in this institution, what have been your experiences regarding your training in "primary health care"?	"As a trainer of undergraduate medical students, what has been your experiences in training them on "primary health care"?
Prompts	Tell us about your experiences of PHC regarding the following: • Your trainers in PHC Primary health care as: • As an approach and/or level of care • The first point of patient contact • Comprehensive care • Coordination care • Continuity of care	Tell us about your experiences in training students on PHC regarding the following: • Your involvement as the trainer of PHC Primary health care as: • An approach and/or level of care • The first point of patient contact • Comprehensive care • Coordination care • Continuity of care
	As students, did you encounter challenges in your training on PHC? Tell us more.	As the trainer, did you encounter challenges in training the students on PHC? Tell us more.

Study design

A qualitative phenomenological design as described in literature (19) was used to explore the experiences of UG medical students and their trainers in PHC training. This design was regarded as appropriate for this study since a phenomenological enquiry elicits the lived experiences of individuals in a particular group (20).

Study setting

At the time of the study, there were nine medical schools in South Africa. All were invited by UKZN to participate in the TiME study (14) and funded by the National Research Foundation of South Africa (NRF). However, only three accepted the invitation: WSU, SMU, and WITS.

Data collection

Data collection was conducted by the principal researcher with the assistance of a final year medical student who had been trained in research methodology (including data collection) by the first author and his PhD supervisor. Data collection from the students' trainers was conducted through in-depth, one-on-one interviews, while focus group discussions (FGDs) were use for the students. Heads of departments or their course coordinators in the various disciplines were purposively recruited to participate. During the interviews, the opening statement for each trainer was: "As a trainer of undergraduate medical students, what has been your experiences in training them on primary health care?" The prompts have been listed in Table 1. Regarding students, the exploratory statement used for each FGD was: "As undergraduate medical students in this institution, what have been your experiences regarding your training in "primary health care?" The prompts have also been listed in the table referred to above. The prompt for both students' trainers and the students were derived from the study objectives. Each in-depth interview and FGD lasted for about 45 min on average. Twenty-seven students' trainers and 16 FGDs (comprising 102 students) participated in the study. Data collection was conducted over a four-year period (2016 to 2020).

The students were from the fourth (MBChB 4) to the final year (MBChB 6) whom the researchers regarded appropriate as they were in their clinical years of training and most likely to have experienced clinical training in PHC. Each FGD comprised five to eight students. In each medical school, four FGDs were arranged: three homogeneous (comprising students in the same year of study from 4th to 6th year), plus one heterogeneous group (comprising mixed year levels from the 4th to the 6th year). The heterogenous group, the FGD consisted of about two students per year group. The heterogenous group was arranged to capture the interaction among students from various year levels in a single group.

Data analysis

The principal researcher used both the inductive and deductive methods of data analysis (21). As indicated in the interview guide (Table 1), there was an unstructured exploratory question for both the one-on-one and FGD interviews which gathered broad information on the experiences in PHC training, for which the inductive analysis method was used (22). This was followed by the open-ended prompts as a follow-up enquiry on matters which a participant had not initially addressed when responding to the broad exploratory question. For the responses to the semi-structured prompts, the deductive method was used (23). The last prompt, which enquired on "challenges experienced" in PHC training was analyzed through the inductive method (21). The analysis was thematic guided by the open-ended questions in the interview guide. The questions were based on Barbara Starfield's proposed four pillars of PHC, namely comprehensiveness, first contact access, coordination and continuity of care (24). All interviews were digitally recorded and transcribed verbatim by a linguistic expert transcriber. Each transcript formed the basis of the data analysis. The authors used the MAXQDA 2020 (Analytics Pro) software program to arrange the data which yielded 2,179 data segments.

Theoretical framework

Vygotsky's Social Constructivist theoretical framework (SCT) (25) as well as Lave and Wegner's Situated Learning theory (SLT) (26) were used as the lens through which this study was conducted. Both theories contend that in the learning setting, there are the "more knowledgeable others" (experts) who train the "novices" (apprentices) to become experts in "the community of practice," and that learning occurs best within the context of its application (27).

Both theories assume a constructivist approach whereby the learner is given knowledge and skills enabling him/her to solve problems independently. Prior to implementation of the skills and knowledge for independent implementation of PHC principles, the students first needed to gain understanding of the concept, as imparted to them by their preceptors. The researchers in this study, in turn, needed to explore the experiences of students and their trainers in PHC training, hence the choice of the phenomenological study design in relation to the theoretical frameworks. In a similar manner, it became appropriate to conduct data collection by means of interviews: FGDs and in-depth interviews for the students and their preceptors, respectively as these also followed the exploratory trend.

For data interpretation, the lens provided by these theoretical frameworks assisted the researchers to compare the information given by both groups and discuss the findings looking at "both sides of the coin." For example, what information did each group provide regarding PHC as "the point of first contact for patients"? Furthermore, it was observed that the students' trainers related with their students as the "more knowledgeable others" moving the former from the position of "novices" to the position of "experts" (25, 26). Thus, throughout the study, the theories gave insight to the researchers in exploring the experiences of the students and their trainers regarding PHC training.

Trustworthiness

In this study, trustworthiness was ensured by consideration of credibility, dependability, confirmability, and transferability as explained in literature (28). Credibility was ensured by the creation of a dataset (see Supplementary materials), containing the study findings for member checking regarding the accuracy of the information captured. Data reproducibility (dependability) was ensured by providing a thick description of the study methods (29).

Confirmability, pertaining to objectivity of the researcher in collecting and interpreting data (30), was ensured by reflexivity. During interaction with the participants, the researcher was self-conscious of his influence on them as a trainer of medical students himself. He allowed independent expression among all participants. Transferability, the degree to which the study findings are applicable to similar settings (28), was ensured by providing thick description of study methods, setting and description of the participants (22). Data triangulation was achieved through field notes taken during the interviews and reference to the students' training manuals obtained from each medical school (30).

Findings

We identified seven major themes on the experiences on PHC training by UG medical students and their trainers (Table 2).

Students

Students described their experiences in the training in PHC by identifying their trainers, PHC as the first contact of patient care, comprehensive care, coordination of care and continuity of care. They also narrated the challenges they had experienced during the training.

Experience of PHC as an approach

Students indicated that they had experienced PHC as an approach rather than a level of patient care, and as an approach, they had observed that some specialists (not only the generalists) had practiced PHC in their various disciplines by educating patients on disease prevention, which indicated to the students that PHC cuts across all disciplines and is not confined to the patient entry levels which were the clinics and other community based health facilities.

> *Yeah, with the primary health care being a care, not a level, … most specialists do practice it, I have experienced [it] in the surgery block*

TABLE 2 Themes and sub-themes on the experiences of medical students and their trainers in PHC.

A. Students		B. Trainers	
1.	PHC—an approach to patient care	1.	PHC—an approach to patient care
2.	Training by generalists and specialists	2.	Training by generalists and specialists
2.1.	Generalists	2.1.	Generalists
2.2.	Specialists	2.2.	Specialists
3.	First contact	3.	First contact
4.	Comprehensive care	4.	Comprehensive care
5.	Coordination of care	5.	Coordination of care
6.	Continuity of care	6.	Continuity of care6.
7.	Challenges experienced	7.	Challenges experienced
7.1.	Training in tertiary health facilities	7.1.	Training in tertiary institutions
7.2.	Practical application of PHC lacking	7.2.	Lack of trainers at distributed platforms
7.3.	Training in PHC implicit		

> *where they educated the patient about the, the prevention of a condition. Also, in psychiatry also I had experienced it,…* (SMSM4.1, MBChB 4, female student, 21 years).

Generalist and specialist trainers in PHC

In their experiences of being trained by generalists and specialists, students compared these experiences.

Generalists

According to the students, generalist practice trainers offered training more than specialists in PHC. However, they also felt that PHC should be trained by all disciplines and not only confined to generalist trainers. This displayed their understanding that, although generalist trainers were advantaged by their training environment (PHC settings), the principles of PHC were also applicable in specialist disciplines.

> *…it's essentially the general practitioner who has a greater caliber of skills to be able to address primary health care as opposed to the surgeon.* (WTSM5.2, MBChB 5, male student, 22 years).

The discipline of Family Medicine was identified as particularly giving students the opportunity of exposure to PHC.

> *I think it's mostly Family Medicine, honestly speaking, our Family Medicine rotation is the one that focusses a lot on it [training in PHC]. In fourth year, we are in clinics, in community health care centres and then in fifth year we are in a district hospital but in a rural area.* (KZS5.1, MBChB 5, male students, 23 years).

However, students expressed further opinion on the responsible disciplines in training students on PHC.

It [teaching primary health care] is supposed to be a sort of shared responsibility among the departments. (SMS5.4, MBChB 5, female student, 23 years).

Specialists

Some students had experienced being trained by specialists on PHC, through reconstruction of the state of the patient on arrival at PHC before referral to specialized disciplines. However, some students also indicated that they had not experienced training in PHC from specialist disciplines because of the specialized setting. Students had the ability compare and contrast the training on PHC they had received from specialists and generalists and managed to state their experiential differences.

> *In my case when we went there, they did [train us on PHC]. They often asked us "what would lead to this? And what did you expect to see before the patient came in?". And then there are certain signs that started presenting before, which could give you a clue towards the diagnosis.* (WTS4.3, MBBCh 4, male student, 24 years).

> *So, they often asked us to, to not only think about what the patient is presenting with now, but also what they might have presented with before, so that … in case we saw a patient at a primary health care setting, that we would uhm… have enough knowledge to pick up a case and either treat it or refer it upwards.* (WTS4.4, MBBCh 4, female student, 21 years).

> *because obviously if you're doing an Obs and Gyne [Obstetrics & Gynaecology] block for example, and you're in a Gyne [Gynaecological] ward, … you don't really want to explore the other problems.* (KZS4.5, MBChB 4, female student, 26 years).

First contact

Students pointed out that they were given guidance on the approach to patients seen at PHC settings at entry points into the healthcare system. They were taught to apply basic principles of recognition of a condition, stabilization of emergencies and appropriate referral determined by limitations. It became clear to the researchers that the students had understood the scope of practice of a generalist medical practitioner in terms of skills and available resources at PHC settings, beyond which they were to refer the patient to more specialized centers.

> *[At primary health care] you have to be able to recognize these conditions and refer where possible. Yeah, and up to so far, yeah, they emphasize on that, yeah, we are being taught that when it gets here, there's nothing you can do … make sure that they're breathing, give them oxygen, give them fluids and then refer, …* (SMS5.5, MBChB 5 female student, 29 years old).

Comprehensive care

Training in comprehensive care entailed consideration of other factors that could influence the patient's wellbeing: the social determinants of health. This enabled the students to address the patient's condition comprehensively, not to lose focus on all the aspects that could affect their wellbeing. Students had developed the sense of appreciation that a patient should be treated contextually and not as a single individual, because unwellness goes beyond the clinical condition.

> *Yeah, we do get trained on comprehensive patient care. It's about treating the patient, everything that has to do with the patient. So, it's not only treating the disease – the biological part of it. So, you consider the social background of the patient, you consider the psychological issues that they might have also. So, if the patient, say you are treating an HIV or TB patient, … maybe they live in a house where they can infect other people, where they can infect children. So, you need to also deal with that, the social background.* (WTS5.3, MBBCh 5, female student, 25 years).

> *So, for social determinants of health, we get taught to include a social history, and a social history will include things like … family history. But we also need to make sure that we look at the patient holistically in terms of occupation, finances, access to clean water, electricity, and all of those things that can affect the patient's health in the long term.* (SMS6.3, MBCHB 6, male students, 28 years).

Coordination of care

Various disciplines trained students on collaborative patient care, giving them insight on which patient's condition should be attended to by which discipline, including receiving back patients who had initially been referred to other disciplines. This aspect of students'

experience of PHC training gave the researchers an indication that the students had gained insight into the teamwork in patient care, which could only function well under proper coordination.

> *…they do teach us … to be able to identify different conditions, … knowing who is responsible or who can help on which particular condition and where is that person. So, you need to know and understand what a dietitian does, you need to know and understand what all these specialists to do. We know if I have a patient who is a diabetic … they need to change their lifestyles, I have to refer them to someone who will give them proper exercises and [diet] schedules …* (WTS5.5, MBBCh 5, male student, 23 years).

> *We are also taught that you don't only send them, you also have to check on their progress while they are still there [where you referred them to] because they'll have to come back to you again after they are done.* (KZSM5.2, MBChB 5, male student, 23 years).

Continuity of care

Continuity of patient care entailed arrangement of patient follow-up. GP attachment gave them the opportunity for training in continuity of care. The students had developed the sense of a life-long relationship between a patient and her/his clinician. The researchers could appreciate that students understood the meaning of being a clinician.

> *Well of course we are trained to … make follow-up, so we ask them [patients] to come back after [a] certain period of time based on the condition … they are having problems with. So that's basically how we see our doctors [trainers] doing it and then we just follow that.* (SMS6.5, MBChB 6, female student, 33 years).

> *… as part of our training also in Family Medicine, we have a week where we rotate [at] the GP's practice. So, within that week you get the exposure as well on the continuity of care and you get to be exposed to the relationship between GPs and their patients.* (WSS5.7, MBChB 5, female student, 24 years old).

Challenges experienced by students

Students had experienced challenges in training on PHC in tertiary settings. They found the practical application of PHC learning lacking in other settings and the training in PHC was found to be implicit as there was no clear structure outlining it, especially among specialist disciplines. The meaning of this experience for students was clear to the researchers – they had expectations of hands-on practice in PHC to implement the theoretical knowledge they had been given by their trainers.

Training in tertiary health facilities

The training at tertiary institutions was mainly conducted by specialist trainers. Students were of the view that it deprived them the exposure to PHC training settings. This statement from students gave the researchers the sense that students had evaluated their training experience in the various training sites and could clearly state their (sites) differences for PHC training.

> *… as medical students [we] are trained predominantly at tertiary institutions and those are on the opposite side of the spectrum to what primary health care is. So, we don't get much training in primary health care there… most of our exposure is to specialist care and tertiary care in the bigger academic hospitals as opposed to primary care.* (WTSM6.1, MBBCh 6, female student, 23 years).

> *So, I feel if we had more time in a clinic, where we will … have better experience in terms of primary health care.* (SMS6.5, MBChB 6, female student, 33 years).

Practical application of PHC lacking

Students had experienced deficiency in the practical application of the theory they had been taught on PHC, such that they would find it difficult to apply the theory on their own if called upon to do so. This meant that students were looking for opportunities to implement what they had been taught theoretically on PHC. They had been frustrated by the lack of such opportunities.

> *As for the primary health care, I think I can define some of the terms in the concept itself, but as for how I can apply it [PHC] and provide that kind of care, I would say "No."* (WTSM5.1, MBBCh 5, male student, 22 years). *… we are more theory-based and we lack practical skills.* (WTS5.4, MBBCh 5, male student, 23 years).

Training in PHC implicit

Students experienced training in PHC as implicit and left to the individual student to discover that a particular activity pertained to PHC, particularly in specialist disciplines. This conveyed the message to the researchers that training in PHC, as experienced by students, was not structured. It also meant that students were not being "sign posted" on PHC, guiding them properly on the implementation of PHC principles during the training.

> *I think it [training in PHC] is more of an individual [student's responsibility] … we usually become… more of primary [health care] physicians when we are in Family Medicine. When we get to other blocks we become surgeons, we become specialists like they want us to be.* (SMS6.2, MBChB 6, male student, 25 years).

> *I don't think it [training in PHC] is explicit. …[as] we focus mostly on the curative part,* (WTS5.4, MBBCh 5, male student, 23 years).

Trainers

The trainers also viewed PHC as an approach to health care, shared their experiences of the contribution of generalists and specialists in PHC training, the first patient encounter with the healthcare system, a multidisciplinary approach inclusive of specialists and the provision of comprehensive care through health promotion

and disease prevention. Like their students, the trainers also indicated the challenges they were encountering in training students in PHC.

Primary health care as an approach

The trainers conducted their training in PHC with the understanding that it was an approach to patient care, rather than a level of care. They regarded patient care as comprehensive, taking into consideration the social determinants of health which cut across every discipline. Regarding social determinants of health, the trainers indicated that they trained students to remember lifestyle modifications when managing patients. The student trainers had managed to impart this knowledge and practical exposure to their students as evidenced by students' similar responses to PHC as an approach to health care delivery.

> *We encourage our students, "when you write a discharge summary of this particular patient, always make sure on the discharge summary that you include lifestyle modifications. It's not just about writing paracetamol or augmentin or whatever it is. There has to be some concerted effort that you impart to the patient that he's going to adopt lifestyle modifications…"* (DWTT3, male trainer, Internal Medicine).

Training by generalists and specialists

Generalists

Family Medicine which is a generalist specialty, took the lead in the coordination of PHC training at the distributed training sites. A family physician indicated that they trained students to consult with any patient, regardless of their clinical condition, in PHC settings. In this way, family physicians regarded themselves as generalist medical practitioners, not confined to a specific area of practice.

> *if a student has a patient who's a pregnant woman who's come for anti-natal care, we [as family physicians] are there, if the student says I've got little John here who's 5 years old with severe malnutrition, we [as family physicians] are also there.* (AWST1, female trainer, Family Medicine).

Specialists

A surgeon also expressed surgeons' involvement in PHC. The researchers inherited the understanding that specialists were aware of the importance of applying the PHC principle of prevention, for example screening patients before the condition is clinically detected.

> *… they [surgeons] wrote a report saying seatbelts were needed … and eventually someone … implemented mandatory seatbelts and then they looked at the morality rate and the mortality rate went down. Now, that study was done by surgeons, it wasn't done by a family physician or primary health – it was done by surgeons because [of] the burden of disease that they were seeing, … So, screening for cancer is an important role, screening for breast cancer in this country is a very important role because it's such a common disease. So, educating around self-examination, those are things that we play a role in as surgeons and understand as surgeons because we know what the end role is. … So, I think that there's lots that surgeons can have to offer in that primary health care preventative component …* (DWTT5, male trainer, General Surgery).

First encounter with the healthcare system

Student trainers indicated that they trained students on basic medical conditions commonly encountered and presenting firstly at PHC settings, using a multi-disciplinary approach. It became evident that student trainers viewed the "first encounter with patients" at PHC important to train their students on. This was intended to equip the students to recognize the basic conditions that can be dealt with at PHC.

> *[At PHC], we teach them the basic mental illnesses that we come across, that are there in the communities on a daily basis, that's what we do. And how they identify those basic mental illnesses, and also emphasise the importance of …a multidisciplinary approach in terms of mental health and illnesses in psychiatry.* (CSMT2, female trainer, Psychiatry).

Comprehensive care

Trainers conducted student training with the understanding that it was comprehensive (holistic) care, offering service in the best interest of the patient. Students had to adopt a comprehensive approach in dealing with patients at PHC, rationalizing on their referral decision in the context of a multidisciplinary team. Only complicated patient conditions warranted referral. The principle of comprehensive patient care was related to the principle of "ubuntu" which, literally translated means "I am because you are" in the African context. This interpretation translated into student training whereby they were taught to manage a patient holistically.

> *So, in terms of the holistic approach, we train students to [respect the principle] of "Ubuntu" [comprehensive way of contexualising a patient's condition] - we do it in a much broader way, … we try and practice it to give students [the] exposure …* (DWTT5, male trainer, General Surgery).

> *So, for example, you see a patient who [needs] a lumber puncture, or you want to do thoracocentesis, … these are GP practices, you know… skills. Then they [students]'ll tell you that "I'm going to wait for ehm… neurology to do a lumbar puncture." I stopped them and said "No, the only time that you're going for a neurologist [referral] is when you have a complicated case where you are not sure." Now they do their own lumbar punctures.* (DWTT4, male trainer, Obstetrics and Gynaecology).

Coordination of care

The training was centered around the view that the generalist should take the lead in coordinating team-based care. To this end, students were trained on inter-professional collaboration where the primary health care practitioner encouraged team building for coordination of patient care. This principle conveyed the message of the importance of teamwork in clinical settings, discouraging treatment of patients in silos.

> *Well, in my view [the doctor at primary health care] is the doctor that should lead the team [to offer coordinated health care services].*

> *They should offer team-based care and leadership which isn't about "I run the team", but "how do I work with teams where I actually encourage leadership among the team members."* (DWTT1, male trainer, Family Medicine).

> *So, for example, we work with the psychologists, we work with the social workers on the floor. But for us, … we have what you call academic meetings, which students get involved in ….* (DWTT6, female trainer, Paediatrics).

Continuity of care

Training in this regard was achieved through longitudinal placement of student, whereby they would be in a training platform for an extended period of time. Student trainers also shared the perspective that PHC should be regarded as a continuum from district to tertiary health, that the care of a patient should be seamless from the PHC to tertiary institutions. The importance of a life-long relationship with a patient was hereby highlighted. The students were thus trained to develop interest in their patients demonstrated by follow-up enquiries, even if they refer patients to more specialized centers.

> *… the training platform has to actually be based on the service platform. So you build up continuity [of care] through longitudinal attachment* (DWTT1, male trainer, Family Medicine).

> *… in our 5th year of Family Medicine, we have decentralized learning where we take them to the health centres; part of it happens at district hospital level and part of it happens at a regional hospital, but most of it happens at the health centers.* (AWST1, female trainer, Family Medicine).

> *So, I think that there's lots that surgeons have to offer in that primary health care preventative component. Hepatitis B vaccine is so important to prevent hepatocellular carcinoma which becomes a surgical disease. We play a role in that continuum. That's when I talk about systems, …* (DWTT5, male trainer, General Surgery).

Challenges experienced by student trainers

The trainers' challenges in training students in PHC were mentioned as (1) those occasioned by training students at tertiary settings and (2) inadequacy of trainers at PHC settings. To the researchers this meant that the trainers were conscious of the inherent challenges in the process of training the students in PHC. The researchers further understood that some of these challenges could not be resolved by the trainers as they related to the training infrastructure.

Training in tertiary institutions

The challenge of training students at tertiary setting is that students are trained on patients devoid of primary health care symptoms, leading to theorization regarding the symptoms that patients presented with on arrival at PHC. Patient symptoms were already masked on arrival at tertiary settings, because of the clinical management already commenced at first encounter with patients and continued at secondary and tertiary settings.

> *So, I think that is one of the challenges that we have. We get patients who are referred, who have already been treated …at lower levels of care. By the time they come here, the symptoms are already masked because… the patient has already been given treatment, and that creates a challenge.* (CSMT4, male trainer, Obstetrics and Gynaecology).

> *… we are teaching them in an environment that is not a primary healthcare environment, we're teaching them, for instance, here … they see patients at a regional level… We're not teaching them about, uhm, if you were sitting at a primary health care clinic or in a community health clinic* (BKZT5, male trainer, General Surgery).

Lack of trainers at distributed platforms

It was a challenge for one trainer to send students to distributed learning platforms where there would be no specialist in his field to ensure continuity of specialized training at those sights. This gave the sense that specialists would have appreciated to be capacitated to deploy their specialist colleagues to the distributed training sites to facilitate PHC.

> *You see, in a sophisticated society in a first world environment these kids [medical students] would be looked after because wherever they go there would be someone there to hold their hands, but [in our case] where these kids are going there's often no one there [in my field] to hold their hands.* (BKZT5, male trainer, General Surgery).

Discussion

The study has outlined medical students' and their trainers' experiences in PHC training in accordance with the internationally known PHC attributes, their approach to PHC and the challenges they encountered in the training process.

PHC as an approach

The understanding of PHC as an approach, rather than a level of healthcare delivery seemed to have influenced both the trainers and their students' training experiences. For the students, they had experienced this approach when various disciplines (including specialists) empowered patients to actively participate in the management of their own conditions by educating them. Patient education is one of the focal points of PHC (31). Evidence indicates that empowering patients with self-efficacy through health education, defined as "one's belief in one's ability to succeed in specific situations," improves health outcomes (32). The trainers also drew students' attention to the importance of social determinants of health (SDH) which cut across all disciplines as an approach to healthcare delivery (33, 34). Trainers linked SDH, the benefits of which have been documented (35), to lifestyle modification practices for a comprehensive approach to patient care, instead of concentrating only on biomedical therapy. Therefore, the view of PHC as an approach to

health care formed the requisite basis for student training on patient education and SDH (1, 36).

Student trainers

Students had experienced the training on PHC as facilitated by both generalist and specialist trainers. They identified the discipline of Family Medicine as having played a major role in affording them the opportunity for exposure to PHC. There is evidence from other settings that the discipline of Family Medicine, as a generalist discipline, is well-place to train students in PHC (37, 38). However, the students were of the view that PHC training was not the sole responsibility of one department, but should be a shared responsibility among all departments, a view also supported by literature (39). Regarding the training on PHC, some students indicated that specialists tended to have a specialized rather than a comprehensive approach to patient care. This has led to the recommendation in other settings, that PHC be facilitated by generalists (40, 41). Family Medicine as a generalist specialty featured prominently in the training of students on PHC. However, specialists also indicated their contribution in this regard, as also backed by literature (42). The researchers in this study are of the view, in keeping with that of the students, that the training in PHC be a collaborative effort between generalists and specialists in each medical school.

Point of first patient contact

Literature has indicated that PHC is the first patient contact with the health system (2, 41). Student training in this regard entailed their exposure to an undifferentiated patient which called for recognition of the clinical condition, stabilization of patients presenting with emergency conditions and referral of those who required management at more specialized centers (43). The student trainers addressed this attribute by training students on common clinical conditions frequently encountered at PHC settings using a multidisciplinary approach. A collaborative approach among disciplines with respect to patients presenting at the entry level of the health system has been found to be a useful clinical tool in addressing diverse common conditions at PHC (44). Again, students indicated that they had experienced the discipline of Family Medicine taking the lead in initiating to patients at the first point of entry to the health care system (45).

Comprehensive care

Student training in comprehensive care entailed consideration of other factors that could influence the patient's wellbeing. They indicated that they were trained not to be disease-focused, but to factor in the patient's biopsychosocial context inclusive of the patient's individual and contextual aspects, exemplified by the patient's concerns and expectations about their conditions and community considerations, respectively. Globally, studies are beginning to show a move toward comprehensive patient care by all disciplines, including specialists (46, 47). Furthermore, students were also trained in health promotion and disease prevention which has been shown to ensure comprehensiveness in patient care (2, 48). The trainers tallied with their students in narrating their experiences in comprehensive care training. They emphasized patient-centered care based on rational clinical judgment, including patient referral to other disciplines (49). Students were encouraged to apply clinical reasoning, whereby every clinical decision taken is backed by evidence, which has been found to be the necessary skill toward comprehensive patient care (50, 51).

Coordination of care

Coordinated care has been described as the integration of health care among providers "across levels of care and time" (52); care that is patient-centered, taking into consideration the patient's needs and preferences (53), and sharing information among all the participants concerned with a patient's care, aimed at achieving safer and more effective care (54). In this study, students narrated that various disciplines trained them on collaborative patient care, giving them insight on which patient's condition should be attended to by which discipline, including receiving back patients who had initially been referred to other disciplines. The training was centered around the view that it is generalist practitioners at PHC facilities who should take the lead in coordinating team-based care (55). In this way, students were also introduced to inter-professional collaboration characterized by team building among health care practitioners (56, 57).

Continuity of care

Students experienced training in continuity of patient care through their involvement in patient follow-up. Patient load and fewer trainers made it difficult for students to properly appreciate the implementation of this skill in the busy tertiary training facilities, but the attachment to a community general practitioner (GP) afforded them the opportunity. The patient congestion experienced in tertiary training institution has been reported elsewhere (58), and the positive role played by GPs in training students on continuity of care has also been documented (59). The student trainers indicated that they achieved training in continuity of care through.

longitudinal placement of students in decentralized training platforms. At one of the institutions, student placements took up to 6 months in their fifth year of training. In a study that compared the performance of students having community-based longitudinal placements to those in traditional placements in the medical school, it was found that the students in longitudinal placement were not disadvantaged by the placement—the performance of the two groups using the objective structured clinical examination was found to be comparable (60). Prior to this study, another study had obtained similar findings (61). Effective longitudinal placements have been found to integrate core disciplines while affording students the opportunity for immersion in the training sites (62).

Challenges of students

Students narrated the challenges they faced regarding specialist participation in their training. Specialists encouraged the students to retrospectively reconstruct the initial patient presentation

scenario, to imagine the signs and symptoms of the patient at the point of first presentation. However, that presented a challenge to students as the signs and symptoms of patients then presenting at tertiary level had already been masked by the management they had been receiving on their way to the tertiary platforms. Thus, in the students' experience, training by specialists lacked the element of the undifferentiated patient with "red flags" (63), frequently encountered in PHC settings.

The other challenge pointed out by the students related to the implicitness of the training in PHC. They indicated that, during the training, it was left to the individual student to work out.

what would be applicable in PHC, particularly among specialist disciplines, where emphasis tended to be on specialized activities, and less so on PHC. Furthermore, although they had indicated that in their observation, PHC was applicable in every discipline they had rotated in, students found that very little effort was made by the trainers to highlight to them the scope that would be applicable in PHC. It was left unstructured, whereas in literature there is evidence of the effectiveness of a properly structured multi-disciplinary integrated PHC program (64).

Challenges of trainers

Like their students, trainers also experienced challenges in student training on PHC. These were also occasioned by students' training at tertiary settings and inadequacy of trainers at PHC settings. The trainers were also aware that at the tertiary training facilities, students encountered patients whose original symptoms and signs had already been masked. They tried improvisation by recreating the PHC patient presentation scenario. However, the specialist trainers acknowledged that students missed out on the hands-on experience at the point of patient entry to the health system (47). However, in spite of these tertiary training settings challenges, it must not be lost sight of that these settings are vital in exposing students to the endpoints of diseases as well as rare conditions (65). Furthermore, students had also expressed an opinion that PHC training should be the responsibility of each discipline. The view of this study researchers is that students and their trainers should maintain a continuous dialog on the signposting of information and skills applicable in PHC in each discipline that they rotate through.

The trainers, particularly specialists, also acknowledged that the number of specialist trainers in distributed training sites was inadequate. The specialists felt they needed to be physically involved in the decentralized training sites. Under these circumstances, literature has shown that outreach programs, whereby the university-based specialists visit students in the distributed platforms (66), as well as the enlisting of the services of community-based specialists, can support the requisite learning (67). This could also suggest that family medicine specialists (who adopt a generalist approach) could be entrusted by other specialists to attend to the specialist areas relevant for a medical practitioner who exits undergraduate training with a generalist overview of the practice of medicine (68). In a study conducted in South Africa, it has been demonstrated that Family Medicine can deliver a successful longitudinal integrated multidisciplinary clerkship among students (64).

Learning contexts and settings

In the four medical schools the training platforms comprised central and distributed settings. It does appear that the distributed training platforms provide the required context for the training in PHC. For example, students indicated that at those settings, the training was mainly conducted by generalist medical practitioners with a PHC approach in patient care, including community GPs. The approach entailed mainly prevention of disease and promotion of health. The context was also conducive for the four pillars of Starfield (5), to be put into practice. Students and their trainers explicitly expressed their concern regarding training in PHC at tertiary institutions which they described as not ideal. While it is important to expose students.

to hospicentric medicine to familiarize them with the management of patients with advanced disease conditions (69), PHC training is best placed in distributed training settings which are mainly within communities (70).

The experiences in PHC training vs. the understanding of PHC

In the previous publication on the "understanding" of the students and their trainers regarding PHC (authored by the same authors of this paper) (17), there was common understanding of PHC among them, in line with Starfield's four pillars of PHC, namely comprehensiveness, first contact access, coordination and continuity of care (24).

There were also areas of convergence and divergence among the students as a group and their trainers as another group. Some among each group understood PHC as an approach to healthcare delivery, while others understood it as a level of care practiced only in PHC settings (community health facilities, including clinics and district hospitals). Strangely enough, in the current study, when exploring their experiences in PHC training, both groups had experienced PHC as an approach to healthcare delivery to patients. The latter is in keeping with the WHO definition of PHC in this regard (2). Therefore, there was a clear discrepancy in "experiences" and "understanding" of PHC in this regard which requires further exploratory studies.

Furthermore, in the previous publication there was no consensus in the understanding on whether specialists needed to be involved in training students in PHC, with some students understanding specialists as part of the training in PHC and others expressing uncertainty in.

this regard (17). The difference of opinions was also evident among the students' trainers. However, in the current study students had experienced PHC training conducted by both generalists and specialists, although to a greater extent by generalists. With regard to students' trainers, they expressed involvement in PHC training and the significance of doing so. It would seem that, regardless of the understanding of both students and their trainers, the practical experience what that both specialists and generalists were involved in student training in PHC. This involvement is backed by literature (71). It is the view of the authors of this current paper that there is need for a decisive development of a collaborative partnership between specialist and generalist trainers in PHC in the four South African medical schools.

Study strengths and limitations

As far as the researchers of this study are aware, at the time when this study was conducted, there were none reporting on the experiences of students and their trainers in PHC in South African medical schools. However, the study was conducted in only four of the nine medical schools in the country at the time of the study. Although there might have been similarities between the selected medical schools and those which were left out, there might also have been significant differences between the two groups. This would therefore limit the transferability of this study findings to the other medical schools. Furthermore, students were not engaged on their assessment experiences in their training on PHC. This would have shed more light on their training experiences, as evidence indicates that assessment drives student learning (72).

Conclusion

The study has shown that students and their trainers (generalists and specialists) had experienced UG student training in PHC in line with the internationally recognized principles on the subject. Compared to specialist disciplines, Family Medicine, as a generalist discipline, was found to be better placed in distributed training sites to train students on in PHC, although specialists also indicated their roles. The view by students and their trainers that PHC is an approach rather than a level of care enhanced its training across disciplines. Training students in PHC by specialists in tertiary settings presented a challenge to both students and their trainers. Students experienced training in PHC as implicit and unstructured. To optimize training in PHC, it is recommended that more time be dedicated to distributed PHC training sites and supportive specialist outreach training programs be ensured in the South African medical schools.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

Ethics statement

The studies involving humans were approved by the Ethical Review Board of the University of KwaZulu-Natal in South Africa (Protocol reference number: HSS/2187/017D). 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. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

LM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. MM: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2024.1337140/full#supplementary-material

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Cultural adaptation of a self-review tool for health promoting universities in Bulgaria

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Introduction: The Health Promoting University initiative is unknown in Bulgaria, and the health promotion potential of Bulgarian universities has not been studied. In order to examine it, a suitable instrument is needed. The UK Healthy Universities Network provides an accessible Self-Review-Tool (SRT). Aim: To present the process of cultural adaptation of the SRT in Bulgarian language.

Methods: The standardized WHO methodology for cultural adaptation of instruments was followed in four stages: (1) Two language translations of the instrument into Bulgarian were made; (2) An expert Delphi discussion reached a consensus on specific health promoting (HP) terms, followed by a backward translation; (3) Pilot testing of the tool among university community representatives was conducted through a survey among a small sample, with independent responses to the SRT questionnaire followed by cognitive interviews; (4) Final revision of the instrument.

Results: Ten public health experts reached a consensus on the name of the initiative and various HP terms. Ten other respondents pre-tested the tool. Difficulties in responding the SRT concerned the meaning of some HP terms, complex words, the system of answers, limited applicability of some statements. Changes were made to 61 of the total 68 elements in the SRT.

Conclusion: All stages of the cultural adaptation were important for the final result. The adapted Bulgarian version of the SRT would be useful to Bulgarian universities that want to make a clear commitment to improving the health of their university community and the wider society.

KEYWORDS

health promoting universities and colleges, self-review tool, health promotion, healthy settings, cross-cultural adaptation

1 Introduction

Health Promoting Universities (HPUs) have proven to be effective settings for improving the health of the university communities—students, faculty, staff and the wider public over the last three decades (1–3). The HPU initiative has evolved into a global movement with regional, national and international networks established. These networks foster collaboration between HPUs across countries, regions and globally, providing valuable resources: strategic documents, action frameworks, practical application experience, good examples, case studies and assessment tools (2, 4–6).

To achieve designation as an HPU, the application of a "whole university approach" to health is a key prerequisite (1, 7, 8). This involves integrating health in all aspects of the institution's life, making it a core value of the university culture, and implementing processes and policies aimed at improving the health of the entire university community through activities at all possible levels (8).

The scientific literature reveals various methods by which HPUs evaluate their efforts and the effectiveness of their activities while striving to achieve "whole university" involvement. Typically HPUs use self-designed questionnaires, focusing on specific health issues such as students' risky health behaviors or health awareness. Additionally, interviews assessing health promotion (HP) activities are conducted with staff or representatives of the HPU initiative coordinators (3, 9, 10). These approaches measure the effectiveness of isolated actions among specific university groups under the HP label.

Given that the "whole university approach" is fundamental to the initiative, comprehensive assessment is necessary (11). In this process, the university should be viewed as a unified entity, and the assessment should encompass the health and behavior of people, the conditions of the university environment, and the built-in organizational structures. The involvement of all people of the institution in the planning and implementation of initiatives improving health and wellbeing is one of the main principles of HPU, and evaluating the participation of the entire university community aims to hear the voice of students, lecturers and staff (11, 12). A number of HPUs have conducted such complex assessments, while those that have not cite the absence of a suitable instrument as a barrier (10).

The UK (13) and the Chilean (14) networks provide questionnaires for comprehensive assessment of the HPUs. The German (15) and North American (16) networks have their own good practice standards. One of the tools that is freely available and therefore used by universities around the world is the UK Healthy Universities Network Self-Review Tool (13). It has been developed for use in all stages of institutional self-assessment.

The HPUs initiative is new to Bulgaria, and the potential of the Bulgarian higher education institutions as health promoting settings has not been studied. However international experience has proved that successful and sustainable implementation of the HPU initiatives depends on their adaptation to local needs, traditions and cultures of the respective countries (3, 9, 17). Earlier studies of HP initiatives and policies' transfer in Bulgaria reveal that international HP programs and documents, created in western environments, in English language may be more effective if culturally adapted to the specific Bulgarian context and language, which applies to all HP documents and instruments (18).

The aim of the present work is to present the process of cultural adaptation of the HPUs' Self-Review Tool into Bulgarian.

2 Materials and methods

2.1 The HPU self-review-tool

The original Self-Review Tool (SRT) is a resource of the UK Healthy Universities Network, developed and applied for assessing the whole system approach to health in the university environment (13). The tool is grounded in strategic HPU documents and criteria (11). It can be applied at all stages of HPU initiative implementation, for both initial and continuous self-assessment. The SRT generates a tabular color image of a "traffic light" type, indicating the degree of fulfillment of the HPU criteria. Green signifies over 70% fulfillment of HPU criteria, yellow indicates partial fulfillment (between 45 and 69%) and red indicates insufficient fulfillment (below 45%) signaling a need for future actions. It is recommended that the instrument be completed by a university team representing the main target groups—students, academic, administrative and management staff—to ensure the voice of the entire university community is "heard" (11). The original instrument is in English, consisting of 68 statements, grouped into five sections reflecting the key HP areas: Leadership and governance; Service provision; Facilities and environment; Communication, information and marketing; Academic, personal, social and professional development. Structured standard responses are provided after each statement, and respondents may also provide free text after each statement and section (13).

2.2 The cultural adaptation process

The development of the Bulgarian version of the SRT followed the WHO methodology for cultural adaptation of research instruments, aiming at conceptual rather than linguistic equivalence between the original and the final version of the tool in another language (19). This methodology, identified as best practice for cultural adaptation by researchers (20) comprises four successive stages as presented in Figure 1.

2.2.1 Forward translation

Two independent licensed translators, native Bulgarians with excellent knowledge of English language and culture, conducted forward translations of the original instrument from English into Bulgarian. The translations were then independently compared by two public health (PH) researchers and synthesized into one file, the first working Bulgarian version of the SRT.

2.2.2 Expert panel and back-translation

The expert panel was conducted in compliance with the applied WHO methodology, of which it was an integral part. Experts in the fields of PH and HP from one town, but from different health institutions were selected for invitation based on their educational background, research activities, and practical experience. Twelve potential respondents were invited via email to participate in the Delphi expert discussion. Each participant received: (1) a written description outlining the purpose of the Delphi discussion, (2) the original SRT, (3) the two independent Bulgarian translations, (4) the first Bulgarian version of the tool (synthesized from the two translations), and (5) a list of HP expressions, phrases and concepts, for which consensus needed to be reached by the experts regarding their presentation in the Bulgarian version of the tool. The invited specialists had to be fluent in English. The expert panel followed a structured discussion scenario aimed at achieving consensus on the Bulgarian wording of the specific HP terms (21). The outcome of the expert panel's work was the revised version of the SRT in Bulgarian.

Back translation—The revised instrument was translated back into English. In this case, the translator was not aware of the original instrument and the purpose of the study and was not involved in the first stage of the translations. The translator had to be native English

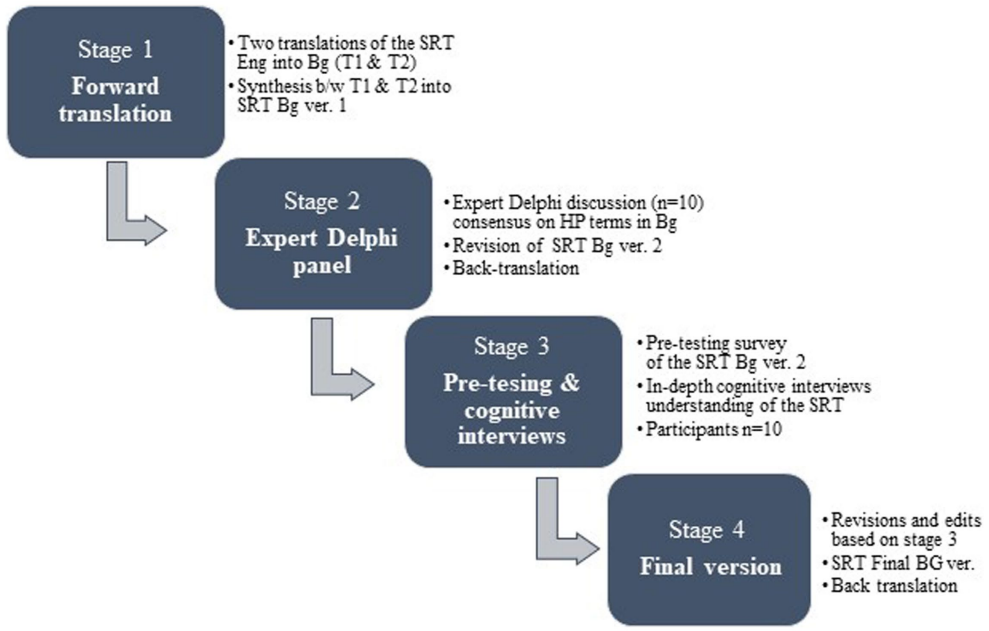


FIGURE 1
Stages of the cultural adaptation process of the HPU self-review tool in Bulgarian.

speaker, fluent in Bulgarian. The original and the new English version of the SRT were analyzed and compared for conceptual equivalence.

2.2.3 Pre-testing and cognitive interviewing

The Bulgarian version of the SRT underwent a pre-testing process. Representatives of the target groups (students, academic, administrative and university management staff) were invited and briefed on the purpose, methodology and their role in the study. Informed consent was sought and obtained. This stage occurred in two phases: (1) The SRT was administered to the participants online, through Google forms for independent survey completion (2) in-depth cognitive interviews were conducted with the respondents to gauge their understanding of specific HP terms, phrases, statements through interpersonal communication (22). Interviews were scheduled at the convenience of the participants, typically 7–20 days (with an average of 15 days) after the survey. Participants were asked to assess the clarity of statements, terms or phrases, and provide suggestions for alternative expressions. The duration of interviews ranged from 60 and 120 min, averaging 90 min. Interviews were recorded, transcribed, coded, and analyzed.

2.2.4 Preparation of final instrument version

At this stage, each respondent's answers to each statement was compared for consistency with survey responses. Each statement was reviewed and compared repeatedly for consistency with the original instrument. Comments, opinions and suggestions from participants in the interviews were taken into account in the final revision of the self-assessment tool in Bulgarian.

Additionally, a reverse translation from Bulgarian to English of the final version of the instrument was conducted. The translated document was provided to the creator of the original tool for review.

The study was conducted after approval from the University Ethics Committee (No 101/ 24.03.2021). Qualitative data analysis was performed using QSR NVivo v. 11 software, and graphical and tabular methods were applied to visualize the results.

3 Results

3.1 Stage 1 Cultural adaptation during forward translation and synthesis

The cultural adaptation process of the SRT to the Bulgarian context and language started with two independent translations from English into Bulgarian by professional licensed translators both native Bulgarian speakers fluent in English. Conceptual discrepancies arose between the two Bulgarian texts and the original document, which was anticipated given the translators' lack of familiarity with health promotion terminology. Two researchers independently compared the two Bulgarian translations to identify discrepancies between them and with the original document.

For example, one of the standard answers "Yes, we are there" was translated directly in Bulgarian as "Yes, we are present here," in one version and as: "Yes, we are active in this direction" in the other. The term "wellbeing" was translated with two different Bulgarian words with distinct meanings. The researchers reached consensus on each problematic expression, selecting the more appropriate translation. This selective synthesis resulted in the initial working Bulgarian Version 1.0 of the instrument, which underwent critical review in a subsequent Delphi expert panel discussion.

3.2 Stage 2 Delphi expert panel

The purpose of the Delphi expert panel was to revise the synthesized Bulgarian translation of the SRT to make it suitable for

application in a Bulgarian context. The rationale for choosing the method was the necessity for achieving expert consensus on the best Bulgarian conceptual rather than literary translation of specific health promoting terms and concepts used in the original SRT.

Ten out of the twelve invited experts participated in the Delphi panel, with nine women and one man, having a mean age of 52 years (median 14.2). All participants were Bulgarian experts in the field of public health and health promotion with significant research and teaching experience (Table 1). All participants had excellent knowledge of English, regularly teaching disciplines in the field of public health including health promotion in English language. A single round of Delphi discussion was conducted facilitated by the lead researcher. Criteria for consensus were predetermined as 75% agreement on specific wording for each discussed term/concept. The discussion lasted for 90 min.

Ten specific English HP terms were proposed to the experts for discussion. For each term at least one Bulgarian version was proposed (Table 2) with maximum 8 Bulgarian possibilities for the name of the initiative. The name of the initiative "Health promoting universities" was most continuously discussed, followed by the expression "whole system approach," and the seemingly straightforward English term "wellbeing." The final consensus on the Bulgarian wording for each term is presented in Table 2.

Following the expert decisions, a second Bulgarian Version of the SRT was developed and translated back into English, by a translator proficient in both English (as a native language), and Bulgarian. The resulting document was assessed by the researchers for conceptual differences with the original instrument. No significant discrepancies were found, leading to the creation of BG Version 2.0 of the SRT, which underwent pilot testing in the subsequent third stage.

TABLE 1 Characteristics of the participants in the Delphi expert panel.

Expert	Gender	Age	Research and teaching expertize
R1	Female	70	Health promotion, Public health
R2	Female	56	Health promotion, Public health
R3	Female	51	Public health, Health promotion, Sociology
R4	Female	68	Public health, Biostatistic
R5	Male	40	Health Promotion, Psychology
R6	Female	48	Public health, Health promotion
R7	Female	51	Health promotion, Public health
R8	Female	51	Public health, Health promotion
R9	Female	34	Public health
R10	Female	57	Public health, Health promotion

TABLE 2 Terms discussed and decisions adopted by the expert panel.

Terms in SRT	Number of discussed BG terms	Expert panel consensus in Bulgarian
Health Promoting University/ Healthy University	8	Университет за промоция на здравето
Self-review tool	2	Инструмент за самооценка
Wellbeing	3	Благополучие
Welfare	2	Благосъстояние
Whole system approach	3	Цялостен университетски подход
Community	3	Общественост
Local community	2	Местна общност
Mental wellbeing	2	Психично здраве
Engagement	2	Ангажиране
Stakeholders	1	Заинтересовани страни

3.3 Stage 3 pre-test and cognitive interviews

Ten participants were involved in the third stage of the adaptation process—four students, two administrative employees, two representatives of the academic staff and two members of the academic management. The age of the participants ranged from 19 to 53 years (median 34), nine of whom were women.

The participants first independently completed all questions from the BG Version 2.0, followed by cognitive interviews to discuss their difficulties related to the content, questions' understandability, clarity of proposed answers, and meaning of particular texts.

During the cognitive interviews the interviewer read the questions aloud with appropriate intonation and pauses to aid comprehension. This process revealed some difficulties experienced during the survey phase. A student remarked: "Now that you are reading it to me…" indicating improved understanding. Similarly a teacher mentioned: "…on the second reading…" suggesting enhanced clarity upon hearing the question read aloud.

The interviews not only helped the participants to understand the meaning of specific health promotion concepts, but also prompted them to recall relevant examples that informed their responses. Some remembered existing access for people with disabilities, others—health services provided by the institution related to dental health etc.

Some participants changed their opinion in the period between the self-completion and the interview stages. For instance an employee remarked while thinking aloud: "…but now I answer that…" indicating a shift in perspective. Additionally, after completing the instrument on their own, some participants began noticing existing activities within the university, that they previously overlooked. For example, a lecturer commented: "… then I saw that there are bicycle racks in the courtyards of two university buildings… that's an encouragement to travel by bike…"highlighting newfound awareness of university initiatives promoting health and wellbeing.

3.3.1 Understandability of HP terms and concepts

During the cognitive interviews specific attention was payed to the understandability of HP terms, both those discussed by the Delphi panel and any additional, identified by the interviewees.

Difficulties persisted with the understandability and clarity of expressions such as "whole system approach." During the interviews, the Bulgarian translation of "whole system approach" prompted questions about its precise meaning. After clarification by the interviewer, it was understood and accepted by the participants. This indicated that the term was unfamiliar to some respondents. However, once its meaning was explained, none of the respondents suggested a better alternative than the one agreed upon by the Delphi panel.

Similarly the Bulgarian translation of "external stakeholders" raised questions "who exactly are they?." Examples provided during the conversation helped clarify the term and the respondents suggested similar examples to be included in the text which was considered.

An interviewee from the academic staff highlighted the differentiation between "wellbeing" and "welfare," emphasizing the economic/financial aspects of welfare. This led to the decision to retain only the Bulgarian term for "wellbeing" in the tool.

Additionally, terms like "sustainable development" required additional clarification. It became evident during the interviews that the content of this term was unclear to respondents not familiar with health promotion and public health. Furthermore, there was a discrepancy in the interpretation of these terms between students and other respondents.

3.3.2 Understandability of other non-specific, but ambiguous terms/words

The term "strategy" whether used alone or in phrases as "strategic links," or "strategic planning" were perceived as complex. Similarly, the expression "the university ensures" in the context of statements as "the university ensures that health and wellbeing related strategic planning and delivery are inclusive" was initially translated into Bulgarian as similar to "the university guarantees." However the respondents were unsure how the university could guarantee inclusive strategic health planning and delivery. The term "guarantees" was deemed vague by all participants leading to its replacement with "the university aims to secure…" in Bulgarian.

The statement "free drinking water is available on campus" was understood as implying that bottled mineral water must be provided to the university community at no cost. The expression was described as both misleading and redundant. The statement was revised to "drinking water is accessible in all university buildings" in the final version of the tool.

The statement "the university has standards for accommodation to ensure that health and wellbeing…" led to confusion among participants, particularly regarding the Bulgarian word for "accommodation." Students interpreted it in the context of the student dormitories, while teachers and administrative staff thought of libraries, teaching rooms, working areas. The wording in the final version was adjusted to focus on the living areas accommodations.

3.3.3 Wording of statements and answers

One consequence of the translation of the original tool was the lengthening of the sentences in the Bulgarian version of the tool. The average number of the words per statement was 22.5 words, and the longest statement comprised 41 words. This led some respondents to perceive the instrument as "complex, written in a high style" and overly lengthy.

Participants agreed that providing examples, or clarifying terms with words in brackets, would enhance understanding. A student commented: "so, giving examples would be better because it makes it clearer to me"; an employee noted: "Yes, here the example suggests…." Some respondents—members of the academic staff and management tried to reason on behalf of another target group: "…I'm not aware of how familiar a student will be"—words of a teacher.

The section "Leadership and governance" was identified as the most difficult for the students, teachers and staff, whereas "Academic, personal, social and professional development" was deemed the easiest, management representatives finding all statements easy to answer.

Issues were reported with the understanding of the standard responses following each statement. The option "Not at all/Do not know" was confusing for many respondents, as it seemed contradictory. A student commented: "It turns out that I disagree… while I actually do not know." A teacher who disagreed with the wording explained his opinion "It implies simultaneously two very different hypothesis: either the university is not doing anything about an issue, or it is active but the respondent is not aware about it." Separating the two parts of this answer into distinct options addressed this confusion. Some respondents found it difficult to distinguish between the responses "Working on this currently"; and "Thinking about it." Some of the comments implied that the thinking process in the institution was a step from the working process. So, the final version of the Bulgarian instrument had the following standard answers: Yes (corresponding to "Yes we are there"); To some extent (corresponding to "Working on this currently"); No; Do not know.

3.3.4 Limited applicability of certain statements

Certain statements in the SRT were deemed not directly applicable to certain respondents. For example, students found it difficult to express opinions about opportunities for professional development offered to teachers and staff. Students, faculty and administrative staff had lower awareness about university policy, strategic planning and budgeting issues than academic leadership respondents.

In total 61 (89.7%) of 68 statements in the working BG Version 2.0 were revised, based on the results of the testing. The changes mainly focused on simplifying wording, reordering words, replacing ambiguous terms, and eliminating misleading or redundant phrases. The final version, designated as BG Version 3.0, was then used for the self-assessment process.

4 Discussion

This paper describes the systematic cultural adaptation process of a specific instrument designed for self—assessment of a health-promoting higher educational institution (university, campus, college etc.) referred to as the SRT. Our aim was to develop a conceptually relevant Bulgarian version of the instrument suitable for a culture different from the original western European context in which the tool was initially developed and applied (13). While the SRT had been applied in institutions outside the UK, it had not been culturally adapted for non-English speaking cultures until this study.

The cultural adaptation of the HPU Self-Assessment Tool in Bulgarian was justified and initiated based on previous research indicating the applicability and effectiveness of international documents in the field of HP, including in Bulgaria (18, 23).

It was recognized that such cultural adaptation is not only important, but also essential, as even translations edited by experts, as in the expert Delphi panel in this study, could not ensure full understanding of HP-related texts by the wider university community.

Despite following an internationally recognized methodology for cultural adaptation, the process did not progress quickly and smoothly. This could be primarily attributed to the lack of familiarity with HP concepts in Bulgaria such as the "healthy settings initiative" and with

the role of educational environments in promoting health, particularly the HPU. Additionally, there was a scarcity of strategic HP documents in Bulgarian and recognizable real-life examples, as, e.g., the HP schools, which could have served as a foundation for the HPU initiative (24).

According to leading HP experts in our country, the adoption of the philosophy of HP in Bulgaria is accompanied by a number of difficulties. One of them is related to specificities of the political culture across all social domains, characterized by a high degree of centralization of management and high-power distance between top and lower levels in institutions, including educational ones (18). On the other hand, there are barriers related to the interpretation of the concept of HP itself.

Created in countries with Western European culture, the terminology is difficult to adapt to the Bulgarian language and culture (18). Even today the HP concepts are defined as insufficiently theoretically developed and practically applied in Bulgaria (25).

Pinto et al. (26) note that HP instruments developed on the basis of generally accepted HP principles need to be adapted to the specific cultural characteristics before their application in diverse national contexts.

In our case the entire cultural adaptation process of the SRT took approximately 10 months. A similar duration was reported for the adaptation of a smoking prevention questionnaire to the Bulgarian language (18) which is comparable to reports by other authors (27).

Some studies validating foreign instruments, report no major discrepancies between the first-stage translations and the original document (28). Others like ours find poor comparability between the translations and the original texts, attributing this to the translators' focus on wording rather than meaning (29).

All stages of the methodology applied by us proved to be important for achieving the intercultural adaptation. The work of the Delphi Expert panel and the pilot-test stage with the participation of representatives from the entire university community were particularly useful. Our experience is supported by other researchers. Oliveira and Bandeira (30) identified these two phases as significant for the successful adaptation of a psychological instrument assessing personality structure and organization to Brazilian culture and traditions.

Expert input was essential for the adaptation of HP terminology but insufficient. It was found that even after the decisions of the Delphi panel, difficulties in understanding some terms and concepts, especially among students persisted. This might be attributed, on one hand, to the professional bilingual competence of the experts. Such hypothesis was proposed by Norwegian researchers working on the cultural adaptation of an English language instrument (29). Experts fluent in English more easily understand the concepts in their language, which does not automatically apply to a monolingual target population (29). On the other hand, while experts use HP terms freely and routinely, these terms are rarely present in daily Bulgarian speech, explaining the differential understanding between experts and the wider audience.

Thus, testing among representatives of the university community proved to be a particularly useful procedure. The active participation, comments and suggestions of the participants greatly aided the cultural adaptation in our research. This was also confirmed by Oliveira and Bandeira (30), according to whom this stage led to the clarification of confusing and misinterpreted elements. Squires et al. (31) described the cultural adaptation of an instrument in 12 European countries, in 11 languages. For the purpose of their study, the adaptation methodology included translations of the original instrument into the target languages and expert panels were held three times. It was found that in one of the countries, Poland, the process of cultural adaptation was impossible without pilot testing, which turned out to be the key success factor.

The apparent difficulties with testing the instrument among some respondents led to the conclusion that not all statements are equally applicable to all participants. According to Chengelova (32), survey questions should correspond to the competence and level of awareness of the social group to which respondents belong. The creators of the original SRT recommended that it should be completed not individually but by a team of representatives from the entire university community (11). Thus, various statements would receive answers from respondents who are competent to provide an opinion on behalf of their target group.

The cultural adaptation of the SRT in our study resulted in a change in 61 of the total 68 statements. Similar results were reported by Lopatina et al. (33), discussing the adaptation of a WHO health literacy assessment tool for Russian-speaking populations in Germany, Israel, Russia, Kazakhstan, and the United States. The linguistically and culturally adapted instrument in Russian was obtained after changing 95% of the questions.

An interesting, but also sought after and expected effect of our research was the popularization of the HPU initiative among the study participants. They shared their positive attitude because their opinion was sought and valued. Respondents showed interest and paid attention to health promotion activities at the university that they had not noticed before.

One possible limitation of our study is the convenience sampling of respondents in the Delphi expert panel. However, the choice of participants could not affect the content of the questionnaire, as the discussion focused on achieving the best possible Bulgarian wording for all the questions from the international instrument, rather than determining which questions to include. A second limitation is that the study was conducted within a specific higher education institution predominantly offering teaching in health and medical specialties and disciplines. However, this does not limit the opportunities for the proposed instrument to be tested in other organizations. On the positive side, we can highlight that this is the first systematic cultural adaptation of a self-assessment tool for the HPU in Bulgarian language.

5 Conclusion

The presented cultural adaptation process of the HPU self-assessment tool confirms earlier experience that the cross-cultural adaptation of theoretical HP documents to the Bulgarian language and culture is a difficult but an essential process. It creates prerequisites for the ideas, concepts and practical experiences of established HPU to be adopted and developed in Bulgarian higher education institutions. Such a process should always be considered in situations aimed at the application of public health or health promotion policies, strategic documents or instruments in societies with cultures different from the Western Europe and languages other than English.

What follows from now on? We hope that the "HPU Self-Assessment Tool" in Bulgarian will be implemented in other Bulgarian

universities to assess their potential to become part of the HPU initiative.

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 Комисия по етика на научните изследвания (КЕНИ) на МУ Варна/Committee on ethics of scientific research of the Medical University of Varna. 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

PB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. KD: Conceptualization, Formal analysis, Methodology, Supervision, Writing – review & editing.

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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.

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Knowledge, attitudes, practice, and public health education demand regarding PARI prevention: a cross-sectional study among Chinese undergraduates

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Objectives: The purpose of this study was to assess the level of knowledge, attitudes, and practices (KAP) of university students in China regarding the need for PARI and public health education.

Methods: A cross-sectional online and offline survey was conducted in China website through Wenjuanxing and in different cities such as Changsha Hunan Province, Shanghai, Chongqing and in different public scenarios, such as hospitals, universities, and commercial venues between September 1 and September 7, 2023, using a 28-question questionnaire designed and reviewed by multidisciplinary experts.

Results: A total of 4,096 respondents were recruited for this study, with 3,957 valid questionnaires. The mean knowledge score was 1.84 ± 0.52, the mean attitude score was 2.12 ± 0.51, and the mean practice score was 3.18 ± 0.55. Regression analyses found that: region, grade, school, and weekly anaerobic exercise time were influences on the knowledge score; region, grade, school, and weekly anaerobic exercise time were influences on the attitude score; region, grade, school attended, weekly anaerobic exercise time and weekly anaerobic exercise time as influences on the practice score. Subgroup analyses revealed that undergraduates from southern regions and 985 schools had higher knowledge attitude scores and lower practice scores. As the grade level increased, the knowledge and attitude scores showed a V-shaped trend and the behavior scores showed an inverted V-shaped trend. Correlation analysis found a positive correlation between knowledge and attitude scores, and a negative correlation between both and behavior, respectively. The public health education needs survey found that undergraduate students generally preferred guided instruction methods and content centered on the RICE principles, they preferred learning through books and pamphlets, and they were happy to see relevant content promoted in the campus environment.

Conclusion: This study shows that Chinese undergraduate students have less knowledge, neutral attitudes, and good behaviors regarding PARI prevention. Special attention should be paid to meeting the needs of undergraduate students for public health education to equip them with relevant knowledge so that they can better behave in PARI prevention.

KEYWORDS
PARI, undergraduates, public health education, KAP, public health

1 Introduction

Physical activity-related injuries (PARI) are becoming increasingly prevalent among Chinese undergraduates (1, 2), reflecting a broader trend observed in various physical activities worldwide. These injuries encompass a wide range, from minor sprains and strains to more severe cases like fractures and concussions (3). Such injuries often occur abruptly during sports or physical exercises. They not only impede the continuation of activities but can also lead to long-term health consequences (4).

In the context of China's rapidly growing engagement in sports and physical activities, especially among university students, these injuries pose a significant challenge (4, 5). Adults and youth participating in these activities are susceptible to different types of injuries (6). Adults commonly report joint and muscle strains, while younger individuals might experience injuries unique to their developing bodies, such as growth plate injuries (7).

These incidents can substantially impact an individual's daily life, leading to reduced physical activity levels and, consequently, affecting overall health and well-being (8). If not properly managed, PARI can evolve into chronic problems and heighten the risk of re-injury (9, 10).

Although the incidence of such injuries is increasing, several relevant studies conducted by previous investigators have found that there is a significant lack of awareness and understanding of the prevention of such injuries (5, 11, 12). Deficiencies in this area may result in inadequate PARI prevention and management strategies, exacerbating the risk of injury and hindering recovery (13–15).

However, there is a paucity of data with large-scale samples focused on China regarding the knowledge, attitude, and practice (KAP) regarding PARI prevention and public health education demand among undergraduates. The undergraduate phase may be accompanied by an increase in high-risk behaviors, leading to health issues such as sports injuries (2, 11, 13). Through research, it is possible to better understand the causes of these behaviors and develop effective prevention and intervention measures. Therefore, the purpose of this study is to assess the current KAP levels and to investigate the public health education needs of Chinese undergraduates for the prevention of PARI. In addition, we further explored the influencing factors for the current KAP level and the public health education demand help to determine whether there exist correlations between the demographic data and medical the current KAP level and the public health education demand, respectively.

2 Methods

2.1 Participants

Before distributing the survey, the minimum sample size was calculated using G*Power (version 3.1; Heinrich Heine University) to achieve a power of 0.80. In the G*Power software, a logistic regression test was conducted for *a priori* power calculation with an odds ratio (OR) of 1.2 and a significance level of 0.05. The minimum sample needed to achieve a power of 0.99 was 3,460 for our study. Considering the missing and non-responsive cases, we expanded it by 10%, yielding a predicted sample size of 3,806 (16).

In the present study, the population was undergraduate students enrolled in Chinese universities. Those who were unwilling to participate were not invited.

In the process of data screening, the inclusion criteria were: ① undergraduate students enrolled in Chinese universities; ② volunteered to participate; ③ competent to comprehend the content of the questionnaire; ④ signed informed consent form. The exclusion criteria were: ① those who answered contradictory or factual content; ② the response time was ≤80s.

2.2 Ethics approval

Ethical approval regarding human subject research was obtained from the Ethics Committee on Third Xiangya Hospital of Central South University (approval number: Fast24084). Informed consent was obtained from each participant online by placing a question about their agreement to participate in the study at the beginning of the survey. Participants were assured of the confidentiality and anonymity of this study and their rights to exit at any time. We declare that the data were collected for academic use only.

2.3 Instrument

The primary version of the questionnaire was developed in Chinese by an investigation team based on a deep literature review of comparable studies and international guidelines (17–19).

Researchers randomly invited 8 participants face-to-face from the general population to answer the questionnaire online for pretext and collected their feedback about the comprehensibility of questions and options.

Two experts in the field of PARI reviewed these responses and each item of the survey and confirmed the final version of a 28-item questionnaire (see Supplementary Material). It comprised basic demographic data and 4 sections about knowledge, attitudes, practices, and demand regarding popular healthcare toward sports health.

A series of options were listed with points for each question. The way in which the options correspond to the points is shown in Table 1. The total scores for knowledge, attitude and practice in PARI were 24. Cronbach's a was >0.7 for each scale (0.823 for knowledge, 0.811 for attitude and 0.842 for practice).

2.4 Procedures

The cross-sectional survey was conducted in China between 1st September and 7th September 2023, using a 28-item questionnaire designed and reviewed by multidisciplinary experts (see Figure 1).

The general Chinese adult population was randomly invited online and offline. Participants were informed that the survey was

TABLE 1 Scoring method.

Option	Point	Option	Point	Option	Point
Not at all	1	Strongly disagree	1	Seldom	1
Not clear	2	Disagree	2	Sometimes	2
Clear	3	Agree	3	Often	3
Completely clear	4	Strongly agree	4	Always	4

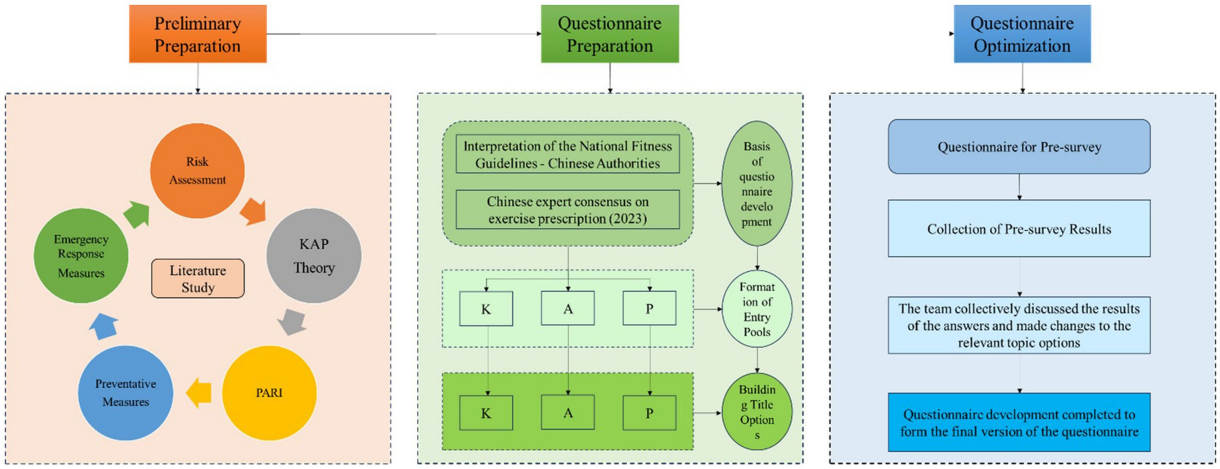


FIGURE 1
Questionnaire production flowchart.

based on voluntary principles and that their data would be anonymous and confidential. First, our investigation team created a questionnaire QR code (quick response code) by Wenjuanxing,[1] which is an online questionnaire platform widely used in academic studies in China. Then, researchers distributed the QR code using Chinese popular social media to get access to the general populations as many as possible, including WeChat and QQ. In addition, 3 researchers performed face-to-face invitations to scan the QR code in possible surveyed populations in different cities such as Changsha Hunan Province, Shanghai, Chongqing and in different public scenarios, such as hospitals, universities, and commercial venues.

Participants' IP addresses were restricted to ensure only 1 submission. The chief researcher was responsible for checking the collected data from Wenjuanxing, and 3.39% of submitted questionnaires were excluded for invalid response times and logistic errors.

2.5 Main outcomes

The main outcomes include scores of each 3 parts: knowledge, attitude and practice and the answer to the questions of the public health education demand part.

2.6 Covariates

Gender, region, grade, school, duration of aerobic exercise per week and duration of anaerobic exercise per week.

We have divided China into six regions. Heilongjiang, Jilin, and Liaoning provinces belong to the northeast region of China. Inner Mongolia Autonomous Region, Shanxi Province, Hebei Province, Beijing Municipality, and Tianjin Municipality belong to the northern region of China. Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Anhui, and Jiangxi provinces belong to the eastern region of China. Henan, Hainan, Hubei, Hunan, Guangdong, Guangxi Zhuang Autonomous Region and Hainan belong to the south-central region of China. Tibet Autonomous Region, Sichuan Province, Yunnan Province, Chongqing Municipality, Guizhou Province belong to the Southwest region of China. Xinjiang Uygur Autonomous Region, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, and Shaanxi Province belong to the northwestern region of China.

In China, we generally have a way of classifying schools into 985 project universities, 211 project universities, public universities, and private universities. Their comprehensive strength and student quality decrease in turn. Thus, in this study, we also use this type of classification to categorize the schools that the participants are in.

The team referred to the "Interpretation of the <National Fitness Guidelines>" and the "Expert Consensus on Exercise Prescription (2023)" (19) for the description of daily recommended exercise duration. The team decided to set the weekly aerobic exercise duration

1 https://www.wjx.cn

interval as 2 h, i.e., weekly aerobic exercise duration ≤2 h, >2 h and ≤4 h, >4 h and ≤6 h, and >6 h. In addition, the weekly anaerobic exercise duration interval was set to 1 h, i.e., weekly aerobic exercise duration ≤1 h, > 1 h and ≤2 h, >2 h and ≤3 h, and >3 h.

2.7 Statistical analysis

Data were summarized as means and standard deviations for continuous variables and percentages for categorical variables. Comparisons between groups were made using t-tests and chi-square tests. ANOVA analysis, multivariate logistic regression model and multiple linear regression model was used to assess the association between various demographic factors and KAP levels and public health educational needs. The relationship between KAP was determined using Pearson correlation. Also, subgroup analyses will be conducted to further assess the stability of the associations between KAP by subgroups of gender, age, location, school location, grade level, aerobic exercise time, and anaerobic exercise time. All statistical analyses were performed using R 4.3.2 and two-sided tests with a significance level of 5% ($p < 0.05$).

3 Results

3.1 Baseline characteristics of individuals

The study surveyed 3,957 individuals (see Table 2). The gender distribution was nearly equal with 1,971 males (49.81%) and 1,986 females (50.19%). Participants were from various regions of China (see Supplementary Figure S1), with the majority from East China (56.79%), followed by South Central China (17.03%), Northeast China (8.24%), North China (6.75%), Northwest China (6.47%), and Southwest China (4.73%). The respondents were spread across academic grades, with 21.51% freshmen, 30.40% sophomores, 29.59% juniors, and 18.50% seniors. Regarding their university type, 15.31% attended Project 985 universities, 13.77% were from Project 211 universities, 46.78% were from state universities, and 24.13% from private universities. For aerobic exercise, 54.36% exercised less than 2 h per week, 27.82% for 2 to 4 h, 11.55% for 4 to 6 h, and 6.27% for more than 6 h. For anaerobic exercise, 28.38% exercised less than 1 h per week, 33.13% for 1 to 2 h, 26.91% for 2 to 3 h, and 11.57% for more than 3 h per week.

3.2 Knowledge of PARI prevention

The average score for the knowledge section was 1.84 ± 0.52. Upon examining the scores of each section, it was observed that the PARI risk assessment (1.84 ± 0.69) mirrored the overall level of knowledge, whereas familiarity with PARI preventative measures was higher (1.88 ± 0.67), and knowledge regarding PARI emergency response measures was comparatively lower (1.81 ± 0.90). Subsequent subgroup analysis (see Table 3) revealed that scores were higher in the Central and Southern regions (1.98 ± 0.61), and the level of knowledge demonstrated a "V-shaped" trend with advancing grades. Additionally, it was discovered that respondents from Project 985 universities (2.3 ± 0.7) and those who engaged in less than 1 h of anaerobic exercise weekly (2.01 ± 0.62) scored higher.

Following this, we explored the factors influencing the overall score and the scores of the 3 sections. The results of the univariate analysis (see Supplementary Table S1) indicated that region, grade, school, and weekly duration of anaerobic exercise were significant factors influencing the overall score ($P < 0.001$); these same factors also affected the scores for PARI risk assessment ($P < 0.001$), PARI preventative measures ($P < 0.001$), and PARI emergency response measures (region: $P < 0.05$; school, and weekly duration of anaerobic exercise: $P < 0.001$). To eliminate the inter-correlation among independent variables, a multivariate linear regression analysis was conducted, which excluded the influence of grade on PARI risk assessment and the influence of region on PARI emergency response measures (see Supplementary Table S2).

Finally, focusing on each question, it was found that the majority of respondents were unaware of the answers (choosing "completely unaware" or "unaware") for most questions, exceeding 75%. The percentage of respondents selecting each option for every question is shown in Supplementary Figure S2. Subsequently, we analyzed the

TABLE 2 Demographics.

Item		Data	
		n	%
Population		3,957	/
Gender	Male	1,971	49.81
	Female	1,986	50.19
Region	East China	2,247	56.79
	North China	267	6.75
	Northeast China	326	8.24
	Northwest China	256	6.47
	South Central China	674	17.03
	South West China	187	4.73
Grade	Freshman	851	21.51
	Sophomore	1,203	30.40
	Junior	1,171	29.59
	Senior	732	18.50
School	Project 985 University	606	15.31
	Project 211 University	545	13.77
	State University	1,851	46.78
	Private University	955	24.13
Duration of aerobic exercise per week	Less than 2 h	2,151	54.36
	2 ~ 4 h	1,101	27.82
	4 ~ 6 h	457	11.55
	More than 6 h	248	6.27
Duration of anaerobic exercise per week	Less than 1 h	1,123	28.38
	1 ~ 2 h	1,311	33.13
	2 ~ 3 h	1,065	26.91
	More than 3 h	458	11.57

TABLE 3 Knowledge scores by subgroup.

First-level items	Second-level items	Total		PARI risk assessment		PARI preventive measures		PARI emergency measures	
Overall		1.84 ± 0.52	1.72(1.44,2.11)	1.84 ± 0.69	1.50(1.50,2.50)	1.88 ± 0.67	1.67(1.33,2.33)	1.81 ± 0.90	2.00(1.00,2.00)
Gender	Male	1.85 ± 0.52	1.67(1.50,2.00)	1.83 ± 0.68	1.50(1.50,2.50)	1.87 ± 0.67	1.67(1.33,2.33)	1.79 ± 0.88	2.00(1.00,2.00)
	Female	1.86 ± 0.52	1.83(1.50,2.17)	1.85 ± 0.69	1.50(1.50,2.50)	1.89 ± 0.67	1.67(1.33,2.33)	1.82 ± 0.92	2.00(1.00,2.00)
Region	Northeast China	1.77 ± 0.46	1.72(1.44,2.04)	1.78 ± 0.66	1.50(1.50,2.00)	1.79 ± 0.60	1.67(1.33,2.00)	1.74 ± 0.91	1.00(1.00,2.00)
	North China	1.85 ± 0.57	1.72(1.44,2.11)	1.85 ± 0.74	1.50(1.25,2.50)	1.95 ± 0.72	1.67(1.33,2.33)	1.76 ± 0.89	2.00(1.00,2.00)
	East China	1.8 ± 0.48	1.72(1.44,2.06)	1.80 ± 0.66	1.50(1.50,2.00)	1.82 ± 0.61	1.67(1.33,2.00)	1.79 ± 0.90	2.00(1.00,2.00)
	South Central China	1.98 ± 0.61	1.83(1.50,2.39)	1.96 ± 0.72	2.00(1.50,2.50)	2.08 ± 0.80	2.00(1.33,2.67)	1.90 ± 0.91	2.00(1.00,2.00)
	Southwest China	1.88 ± 0.56	1.78(1.50,2.17)	1.87 ± 0.72	1.50(1.50,2.50)	1.97 ± 0.70	2.00(1.33,2.33)	1.81 ± 0.87	2.00(1.00,2.00)
	Northwest China	1.89 ± 0.54	1.78(1.44,2.22)	1.9 0 ± 0.71	2.00(1.50,2.50)	1.91 ± 0.70	1.67(1.33,2.33)	1.86 ± 0.91	2.00(1.00,2.00)
Grade	Grade 1	1.93 ± 0.56	1.83(1.50,2.28)	1.92 ± 0.73	2.00(1.50,2.50)	2.01 ± 0.75	2.00(1.33,2.33)	1.85 ± 0.90	2.00(1.00,2.00)
	Grade 2	1.87 ± 0.55	1.78(1.44,2.17)	1.85 ± 0.66	1.50(1.50,2.50)	1.91 ± 0.70	1.67(1.33,2.33)	1.84 ± 0.92	2.00(1.00,2.00)
	Grade 3	1.76 ± 0.45	1.72(1.44,2.00)	1.76 ± 0.65	1.50(1.00,2.00)	1.76 ± 0.55	1.67(1.33,2.00)	1.76 ± 0.88	2.00(1.00,2.00)
	Grade 4	1.82 ± 0.52	1.72(1.44,2.06)	1.85 ± 0.70	1.50(1.50,2.50)	1.85 ± 0.65	1.67(1.33,2.33)	1.77 ± 0.90	2.00(1.00,2.00)
	Grade 5	1.90 ± 0.59	1.78(1.50,2.11)	1.92 ± 0.70	2.00(1.50,2.00)	1.99 ± 0.74	2.00(1.33,2.33)	1.78 ± 0.90	2.00(1.00,2.00)
School	Project 985 University	2.30 ± 0.70	2.33(1.72,2.83)	2.26 ± 0.76	2.50(1.50,3.00)	2.52 ± 0.88	2.67(1.67,3.00)	2.13 ± 0.93	2.00(1.00,3.00)
	Project 211 University	1.81 ± 0.47	1.72(1.50,2.06)	1.82 ± 0.66	1.50(1.50,2.50)	1.83 ± 0.60	1.67(1.33,2.00)	1.77 ± 0.88	2.00(1.00,2.00)
	State University	1.75 ± 0.43	1.72(1.44,2.00)	1.75 ± 0.64	1.50(1.50,2.00)	1.76 ± 0.56	1.67(1.33,2.00)	1.75 ± 0.88	2.00(1.00,2.00)
	Private University	1.74 ± 0.43	1.67(1.42,2.00)	1.75 ± 0.64	1.50(1.00,2.00)	1.74 ± 0.52	1.67(1.33,2.00)	1.73 ± 0.89	1.00(1.00,2.00)
Duration of aerobic exercise per week	Less than 2 h	1.85 ± 0.53	1.78(1.44,2.17)	1.85 ± 0.69	1.50(1.50,2.50)	1.90 ± 0.68	1.67(1.33,2.33)	1.80 ± 0.89	2.00(1.00,2.00)
	2 ~ 4 h	1.84 ± 0.52	1.72(1.44,2.11)	1.83 ± 0.68	1.50(1.50,2.50)	1.88 ± 0.66	1.67(1.33,2.33)	1.81 ± 0.90	2.00(1.00,2.00)
	4 ~ 6 h	1.82 ± 0.51	1.72(1.44,2.06)	1.82 ± 0.68	1.50(1.50,2.50)	1.85 ± 0.65	1.67(1.33,2.00)	1.80 ± 0.93	2.00(1.00,2.00)
	More than 6 h	1.80 ± 0.55	1.72(1.44,2.00)	1.81 ± 0.69	1.50(1.50,2.00)	1.79 ± 0.68	1.67(1.33,2.00)	1.81 ± 0.90	2.00(1.00,2.00)
Duration of anaerobic exercise per week	Less than 1 h	2.01 ± 0.62	1.89(1.56,2.44)	1.99 ± 0.73	2.00(1.50,2.50)	2.14 ± 0.79	2.00(1.33,3.00)	1.91 ± 0.92	2.00(1.00,2.00)
	1 ~ 2 h	1.78 ± 0.47	1.72(1.44,2.06)	1.77 ± 0.65	1.50(1.50,2.00)	1.78 ± 0.59	1.67(1.33,2.00)	1.78 ± 0.90	2.00(1.00,2.00)
	2 ~ 3 h	1.76 ± 0.44	1.72(1.44,2.00)	1.79 ± 0.66	1.50(1.50,2.00)	1.75 ± 0.55	1.67(1.33,2.00)	1.74 ± 0.87	2.00(1.00,2.00)
	More than 3 h	1.80 ± 0.50	1.72(1.44,2.04)	1.81 ± 0.70	1.50(1.00,2.00)	1.82 ± 0.65	1.67(1.33,2.00)	1.77 ± 0.90	2.00(1.00,2.00)

selection frequency of each option for every question in different subgroups and found the responses to be similar to the overall trend, as shown in Figure 2.

3.3 Attitude of PARI prevention

The average score for the attitude section was 2.12 ± 0.51. Observing the scores across different sections, the PARI risk assessment (2.11 ± 0.66), PARI preventative measures (2.14 ± 0.61), and PARI emergency response measures (2.10 ± 0.87) were consistent with the overall attitude. Subsequent subgroup analysis (see Table 4) revealed more positive attitudes in the Central and Southern (2.29 ± 0.61) and Southwestern regions (2.22 ± 0.58), with a "V-shaped" trend in attitudes corresponding with ascending grade levels. Additionally, respondents from Project 985 universities (2.59 ± 0.69) and those engaging in less than 1 h of anaerobic exercise weekly (2.28 ± 0.64) demonstrated more positive attitudes.

Further investigation into the factors influencing the overall and individual section scores was conducted. Univariate analysis results (see Supplementary Table S3) showed that region, grade, school, and weekly duration of anaerobic exercise were significant factors for the overall score (P<0.001), and similarly influenced the scores for PARI

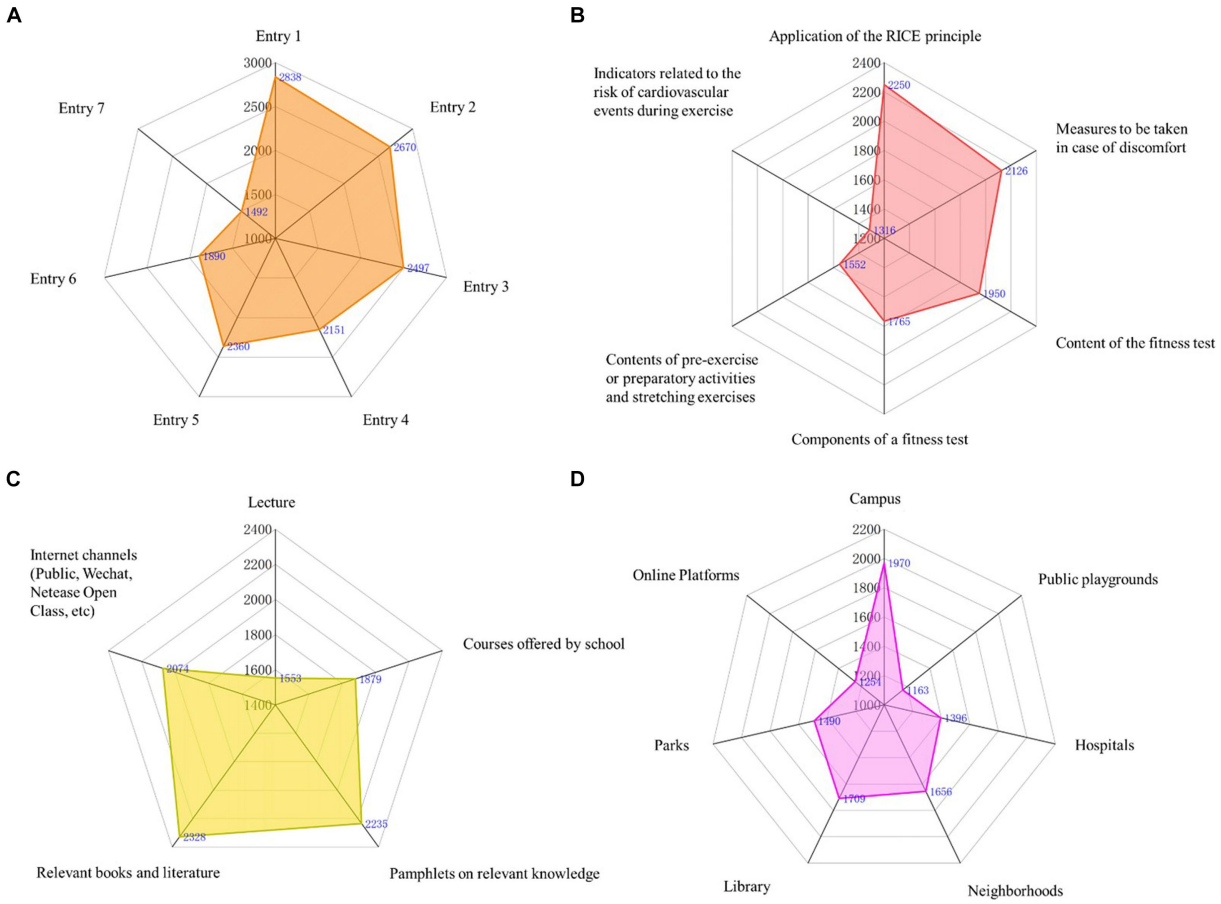


FIGURE 2
Number of people with each option for each question by subgroup.

risk assessment ($P < 0.001$), PARI preventative measures ($P < 0.001$), and PARI emergency response measures ($P < 0.001$). Then, a multivariate linear regression analysis was undertaken, which eliminated the influence of region on PARI emergency response measures (see Supplementary Table S4).

Finally, focusing on each question, it was observed that the majority of respondents exhibited a neutral attitude (choosing either "disagree" or "agree") toward each question, exceeding 65%. The percentage of respondents selecting each option for every question is illustrated in Supplementary Figure S3. Subsequently, the selection frequencies for each option of every question among different subgroups were analyzed, revealing that the response patterns were similar to the overall trend, as depicted in Figure 3.

3.4 Practice of PARI prevention

The average score for the practice section was 3.18 ± 0.55. Analyzing the scores across various components, it was found that the scores for PARI risk assessment (3.16 ± 0.78), PARI preventive measures (3.27 ± 0.56), and PARI emergency response measures (3.10 ± 1.04) were consistent with the overall practice pattern. Further subgroup analysis (see Table 5) revealed relatively poorer practices in the Central and Southern regions (3.03 ± 0.65) and the Southwestern regions (3.02 ± 0.66), with a trend in practice among respondents exhibiting an inverted "V-shape" as grades progressed. Additionally, it was noted that respondents from Project 985 universities (2.68 ± 0.74) and those engaging in less than 1 h of anaerobic exercise per week (2.95 ± 0.68) demonstrated poorer practices.

Subsequent investigations into the factors influencing the overall score and the scores of the 3 components were conducted. The results of the univariate analysis (see Supplementary Table S5) indicated that region, grade, school, weekly aerobic exercise duration, and weekly anaerobic exercise duration were significant factors influencing the overall practice score ($P < 0.001$). These factors also affected the scores for PARI risk assessment ($P < 0.001$), while grade ($P < 0.05$), school, weekly aerobic exercise duration ($P < 0.05$), and weekly anaerobic exercise duration influenced the PARI preventive measures score. Region, grade, school, and weekly anaerobic exercise duration impacted the scores for PARI emergency response measures ($P < 0.001$). To mitigate the inter-correlation among independent variables, multivariate linear regression analysis was employed, which discounted the effect of grade on PARI preventive measures (see Supplementary Table S6).

Finally, focusing on each individual question, a majority of respondents demonstrated a high rate of good practice (selecting "always" or "often"), ranging between 70 and 80% for each question. The percentage of respondents selecting each option for

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TABLE 4 Attitude scores by subgroup.

First-level items	Second-level items	Total		PARI risk assessment		PARI preventive measures		PARI emergency measures	
Overall		2.12 ± 0.51	2(1.78,2.33)	2.11 ± 0.66	2(1.5,2.5)	2.14 ± 0.61	2(1.67,2.33)	2.1 ± 0.87	2(2,3)
Gender	Male	2.13 ± 0.48	2(1.83,2.33)	2.11 ± 0.65	2(1.5,2.5)	2.14 ± 0.61	2(1.67,2.5)	2.11 ± 0.86	2(2,3)
	Female	2.12 ± 0.51	2(1.83,2.33)	2.1 ± 0.67	2(1.5,2.5)	2.13 ± 0.61	2(1.67,2.33)	2.1 ± 0.88	2(1,3)
Region	Northeast China	2.01 ± 0.4	1.94(1.72,2.22)	1.98 ± 0.64	2(1.5,2.5)	2.02 ± 0.49	2(1.67,2.33)	2.02 ± 0.81	2(2,2)
	North China	2.16 ± 0.58	2(1.78,2.39)	2.13 ± 0.69	2(1.5,2.5)	2.11 ± 0.65	2(1.67,2.33)	2.24 ± 0.94	2(2,3)
	East China	2.06 ± 0.46	2(1.78,2.28)	2.07 ± 0.63	2(1.5,2.5)	2.08 ± 0.56	2(1.67,2.33)	2.04 ± 0.85	2(1,2)
	South Central China	2.29 ± 0.61	2.11(1.89,2.67)	2.24 ± 0.71	2(1.5,2.62)	2.35 ± 0.7	2.33(1.67,3)	2.27 ± 0.89	2(2,3)
	Southwest China	2.22 ± 0.58	2.11(1.83,2.56)	2.24 ± 0.67	2(1.5,2.5)	2.26 ± 0.7	2(1.67,2.67)	2.17 ± 0.86	2(2,3)
	Northwest China	2.12 ± 0.51	2(1.78,2.33)	2.11 ± 0.67	2(1.5,2.5)	2.14 ± 0.6	2(1.67,2.33)	2.11 ± 0.85	2(2,3)
Grade	Grade 1	2.22 ± 0.61	2.06(1.78,2.5)	2.19 ± 0.72	2(1.5,2.5)	2.24 ± 0.7	2(1.67,2.67)	2.22 ± 0.92	2(2,3)
	Grade 2	2.14 ± 0.52	2.06(1.78,2.39)	2.16 ± 0.66	2(1.5,2.5)	2.16 ± 0.63	2(1.67,2.67)	2.11 ± 0.85	2(2,3)
	Grade 3	2.03 ± 0.43	2(1.72,2.28)	2.02 ± 0.61	2(1.5,2.5)	2.05 ± 0.51	2(1.67,2.33)	2.02 ± 0.84	2(1,2)
	Grade 4	2.08 ± 0.45	2(1.78,2.33)	2.05 ± 0.61	2(1.5,2.5)	2.11 ± 0.58	2(1.67,2.33)	2.09 ± 0.84	2(2,2)
	Grade 5	2.14 ± 0.55	2(1.83,2.33)	2.08 ± 0.69	2(1.5,2.5)	2.18 ± 0.63	2(1.67,2.67)	2.16 ± 0.89	2(2,3)
School	Project 985 University	2.59 ± 0.69	2.61(2.01,3)	2.53 ± 0.76	2.5(2,3)	2.73 ± 0.74	3(2,3)	2.52 ± 0.92	3(2,3)
	Project 211 University	2.07 ± 0.48	2(1.78,2.28)	2.06 ± 0.64	2(1.5,2.5)	2.09 ± 0.57	2(1.67,2.33)	2.07 ± 0.85	2(2,2)
	State University	2.03 ± 0.41	2(1.72,2.28)	2.02 ± 0.61	2(1.5,2.5)	2.03 ± 0.51	2(1.67,2.33)	2.04 ± 0.83	2(1,2)
	Private University	2.01 ± 0.4	2(1.72,2.22)	2.03 ± 0.6	2(1.5,2.5)	2 ± 0.5	2(1.67,2.33)	1.99 ± 0.83	2(1,2)
Duration of aerobic exercise per week	Less than 2 h	2.13 ± 0.52	2.06(1.78,2.36)	2.13 ± 0.67	2(1.5,2.5)	2.15 ± 0.62	2(1.67,2.67)	2.1 ± 0.86	2(2,3)
	2 ~ 4 h	2.11 ± 0.5	2(1.78,2.33)	2.1 ± 0.65	2(1.5,2.5)	2.13 ± 0.61	2(1.67,2.33)	2.1 ± 0.85	2(2,3)
	4 ~ 6 h	2.09 ± 0.49	2(1.78,2.33)	2.05 ± 0.63	2(1.5,2.5)	2.1 ± 0.57	2(1.67,2.33)	2.12 ± 0.89	2(2,3)
	More than 6 h	2.1 ± 0.52	2(1.78,2.33)	2.06 ± 0.65	2(1.5,2.5)	2.12 ± 0.58	2(1.67,2.33)	2.14 ± 0.93	2(1,3)
Duration of anaerobic exercise per week	Less than 1 h	2.28 ± 0.64	2.17(1.83,2.72)	2.26 ± 0.73	2(1.5,3)	2.36 ± 0.71	2.33(1.67,3)	2.23 ± 0.91	2(2,3)
	1 ~ 2 h	2.06 ± 0.44	2(1.78,2.28)	2.06 ± 0.63	2(1.5,2.5)	2.06 ± 0.55	2(1.67,2.33)	2.06 ± 0.84	2(2,2)
	2 ~ 3 h	2.04 ± 0.41	2(1.78,2.28)	2.04 ± 0.6	2(1.5,2.5)	2.02 ± 0.5	2(1.67,2.33)	2.04 ± 0.85	2(1,2)
	More than 3 h	2.06 ± 0.48	2(1.72,2.22)	2.03 ± 0.64	2(1.5,2.5)	2.1 ± 0.59	2(1.67,2.33)	2.05 ± 0.84	2(2,2)

every question is illustrated in Supplementary Figure S4. Subsequently, the selection frequencies for each option of every question in different subgroups were analyzed, revealing that the response patterns closely paralleled the overall trend, as shown in Figure 4.

3.5 Correlation among scores of knowledges, attitude and behavior

Integrating the scores from the knowledge, attitude, and practice sections, a Pearson correlation analysis was conducted. This revealed a positive correlation between overall scores and the three components, as well as between knowledge and attitude, accompanied by a negative correlation of both with practice ($P < 0.001$).

Subsequently, subgroup analyses were performed to evaluate the consistency of these correlations across different subgroups (see Supplementary Table S7). It was found that in the case of 5th-grade students, the majority of these correlations were not significant. Similarly, in the section pertaining to PARI preventive measures, most correlations were found to be insignificant. Additionally, for students engaging in ≥2 h of weekly aerobic exercise or ≥1 h of weekly anaerobic exercise, the majority of these correlations were also not significant.

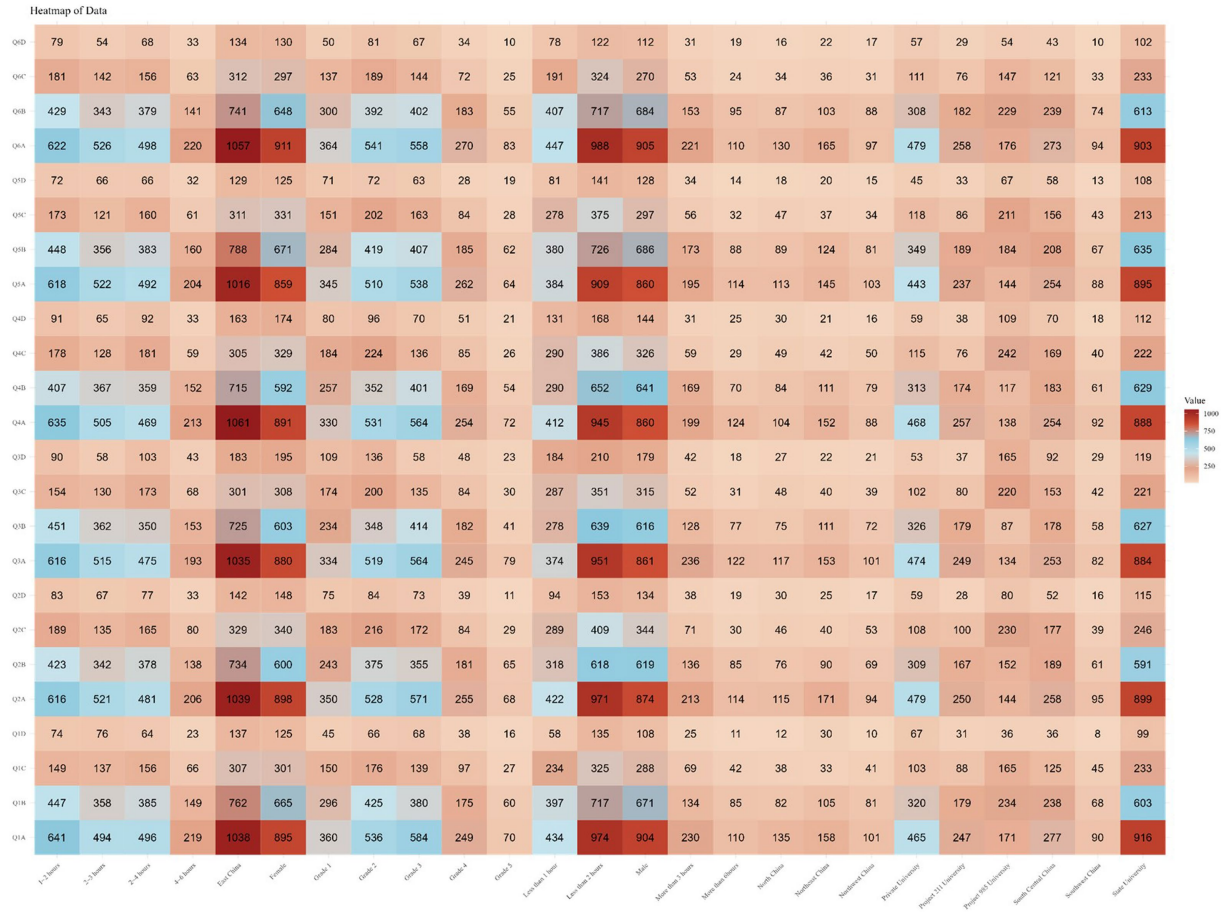


FIGURE 3
Number of people with each option for each question by subgroup.

3.6 Public health education demands of PARI prevention

In the ranking question regarding preferred teaching methods, respondents predominantly favored "guiding students to independently discover, propose, and solve problems, thereby stimulating their learning interest and initiative." Conversely, there was a general lack of preference for "organizing students into teams to collaboratively research acute sports injury prevention and management outside of class hours, culminating in the presentation of the team's research findings" (see Figure 5A). The responses from various subgroups aligned with these findings (see Supplementary Table S8).

In the multiple-choice question about desired training content, respondents widely preferred training on "the application of the RICE principle" (56.86%), while only 33.26% expressed a preference for training on "indicators related to cardiovascular events during exercise" (see Figure 5B). The responses from various subgroups were consistent with this trend (see Supplementary Table S9).

In the multiple-choice question about the preferred formats for training delivery in the multiple-choice question, respondents commonly favored "relevant books and literature" (58.83%) and "informational brochures on relevant knowledge" (56.48%), whereas only 39.25% preferred the "lecture" format (see Figure 5C). The responses across different subgroups were in agreement with these preferences (see Supplementary Table S10).

In the multiple-choice question about preferred locations for seeing related promotional content, respondents most desired to see such content in "school campuses" (49.79%), while only 29.39% wished to see it in "public sports venues" (see Figure 5D). The responses from various subgroups corresponded with these findings (see Supplementary Table S11).

4 Discussion

Physical activity-related injuries (PARI) are increasingly prevalent among Chinese university students (12). These injuries encompass both acute damages, such as sprains and fractures, and chronic harms caused by repetitive stress (2). Not only do these injuries hinder daily activities, but they also may lead to long-term health issues (4). Despite the significant impact of these injuries, public knowledge about their prevention and management is generally limited, highlighting the need for enhanced public health education and more resources (1).

Our study found that while approximately half of the Chinese university students lack knowledge about PARI and hold relatively negative attitudes, they still demonstrate good behavioral practices. In

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TABLE 5 Practice scores by subgroup.

First-level items	Second-level items	Total		PARI risk assessment		PARI preventive measures		PARI emergency measures	
Overall		3.18 ± 0.55	3.28(2.89,3.56)	3.16 ± 0.78	3.5(2.5,4)	3.27 ± 0.56	3.33(3,3.67)	3.1 ± 1.04	3(2,4)
Gender	Male	3.2 ± 0.49	3.33(3,3.5)	3.15 ± 0.78	3.5(2.5,4)	3.26 ± 0.56	3.33(3,3.67)	3.12 ± 1.02	3(2,4)
	Female	3.21 ± 0.49	3.33(3,3.5)	3.16 ± 0.78	3.5(2.5,4)	3.28 ± 0.56	3.33(3,3.67)	3.08 ± 1.06	3(2,4)
Region	Northeast China	3.28 ± 0.46	3.33(3,3.67)	3.33 ± 0.69	3.5(3,4)	3.31 ± 0.54	3.33(3,3.67)	3.19 ± 1.01	4(3,4)
	North China	3.14 ± 0.55	3.22(2.89,3.56)	3.15 ± 0.81	3.5(2.5,4)	3.25 ± 0.56	3.33(3,3.67)	3.02 ± 1.06	3(2,4)
	East China	3.23 ± 0.5	3.33(2.94,3.61)	3.2 ± 0.74	3.5(2.5,4)	3.29 ± 0.55	3.33(3,3.67)	3.2 ± 0.99	4(3,4)
	South Central China	3.03 ± 0.65	3.17(2.67,3.56)	2.98 ± 0.85	3(2.5,3.5)	3.23 ± 0.59	3.33(3,3.67)	2.88 ± 1.13	3(2,4)
	Southwest China	3.02 ± 0.66	3.11(2.56,3.56)	2.97 ± 0.88	3(2.5,3.5)	3.21 ± 0.59	3.33(3,3.67)	2.87 ± 1.12	3(2,4)
	Northwest China	3.14 ± 0.58	3.22(2.83,3.56)	3.18 ± 0.79	3.5(3,4)	3.26 ± 0.56	3.33(3,3.67)	2.98 ± 1.07	3(2,4)
Grade	Grade 1	3.07 ± 0.63	3.22(2.67,3.56)	3.01 ± 0.85	3(2.5,3.5)	3.25 ± 0.58	3.33(3,3.67)	2.95 ± 1.12	3(2,4)
	Grade 2	3.15 ± 0.57	3.22(2.83,3.56)	3.13 ± 0.79	3.5(2.5,4)	3.25 ± 0.56	3.33(3,3.67)	3.05 ± 1.05	3(2,4)
	Grade 3	3.27 ± 0.46	3.33(3,3.61)	3.28 ± 0.71	3.5(3,4)	3.31 ± 0.55	3.33(3,3.67)	3.22 ± 0.97	4(3,4)
	Grade 4	3.2 ± 0.51	3.28(2.94,3.56)	3.18 ± 0.76	3.5(2.5,4)	3.26 ± 0.53	3.33(3,3.67)	3.17 ± 1.01	4(2,4)
	Grade 5	3.19 ± 0.57	3.28(2.89,3.61)	3.17 ± 0.79	3.5(3,4)	3.31 ± 0.62	3.33(3,3.67)	3.11 ± 1.01	3(2,4)
School	Project 985 University	2.68 ± 0.74	2.67(2.06,3.28)	2.6 ± 0.96	2.5(2,3.5)	3.09 ± 0.62	3(2.67,3.67)	2.35 ± 1.16	2(1,3)
	Project 211 University	3.21 ± 0.51	3.28(2.89,3.56)	3.21 ± 0.74	3.5(2.5,4)	3.27 ± 0.57	3.33(3,3.67)	3.14 ± 1.02	3(2,4)
	State University	3.28 ± 0.45	3.33(3,3.61)	3.26 ± 0.7	3.5(3,4)	3.3 ± 0.54	3.33(3,3.67)	3.27 ± 0.93	4(3,4)
	Private University	3.28 ± 0.43	3.33(3,3.61)	3.29 ± 0.66	3.5(3,4)	3.33 ± 0.52	3.33(3,3.67)	3.23 ± 0.97	4(3,4)
Duration of aerobic exercise per week	Less than 2 h	3.14 ± 0.59	3.22(2.83,3.56)	3.12 ± 0.8	3.5(2.5,4)	3.25 ± 0.58	3.33(3,3.67)	3.07 ± 1.06	3(2,4)
	2 ~ 4 h	3.21 ± 0.51	3.28(2.89,3.56)	3.19 ± 0.75	3.5(2.5,4)	3.31 ± 0.53	3.33(3,3.67)	3.13 ± 1.03	3(2,4)
	4 ~ 6 h	3.21 ± 0.51	3.33(2.89,3.56)	3.21 ± 0.76	3.5(3,4)	3.28 ± 0.54	3.33(3,3.67)	3.15 ± 1	3(2,4)
	More than 6 h	3.25 ± 0.49	3.33(2.94,3.61)	3.28 ± 0.73	3.5(3,4)	3.32 ± 0.55	3.33(3,3.67)	3.15 ± 1.01	3.5(2,4)
Duration of anaerobic exercise per week	Less than 1 h	2.95 ± 0.68	3.06(2.44,3.5)	2.91 ± 0.91	3(2,3.5)	3.17 ± 0.6	3.33(2.67,3.67)	2.77 ± 1.16	3(2,4)
	1 ~ 2 h	3.26 ± 0.47	3.33(2.94,3.61)	3.23 ± 0.71	3.5(3,4)	3.32 ± 0.53	3.33(3,3.67)	3.22 ± 0.96	4(3,4)
	2 ~ 3 h	3.28 ± 0.44	3.33(3,3.61)	3.29 ± 0.68	3.5(3,4)	3.31 ± 0.52	3.33(3,3.67)	3.23 ± 0.96	4(3,4)
	More than 3 h	3.28 ± 0.48	3.33(3,3.65)	3.26 ± 0.71	3.5(3,4)	3.31 ± 0.56	3.33(3,3.67)	3.26 ± 0.97	4(3,4)

terms of preventive measures, the Knowledge, Attitudes, and Practices (KAP) levels were relatively high, but the KAP levels for emergency response measures were lower. These results underscore the need to elevate public health education among students about PARI prevention and emergency response. In the public health educational needs survey, participants expressed a preference for "guiding students to independently discover, propose, and solve problems." In terms of training content, students showed a preference for learning the RICE principles. Meanwhile, in terms of training formats, they favored "relevant books and literature" and "information booklets on relevant knowledge." Furthermore, students preferred seeing related promotional content on "school campuses" rather than in "public sports venues."

4.1 Knowledge of PARI prevention

In the knowledge aspect, participants' average knowledge score was 1.84 ± 0.52, indicating a generally poor understanding of PARI among university students (20). This might reflect the limited coverage of PARI in standard public health education and physical education curricula, suggesting room for improvement in disseminating this knowledge among university students (21). The students' understanding of PARI prevention measures was relatively higher, with an average score of 1.88 ± 0.67. This could be due to more emphasis in physical education and public health education on more intuitive and straightforward preventive measures like warm-up exercises and the use of safety equipment (20). In contrast, the average

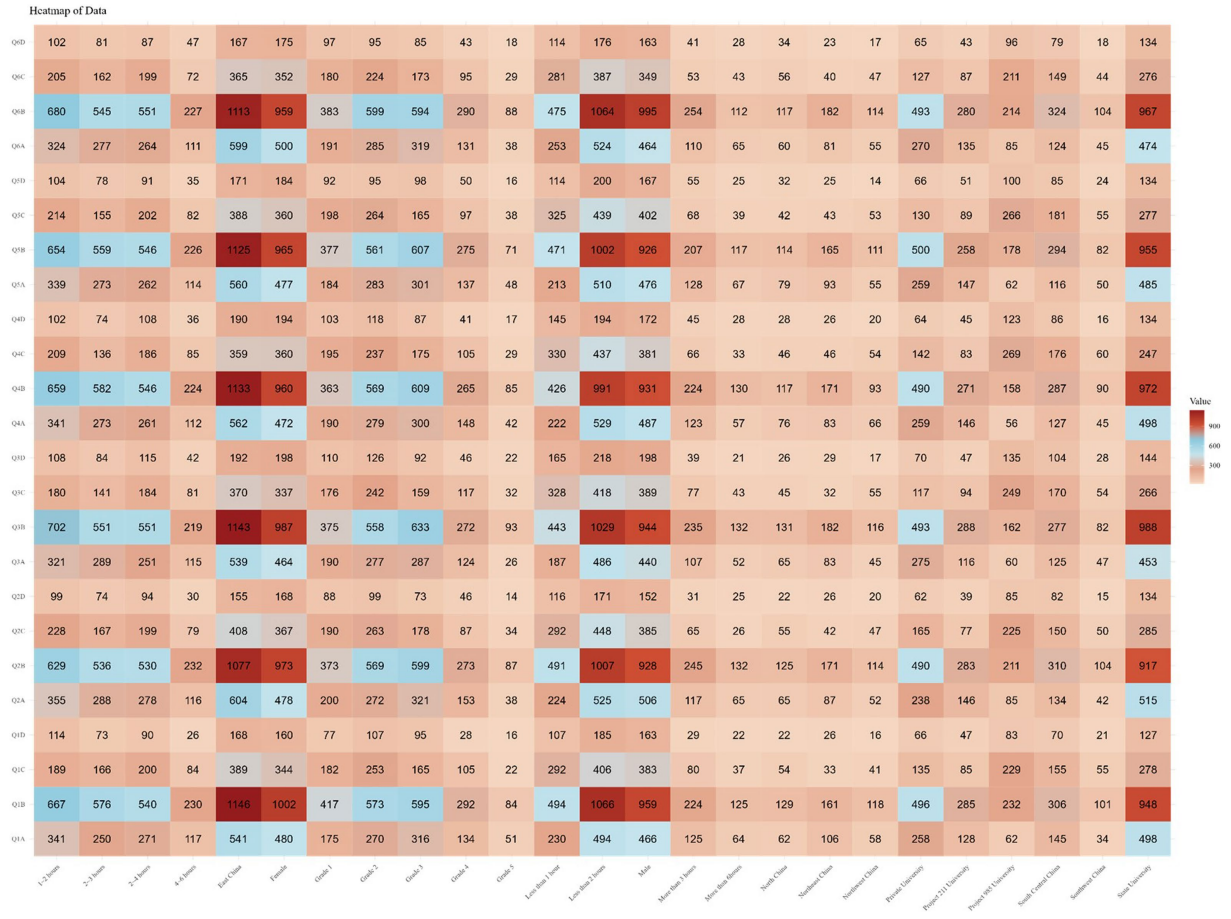


FIGURE 4
Number of people with each option for each question by subgroup.

score for PARI emergency measures was lower at 1.81 ± 0.90, indicating a gap in knowledge. This gap may be due to the professional skills and knowledge required for emergency measures, such as first aid and emergency decision-making, which may not often be included in basic health and physical education (21).

Notably, respondents from '985 Project' universities scored the highest (2.3 ± 0.7). This is attributed to these institutions' higher educational resources and teaching quality, offering more comprehensive health and physical education programs. More importantly, these universities typically prioritize prevention in health and physical education curricula, recognizing the long-term benefits of preventing sports injuries. Compared to more complex emergency techniques, this emphasis makes it easier for students to grasp and retain prevention measures (22).

Multivariate linear regression analysis found that region, grade, school, and weekly anaerobic exercise time significantly influence the overall average score for PARI knowledge ($P < 0.001$). Regionally, differences in educational resources and sports facilities among regions may be one of the reasons for the discrepancy in PARI knowledge (23). Some areas, with more advanced sports infrastructure and diverse sports activities, provide better opportunities for education and practice in PARI prevention and management. Cultural and lifestyle differences among regions might also affect students' attitudes toward sports safety (24, 25). Regarding grade, as students' progress through university, their mastery of knowledge shows a V-shaped change. This might be because students are more attentive to PARI in their early university years, but this attention may wane over time if they do not experience related injuries directly. However, in higher grades, due to personal or surrounding sports injury experiences, students may re-acknowledge the importance of PARI and enhance their learning of related knowledge (26). Additionally, as students' roles in sports activities and clubs change, their practical understanding and application of PARI might also strengthen, reflecting their dynamic attention to health and safety issues (26). Concerning anaerobic exercise time, the longer students participate in anaerobic activities like weightlifting and sprinting, the higher the risk of injury and their awareness of PARI. These activities necessitate more attention to injury prevention and response measures, thus influencing students' knowledge level in this area (12).

4.2 Attitude of PARI prevention

The average attitude score was 2.12 ± 0.51. This score was fairly consistent across different aspects of PARI, including risk assessment (2.11 ± 0.66), preventive measures (2.14 ± 0.61), and emergency measures (2.10 ± 0.87). Notably, participants from '985 Project' universities scored the highest (2.59 ± 0.69), indicating a more positive attitude toward these aspects of PARI. As 985 universities, they often provide research and practical opportunities for students to deepen their understanding of PARI and witness or experience its potential

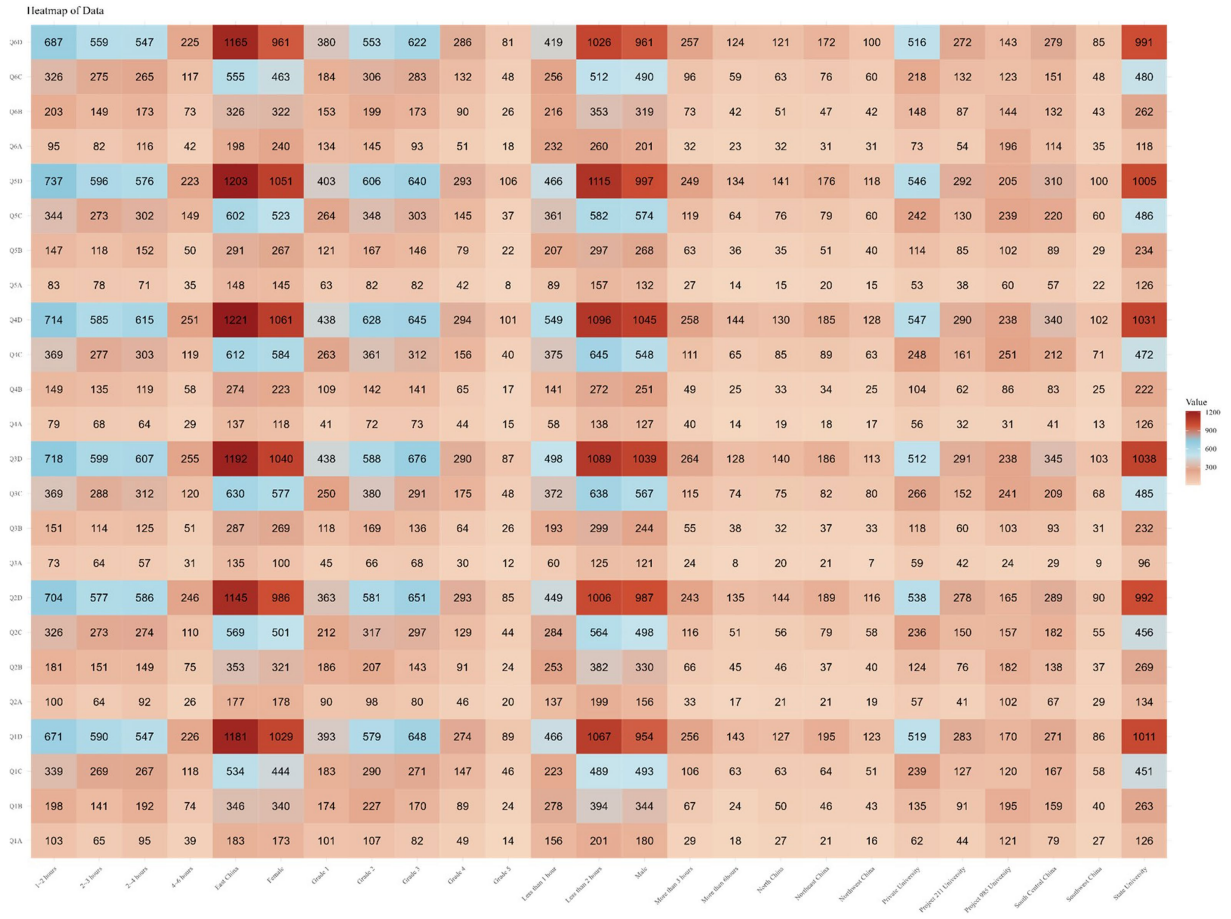


FIGURE 5
Needs for scientific popularization.

impacts firsthand, thereby reinforcing the importance of prevention and response measures.

The PARI prevention measures score for students from 985 universities was high at 2.73 ± 0.74, reflecting their positive attitude, thanks to the multifaceted educational and environmental measures taken by these institutions. Nine hundred eighty-five universities often have advanced sports facilities and resources, providing students with practical experiences and demonstrations of injury prevention techniques, enhancing their understanding and application of these measures. Furthermore, the faculty at '985 Project' universities, often being leaders in their respective fields, can provide high-quality and up-to-date information on best practices for injury prevention. More importantly, the overall environment at these universities, characterized by a culture of health and safety awareness and positive peer influence, plays a crucial role in shaping students' attitudes toward PARI prevention measures (27, 28).

Multivariate linear regression analysis revealed significant effects of factors such as region, academic year, institution, and the weekly duration of aerobic exercise on the cumulative scores ($P < 0.001$). These factors similarly influenced scores for PARI risk assessment ($P < 0.001$), PARI preventive strategies ($P < 0.001$), and PARI emergency procedures ($P < 0.001$).

Regionally, the impact of the area highlights the role of geographical differences in educational policies, availability of sports facilities, and cultural attitudes toward sports and health, suggesting that regions with more resources and greater emphasis on sports safety provide more comprehensive PARI education, leading to higher scores (29). Regarding academic year, we observed a V-shaped trend, which may partly be attributed to changes in social influences, environmental factors, and the impact of educational and promotional activities. Specifically, at the beginning of university, students might have a heightened attitude toward PARI due to the novelty of the campus environment and active health promotion. However, as they adapt to university life, this initial high level of concern may gradually diminish. Yet, in the senior years, facing long-term considerations for future careers and health, students might re-elevate their attention to PARI due to new educational activities or personal growth experiences. This reflects the dynamic change in university students' attitudes toward health and safety issues throughout their academic journey and also highlights the significant role of educational and social environments in shaping their attitudes (30). Finally, the time spent on anaerobic exercise, known for its higher intensity and greater risk of injury, might heighten students' awareness and understanding of PARI, especially in prevention and emergency practices.

4.3 Practice of PARI prevention

The practice part's average score was 3.18 ± 0.55. Upon studying scores for different elements, it was found that scores for assessing PARI risks (3.16 ± 0.78), implementing PARI preventive actions

(3.27 ± 0.56), and executing PARI emergency interventions (3.10 ± 1.04) were essentially similar.

However, we noted that respondents from '985 Project' universities (2.68 ± 0.74) and those engaging in less than 1 h of anaerobic exercise per week (2.95 ± 0.68) had poorer performance in practice. For students from '985 Project' universities, their lower scores in practice compared to the general trend could be attributed to the gap between theoretical knowledge and practical application. These prestigious institutions, while excelling in academics and research, might not place enough emphasis on practical training in physical activity-related injuries (PARI), leading to a gap between the knowledge students possess and how to apply this knowledge in real-world scenarios (31). Additionally, these students might be overconfident in their practical skills due to their strong theoretical knowledge, which may not effectively translate into practical efficacy (1).

For students engaging in less than 1 h of anaerobic exercise per week, their lower scores in practice could be due to limited exposure and experience in handling PARI. Moreover, these students might reduce their focus on preventive and emergency measures, perceiving a lower risk of injury due to less participation in sports activities (1). Therefore, limited opportunities to engage in sports or physical activities result in fewer chances to learn and apply practical PARI measures.

Multivariate linear regression analysis showed that the academic year, institution, weekly aerobic exercise time, and weekly anaerobic exercise time significantly influenced the overall practice score ($P < 0.001$). These variables also similarly affected the scores for assessing PARI risks ($P < 0.001$). Regional differences in health and sports infrastructure, as well as cultural attitudes toward safety, greatly affect PARI practices.

In terms of academic year, we noticed an inverted-V trend. This may be due to students exhibiting higher sensitivity and adaptability to new environments and health information upon first entering university, hence being more active and proactive in preventing PARI. They are likely to more diligently follow sports safety rules, participate in public health education activities, and take other preventive measures. However, as they adapt to university life, this initial vigilance may gradually diminish. Concurrently, with the progression in academic years, students might start neglecting the importance of preventing PARI due to overconfidence or underestimation of risks. This overconfidence might stem from an overestimation of their physical abilities and risk assessment, leading them to engage in riskier behaviors during sports and reduce the preventive measures previously taken (32).

However, regionally, geographical location does not influence the measures taken for PARI prevention. This indicates that there is little variation between regions in terms of preventive measures, suggesting that health and physical education curricula have adopted standardized methods, thus enabling a uniform understanding and practice regardless of geographical differences.

For the emergency intervention scores of PARI, region, academic year, institution, and weekly duration of aerobic exercise all had an impact ($P < 0.001$), except for the duration of aerobic exercise. The significance of anaerobic exercise is often linked with higher injury risks and more frequent emergency situations, highlighting its importance in developing emergency capabilities (33). In contrast, the duration of aerobic exercise, usually lower in intensity and associated with lesser injury risk, seems to have a lesser impact on emergency intervention skills, indicating that the type and intensity of physical exercise have distinctly different impacts on emergency response readiness.

4.4 Correlation among scores of knowledges, attitude and behavior

The Pearson correlation analysis combined with the study results indicates a nuanced relationship between knowledge, attitudes, and practices concerning Physical Activity-Related Injuries (PARI). While there is a positive correlation between knowledge and attitudes, indicating that increased awareness of PARI positively influences attitudes toward its prevention and management, there is a puzzling negative correlation between these factors and actual practices.

This disparity suggests a 'knowledge-attitude-practice gap,' where increased awareness and improved attitudes do not necessarily lead to corresponding behavioral changes. Reasons for this gap may be multifaceted, such as psychological barriers like fear of injury or lack of self-efficacy (34), perceived barriers to practice, or a complacency effect due to increased knowledge creating a false sense of security (35). Moreover, the practical application of PARI knowledge and attitudes is complex, often constrained by contextual and environmental factors like limited resources or insufficient practical training opportunities. Therefore, this correlation analysis emphasizes a key challenge in PARI management: transforming theoretical knowledge and positive attitudes into effective practical actions.

4.5 Public health education demands of PARI prevention

Upon completing the analysis of undergraduate students' levels and influencing factors of knowledge, beliefs, and practices regarding PARI, we further investigated the views and needs of university students regarding the implementation of PARI training and promotion.

In the context of preferred training methods, participants demonstrated a preference for "guiding students to independently discover, pose, and solve problems," indicating that autonomous and inquiry-based learning might be more effective in PARI prevention education (36). In contrast, the approach of "organizing students to collaboratively research the prevention and treatment of acute sports injuries outside of class" was less popular. This may relate to students' time constraints and the feasibility of teamwork. Most university students juggle between heavy academic loads, part-time jobs, and personal life, making involvement in additional extracurricular projects potentially burdensome, especially when not directly related to their primary academic goals and career planning (15, 37). Moreover, effective teamwork requires good coordination and communication among members, which might be challenging among students with different academic backgrounds, schedules, and geographical locations.

In terms of desired training content, participants showed a stronger preference for training in the implementation of the RICE

principles (56.86%) over training for cardiovascular incidents in physical activities (33.26%). This could be due to the practicality and immediate applicability of the RICE method. The RICE principle, a well-known direct approach for treating acute sports injuries, holds significant practicality and operability for individuals involved in physical activities. Conversely, interest in recognizing signs of cardiovascular events is lower, possibly because it's perceived as lacking immediacy or direct relevance. Although identifying cardiovascular events is crucial, they may be less common or not directly linked to participants' routine physical activities (38).

Regarding preferred training formats, the majority of participants favored "relevant books and publications" (58.83%) and "educational pamphlets on related topics" (56.48%), indicating a preference for self-learning and easily accessible learning resources. These formats offer flexibility in self-paced learning and the ability to consult materials as needed, providing convenient and enduring resources for learners (39). The lower preference for "workshops" (39.25%) may reflect practical constraints such as availability of time or scheduling conflicts. Workshops are usually scheduled at specific times, but with students' already tight schedules, finding additional time for fixed-schedule workshops can be challenging. Moreover, workshops often require several hours or more, and for students with limited time resources, participation might mean sacrificing other important activities or study time, especially when the workshop content is not directly related to their main interests or academic requirements. Most importantly, compared to more flexible learning methods, such as online courses, workshops typically lack flexibility in scheduling, not allowing students to adjust freely according to their own timetables (40).

As for preferred locations for PARI promotion, the highest proportion of respondents favored encountering promotional materials "within educational institutions" (49.79%), highlighting the importance of educational institutions as primary sources of credible and relevant information. This preference underscores the role of educational institutions in health and safety promotion, reflecting the convenience and frequent contact these venues provide for learners (41). In contrast, interest in receiving such information at "public sports facilities" (29.39%) was lower, possibly due to university students spending less time at public sports facilities compared to campuses.

As with any survey-based research, some possible limitations should be noted in this study. Firstly, the sample may not be entirely representative of all Chinese undergraduate students, potentially limiting the generalizability of the results. Secondly, the reliance on self-reported data could introduce biases, as respondents may not accurately recall or report their knowledge, attitudes, and practices regarding PARI. Thirdly, the cross-sectional nature of the study restricts the ability to establish causality between the identified factors and PARI prevention practices. Additionally, the study might not have accounted for all possible confounding variables that could influence the outcomes, such as socio-economic status or prior exposure to public health education. Finally, the study's focus on undergraduates means that the findings may not be applicable to other groups, such as professionals or amateur sports enthusiasts, who might have different levels of awareness and practice concerning PARI.

As with any survey-based research, this study should also acknowledge some potential limitations. Firstly, the reliance on self-reported data could introduce biases, as respondents may not accurately recall or report their knowledge, attitudes, and practices regarding PARI. Secondly, the cross-sectional nature of the study limits the ability to establish causality between identified factors and PARI prevention measures. Additionally, the focus on university students means that the findings may not be applicable to other groups, such as professionals or amateur sports enthusiasts, who might have different levels of awareness and practice concerning PARI.

There are also strengths to consider, such as the nationwide scope of the survey among university students, which provides broad coverage, and the fact that our research addresses issues highlighted in the latest guidelines, making the findings representative and typical. Lastly, undergraduates, as a large and accessible group, provide a unique sample that can be used to assess the effectiveness of health education programs. The research outcomes can guide broader public health strategies.

The theoretical implications of this study were that a high level of knowledge and good attitude do not always directly affect good practice. When establishing an educational model for PARI public health education, especially for undergraduates, practice-oriented courses can be offered, such as organizing field visits, participating in volunteer services or conducting practical projects to help college students translate what they have learned into practical actions.

In addition, the research results also highlight the impact of population and behavioral factors on healthy behavior. When establishing the education model, the course content and education methods can be adjusted according to local conditions. For example, PARI public health education courses implemented in different regions can be adjusted according to the specific local environment and needs, while for different types of universities, corresponding educational models can be designed according to their socio-economic background and the characteristics of student groups.

5 Conclusion

This study surveyed 3,957 Chinese undergraduates, uncovering a gap in knowledge, attitudes, and practices regarding PARI among this group. Despite showing proficiency in practical application, their understanding of PARI is not comprehensive, and their attitudes are neutral. The research highlights the urgent need for more practical and application-focused public health educational interventions and resources in university environments. By addressing these gaps and utilizing students' preferred learning methods, public health educational institutions can strengthen PARI prevention and management, thereby enhancing the overall health and safety of university students.

Therefore, in the future, when building a teaching model of PARI's public health education for college students, we need to pay more attention to the connection among knowledge, attitude and practice, and choose the guided teaching methods and content that undergraduates generally want to focus on and the way they prefer to learn.

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 Ethics Committee on Third Xiangya Hospital of Central South 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

YK: Formal analysis, Funding acquisition, Validation, Visualization, Writing – original draft, Writing – review & editing. XZ: Writing – original draft. YY: Data curation, Formal analysis, Methodology, Writing – original draft. HX: Investigation, Methodology, Writing – original draft. LM: Investigation, Writing – original draft. YZ: Project administration, Supervision, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1387789/full#supplementary-material

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Insights into determinants of health-seeking behavior: a cross-sectional investigation in the Iraqi context

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Background: Health-seeking behavior (HSB) is a choice taken by an individual to maintain, achieve, or restore good health and prevent diseases. The purpose of this study is to examine the determinants of HSB among the Iraqi population.

Methods: This cross-sectional study in the Rusafa and Karkh districts of Baghdad investigated determinants of HSB from 2022 to 2023. With a sample size of 993 participants meeting inclusion criteria, data were collected through a self-reported questionnaire, utilizing four indicators to measure HSB. The study employed various statistical methods especially logistic regression models, facilitated by Stata 17 software.

Results: Results highlights that married individuals consistently have higher odds of having HSB compared to their single counterparts, with an odds ratio (OR) of 2.09 (95% confidence interval: 1.41–3.10). This relationship remains robust even after controlling for other variables. Furthermore, individuals with higher social class exhibit stronger connections to HSB, although the OR is 1.69 (95% CI: 0.47–6.13), indicating a wide confidence interval. Regarding underlying diseases and their duration, the results indicate that chronic diseases are associated with a higher likelihood of HSB, with an OR of 2.05 (95% CI: 1.35–3.11). Additionally, a longer duration of diseases in terms of years is also linked to a stronger association with HSB, with an OR of 2.86 (95% CI: 1.32–6.23).

Conclusion: In conclusion, this work provides important insights into HSB. Married people are continuously more likely to engage in HSB than single people, highlighting the importance of customized interventions. Furthermore, persons from higher social classes have stronger ties to HSB, highlighting the importance of socioeconomic considerations. The link between HSB and chronic diseases, combined with longer disease durations, emphasizes the importance of early detection and thorough healthcare management. These findings give critical guidance for healthcare providers, marketers, and politicians developing effective initiatives to promote HSB.

KEYWORDS

health-seeking behavior, determinants, Iraq, HSB, health behavior

1 Introduction

Health-seeking behavior (HSB) encompasses the actions individuals take to maintain, attain, or restore good health and prevent illness, ranging from seeking care at public or private health facilities to self-medication or refraining from utilizing available health services (1). This behavior is influenced by a multifaceted interplay of provider, patient, disease, and household factors (2), alongside various socioeconomic determinants including gender, age, social status, illness type, service accessibility, and perceived care quality (3, 4). Conflict situations, population displacement, and food scarcity further complicate HSB, posing challenges to both healthcare systems and individual well-being (5, 6). Iraq, enduring over four decades of conflict, war, and sanctions, has faced a deteriorating healthcare infrastructure and ongoing environmental hazards, contributing to adverse health outcomes (7).

The concept of intended HSB often involves seeking care through recognized healthcare channels, encompassing both public and private sectors, particularly prevalent in urban areas where the majority of health facilities are concentrated (1). Iraq's healthcare landscape has gradually transitioned from predominantly hospital-centric, curative care to a primary focus on preventive care delivered through primary health clinics (PHCs) (8). Shabila et al. (9) identified four distinct HSB patterns among Iraqis, ranging from negative perceptions of private sector care to varying degrees of satisfaction and utilization of primary care services. While existing literature acknowledges these shifts, a comprehensive understanding of how evolving healthcare services influence HSB determinants remains elusive.

This study aims to address this gap by examining the factors shaping HSB in Iraq within the context of the country's evolving healthcare delivery model, particularly emphasizing the shift toward PHCs and preventive care. By elucidating these dynamics, the research aims to provide insights crucial for healthcare providers, policymakers, and researchers, facilitating the development of targeted interventions to enhance equitable access to healthcare services in Iraq. Specifically, this study seeks to build upon existing literature by exploring novel aspects such as the impact of marital status and economic levels on HSB, thereby contributing new insights to the understanding of HSB in Iraq. By articulating these unique contributions, the study aims to firmly position itself within the existing literature while filling crucial gaps in knowledge regarding HSB determinants in the Iraqi context.

2 Methods

2.1 Study design

This cross-sectional study aimed to investigate the determinants of health-seeking behavior (HSB) in the districts of Rusafa and Karkh in Baghdad, Iraq, between 2022 and 2023. The study design adhered to the STROBE guidelines for reporting observational studies to ensure transparency and rigor in reporting (10). It was developed to provide a comprehensive understanding of HSB in these specific districts, considering their unique socio-economic, cultural, and infrastructural characteristics that may influence healthcare access and utilization.

2.2 Questionnaire development and pilot study

A structured questionnaire was developed based on the Pourreza model (11). The questionnaire underwent a rigorous adaptation process to suit the Iraqi context. To assess the clarity, appropriateness, and relevance of the questionnaire items, a pilot study was conducted with a small sample of participants from similar districts in Baghdad. The feedback from the pilot study participants was used to refine the questionnaire further, ensuring its suitability for the study population. The final version of the questionnaire was reviewed by 11 specialists in healthcare management and community medicine. Content validity ratio (CVR) and content validity index (CVI) were calculated for each question, with the CVR ranging between 63.6 and 81.8 for all questions and an average CVI of 0.83.

2.3 Participant recruitment and sampling

A multifaceted approach to recruiting participants was used to ensure a thorough understanding of HSB, including people who had recently used health services as well as those who had not. Initially, health centers providing primary health care services in the Rusafa and Karkh districts of Baghdad were selected. These centers served as the main sampling points for participant recruitment. Efforts were made to reach members of the community who may not have recently received health services. The results of the study were disseminated through a variety of channels, including community leaders and health care providers. Participants were selected from health centers that provided primary health care services to ensure that they were individuals who had recently received health care services. In addition, efforts were made to recruit individuals from the community who had not recently sought care to reflect a broad spectrum of HSB. This process was based on a multistage sampling design. The sample size was determined to be 664 individuals based on a 99% confidence level, a 50% response rate distribution, and an acceptable precision level of 0.05. However, during the actual data collection phase, a total of 993 individuals were enrolled to enhance the study's statistical power and ensure a more robust representation of the population under examination.

2.4 Data collection

Trained data collectors, familiar with the local context and fluent in both Arabic and English, were responsible for administering the questionnaire. They underwent comprehensive training on the study objectives, ethical considerations, data collection procedures, and interview techniques. The training sessions included role-playing exercises and discussions to ensure consistency and standardization in data collection.

During the data collection phase, several measures were implemented to monitor and enhance data quality. Regular meetings were conducted with the data collectors to address questions, concerns, and ensure a shared understanding of the study objectives and procedures. Field supervisors were appointed to oversee the data collection process, providing ongoing support, guidance, and quality control. A random subset of completed questionnaires was selected

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for quality control purposes, and double data entry was performed to minimize data entry errors.

2.5 Ethical considerations

Ethical approval for the study was obtained from the Islamic Azad University Sanandaj (IR.IAU.SDJ.REC.1402.027). Informed consent was obtained from each participant before their inclusion in the study. Participants were provided with detailed information about the study objectives, procedures, potential risks, benefits, and their right to withdraw from the study at any time.

2.6 Statistical analysis

The collected data were entered into a statistical software program for analysis. Descriptive statistics were used to summarize the socio-demographic characteristics of the participants and the key variables related to HSB. Inferential statistics, such as chi-square tests, were performed to examine the associations between various determinants and HSB. Logistic regression analysis was specifically chosen to assess the relationship between the determinants and HSB, as it allows for the estimation of odds ratios (ORs) and the identification of significant predictors while controlling for confounding factors.

TABLE 1 Sociodemographic characteristics of participants ($N = 993$).

Variable	Frequency	Percent
Gender		
Male	431	43.4
Female	562	56.6
Marital Status		
Single/ Divorced/Widow/Widower	278	28.0
Married	715	72.0
Educational		
Unable to read and write to middle school	278	28.0
High school and diploma	412	41.5
University degree	303	30.5
Family members		
<=4	414	41.7
>4	579	58.3
Socioeconomic level		
Low	289	29.1
Middle	669	67.4
High	35	3.5

Variable	Mean	SD*
Age (Years)	36.83	11.50
SD = Standard deviation		

3 Results

In total, 993 individuals were involved in this research. The average age of the participants was 36.83 years with a standard deviation (SD) of 11.50 (36.83 ± 11.50). Among them, 56.6% ($n = 562$) were female, and 72% ($n = 715$) were married.

Regarding educational attainment, the distribution among participants was as follows: 278 individuals (28.0%) had completed middle school, 412 (41.5%) held a high school diploma, and 303 (30.5%) possessed a university degree. A majority of participants (58.3%) reported having a family size of four or fewer members (Table 1). In terms of socioeconomic status, 67.4% of participants fell into the middle-level category, while only 3.5% belonged to the high-level category (Table 1).

All participants expressed a need for healthcare within the last 3 months. Among them, 867 individuals (87.1%) reported having sought HSB. Of these, 456 people (52.5%) sought treatment in the first days with mild symptoms of the disease, 369 individuals (42.5%) sought treatment at the onset of the disease and its symptoms, and 43 people (5%) sought treatment at a serious stage of the disease (Table 2).

In response to the question "How many days after the onset of disease symptoms did you seek care from a provider?" the majority of participants sought care on the same day (23.9%) or the next day (28.8%). Additionally, 62 individuals (7.1%) initially visited a pharmacy without a prescription but consulted with the pharmacist as their first step for treatment. Only 52.3% of individuals who received treatment completed their course of treatment until recovery, while 47.9% did not complete their course of treatment (Table 2). The frequency with which people react to the question "Have you ever had an experience with care reception from a health care center?" (Clinic, emergency room, doctor's office, hospital, or health center)?" Equal to 993. In this population, 883 people (88.9%) said yes (Table 2).

The chi-square test revealed a significant relationship between HSB and gender ($p = 0.09$), marital status ($p < 0.001$), educational qualification ($p = 0.03$), illness duration ($p < 0.001$), and health condition ($p = 0.001$), as indicated in Table 3. However, there was no significant relationship observed between HSB and family members or social class.

According to the results of univariate regression analysis, married individuals exhibit approximately twice the likelihood of having HSB compared to single individuals (OR: 2.07, 95% CI 1.40–3.04). After controlling for other variables, this association remained relatively stable (OR: 2.09, 95% CI 1.41–3.10). Additionally, individuals belonging to middle socioeconomic levels demonstrate a lower likelihood of HSB compared to those at low levels (OR: 0.64, 95% CI 0.41–1.01). Furthermore, individuals with a university level of education exhibit a decreased likelihood of HSB compared to those with a middle school education or less (OR: 0.52, 95% CI 0.31–0.86), a trend that persists even after adjusting for other variables (OR: 0.54, 95% CI 0.32–0.92) (Table 4). Regarding underlying diseases and their duration, the results indicate that chronic diseases are associated with a higher likelihood of HSB, with an OR of 2.05 (95% CI: 1.35–3.11). Additionally, a longer duration of diseases in terms of years is also linked to a stronger association with HSB, with an OR of 2.86 (95% CI: 1.32–6.23) (Table 4).

Adjusted variables: Gender, Marital status, Educational qualification, Social class, Health condition, Illness duration.

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TABLE 2 Health seeking behavior (HSB) of participants in the last 3 months ($N = 993$).

Variable	Frequency	Percent
Health condition		
Acute	585	58.9
Chronic	408	41.1
Illness duration (years)		
1	456	46.8
2	205	20.7
3	323	32.5
Do you have attempted to treat your illness?		
Yes	867	87.1
No	126	12.7
How many days after the onset of disease symptoms did you get care from a provider? (n = 868)		
The same day	207	23.9
The next day	250	28.8
Two days later	172	19.8
3–7 days	72	8.3
More than seven days	167	19.2
At what stage of your disease have you gone to a provider? (n = 868)		
In early stages and onset of symptoms mild	456	52.5
Incidence of disease and its symptoms	369	42.5
In serious stage of disease	43	5.0
Where did you go to treatment in the first step? (n = 868)		
General practitioner's office, health center, emergency room	395	45.5
Clinic, private or governmental hospital	335	38.6
Pharmacy without a prescription but consultation with the pharmacist	62	7.1
Traditional healers, Pharmacy without a prescription and consultation with the pharmacist, I have not referred to	76	8.8
Until what step of treatment have you completed your course of treatment according to provider (n = 868)		
To received	454	52.3
To relieve the symptoms	334	38.5
Do not complete my course of treatment	80	9.2
Have you ever had experience of care reception from health care centers? (Clinic, emergency room, doctor's office, hospital, health centers)?		
Yes	883	88.9
No	110	11.1

4 Discussion

This study engaged a cohort of 993 individuals from Iraq, focusing primarily on HSB among the Iraqi population. A significant finding was that 87.1% of respondents had engaged in HSB within the previous 3 months. Additionally, demographic variables such as marital status, social class, chronic disease and duration of the disease were identified as significant factors influencing HSB. Our research revealed statistically significant differences in HSB between gender. Khajeh et al. (12) reported that women exhibited higher levels of adherence to treatment regimens and expressed greater satisfaction with their healthcare experience. While the association between gender and treatment-seeking behavior was inconclusive, our findings suggest that men are more inclined to self-medicate, potentially influenced by gender-related factors. Existing literature on this topic presents conflicting results, with some studies suggesting higher rates of self-medication among women, while others report the opposite (12). In a different study, men reported self-medicating more frequently than women (13).

Notably, a comprehensive survey conducted in the United Kingdom revealed that women engage with their primary healthcare providers more than twice as frequently as men. Similar patterns were observed in mental health studies conducted in Canada and the United States. However, it is important to acknowledge that these gender discrepancies in healthcare utilization may not always reach statistical significance due to the heterogeneity of study methodologies and the diverse influences of socioeconomic factors on different gender groups (14). The evident gender disparities in healthcare utilization, as highlighted by extensive surveys in the UK and echoed in mental health research across North America, underscore the complex interplay of societal, cultural, and individual factors shaping HSB. These observations align with broader discussions on gender roles, where women may be socialized to prioritize health maintenance, while societal norms surrounding masculinity may discourage men from seeking medical care or openly discussing health concerns (15, 16).

The study underlines the importance of considering both sex and gender in healthcare utilization research. This approach allows for a better understanding of whether differences are explained by biological factors or indirect and consequently helps identify modifiable risk factors for unfavorable outcomes. The study also highlights the need for policy-makers to plan the measurement of sex at birth, gender identity, and gender-related variables in survey and patient registry developers to allow for more relevant, equitable, diversified, and inclusive future research (17–21).

The significant gender discrepancies in healthcare consumption, as revealed by a large survey in the UK and repeated in mental health research across North America, provide a nuanced view of how societal, cultural, and individual factors interact to determine HSB. The fact that women contact their primary healthcare providers more frequently than males shows that there may be discrepancies in health awareness, societal expectations, and goals for well-being (19–21). These findings are consistent with broader conversations about gender roles, in which women may be taught to prioritize health maintenance, while cultural norms around masculinity may contribute to men's reluctance to seek medical care or openly address health concerns. Furthermore, socioeconomic factors exacerbate gender disparities in healthcare consumption. Economic gaps affect access to healthcare resources, insurance coverage, and the capacity to leave work for medical appointments. The complex interplay between gender and socioeconomic position highlights the importance of specialized interventions that address the unique obstacles faced by different gender groups. Furthermore, the variation in outcomes

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TABLE 3 Comparison of health-seeking behavior and demographic variables ($N = 993$).

Variable	HSB		Chi2*	
	Yes	No	X_2	*p*-value
Gender				
Male	385 (89.33)	46 (10.67)	2.79	0.09
Female	482 (85.77)	80 (14.23)		
Marital status				
Single/Divorced/Widow/ Widower	225 (80.94)	53 (19.06)	14.16	<0.001
Married	642 (89.79)	73 (10.21)		
Educational qualification				
Unable to read and write to middle school	252 (90.65)	26 (9.35)	6.88	0.032
High school and diploma	362 (87.86)	50 (12.14)		
University degree	253 (83.50)	50 (16.50)		
Family members				
<=4	365 (88.16)	49 (11.84)	0.46	0.49
>4	502 (86.70)	77 (13.30)		
Social class				
Low	261 (90.31)	28 (9.69)	4.26	0.11
Middle	574 (85.80)	95 (14.20)		
High	32 (91.43)	3 (8.57)		
Health condition				
Acute	493 (84.27)	92 (15.73)	11.85	0.001
Chronic	374 (91.67)	37 (8.33)		
Illness duration (years)				
1	386 (83.01)	79 (16.99)		
2	180 (87.80)	25 (12.20)	17.87	>0.001
+3	301 (93.19)	22 (6.81)		

*Chi-square test.

between studies emphasizes the need of examining different approaches and definitions of healthcare usage. To gain a thorough understanding of these differences, we must recognize not just the variation between gender groups, but also the complex interplay of cultural, economic, and individual factors impacting healthcare practices (22–28).

As societies grapple with the implications of these gender-related healthcare patterns, policymakers and healthcare providers are challenged to develop strategies that foster inclusivity and address the unique needs of diverse populations. Tailoring interventions to account for the intersectionality of gender with other social determinants, such as socioeconomic status, can pave the way for more equitable healthcare access and outcomes. Embracing a holistic and interdisciplinary approach will be essential in dismantling the barriers that contribute to gender disparities in healthcare utilization and working toward a more inclusive and responsive healthcare system.

Similarly, Patel et al. (29) discovered that registration in any government program, educational level, and poverty status were all significant predictors of HSB in the older adult residing in Shri Vasantrao Naik Government Medical College's urban field practice area in Yavatmal, Maharashtra. According to Thompson et al. (30), there were gender disparities in how people sought medical assistance, with women indicating that they saw their primary care physician for physical and mental health concerns more frequently than males. This finding supports the notion that women are more concerned about their health than males. Patients were generally less likely to seek treatment for mental health difficulties than for physical ones. According to the regression analyses, age, disease prevention, physician trust, and chronic conditions were all important variables in explaining healthcare-seeking behaviors for mental health problems in both men and women (30).

Education level was identified as one of the variables affecting HBS. Education plays a crucial role in determining various aspects of healthcare behavior, including adherence to treatment programs, the propensity for self-medication, recognizing when to seek medical attention, and more. Research indicates that public education initiatives and the application of behavioral models can significantly reduce the prevalence of self-medication. Muriithi (31) found that educated individuals are more likely to opt for professional healthcare services over self-care practices. These findings are consistent with numerous other studies in the literature, indicating robust and consistent parameter estimations across various healthcare settings (31). Contrary to Sahn et al. (32, 33), it is noteworthy that the demand growth rate for public health facilities is larger than for private ones. Cisse (32) discovered that education positively affected healthcare demand. Hutchison et al. (34) discovered that educated women were more likely than illiterate women to seek medical treatment. The study suggests that educated individuals may tell the difference between actual and perceived health treatment quality by seeing the health practitioners' credentials. As opposed to private clinics, where the qualification of the health workers is not readily recognized, a public health institution guarantees quality and trained health personnel (34). Muriithi (31)refutes the generally accepted belief that years of education diminish the likelihood of obtaining health care from a public health institution vs. self-treatment.

Furthermore, our data suggest that more than half (58.9%) of individuals had acute health issues. Health status was identified as one of the variables affecting HBS. The survey outcomes also demonstrated statistically significant differences in consumers' perceptions of healthcare providers and overall HBS across categories of health problems. According to a 2019 study by Khajeh et al. (12), there was no association between the severity of the sickness and the frequency of clinic visits.

Interestingly, our research uncovered a counterintuitive trend regarding the negative link between disregarding therapy and the severity of the condition. Contrary to conventional expectations, individuals exhibited a reduced tendency to seek formal medical treatment when faced with more severe health issues. The authors of this study discovered numerous critical data that support their hypothesis about the impact of the developing healthcare delivery landscape on HSB among the Iraqi population. Specifically, a sizable proportion of participants reported receiving healthcare primarily through primary health clinics (PHCs) rather than traditional hospital-based systems. This shift to PHCs is consistent with Iraq's healthcare system's transition from curative to preventative treatment. Furthermore, the findings of this study suggested that people from higher social classes had stronger ties to HSB. This study implies that as healthcare delivery in Iraq has transitioned to preventative care via PHCs, people with more means and

TABLE 4 Factors associated with HSB among Iraqi population (*N* = 993).

Variable	Health-seeking behavior Unadjusted *OR* (95% CI)	Health-seeking behavior adjusted *OR* (95% CI)
Social class		
Low	Reference	Reference
Middle	0.64 (0.41–1.01) *	0.74 (0.47–1.19)
High	1.14 (0.32–3.97)	1.69 (0.47–6.13)
Gender		
Female	Reference	Reference
Male	1.38 (0.94–2.04)	1.34 (0.90–2.00)
Marital Status		
Single/ Divorced/ Widow/ Widower	Reference	Reference
Married	2.07 (1.40–3.04) ***	2.09 (1.41–3.10) ***
Educational Qualification		
Unable to read and write to Middle school	Reference	Reference
High school and Diploma	0.74 (0.45–1.23)	0.82 (0.49–1.38)
University degree	0.52 (0.31–0.86) *	0.54 (0.32–0.92) *
Health condition		
Acute	Reference	Reference
Chronic	2.05 (1.35–3.11) ***	0.97 (0.50–1.89)
Illness duration (years)		
1	Reference	Reference
2	1.47 (0.90–2.38)	1.44 (0.81–2.56)
+3	2.80 (1.70–4.59) ***	2.86 (1.32–6.23) **

* < 0.05 ** < 0.01 *** < 0.001. Adjusted variables: Gender, Marital Status, Educational Qualification, Social class, Health condition, Illness duration.

a higher socioeconomic standing may be better positioned to take advantage of these services. In contrast, persons from lower socioeconomic backgrounds may experience challenges to accessing PHCs and engaging in preventative treatment, thus contributing to HSB inequities. Furthermore, the found disparities in HSB by demographic parameters such as gender, marital status, and educational level highlight the influence of the changing healthcare landscape. These demographic discrepancies may reflect differences in access to and use of PHC services, emphasizing the importance of targeted interventions to achieve equitable access to preventative care across varied demographic groups. This finding prompts consideration of alternative explanations, such as the possibility that individuals seek therapy when an illness reaches a critical point but may opt for non-medical avenues, including traditional treatments. Another plausible explanation is that individuals may perceive their sickness as more severe than it actually is, leading them to bypass formal medical consultations in favor of alternative approaches.

Our findings have far-reaching implications for policy and practice, informing broader health policy in Iraq, particularly during post-conflict reconstruction. Understanding the factors of HSB found in this study might help drive the creation of tailored interventions to improve healthcare access and usage across the country.

First, policymakers might use our findings to select areas for intervention, with an emphasis on addressing the reported discrepancies in HSB across demographic groups. For example, campaigns could be designed to raise awareness and education regarding healthcare-seeking behaviors among people with lower educational attainment or socioeconomic level. Furthermore, focused efforts may be required to address cultural attitudes and norms that influence health-seeking decisions, particularly those involving traditional vs. formal medical treatments.

Furthermore, our findings emphasize the importance of integrated healthcare delivery systems that incorporate both traditional and modern healthcare methods. This acknowledgment can help to shape healthcare policies and initiatives that embrace culturally sensitive approaches and value traditional healers as vital partners in the healthcare system. In addition, in the context of post-conflict reconstruction, where healthcare infrastructure may have been badly affected, our findings highlight the critical need of restoring and enhancing primary healthcare services. Investments in primary care facilities and worker capacity building can improve access to basic healthcare services while also encouraging early detection and management of health issues.

Specific interventions could include community-based health education initiatives, targeted outreach efforts to vulnerable populations, and the formation of referral networks to ease access to specialized treatment when necessary. Furthermore, initiatives to strengthen healthcare finance systems, such as increasing health insurance coverage or establishing subsidies for important health services, can assist lower financial barriers to care access.

This study has several limitations. First, the cross-sectional design of our study limits our ability to determine causality between variables. Cross-sectional studies collect data at a single point in time, which precludes the assessment of temporal relationships between variables. As a result, while our study identified associations between HSB and various demographic and socioeconomic factors, we cannot infer causality. Future research should utilize longitudinal designs. Second, the self-reported nature of data collection may have introduced biases and limitations. Participants' responses may have been influenced by social desirability bias, which occurs when people provide comments that they believe are socially acceptable rather than reflective of their actual behavior or experiences. In addition, recall bias may affect the accuracy of participants' reports, especially those related to past health-seeking behaviors and experiences. In addition, relying on self-reported data may introduce measurement error because people may misinterpret survey questions or unintentionally provide false responses. To address these limitations, future research could use mixed-methods approaches that combine self-reported data with objective measures or observational data to provide a more complete picture of HSB. Validation studies could also be conducted to assess the accuracy of self-reported measures compared with objective measures of health care utilization.

5 Conclusion

In conclusion, this study offers insight on the intricacies of HSB among the Iraqi population, as well as the barriers within the current healthcare system that may prevent individuals from receiving adequate and quality care. The found HSB inequalities by gender,

marital status, and educational level highlight the need of addressing socioeconomic inequities in healthcare consumption.

These findings have major implications for Iraqi healthcare policy and practice, especially given the country's persistent healthcare issues. By identifying and addressing the factors that influence HSB, policymakers and practitioners can design more targeted and effective interventions to improve healthcare access and utilization. Such initiatives have the potential to improve health outcomes while also helping to develop Iraq's healthcare system. Moving forward, efforts to address economic and educational inequities, as well as programs to raise awareness and education about healthcare-seeking behaviors, are critical for establishing a healthcare system that is accessible, egalitarian, and responsive to the needs of all Iraqi residents. We can work together to create a healthy future for Iraqis by implementing evidence-based solutions.

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 this study was inspected based on ethical criteria and approved by the Islamic Azad University Sanandaj (with ethics code IR.IAU.SDJ.REC.1402.027). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

MM: Writing – review & editing, Conceptualization, Data curation, Investigation, Methodology, Validation, Writing – original draft. KB: Writing – review & editing. AM-B: Writing – review & editing. YM: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft. GM: Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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The Puerto Rico community engagement alliance (PR-CEAL) against COVID-19 disparities: outreach and research engagement efforts in disproportionately affected communities

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In September 2020, the National Institutes of Health acted in response to the COVID-19 pandemic, recognizing the critical need to combat misinformation, particularly in communities disproportionately affected by the crisis. The Community Engagement Alliance (CEAL) emerged as an initiative dedicated to fostering reliable, science-based information, diversity, and inclusion; aiming to implement effective strategies to mitigate the spread of COVID-19 nationwide. One of the teams participating in this initiative is Puerto Rico-CEAL (PR-CEAL). Our whose goal was to raise awareness about the coronavirus disease and advance research, mainly focusing on vulnerable and underserved populations. This concept paper seeks to outline PR-CEAL's infrastructure during its initial two cycles, providing insights into the research and community engagement activities designed to enhance prevention, counter misinformation, and foster awareness and uptake of COVID-19 vaccines. Ultimately, our objective is to reflect on the strengths and challenges encountered thus far as we endeavor to sustain this robust infrastructure, addressing ongoing public health issues with a forward-looking approach.

KEYWORDS

COVID-19, vaccine, disparities, outreach, research, prevention, Puerto Rico

1 Introduction

On March 11, 2020, the World Health Organization officially declared COVID-19 a pandemic (1). Since then, global efforts have combated the spread of SARS-CoV-2 relentlessly. In the United States (US), disturbingly, studies consistently reveal striking disparities, with Black and Hispanic individuals facing a two-fold higher risk of COVID-19-related mortality and a four-fold higher likelihood of hospitalization compared to their White counterparts (2–5). In response to these alarming inequities and the pressing need to combat COVID-19 and vaccine misinformation, the National Institutes of Health (NIH) launched the Community Engagement Alliance (CEAL) Consortium. Eleven states received grants on September 16, 2020; by April 2021, 10 additional states and jurisdictions had been funded. Puerto Rico CEAL (PR-CEAL) emerged as part of the second cohort of consortiums awarded (6, 7). This nationwide initiative aimed to raise awareness, foster educational research, and address outreach and engagement in communities disproportionately affected by the pandemic (7–9).

This community case study outlines the infrastructure of PR-CEAL and the research efforts that have laid the foundation for establishing a targeted community engagement and research network. Furthermore, it aims to reflect on the program's strengths and challenges as it strives to sustain its infrastructure while continuing to address critical public health issues among medically underserved minority groups disproportionately burdened by disease, hospitalizations, and mortality.

2 Context

According to the 2020 US Census, Puerto Rico's population was estimated at 3.2 million people, with a median age of 42.4 years and a median household income of $21,967, significantly lower than the United States' median household income of $61,521 (10). Preceding the pandemic, the enduring impact of environmental disasters on the island had already taken a toll on its economy, health, and security, triggering a substantial migration of Puerto Ricans to the mainland United States (11–18). In addition, the population in Puerto Rico has dwindled by an estimated 4.4% since 2017 (17). This migration dynamic extended to healthcare professionals, with approximately 15% of medical specialists leaving in pursuit of enhanced resources and salaries in the US (16, 18).

The COVID-19 pandemic further compounded the cumulative effects of socioeconomic issues and environmental disasters over the preceding 6 years in Puerto Rico, exerting a detrimental impact on morbidity and mortality in the island. This sequence of events resulted in what can be described as "parallel pandemics," exacerbating socioeconomic and health inequalities (19). Despite facing these challenges, Puerto Rico boasted one of the lowest rates of confirmed cases and deaths related to COVID-19 in the US. As of June 30, 2023, Puerto Rico had reported 1,285,787 confirmed cases and 6,099 deaths (20). This success is attributed to an effective collaborative partnership between academic institutions, government entities, and community-based organizations. This collaborative effort has proven instrumental in implementing preventive and educational initiatives, playing a crucial role in mitigating the burden of COVID-19 in underserved communities on the island (3).

3 PR-CEAL infrastructure

3.1 PR-CEAL Cycle 1: September 2021–March 2022

During the inaugural year of funding, our primary objective at PR-CEAL was to spearhead urgent research initiatives to bolster mitigation efforts for COVID-19. This encompassed the development of prevention strategies and educational campaigns tailored to diminish distrust and misinformation surrounding this public health crisis. In its initial configuration, PR-CEAL comprised five main components: four standalone research projects and a Community Outreach Engagement Group (COEG). Additionally, PR-CEAL collaborated with two distinct, yet interconnected coalitions (Figure 1).

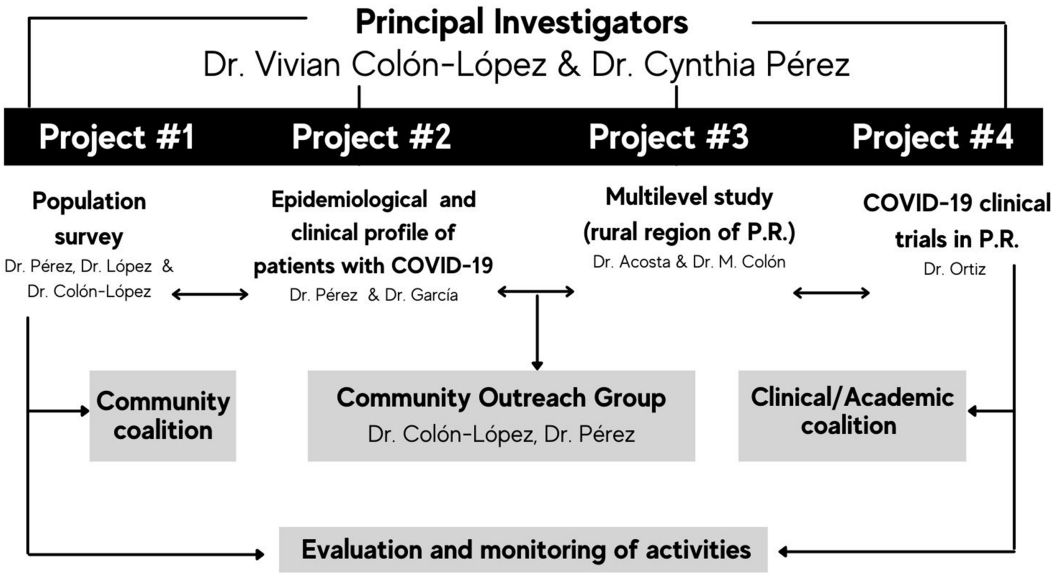


FIGURE 1
PR-CEAL infrastructure for Cycle 1.

The four research projects and a community outreach component delved into critical areas for an immediate understanding of health disparities, emphasizing the dissemination and implementation of community-engagement strategies overseen by the COEG. The principal investigators who lead these efforts are leaders in the field with vast experience in infectious disease, epidemiology, Community-Based Participatory Research, and Community Outreach and Engagement. Support staff from PR-CEAL varies as more experienced staff were supporting the emergency efforts at the time. Research findings were deliberated with the two-coalitions. The clinical-academic coalition played a pivotal role in interpreting results and identifying impactful community strategies. Simultaneously, the community-advisory coalition, including stakeholders and community leaders, contextualized findings within their communities, considering emergent challenges.

Continuous research endeavors, coupled with the collaborative processing of data and addressing needs in tandem with the coalitions, paved the way for developing numerous successful community-based strategies islandwide. All these strategies were conceived in active collaboration with our community and clinical partners (Figure 2). The four research projects that were part of cycle 1 of PR-CEAL were the following:

3.1.1 Project 1—Intention, beliefs, and predictors of vaccination against COVID-19 among adults in Puerto Rico

Project 1 was designed to comprehensively assess COVID-19 vaccine and booster uptake and attitudes and beliefs toward vaccination. The project also aimed to understand perceived barriers and enablers of vaccination, testing behaviors, and various modules related to health behaviors and their impact on mental health outcomes during the pandemic. Adopting a cross-sectional design, the study recruited 784 participants in Puerto Rico through online and in-person channels between December 2021 and January 2022 (9).

Collaborating with our nationwide CEAL partners, a concerted effort was made to develop a survey applicable across diverse settings. Employing the CEAL Common Survey, a cross-sectional study was conducted using a convenience sampling approach. The survey encompassed a range of variables, including sociodemographic characteristics, social determinants of health, COVID-19 prevention behaviors, testing behaviors, trusted sources of information about COVID-19, and general perceptions of the virus. The initial version of the survey was crafted in October 2021. Given the dynamic nature of the pandemic and the introduction of vaccines, a second version of the Common Survey was generated in December 2021. This revised edition incorporated questions about the intent to receive a COVID-19 booster vaccine, self-reported chronic conditions, influenza vaccine uptake, and cancer screening practices.

Building on the work of Wong et al. (21), PR-CEAL integrated additional questions based on the Health Belief Model (HBM) (22) to explore COVID-19 vaccination beliefs, attitudes, and behaviors. An analysis of the HBM constructs revealed that 83% of these constructs exhibited significant associations with booster refusal. Notably, participants who disagreed with the notion that receiving the booster dose made them feel less worried about COVID-19 or believed that the vaccine decreased their chances of contracting COVID-19 demonstrated higher prevalence ratios for booster refusal (9). Participants who expressed concerns about booster side effects, efficacy, and safety were significantly more likely to refuse the booster. Beyond vaccine-related factors, the dataset enabled analyses to explore



FIGURE 2
PR-CEAL: Community-Academic partnership.

challenges related to accessing basic needs such as healthcare services, medications, food, and water during the later stages of the pandemic (23). Furthermore, Project 1 uncovered a significant association between individual and external stressors and their impact on self-reported health. This study also revealed that a considerable proportion of participants, particularly women, experienced changes in stress (78%), weight (56.4%), and eating frequency (45.2%) during the pandemic. These findings underscore the multifaceted nature of factors influencing booster vaccine acceptance and refusal, as well as the broader impact of the pandemic on various aspects of individuals' lives, health, and well-being.

3.1.2 Project 2: Identifying communities that have been disproportionately affected during the COVID-19 pandemic

Project 2 aimed to enhance our understanding of the sociodemographic and clinical characteristics of suspected and confirmed COVID-19 patients receiving care at primary care clinics in Puerto Rico (24). Collaborating with four Federally Qualified Health Care Centers (FQHC) situated in low-income communities, this project sought to shed light on how the pandemic impacted vulnerable populations. The recruitment of suspected and confirmed COVID-19 patients occurred between April 1, 2020, and March 31, 2021. PR-CEAL staff visited the centers and performed medical record reviews to collect epidemiological and clinical information, resulting in a comprehensive database comprising 2,501 patients. Over half (53.8%) of the patients visiting the centers for COVID-19 testing were confirmed to have SARS-CoV-2 infection during the first year of the pandemic. Notably, compared to unconfirmed cases, those with confirmed infections were significantly younger (35.7 ± 19.1 years versus 42.7 ± 19.2 years). Confirmed cases also reported experiencing various symptoms, including cough, headache, muscle aches, and fever. The data also revealed a high prevalence of comorbidities among confirmed COVID-19 cases, with almost 50% of the patients reporting at least one chronic condition, including hypertension, mental health conditions, and diabetes. This insight into the sociodemographic and clinical characteristics of COVID-19 patients in primary care settings contributes valuable information for tailoring healthcare strategies and interventions to better address the needs of vulnerable communities during the ongoing pandemic.

3.1.3 Project 3: Understanding community preparedness, barriers, and facilitators related to COVID-19: community participatory research in Castañer, Puerto Rico

Castañer, located in the central rural expanse of Puerto Rico, is recognized as one of the most geographically secluded communities in the island. It features its own hospital and benefits from a Health Resources and Services Administration (HRSA)-funded FQHC (25). Project 3 utilized a participatory comprehensive community-engaged, mixed-method, multilevel approach to examine barriers and facilitators in the patient, provider, and stakeholder spheres of the Castañer region (26). The methodology involved: (1) Qualitative Exploration: Three focus groups and 23 in-depth interviews, for a total of 56 participants, were conducted via face to face, virtual platforms, or telephone, engaging patients, providers, and key stakeholders within Castañer General Hospital (CGH) and its affiliated primary care clinics in Adjuntas and Jayuya. (2) Quantitative Survey Instrument: One hundred household-based quantitative surveys were systematically administered across four municipalities in the service region of CGH, namely Maricao, Jayuya, Adjuntas, and Lares. Survey participants were recruited through strategic locations like town squares, engagement with school personnel, and involvement with the extended family members of students.

The narratives from participants in the focus groups vividly highlighted the widespread impact of misinformation and mistrust surrounding COVID-19 vaccines (26). These sentiments, which centered on uncertainties regarding vaccine manufacturing, intended purpose, and overall credibility, emerged as significant barriers to broad vaccination efforts. One participant aptly expressed, *"[People would tell me] they are* using us as guinea pigs*, that [the vaccine] is* still not approved*. That is the type of* misinformation *many people received that prevented them from getting vaccinated. So then, we would get many people infected again. People would ask me: "how dare you get vaccinated?" And I would answer: 'Well, because it is a resource available for everyone, so 'let us use it', but people still did not want to get vaccinated'."*

Participants highlighted their primary concerns about family, community, and workplace. They discussed the need for continuous services for older adults lacking transportation, the challenge posed by low technological literacy, and the effects of the pandemic on children. These led to notable shifts in mental health and well-being due to the physical and emotional toll of the pandemic. *"[...] many patients express their depression is directly linked to the isolation imposed by the pandemic,"* a health personnel shared. They often say, "*I feel depressed because I cannot go out or my kids will not spend time with me. It feels like I cannot do anything; I am locked up all the time.*"

Most of the survey participants consistently followed the best COVID-19 public health practices, with 91% reporting steadfast mask usage, 84% practicing diligent handwashing, 72% maintaining physical distancing, and 68% actively avoiding crowded spaces. Notably, one in five participants tested positive for COVID-19 and among those who contracted the virus, one in 10 reported lingering effects. The vast majority (90%) found COVID-19 testing either 'very easy' or 'easy'. Responses revealed a nuanced perspective regarding the perceived safety of available COVID-19 vaccines. Approximately 44% expressed confidence (felt somewhat safe), albeit tentative, while 26% conveyed a strong sense of assurance (felt very safe).

The findings underscored the necessity of combating misinformation, dispelling misconceptions, and mitigating message fatigue. This can be achieved by collaborative efforts with faith-based sectors, enhancing the skills of healthcare personnel, rather than solely focusing on emergency departments and employing individual and social behavior change models in crafting and delivering messages related to the protection, prevention, and management of COVID-19.

3.1.4 Project 4: Promoting and facilitating the inclusion and diversity of Hispanics in clinical trials in Puerto Rico

Given that the COVID-19 pandemic spurred a surge in the initiation of treatment and vaccine clinical trials, this project compiled a directory of COVID-19 clinical trials in Puerto Rico and elucidated the perceived perspectives on participant recruitment among healthcare workers involved in conducting these trials on the island (27). The search from September 2021 to December 2021 utilized NIH RePORTER, clinicaltrials.gov, and centerwatch.com. Additionally, 14

professionals engaged in COVID-19 clinical trials were interviewed regarding details about the trials involved and queries about barriers and facilitators experienced in recruiting participants for these studies. A total of 23 COVID-19-related trials were identified, predominantly focused on treatment (73.9%) followed by vaccine development and efficacy (13.1%). Most trials were funded by pharmaceutical (34.8%) and biotechnology companies (30.4%), with 21.7% financed from federal sources (NIH and the Veterans Affairs Office). According to the interviewed research staff, participants agreed to join COVID-19 trials primarily if they had chronic diseases (92.9%) and because of the importance of clinical trials for developing an effective treatment for COVID-19 (85.7%) (27). Barriers to participation, as perceived by the research staff, included fear of side effects (85.7%), concerns about being treated as "guinea pigs" (71.4%), lack of interest (71.4%), time constraints (71.4%), among others (27). This data underscored the importance of enhancing efforts to promote and increase participant recruitment for COVID-19 trials in Puerto Rico.

This project also sought to understand why people participate in clinical trials using data from a cross-sectional study that collected information from 200 individuals aged ≥21 between November 2021 and March 2022 (28). Nearly all participants were vaccinated against COVID-19 (97.5%), and 65.5% had received the booster dose. Awareness of the availability of COVID-19 clinical trials was noted in only 63.5% of participants. In terms of willingness, 72.2% expressed that they would participate in a trial to receive COVID-19 treatment if infected (28). However, only 7.5% ($n = 15$) had been invited to participate, and merely 3.5% ($n = 7$) had participated in the trial. Among those who participated, common reasons included recognizing the importance of developing COVID-19 treatments and the desire to return to normalcy. Reasons for refusal to participate in a trial included a lack of sufficient information about the trial and concerns about treatment safety, among others (28). The study findings indicate interest in participating in COVID-19-related clinical trials among the studied population. Nevertheless, there is a need for increased efforts to raise awareness to enhance the likelihood of participation, particularly among Hispanic populations.

Given that cancer patients face heightened risks from severe COVID-19 complications, the project also examined COVID-19 clinical trial engagement, willingness, and trust among individuals with and without a history of cancer (29). Merging data from two cross-sectional studies conducted from November 2021 to March 2022 ($n = 987$), the study employed various interview methods with participants aged ≥18. Only 1.5% of the population participated in a COVID-19 clinical trial, with none of the cancer patients involved, and only 1.6% of non-cancer patients participated. While 37.0% expressed strong willingness to enroll in a COVID-19 treatment trial, willingness was higher in cancer patients (55.8%) than in those without cancer (36.1%) (29). Trust in information sources for clinical trials from cancer patients varied, with the highest levels observed at the NIH (90.2%), researchers (88.1%), physicians (85.4%), local clinics (80.9%), and a university hospital (78.6%) but lower for a pharmaceutical company (64.3%), and friend, relative, or community leader (40.5%); no differences were observed by cancer status (29). In conclusion, COVID-19 clinical trial participation was notably low, highlighting the need for education and awareness efforts, mainly targeting cancer patients to enhance representation among Hispanic and vulnerable populations for improved generalizability in future studies.

Finally, the public response to the COVID-19 pandemic has underscored the importance of trust, particularly among minority populations. Using data from PR-CEAL, we assessed the cross-sectional association between trust in information sources and COVID-19 vaccine trust in a sample of 200 adults living in Puerto Rico (30). Participants' confidence in the safety of the COVID-19 vaccine was evaluated based on their level of certainty ("Not at all sure/Not very sure" or "Somewhat sure/Very sure"). Trust in COVID-19 information sources was assessed by the participants' trust levels in that the information sources will provide accurate information of COVID-19, including the US-federal government, PR government, CDC, medical providers, and news (TV/radio/newspaper/internet; "Not at all/A little/Do not know" or "Very much") (30). While most of the study sample (97.5%) had been inoculated with at least one dose of the COVID-19 vaccine, only 86% trusted the COVID-19 vaccine. After adjusting for age and sex, participants who attested greater trust in their medical providers (OR = 4.76, 95%CI: 1.95–11.61), the US federal government (OR = 6.62, 95%CI: 2.18–20.11), and the CDC (OR = 13.22, 95%CI: 5.21–33.53) reported increased vaccine trust as compared to those not having great confidence in these entities (30). These findings support that trust in information from US government agencies and medical providers is positively associated with COVID-19 vaccine trust. Acknowledging predictors of trust supports developing updated and new public health strategies to build vaccine confidence and benefit common welfare.

3.1.5 Community Outreach Engagement Group (COEG)

The Community Outreach Engagement Group (COEG) is an integral component of PR-CEAL, focusing on translating research-driven information into accessible and actionable insights for communities. In pursuit of this objective, COEG has implemented various health promotion and education strategies across Puerto Rico aligned with the above mentioned projects and coalitions. During cycle 1, the COEG actively participated in 149 community events, demonstrating a dedicated commitment to community-engagement (31). Throughout this cycle, COEG focused on one-on-one educational support to counteract COVID-19 vaccine misinformation, debunking myths and emphasizing preventive practices such as disinfecting areas, physical distancing, handwashing, and mask usage. Moreover, COEG distributed resources like hand sanitizers and face masks in 54% of the municipalities in Puerto Rico, as illustrated in Figure 3. These community-events served as valuable platforms for gathering perspectives and concerns from the community, fostering a two-way communication. COEG utilized these interactions to share trusted, evidence-based resources, address the community's needs, and dispel misinformation.

As part of this community-based effort, COEG also developed a survey tool to capture sociodemographic data from participants directly impacted by our educational activities. The first version of this survey, implemented in November 2021, focused on initial dose status, vaccine intentions, preferred vaccine manufacturer, booster eligibility, and influenza vaccine status and intentions. After new recommendations regarding boosters, a second survey version was adapted in December 2021. This revised version included questions about the intention to receive a booster and chronic diseases (i.e., diabetes, cancer, and liver disease) that could elevate the risk of severe illness if infected with COVID-19. The outreach team successfully engaged with 443 participants during this cycle using this survey-tool.



FIGURE 3
Municipalities reached by the community outreach engagement group.

The findings from this study played a pivotal role in shaping targeted communication strategies across communities, with a specific focus on enhancing education, prevention, and inclusion (31).

In addition to measuring beliefs, perceptions, and knowledge regarding vaccine uptake, the COEG developed a series of tailored educational programs targeted to the general population. In December 2021, the COEG launched its inaugural educational campaign, 'Tú Eres Esencial' (You Are Essential), to counter misinformation and curb the spread of COVID-19 (32). This initiative, developed in collaboration with reputable scientists and physicians, significantly contributed to evidence-based vaccination campaigns in Spanish. The campaign comprised 34 short educational-videos featuring Puerto Rican health professionals, including medical doctors, psychologists, medical students, and public health experts. Addressing common questions and dispelled prevalent myths about COVID-19 and the vaccine, ultimately aiming to reduce the spread of the virus. The campaign created educational resources for dissemination across Puerto Rico, collaborating with clinical, academic, and community partners. The campaign targeted older adults, individuals with chronic illnesses, immunocompromised patients, pregnant women, children, and adolescents. Resulting in the establishment of a digital library building a social media presence. The videos were uploaded to the PR-CEAL YouTube page and shared across social media platforms, reaching nearly 3,000 individuals. The campaign played a positive role in increasing vaccine uptake, encouraging communities to stay current with COVID-19 vaccinations, receive booster doses, undergo COVID-19 screening tests, and understand and prevent prolonged COVID-19 conditions.

3.2 PR-CEAL Cycle 2 (April 2022–July 2023)

Building upon the evolving landscape of the pandemic and drawing insights from the data collected through research projects and community engagement, PR-CEAL outlined new objectives for Cycle 2. The aims encompassed the development of a novel component focused on health promoters and the collaborative support of other Community-Based Organizations (CBOs) across the island. The overarching goal was to expand the scope of strategies and engage with diverse subgroups while maintaining a central theme. The specific aims for Cycle 2 included:

1 Conduct community-engaged research and outreach activities focused on COVID-19 awareness, testing, vaccine booster, long COVID-19, and new variant infections.
2 Support community outreach initiatives in vulnerable and underserved populations by creating a pilot program to enhance the scope and reach.
3 Support ongoing NIH-funded research projects in PR aimed at improving recruitment strategies.
4 Conduct clinic-based research to understand the epidemiology, access to care, and quality of life of patients with COVID-19.

As of July 2022, Puerto Rico has achieved one of the highest COVID-19 vaccine uptake rates. However, despite this success, only 53.1% of the population had received booster doses (20), a particularly concerning statistic given the high burden of chronic diseases. In response, PR-CEAL, in collaboration with its community coalition and a communication agency, initiated a second educational campaign called 'Con Refuerzo' (Boosted) (33). The campaign aimed to complement Puerto Rico's public health efforts by issuing a call to action for individuals who had received their primary vaccine doses to get booster shots. Additionally, the campaign encouraged those who received boosters to inspire others, including family, friends, and acquaintances, to follow suit. 'Con Refuerzo' utilized various mediums, including billboards, social networks, videos, and radio spots, to emphasize the critical importance of receiving booster doses. The campaign featured P.J. Sin Suela, a renowned exponent of urban music who also practices medicine in Puerto Rico, as its spokesperson. Leveraging P.J. Sin Suela's dual role as a prominent musician and medical professional provided a unique opportunity to connect with and motivate the Puerto Rican population. Notably, this collaboration aimed to encourage individuals to act by getting their booster shots, focusing on reaching as many people as possible before P.J. Sin Suela's August 2022 concert.

Continuing our commitment to health promotion and education, the COEG team initiated the 'Retomando mi Salud' (Regaining My Health) campaign, officially launched in February 2023 (34). This campaign leveraged our social media platforms and a dedicated

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supplement in a local newspaper to disseminate its message. The primary goal of this campaign was to inspire individuals to prioritize their health by attending scheduled medical appointments and seeking screenings, prevention measures, diagnoses, and treatment for chronic illnesses.

To expand the impact of our community outreach efforts, PR-CEAL initiated a pilot program focused on supporting the development of community initiatives. Three non-profit community-based organizations, namely *Coalición de Coaliciones Pro Personas Sin Hogar*, *CienciaPR*, and *Arecma Inc.*, were recipients of grants from PR-CEAL. These grants were allocated to facilitate the creation of community initiatives specifically designed to address COVID-19 prevention and misinformation within Puerto Rico's vulnerable and underserved populations. The selected organizations pursued distinct objectives aligned with their unique strengths and target communities, including homeless populations in Puerto Rico, reaching a diverse community through science, and impacting the rural region in the southeast of the island.

In response to the lack of comprehensive information on Long COVID within underserved populations in Puerto Rico, we conducted a prospective cohort study in 2022 focusing on individuals with confirmed SARS-CoV-2 infection (35, 36). Initial interviews covered sociodemographic details, comorbidities, vaccination status, and persistent or new symptoms post-acute infection. Out of 263 participants, 256 had the infection at least 4 weeks before the interview. The mean age of the participants was 48.1 ± 15.9 years, 201 (78.8%) were women, and 191 (74.6%) were presenting Long COVID symptoms. Those with Long COVID experienced a significantly higher prevalence of tiredness, muscle pain, headaches, joint pain, and anxiety. Adjusting for age, sex, and severity, having a chronic condition was significantly associated with higher odds of Long COVID (OR 3.38; 95% CI, 1.62–7.04). Specifically, individuals with asthma, obesity, hypertension, and diabetes had significantly higher odds of Long COVID. Preliminary data reveals a notable prevalence of Long COVID, particularly among those with comorbidities in Puerto Rico, indicating an elevated risk in this population.

A new health promoters' component was developed to address the impact of the COVID-19 pandemic on NIH-funded research studies and to enhance the participation of Puerto Ricans in clinical trials and other initiatives. Recognizing the increased risk for severe disease and the underrepresentation of Puerto Ricans in research studies, the health promoters collaborated with the recruitment, in-person assessment, and follow-up of study participants in Puerto Rico, as illustrated in Figure 4. Several NIH-funded research studies benefitted from the support and involvement of the health promoters' component, including PR-OUTLOOK (Puerto Rico Young Adults Stress, Contextual, Behavioral and Cardiometabolic Risk) (37), the California-Mexico-Puerto Rico (CAMPO) partnership center (38), All of Us Research Program (39), and Puerto Rico COVID-19 Vaccine Uptake Study (PR-COVACUPS) (40). The health promoters actively engaged with these research studies' recruitment and retention support. Additionally, mutual support was evidence with the

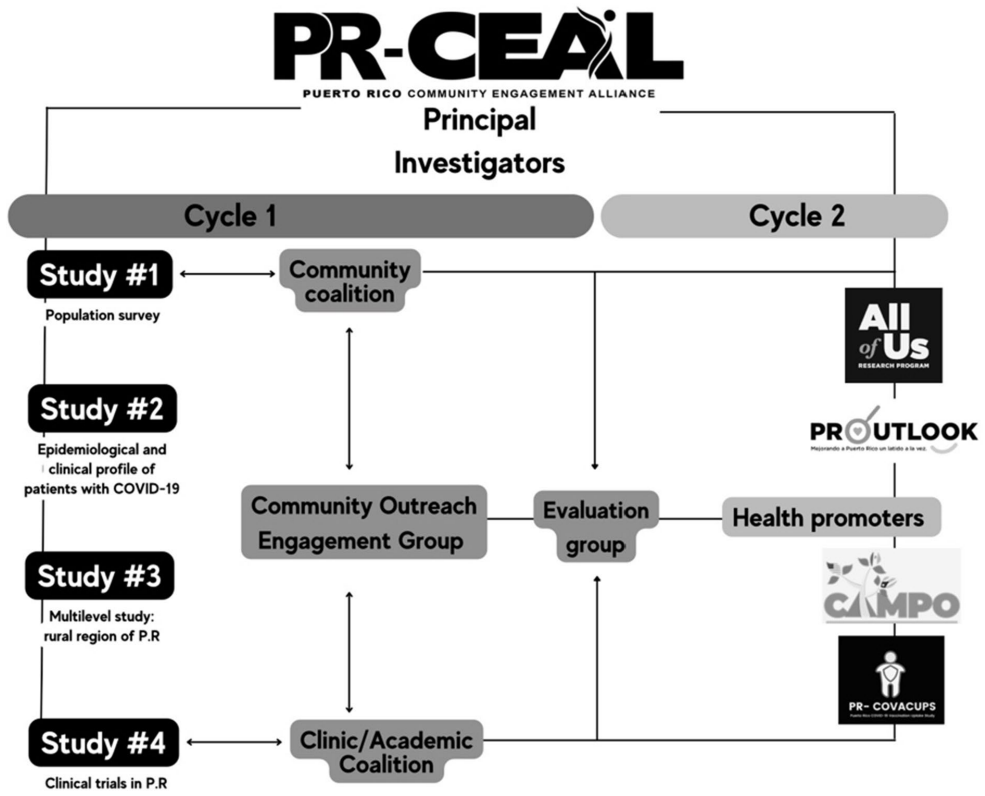


FIGURE 4
PR-CEAL infrastructure for Cycles 1 and 2.

Community Engagement and Outreach Core of the Hispanic Alliance in Clinical and Translational Research (Clinical and Translational Research Network, Institutional Development Award). Through their efforts, many interested individuals, totaling 3,907, were reached in various community settings. The health promoters played a crucial role in informing individuals about opportunities for participation in clinical trials or population-based research, contributing to the broader goal of increasing representation and engagement in research studies among the Puerto Rican population. This collaborative approach ensures that research outcomes are more inclusive and representative of diverse communities.

4 Discussion

The CEAL initiative has successfully implemented an integrated infrastructure that enhances collaboration between scientists and community-based partners nationwide. This infrastructure enables the rapid development of evidence-based community engagement responses to address and reduce disparities in disease outcomes. Specifically, for PR-CEAL, the initiative has strengthened ties with community partners, promoted bilateral communication between academia and the community, and fostered a valuable partnership that allowed us to achieve our goals and pinpoint areas requiring attention. It has also expanded our network with new community partners and organizations that serve specific groups and communities, which has helped to increase the reach of vulnerable and underserved communities. These vulnerable, non-institutionalized populations include the older adults, homeless, children, immunocompromised individuals, families living in poorer areas, caretakers of functional diversity patients, and pregnant women. The COEG team reached these groups during various activities and project-related initiatives throughout the island. During our collaboration with Coalición de Coaliciones Pro Personas Sin Hogar, Inc., homeless individuals o in the South Region of Puerto Rico were impacted as the team provided COVID-19 prevention materials, clothing, and evidence-based information of COVID-19. However, several limitations posed challenges to establishing collaborations with certain organizations to address needs effectively. Specifically, constraints on the financing period, limited from the CBO and limited administrative support for the allocation of funds for team personnel contracts, creates gaps in an expedite collaboration with our partners. Despite limited funding due to the timeline of the grant, community-based relationships can be sustained with strategic planning and capacity building.

Moreover, through dynamic exchanges with our partners, we bridged the gap between theoretical insights and practical applications, ensuring that our initiatives had a meaningful impact on people living in Puerto Rico. Our community partners provided valuable insights, real-world perspectives, and a deeper understanding of the challenges faced by these communities. Meanwhile, the academic community contributed expertise, cutting-edge research, and extensive resources. Information gleaned from research projects and community interactions has been instrumental in understanding the challenges faced by different communities and establishing trust in the scientific process. Furthermore, these data have been crucial in targeting COVID-19 resources equitably to each community.

These initiatives have not only shed light on effective ways to address challenges but have also contributed to understand the burden of COVID-19 in underserved communities. Lessons learned led to a robust infrastructure to efficiently address a variety of public health inequities, from a local context perspective, in collaboration with our community partners. Insights have identified information-based needs and perceptions about vaccines and treatments, addressing concerns about medical mistrust and healthcare access inequities. These findings have been instrumental in guiding future community outreach initiatives and strategic action. The collected data serves as a valuable tool for decision-makers, enabling them to analyze and understand the community's unique needs and challenges, and have served as a learning lesson to scientists in conveying community partners into research protocols since its inception.

It has also promoted a continued dissemination of findings, leading to new initiatives that are research-driven and value-added for investment in our community partners. With this infrastructure, future efforts from CEAL will implement evidence-based interventions to address Social Determinants of Health in underserved communities nationwide. PR-CEAL will focus on health literacy, food insecurity, and access to healthcare as we aim to help break down the systematic barriers that contribute to health disparities. Community outreach and engagement will be at the core of our approach, ensuring that interventions are culturally tailored to assess specific community needs.

5 Conceptual or methodological constraints

While PR-CEAL has made significant strides in its community engagement efforts, it is crucial to acknowledge the challenges and limitations encountered, which can inform and guide future projects that provide rapid responses. The spread of the Omicron variant and adherence to social distancing guidelines posed significant challenges to data collection settings and methods. Participant recruitment faced hurdles due to restrictions and safety concerns associated with the evolving pandemic situation. Additionally, Project 4 encountered recruitment challenges due to the resistance from community members stemming from a lack of trust in participating in research initiatives and clinical trials. However, different mechanisms were implemented to overcome these challenges, utilizing typical recruitment venues such as flyers, official university e-mail blasts, and crowdsourced research platforms. The dynamic nature of COVID-19 guidelines, including mask recommendations, vaccination protocols, social distancing measures, the spread of misinformation, and the uncertain and prolonged pandemic timeline, introduced challenges in planning and executing projects. Moreover, these continuous preventive guidelines caused pandemic fatigue among Puerto Ricans, disrupting health promotion practices for COVID-19. Furthermore, due to the limited availability of ferry transportation, we were unable to impact the municipalities of Vieques and Culebra, two nearby islands that are off the east coast of Puerto Rico. Future projects should consider these challenges and proactively plan for strategies to mitigate their impact. Flexibility in project design, robust communication and dissemination strategies, and ongoing support for community

health workers are essential for success in the rapidly evolving landscape of public health emergencies.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the University of Puerto Rico Institutional Review Board (Protocol # A806022). Written informed consent for participation was not required for this study in accordance with the national legislation and institutional requirements.

Author contributions

AP-C: Writing – original draft, Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing. CP: Writing – review & editing, Conceptualization, Data curation, Writing – original draft, Methodology. KC-B: Writing – review & editing, Data curation, Formal analysis, Methodology. ZT-Q: Writing – review & editing. NS-T: Writing – review & editing, Data curation, Formal analysis, Methodology. AL-C: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Methodology. EG-R: Conceptualization, Data curation, Formal analysis, Writing – review & editing, Methodology. ML: Writing – review & editing. EA-P: Conceptualization, Data curation, Formal analysis, Writing – review & editing, Methodology. MC: Conceptualization, Data curation, Formal analysis, Writing – review & editing, Methodology. ZR: Data curation, Formal analysis, Writing – review & editing. AO: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Methodology. FR-G: Writing – review & editing. VC-L: Writing – review & editing, Conceptualization, Data curation, Writing – original draft, Methodology.

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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.

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A study on the academic innovation ability and influencing factors of public health graduate students based on nomograms: a cross-sectional survey from Shandong, China

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Background: In recent years, the impact of the COVID-19 pandemic and various public crises has highlighted the importance of cultivating high-quality public health talents, especially those with innovative capabilities. This study focuses on the academic innovation ability of public health postgraduate students, which can provide important theoretical support for the cultivation of more public health workers with high innovative capabilities.

Methods: From May to October 2022, a cluster sampling method was used to select 1,076 public health postgraduate students from five universities in Shandong Province. A self-designed questionnaire survey was conducted. A chi-square test and binary logistic regression analysis were used to analyze the influencing factors of students' academic innovation ability. Based on these factors, a nomogram was constructed to intuitively demonstrate the impact of these complex factors on students' innovation ability.

Results: The results showed that gender, whether serving as a student leader, teacher-student relationship, academic motivation, learning style, academic environment, and teaching mode were the influencing factors of postgraduate students' academic innovation ability. The column-line diagram (AUC = 0.892, 95% CI = 0.803 ~ 0.833) constructed based on the above influencing factors has good differentiation. The area under the ROC curve is 0.892 (95% CI = 0.803 ~ 0.833), and the calibration curve shows that the predicted value is the same as the measured value.

Conclusion: The nomogram constructed in this study can be used to predict the academic innovation level of public health graduate students, which is helpful for university education administrators to evaluate students' academic innovation ability based on nomogram scores and carry out accurate and efficient training.

KEYWORDS

nomogram, academic innovation ability, graduate student, public health, medical education reform, cross-sectional study, China

1 Introduction

The COVID-19 pandemic has made countries around the world realize that having a well-rounded public health workforce is an important guarantee for responding to public health crises, especially those with high-quality public health talents who can lead innovation and drive technological progress (1). As high-level talents in the future field of public health, graduate students in public health cultivate their academic innovation ability during their time at university so that they can become more innovative public health workers to respond to various public health disasters (2).

Over the past decade, the scale of postgraduate education in China has increased rapidly, making it the second-largest country in the world in this area of education (3). Unfortunately, the overall quality of graduate education in China is inadequate, and graduate students' lack of innovation ability is considered a significant problem in graduate education (4). There is an urgent need to address the obvious contradiction between the lack of public health human innovation capacity and the increasing complexity of local public health emergency tasks (5, 6). Therefore, in-depth research must be conducted on the cultivation of innovation ability in graduate students' education in public health, and the problems and influencing factors in students' training must be clarified.

The existing research on the influencing factors of graduate students' innovation ability mainly focuses on the influence of mentor support and guidance style, creative self-efficacy, cognitive skills, and early research experience on graduate students' innovation ability (7–9). The psychologist Amabile proposed the componential theory of creativity (10) and Woodman proposed the interactional model of creativity (11), revealing the influence mechanism of personal endowment and external environmental variables on innovation ability, including knowledge, intrinsic motivation, cognitive ability, and personality. The external environment includes external evaluation, reward, and supervision. Subsequent studies have also explored the influencing factors affecting the academic innovation ability of public health graduate students from both individual and environmental aspects. A systematic review of this literature shows that individual factors mainly include academic motivation, learning style, and scientific research participation (12, 13), while environmental factors mainly include academic environment, teaching mode, teacher-student relationship, academic support from tutors, academic platforms, training models, and degree policy requirements (14–17).

It is worth noting that although a large number of studies have explored the influencing factors of graduate students' innovation ability, lack of research in the field of public health persists. Most of the existing studies do not distinguish between disciplines but include all graduate students in various disciplines in the research scope to explore the cultivation of such students' innovation ability and analyze the influencing factors. In addition, many studies tend to explore the impact on innovation ability from only one perspective, such as external factors (e.g., mentoring style) or individual factors (e.g., self-efficacy) (18–20). Research on graduate students' innovation ability in the field of public health from the perspective of comprehensive factors is lacking.

Nomograms can quantify the risk of an event through a variety of predictors, visually showing the results of logistic regression (21). At present, nomograms are widely used in the prediction of clinical diseases and show good predictive ability in the study of non-clinical problems, such as the prediction of undergraduate students' self-regulated learning level (22), the risk of adolescent bullying (23), and primary and secondary school students' suicidal tendency (24). Therefore, nomograms can be applied to the quantitative prediction and evaluation of the influencing factors of academic innovation to provide more accurate theoretical support for the improvement of the innovation level of public health graduate students.

2 Materials and methods

2.1 Research design and data sources

From May to October 2022, this cross-sectional study used a cluster sampling method to select five universities in Shandong Province with this the public health major as survey sites; all public health graduate students from the five universities were selected as survey participants. In light of strict COVID-19 control measures, data were collected online through the use of Wenjuanxing. Wenjuanxing is a professional online survey tool with comprehensive data collection and privacy protection features. The purpose of this study and the privacy policy were explained to participants, who could decide whether or not to complete the questionnaire after reading the questionnaire instructions. Before the start of the questionnaire, participants were required to check the following: "I have read and agree to participate in this study," indicating that they were willing to participate and provide informed consent. To ensure the quality of the questionnaire, questionnaires with a filling time of less than 5 min and incomplete filling were excluded.

We used WeChat to distribute the surveys, given the high popularity and convenience of the platform. First, we established close cooperation with the five universities in Shandong Province with public health-related majors and appointed investigators from each university as our liaison. These investigators were rigorously screened and trained to ensure that they had a thorough understanding of the purpose of the study, the content of the questionnaire, and the distribution process. After, the investigators contacted the heads of public health disciplines at their respective institutions to introduce the importance of the study, the content of the questionnaire, and the precautions for filling it out. After, the heads of the disciplines forwarded the link to all class representatives in each school year to ensure that every student would promptly receive the link to the questionnaire and clearly understand the meaning and requirements of filling it out. From a total of 1,255 graduate students, 1,150 questionnaires were collected, with a response rate of 91.64%. Seventy-four invalid questionnaires were eliminated; 1,076 valid questionnaires were valid, with an effective rate of 93.57%.

2.2 Questionnaire

Combined with the characteristics of expert consultation, preliminary research foundation (25–29), and the subjectivity, initiative, and practicality of Chinese public health graduate students, we compiled the Questionnaire on Academic Innovation Ability of Public Health Graduate Students. After the questionnaire was completed, we conducted a pilot test at Shandong Second Medical University. In

response to the problems in the pilot test process, we modified the questionnaire. The questionnaire consisted of three parts: demographic information, questionnaire on academic innovation ability, and questionnaire on influencing factors of academic innovation ability.

The questionnaire on academic innovation ability included four dimensions: personal traits (4 items), professionalism (6 items), basic abilities (5 items), and thinking characteristics (2 items). Each item adopted a 5-level Likert scoring system, and was assigned 1–5 points ranging: "very disagreeable," "somewhat dissatisfied," "somewhat compliant," "compliant," and "very consistent." The higher the score, the higher the individual academic innovation ability. The total score ranged from 43 to 215, and a score of >129 indicates high academic innovation ability; otherwise, scores were recorded as low academic innovation ability (30, 31). In this study, Cronbach's alpha of the four dimensions of personal traits, professional qualities, basic abilities, and thinking characteristics were 0.967, 0.960, 0.951, and 0.901, respectively, indicating that the questionnaire had good reliability. The Kaiser-Meyer-Olkin (KMO) value was 0.984, which verified the construct validity of the questionnaire construction.

The design of the influencing factors of academic innovation ability was mainly based on the previously published literature represented by Amabile's innovation ability component theory and Woodman's innovation ability interaction model. The influencing factors were divided into two dimensions: individual and environment. Among them, the individual dimension mainly covers sex, degree, degree type, student leadership, scientific research participation, academic motivation, and learning style. The environmental dimension mainly covered academic platform, teacher-student relationship, tutor academic support, academic environment, training mode, degree requirement policy, and teaching mode. The above factors formed the academic innovation ability questionnaire, and the content of the survey was mainly in the form of students' own attitudes and cognitions. In this study, Cronbach's alpha of the questionnaire was 0.847, indicating that the scale has good internal consistency and reliability. The KMO value was 0.831, which verified that the questionnaire had good construct validity.

2.3 Statistical methods

SPSS26.0 and R version 4.3.1 software were used for data analysis; the measurement data were expressed as mean ± standard deviation and the count data were expressed as the number of cases and percentage (%). The *t*-test was used for the comparison of quantitative data between groups; The χ^2 test was used for the comparison of categorical data between groups, and binary logistic regression was used for the analysis of influencing factors; the difference was statistically significant, with $p < 0.05$. According to the identified influencing factors, a nomogram was constructed to predict the academic innovation ability of graduate students in public health. The receiver operating characteristic (ROC) curve, area under the ROC curve (AUC), and calibration curve were used to evaluate the prediction accuracy and consistency of the model.

2.4 Ethics approval

This study was approved by the Ethics Committee of Weifang Medical University (No. 2021YX130, Weifang Medical University was renamed Shandong Second Medical University in December 2023). Prior to the study, all participants were informed of the study's research purpose and content and provided informed consent online.

3 Results

3.1 Statistical analysis of the description of the academic innovation ability of graduate students in public health

As shown in Table 1, the graduate students' academic innovation ability scored 3.50 ± 0.71. Among the four dimensions, professionalism scored the highest, with an average score of 3.65 ± 0.73, while the other dimensions scored an average of 3.5 or less; personal traits scored an average of 3.31 ± 0.86, basic abilities averaged 3.47 ± 0.76, and thinking characteristics scored an average of 3.48 ± 0.81. Among the secondary indicators, postgraduate career planning scored the highest, with a mean score of 3.82 ± 0.87. Psychological adaptation and decision-making ability scored the lowest, with 3.29 ± 0.89 and 3.29 ± 0.96, respectively.

The radar chart in Figure 1 shows the academic innovativeness scores of different postgraduate students. As shown in Figure 1, there is a difference in the academic innovativeness scores of different students. Students with low academic innovativeness scored between 2 and 3, while all the students with high academic innovativeness scored more than 4. The average graduate student score was about 3. Across all items, both categories of postgraduate students had higher mean scores on professionalism (3.27 and 4.32, respectively) and lower scores on personal traits, which were particularly pronounced for postgraduate students with low levels of academic innovativeness.

As shown in Table 2, a total of 1,076 postgraduate students were surveyed in this study, including 753 cases in the modeling group and 323 cases in the validation group. There were 409 cases (38%) of males and 667 cases (62%) of females. Most of the study participants were in the master's degree segment, accounting for 92.2%. Professional degrees had the highest number, accounting for 73%. More graduate students did not serve as student leaders, accounting for 60.7%. Among the postgraduate students with different genders, degree, whether they served as student cadres, academic platforms, teacher-student relationships, scientific research participation, academic motivation, learning style, academic support from supervisors, academic environment, training mode, degree requirement policy perception, and teaching mode were statistically significant ($p < 0.05$) in different academic innovation capabilities.

3.2 Analysis of factors influencing public health postgraduate students' academic innovation capacity

The results of the logistic regression analyses in Table 3 show that gender, whether or not they are student leaders, teacher-student relationships, academic motivation, learning styles, academic environment, and teaching modes are influential factors in the academic innovativeness of public health postgraduate students. Males were 1.769 times more likely than females to have high levels of innovation (95% CI = 1.255–2.492). Graduate

TABLE 1 Score on the academic innovation ability of public health graduate students.

First-level indicators	Secondary indicators	Low academic innovation M ± SD	High academic innovation M ± SD	All M ± SD
Personal traits	Self-control	2.88 ± 0.64	4.10 ± 0.63	3.31 ± 0.86
	Psychological adjustment	2.83 ± 0.64	4.13 ± 0.61	3.29 ± 0.89
	Trait of flexibility	2.94 ± 0.61	4.16 ± 0.58	3.38 ± 0.84
	Achievement oriented	3.06 ± 0.59	4.29 ± 0.45	3.50 ± 0.80
Professionalism	Foresight of science	3.17 ± 0.64	4.29 ± 0.46	3.57 ± 0.79
	Ethics of work	3.30 ± 0.76	4.33 ± 0.49	3.67 ± 0.84
	Awareness of service	3.23 ± 0.69	4.35 ± 0.48	3.63 ± 0.82
	Professional responsibility	3.00 ± 0.67	4.26 ± 0.53	3.45 ± 0.87
	Career planning	3.51 ± 0.88	4.37 ± 0.51	3.82 ± 0.87
	Working in a team	3.42 ± 0.75	4.36 ± 0.48	3.76 ± 0.80
Basic abilities	Ability to execute	3.30 ± 0.66	4.34 ± 0.47	3.67 ± 0.78
	Communication skills	3.28 ± 0.68	4.29 ± 0.51	3.64 ± 0.79
	Ability to learn	2.96 ± 0.69	4.13 ± 0.63	3.37 ± 0.87
	Decision-making skills	2.86 ± 0.78	4.06 ± 0.76	3.29 ± 0.96
	Outreach capability	2.95 ± 0.77	4.12 ± 0.69	3.37 ± 0.93
Thinking characteristics	Critical creative thinking	3.03 ± 0.67	4.21 ± 0.54	3.45 ± 0.84
	Information integration management	3.11 ± 0.76	4.22 ± 0.57	3.50 ± 0.88

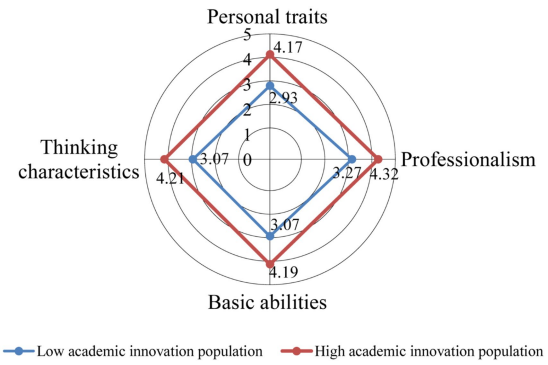


FIGURE 1
Radar chart of the scores of the two types of graduate students on academic innovation ability.

students who served as student leaders were 1.616 times more likely to have high levels of academic innovativeness than those who did not (95% CI = 1.149, 2.273). For every 1-point increase in the self-scoring score of the student-faculty relationship, the likelihood of having a high level of academic innovativeness increased by 1.83 times (95% CI: 1.478–2.264). In addition, the likelihood of having a high level of academic innovativeness increases by 2.04 times (95% CI: 1.567–2.657), 2.909 times (95% CI: 2.185–3.872), and 1.646 times (95% CI: 1.288–2.103) for each 1-point increase in the self-rating scores of Academic Motivation, Learning Styles, Academic Environment, and Teaching Mode, respectively, 2.331 times (95% CI: 1.849–2.939).

3.3 Construction of nomogram of academic innovation ability of graduate students in public health

Based on the results of logistic regression analyses, we further constructed a nomogram by combining variables including sex, whether serving as a student leader, teacher-student relationship, academic motivation, learning style, academic environment, and teaching mode. As shown in Figure 2, the values of each factor correspond to the individual scores in the first row of the nomogram; the scores of the seven risk factors are added together to obtain the total score. The higher the total score, the more likely the student is to have a high level of academic innovation. As shown in Figure 2, the values of each factor correspond to the individual scores in the first row of the nomogram; the scores of the seven risk factors are added together to obtain the total score. The higher the total score, the more likely the student is to have a high level of academic innovation. For example, if a female student is a student leader and her self-rating scores for academic motivation, learning style, academic environment, and teaching mode are 4, 5, 5, 5, and 3, respectively, then the nomogram corresponds to 0, 13, 52, 82, 100, 68, and 48, respectively, with a total score of 363, indicating that the probability of the graduate student's high level of academic innovation is greater than 90%. A high score on the nomogram indicates that the student's academic innovation ability will be high. Conversely, a low score indicates that the student's academic innovation ability will be low. Therefore, educators can improve the nomogram score by reinforcing one or more of the influencing factors for different individual students to improve students' academic innovation

TABLE 2 General characteristics and univariate analysis of public health graduate students.

Categories	Low academic innovation ability (*N* = 693)	High academic innovation ability (*N* = 383)	*p*-value
Gender*			
Men	231 (33.33)	178 (46.48)	<0.001
Women	462 (66.67)	205 (53.52)	
Degree*			
Master	638 (92.06)	354 (92.43)	0.831
Doctor	55 (7.94)	29 (7.57)	
Degree type*			
Academic degree	204 (29.44)	86 (22.45)	0.014
Professional degree	489 (70.56)	297 (77.55)	
Whether serving as a student leader*			
Yes	238 (34.34)	185 (48.30)	<0.001
No	455 (65.66)	198 (51.70)	
Academic platform**	3.39 ± 0.82	3.73 ± 0.92	<0.001
Teacher-student relationship**	3.38 ± 0.82	3.79 ± 0.88	<0.001
Scientific research participation**	3.79 ± 0.76	3.93 ± 0.64	<0.001
Academic motivation**	3.17 ± 0.78	4.04 ± 0.75	<0.001
Learning style**	3.20 ± 0.77	4.09 ± 0.67	<0.001
academic support from supervisors**	3.11 ± 0.81	3.91 ± 0.81	<0.001
Academic environment**	2.97 ± 0.75	3.80 ± 0.89	<0.001
Training model**	3.00 ± 0.77	3.79 ± 0.91	<0.001
Degree requirement policy**	3.06 ± 0.81	3.81 ± 0.87	<0.001
Teaching model**	3.04 ± 0.82	3.77 ± 0.82	<0.001

The supplementary footnotes are as follows: *describe the characteristics of participants with n(%); **describe the characteristics of participants with M±SD.

TABLE 3 Logistic regression analysis of the influencing factors of academic innovation ability of graduate students.

Categories	*β*	SE	Wald	*p*	OR (95%CI)
Sex (Women)	0.570	0.175	10.630	0.001	1.769 (1.255, 2.492)
Whether serving as a student leader (No)	0.480	0.174	7.614	0.006	1.616 (1.149, 2.273)
Teacher-student relationships	0.604	0.109	30.840	<0.001	1.830 (1.478, 2.264)
Academic motivation	0.713	0.135	28.060	<0.001	2.040 (1.567, 2.657)
Learning style	1.068	0.146	53.511	<0.001	2.909 (2.185, 3.872)
Academic environment	0.498	0.125	15.868	<0.001	1.646 (1.288, 2.103)
Teaching model	0.846	0.118	51.230	<0.001	2.331 (1.849, 2.939)
Constant quantity	−14.174	0.875	262.219	<0.001	

ability. Furthermore, educators can also evaluate students' academic innovation ability potential based on nomogram scores to carry out accurate and efficient training.

The AUC = 0.892 (95%CI = 0.803 ~ 0.833) of the model indicates that the nomogram has a good degree of discrimination. The model was applied to the test set, as shown in Figure 3, AUC = 0.870 (95%CI = 0.781 ~ 0.813), indicating that the nomogram still had a good degree of discrimination. As shown in Figure 4, the calibration plot shows that the predicted values are in good agreement with the actual values.

4 Discussion

In recent years, the impact of the COVID-19 pandemic and various public crises indicates that we should pay attention to public health disciplines and reform the traditional teaching mode according to current times and student characteristics (32). Focusing on the academic innovation ability of graduate students majoring in public health, this study designed a questionnaire to carry out a cross-sectional survey to clarify the current situation and existing problems of graduate students' academic innovation ability and used logistic regression to determine the

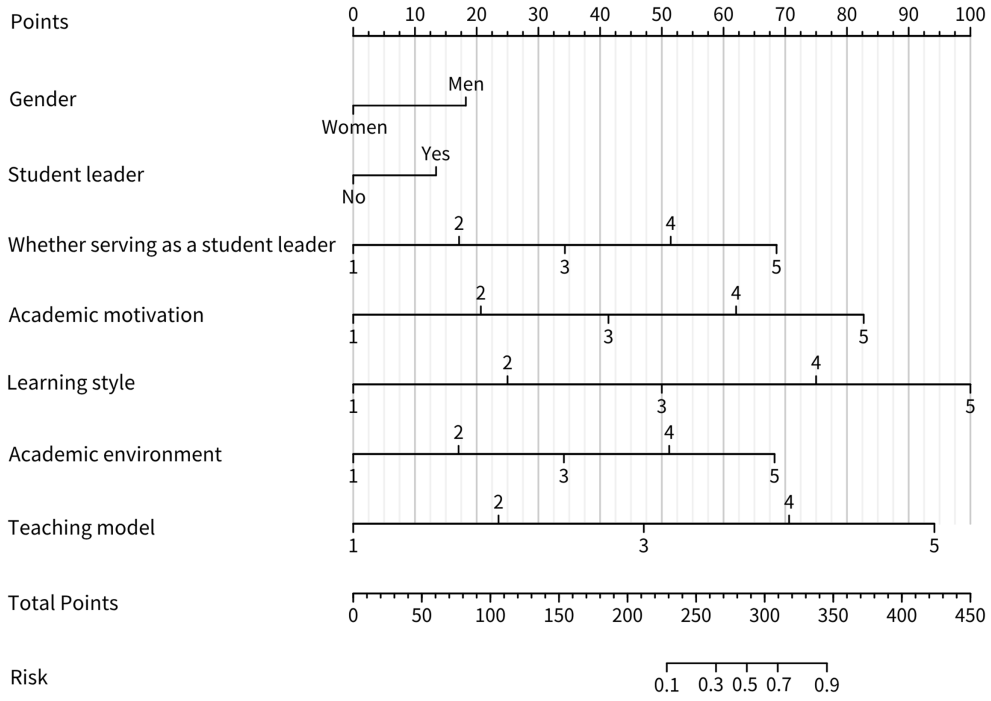


FIGURE 2
A nomogram predicting the academic innovation capacity of graduate students.

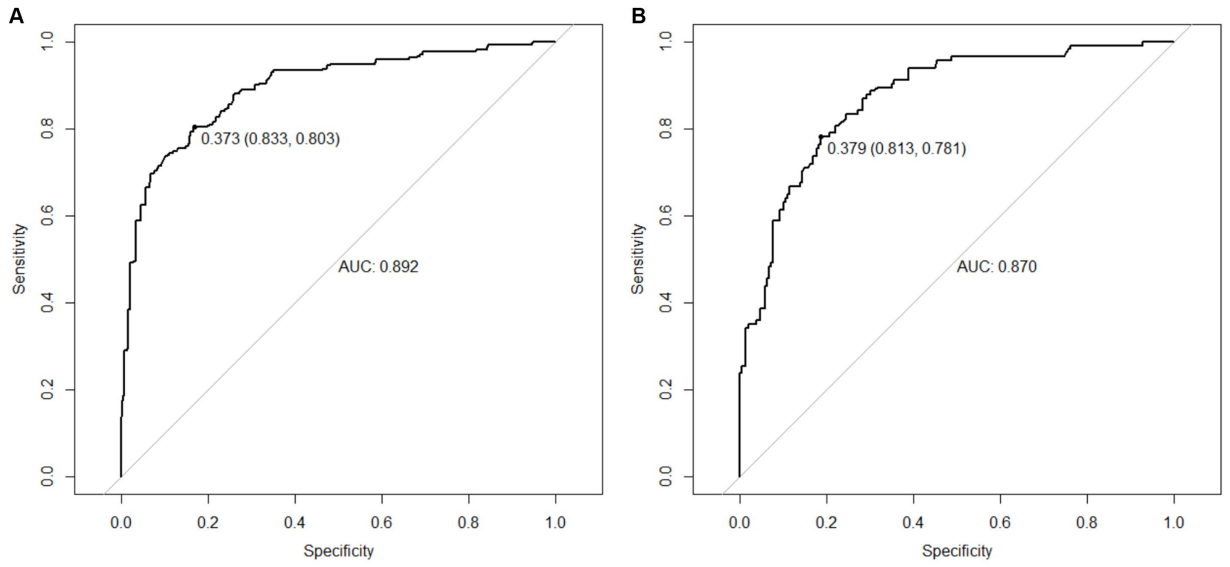


FIGURE 3
ROC curve of the nomogram prediction model. **(A)** ROC curve of the training set. **(B)** ROC curve of the validation set.

influencing factors and predictors of the academic innovation level of graduate students in public health. It provides strong theoretical support for improving the innovation ability of public health graduate students and cultivating more high-quality public health manpower.

The study found that the level of academic innovation of public health graduate students was not high, with an average score of 3.50 ± 0.71, consistent with earlier studies (33). Among them, the professional quality score was the highest, with an average score of 3.65 ± 0.73. This suggests that public health graduate students have a strong sense of career planning and teamwork, which is consistent with other findings (34). In addition, the personal trait score was the lowest (3.37 ± 0.78), especially in the psychological adjustment index (3.29 ± 0.89), which was also consistent with the results of earlier studies (35). Studies have shown that graduate students face heavy research tasks, work uncertainty, interpersonal communication, and other pressures (36, 37), and their self-regulation ability is limited.

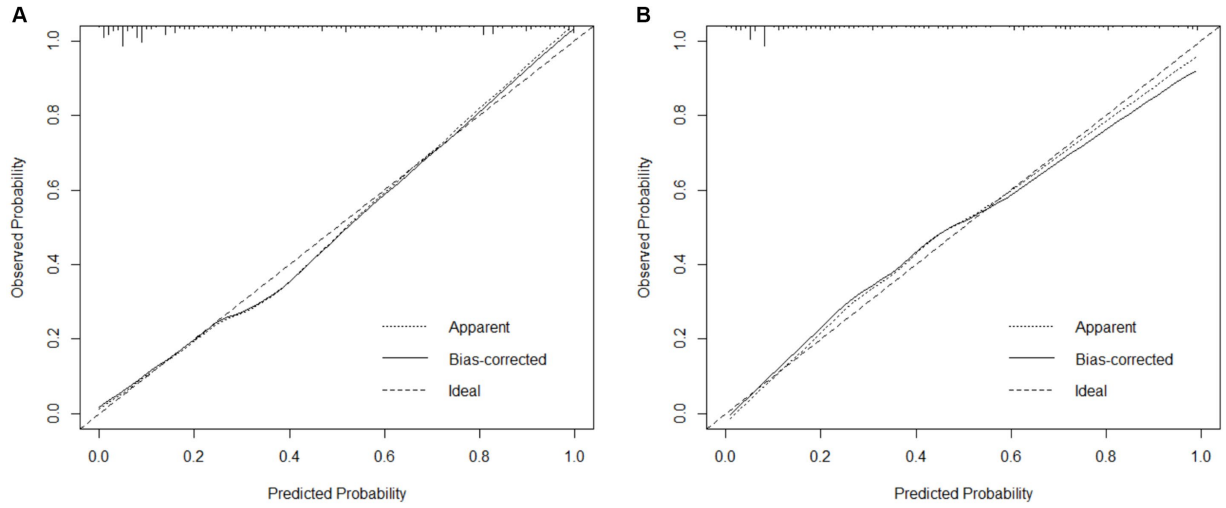


FIGURE 4
Calibration curves of nomograms. **(A)** Calibration curves of the training set. **(B)** Calibration curves for the test set.

When students' psychological pressure is overloaded and their regulation is out of control, negative emotions such as depression and anxiety occur, which affect students' research progress, career development, academic efficiency, and personal life (38). Therefore, the managers of graduate education should pay attention to strengthening the investment of resources to ensure graduate students' mental health and the construction of facilities for psychological counseling services to continuously improve their psychological resilience and adaptability.

Personal factors are the foundation of and an important motivation for graduate students' academic innovation. Among them, academic motivation is closely related to innovation tendency (39), and motivation can be regarded as a necessary "starting ingredient" in the innovation process. In this study, there was a positive correlation between learning motivation and academic innovation ability, and strong learning motivation could promote students' academic creation. This may be because when students have strong individual initiative, they are more willing to devote energy to tackling challenging tasks, which is consistent with other studies (40, 41) and further validates the role of individual internal factors on academic innovation ability in theory. The learning style of this study emphasizes whether individuals can acquire knowledge stably, continuously, and effectively, and fully discover and make use of surrounding resources. Through the reorganization of existing knowledge and the independent transformation of university resources, students can cultivate independent thinking, problem analysis, and problem-solving skills, which are conducive to creative problem-solving and improving the level of academic innovation (12, 42).

Studies have shown that men have a higher level of academic innovation than women, which is consistent with the results of other studies (43). This may be due to personality differences between genders, resulting in differences in academic innovation. In general, men are more adventurous and independent, which can help inspire innovation. Comparatively, women may be more secure and detail-oriented. This difference may also be related to the way the scale is self-rated (44); men have higher levels of self-esteem than women (45) and men may rate themselves higher when self-rating indicators, leading to a higher level of innovation. In actual research, the diversity of gender composition in the team can promote scientific discovery and innovation potential, so it is necessary to give full play to the creative advantages of different genders (46, 47). Graduate students who serve as student leaders have a higher level of academic innovation ability. During their tenure as student leaders, students improve their planning, cooperation, communication, and time management skills through the completion of organizational activities. These enhancements enable them to integrate resources more effectively, thereby demonstrating greater innovation and practice in academic research (48, 49). Further, they usually have more opportunities and access to a variety of academic resources, which can help them broaden their horizons and up-do-date with the latest research developments, thereby promoting academic innovation.

Moreover, the conclusion that environmental factors affect the academic innovation of graduate students in an indirect way has been widely recognized by scholars. The environmental factors in this study mainly include the academic environment, teacher-student relationship, and teaching mode. Studies have shown that a good academic environment can improve graduate students' academic innovation ability. The academic environment is the creation of a positive or negative human environment that affects an individual's ability to innovate academically (50). This study focuses on the attitudes that individuals perceive as being supported or resisted by society and those around them toward academic innovation. By creating a positive environment, students' intrinsic motivation for scientific research can be stimulated and their enthusiasm for academic innovation can be enhanced (51, 52). In graduate education, the supervisor is primarily responsible for the training of graduate students, and the teacher-student relationship has an important impact on the cultivation of students' academic innovation ability. A good teacher-student relationship is convenient for full communication and trust between teachers and students. Additionally, tutors can better guide and help students carry out various learning activities, and students also actively absorb experience and knowledge to improve their academic innovation ability; similar results have been found in other studies (16, 53, 54). Teaching mode is also an important

factor affecting graduate students' academic innovation ability. Encouraging academic innovation through teaching mode can improve students' sense of innovation, resulting in creativity and students actively carrying out scientific research. Research shows that the multidisciplinary integrated teaching mode can promote the cultivation of students' academic innovation ability. By integrating other disciplines into public health teaching, students can broaden their horizons and cultivate interdisciplinary talents, using new knowledge and skills in multiple fields to create academics and improve their academic innovation ability (15, 55, 56). Some scholars have proposed the collaboration-inquiry teaching model, which is organized and implemented in three rounds, proving that this teaching model can cultivate and improve students' innovation ability (57). By reforming the traditional teaching model, students can be stimulated to independently innovate (58). In this study, a good academic environment, teacher-student relationship, and teaching mode all positively affect academic innovation ability and confirm the importance of implementing these environments, relationships, and modes to improve graduate students' academic innovation ability of in public health.

The nomogram constructed in this study can be used to evaluate the academic innovation level of public health graduate students in China. The AUC = 0.892 (95%CI = 0.803 ~ 0.833) of the nomogram indicated that the nomogram had good discrimination, and the calibration chart showed that the predicted value was in good agreement with the actual value. Based on the above findings, the training institutions of public health graduate students can rely on this nomogram to quickly identify students whose academic innovation ability needs to be improved and take targeted measures, such as enhancing learning motivation, improving teaching mode, and optimizing the academic atmosphere. This effectively responds to the challenges of public health education, helps universities to cultivate more high-quality talents with both innovation and practice, and provides a scientific basis and practical path for the high-quality innovation and development of public health graduate education in China.

There are some limitations in this study. First, the survey subjects are mainly from one region of China, and there may be an issue of regional homogeneity of the sample. Thus, in future research, it is necessary to further expand the sample size, carry out the survey in more regions of China, and conduct inter-regional comparative analysis. Second, we mainly used self-reported measurements from respondents, which were prone to bias. This may be further solved by adding categories of survey respondents. For example, the survey data from the perspective of graduate students' tutors can be collected at the same time; the results of other people's evaluations can be compared with the students' self-evaluation and the results of the comparative analysis can be supplemented by the results of this study.

5 Conclusion

The influencing factors of public health graduate students' academic innovation ability mainly include gender, whether they are currently serving as student leaders, teacher-student relationship, academic motivation, learning style, academic environment, and teaching mode. The nomogram model constructed in this study can be used to predict the academic innovation level of public health graduate students, which is helpful for university education administrators to evaluate students' academic innovation ability based on nomogram scores and carry out accurate and efficient training.

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 Ethics Committee Board of Weifang Medical 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

XW: Data curation, Formal analysis, Writing – original draft, Conceptualization. PG: Data curation, Methodology, Writing – original draft. XC: Investigation, Methodology, Writing – original draft. WC: Data curation, Funding acquisition, Supervision, Writing – review & editing, Investigation. HA: Supervision, Writing – review & editing, Data curation, Funding acquisition, Investigation.

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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.

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Modernizing undergraduate medical education by bringing public health into focus

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Healthcare and healthcare education are changing rapidly, being pulled in a number of directions by political, economic, environmental and technological imperatives. At the University of Dundee Medical School a curriculum review during the Covid-19 pandemic has allowed opportunities to reframe aspects of the program to emphasize themes linking public health and social determinants of health to the wider curriculum, while also bringing a shared understanding of the core outcomes of the program. This brings some adaptability into the structure and content of the course, helping graduates and staff to be "future proof."

KEYWORDS

medical education, curriculum design, population health, undergraduate education, social determinants of health

1 Introduction

Healthcare and healthcare education are at a time of significant flux and uncertainty, creating a rapidly changing landscape, and a need to create systems responsive to an unprecedented number of variables. Through all of this, Public Health (or Population Health) remains at the heart of healthcare. Rightly so: as the prevalence of non-communicable diseases rises inexorably there is a strong economic argument for preventive medicine, with even corporations understanding that there is more potential for profit from decades of healthy individuals compared with a shorter, less healthy life (1). There have been international calls for updates and changes to public health education (2–5). In a 2017 review of implementation of health promotion teaching in medical schools internationally, Hays commented that although public health increasingly features in the intended learning outcomes for medical graduates, how those topics are taught can be highly varied, and there is a lack of consensus of where the balance should lie between "awareness of concepts, knowledge about specific strategies and skills in implementing specific strategies" (6). This paper outlines how we are adapting an undergraduate medical program in Scotland to address the three main areas which are driving a need for change (changing technology, curriculum overload, and changes to the practice of medicine).

1.1 Changing technology

The Topol review (7) highlighted many ways that healthcare could be altered by technological improvements and innovations in the near future, but currently these changes have had comparatively little impact in healthcare, and so the ripples have not yet made their way back to education. There is considerable discussion about the impact that machine

learning and artificial intelligence will have on provision of healthcare, but this is not yet taught in any detail.

Health promotion is similarly shifting from in-person delivery of services to virtual and asynchronous. The consequences for health inequalities are concerning. The most affluent can already have the experience of a cardiac disturbance highlighted by their smart watch, advising appropriate follow up (8). It was formerly science fiction to conceive of a society where most primary healthcare is delivered remotely or automatically, including behavior change, but the market in diet, exercise, and mental health support is already extensive. As inequalities in non-communicable conditions such as obesity (9) are widened by this differential access, so health inequalities will widen both within and between countries. Currently these concepts are not prominent in medical education curricula (10), but there is a clear need to include them.

1.2 Curriculum overload

Attempts to create overarching summaries of the medical curriculum have been most successful when summarizing a very abstract level of detail. For example, CanMEDs domains have titles such as *Leader*, *Health Advocate*, and *Professional* (11); in Pakistan the Standards for a Seven Star Doctor (12) include *Community Health Promoter*, *Professional*, and *Leader and Role Model*. Likewise, the UK's General Medical Council highlights the need for *Professional Values and Behaviors* in medical students (13, 14). At the same time, the amount of factual knowledge a learner could potentially be expected to absorb increases daily—whether or not it is literally true that medical knowledge doubles every 73 days (15). To a learner, struggling with the "basics" of medicine, the prospect must be daunting indeed.

Meanwhile, the understandable desire for standardization, and accountability of our healthcare practitioners means that there is an increasing demand for standardized assessments and shared curricula. The implementation of the new Medical Licensing Assessment in the UK (16) for new graduates has generated debate about core content for assessment, and the validity or otherwise of these high stakes exams (17).

Medical training today still very closely resembles the experiences of doctors in training from the early 20th century. The emphasis on core science has a strong tendency to focus on cellular or even sub-cellular function and dysfunction, with decreasing emphasis the further one zooms out from that level of detail. For many years the need for doctors to understand interpersonal communication, including skills such as counseling, coaching, leadership and teamwork were completely overlooked by curriculum designers, concentrating on cramming as many facts as possible into the hours of teaching. This trend has been partially reversed (18, 19), and many medical schools now include "communication skills" within their curriculum (20), but this often still focuses on the one-to-one interaction between doctor and patient, rather than situating the doctor within a wider context. To avoid overloading the curriculum with excessive quantities of both facts, and concepts, medical education needs to start to move from "micro" to "macro."

Meanwhile, innovation in the technology sector means that artificial intelligence and sophisticated algorithms may abruptly remove the need for what is currently core material (7). The challenge then will be to identify what is not needed, and how to identify the errors and biases inherent in the system. These are very different skills and paradigms from those normally emphasized when medical curricula are being developed (21). Until it is possible to predict which knowledge and/or skills will be unnecessary, educators continue to cram more and more in, while removing very little.

1.3 Changes to the practice of medicine

Political, environmental, financial and technological shifts in society mean that there are a wide range of priorities for healthcare and medicine, while the World Health Organization highlights an increasing deficit in healthcare providers worldwide (22). Students must attempt to navigate their way through these rapid shifts, to identify what is needed to enable them to progress through their current studies, but also what will be needed in the future.

At the same time as the role of the doctor is changing, so are the expectations and attitudes of the populations they serve. The recent Covid-19 pandemic brought challenges to those working in, or contemplating a career in, healthcare: at once it was apparent how much the population needs good healthcare provision, but also the level of frustration and antipathy expressed in some quarters caused many to question their role in society: is the demanding training and arduous work worth it in a world filled with skepticism and misinformation? This may be particularly pertinent in countries where remuneration of healthcare workers is comparatively low. Students experienced significant trauma during the pandemic, but made a significant contribution to the emergency workforce needed during this time (23, 24). In the long term, these experiences may themselves create dramatic changes to healthcare workers and systems.

To best serve the population, to adapt or design the best services and meet the needs of those we are charged with caring for, one needs high quality data, expert interpretation, and appropriate planning (25). To make decisions and proposals that are needs-based, and evidence-based rather than merely reactive or self-serving, those involved need a solid educational foundation which develops these skills, and enables doctors to articulate and actualize their values.

2 Context

The medical curriculum at the University of Dundee is designed to enable school leavers to gain a primary medical qualification and begin working as doctors in 5 years, in common with most medical courses in the United Kingdom. While some students may have a prior degree, or other qualification, many come directly from school, and due to the Scottish school system, can be as young as 17 when they first begin the course. Currently around 200 students matriculate onto the course each year. As the UK national health service (NHS) provides free healthcare at point of use, there is limited opportunity to increase student experience of healthcare through for example student-run free clinics (26). Almost 100% of graduates take up training roles in the NHS initially (27), though many migrate across the globe later in their careers. The main aim of the program is therefore to produce graduates who are ready for work as UK doctors

from the point of graduation, with secondary aims of influencing later career development, including local retention and encouraging research activity.

Dundee has had an integrated curriculum since 1997, implemented by Harden and colleagues (28). Based on constructivist principles, the "spiral curriculum" allows students to revisit core learning over the years of their course, while also developing longitudinal themes which add enrichment and complexity to the experience. The primary focus is on competency-based education, with assessment through knowledge and clinical skill exams each year. The first 3 years of the course are highly structured, with a significant proportion of teaching in lecture and small group format, punctuated with clinical teaching to consolidate learning. The last 3 years of the course have an apprenticeship format, with students spending almost all of their time in clinical settings, gradually gaining confidence and skills, until ready to graduate as Foundation Year doctors.

While key themes such as communication skills and social medicine have been part of the curriculum from its initiation, the creation of Professionalism as a named component was a later evolution, made concrete by the UK General Medical Council's release of the third iteration of their curriculum requirements, *Tomorrow's Doctors* (29), in 2009. The most recent update of this document, now known as *Outcomes for Graduates* (13), lists key learning objectives relating to professionalism under the heading of "Professional Values and Behaviors."

2.1 Curriculum review

At the University of Dundee medical school, we initiated a curriculum review immediately before the Covid-19 pandemic, so the content and implementation have both been necessarily affected by those events. In addition to a need to respond to the social changes outlined above, we wanted to adjust our curriculum to facilitate the transition for learners, particularly the increasing numbers coming from non-traditional medical backgrounds ("widening participation"). Additionally, we wanted to make changes to the structure of the course that would build a sense of community through educational continuity and small group working, that would support students in contextualizing their learning.

Using the double diamond design methodology from the Design Council (30), the core curriculum review team included the core academic leads for the program (experienced medical educators, coming from a range of medical disciplines including Public Health, Psychiatry, General Practice, Anesthesiology, Gynecology, Infectious Diseases, and Renal medicine), several medical students, and a number of colleagues from the Postgraduate Centre for Medical Education, including two of the School Associate Deans. Multiple stakeholder engagement events (including patient representatives, student groups and healthcare staff) were held both during the information gathering phase, and during the solution design phases, to ensure there was consensus across the school. Proposals were reviewed by a panel composed of experts from the medical school, other professional schools in the university, and external experts from other UK medical schools, and then later by the university periodic review process.

We identified twin strands of reform which we wanted to bring into the work. Both of these can be thought of as "future proofing," however, one is public health facing, while the other seeks to develop adaptability in graduates, recognizing the rapidly changing healthcare environment contemporary graduates are likely to experience. Both are longitudinal strands, with representation in each year of the curriculum.

2.1.1 The bigger picture

This strand has a strong public health emphasis, with the explicit aim of bringing students to a greater awareness of both the social determinants of health (following models such as Dalgren and Whitehead (31)), and also the role of the doctor within society (see Figure 1). Ultimately the intention is for students to understand that each interaction they have as a healthcare provider (including when students) has wider ramifications, whether through antimicrobial stewardship thereby delaying the risk of multiresistant organisms (32), reducing inappropriate test requests, or pathologizing normal behaviors (33). The other significant dimension to enhance is the learner's understanding of their role as an advocate for their patient and their population: by using their expertise and influence they can be powerful agents for change.

The Bigger Picture is introduced to students from the beginning of the course, with plenary sessions providing Scottish and local context for healthcare, and an explicit outline of the aims of the strand. Students also attend lectures, tutorials and workshops on related topics (particularly Healthcare Sustainability) within core teaching hours. These have not required additional hours in the syllabus as they have replaced previous didactic sessions in related areas, such as Public Health and Behavioral Sciences, but also some content which was previously taught elsewhere, such as a reflection on death and anatomy dissection is now part of this strand. By

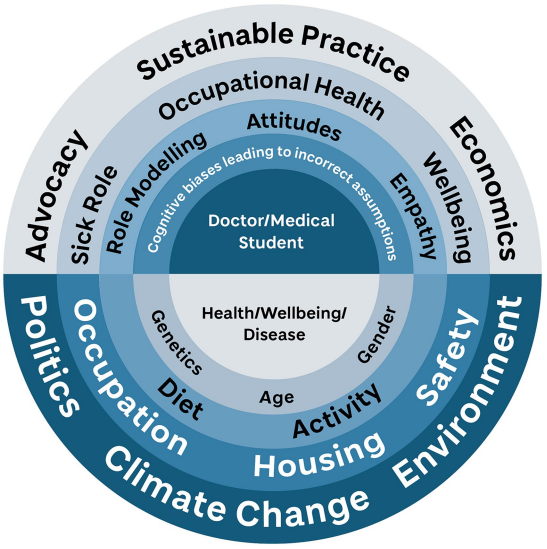


FIGURE 1
The core concept of the Bigger Picture elements of the Dundee curriculum. The student as healthcare professional is encouraged to see how all the layers of diagram influence the health and wellbeing of an individual and community, while at the same time seeing how they can affect and influence those layers. Designed by Eve Laws for University of Dundee, after Dahlgren and Whitehead (31).

adding these additional insights to existing sessions, we provided deeper, contextual learning, a common challenge in teaching in this area (21). Additional teaching material is provided in elective components within the course, and opportunities for reflection on Bigger Picture topics. This is facilitated by a repository of learning materials designed mostly by students, outlining key areas they have identified as relevant, ranging from LGBTQ+ issues in healthcare, to social media and disinformation, to entrepreneurship and innovation, including artificial intelligence. We help students to link this learning back to other areas, particularly Quality Improvement, Public Health, and General Practice. At its core, the concept of the Bigger Picture is so wide-reaching that it is unrealistic and counter-productive to try to cover all of the individual areas of interest for each student. By following this model, we encourage students to identify areas of the Bigger Picture that are particularly resonant with them. By using their personal interests and experiences we encourage development of lifelong learning, and strengthen their reflective abilities.

2.1.2 The Dundee Doctor

The multiple stages of stakeholder engagement carried out during the information gathering phase of the curriculum review identified a common understanding of what makes a Dundee graduate unique. Where The Bigger Picture provides context for professional development, the Dundee Doctor has proved a valuable structure for curriculum implementation. The Dundee Doctor represents what may be lost if there is excessive "teaching to the test," in light of the new national assessments (Figure 2).

2.1.3 Assessment

Aspects of the Bigger Picture strand which are core taught material are included within the annual summative exam diet, however, more elements are within elective parts of the curriculum. Where students undertake a student selected component, these are normally four-week blocks with a summative assessment (for example an essay or presentation) at the end. Otherwise, Bigger Picture reflections are included in the students' portfolio each year. These are reviewed but are not summatively assessed, until included within a final portfolio review assessment prior to graduation.

There is a significant challenge internationally to summatively assess these contextual learning outcomes (6)—in an era of increasing homogeneity in assessment via licensing exams, these more subtle outcomes need to be emphasized, for example through workplace based assessment, observed practice, or reflective portfolios, but these all have workload implications and it can be difficult to accurately assess these topics in short timescales (34). One reason this is difficult is because of the need to demonstrate a layer of application and process that goes deeper than knowledge acquisition (21, 35).

The Dundee Doctor does not have an assessed component specifically, but is rather used as a way of scrutinizing new proposals for taught content ("Is this consistent with the Dundee Doctor?"), and as a unifying vision for both staff and students.

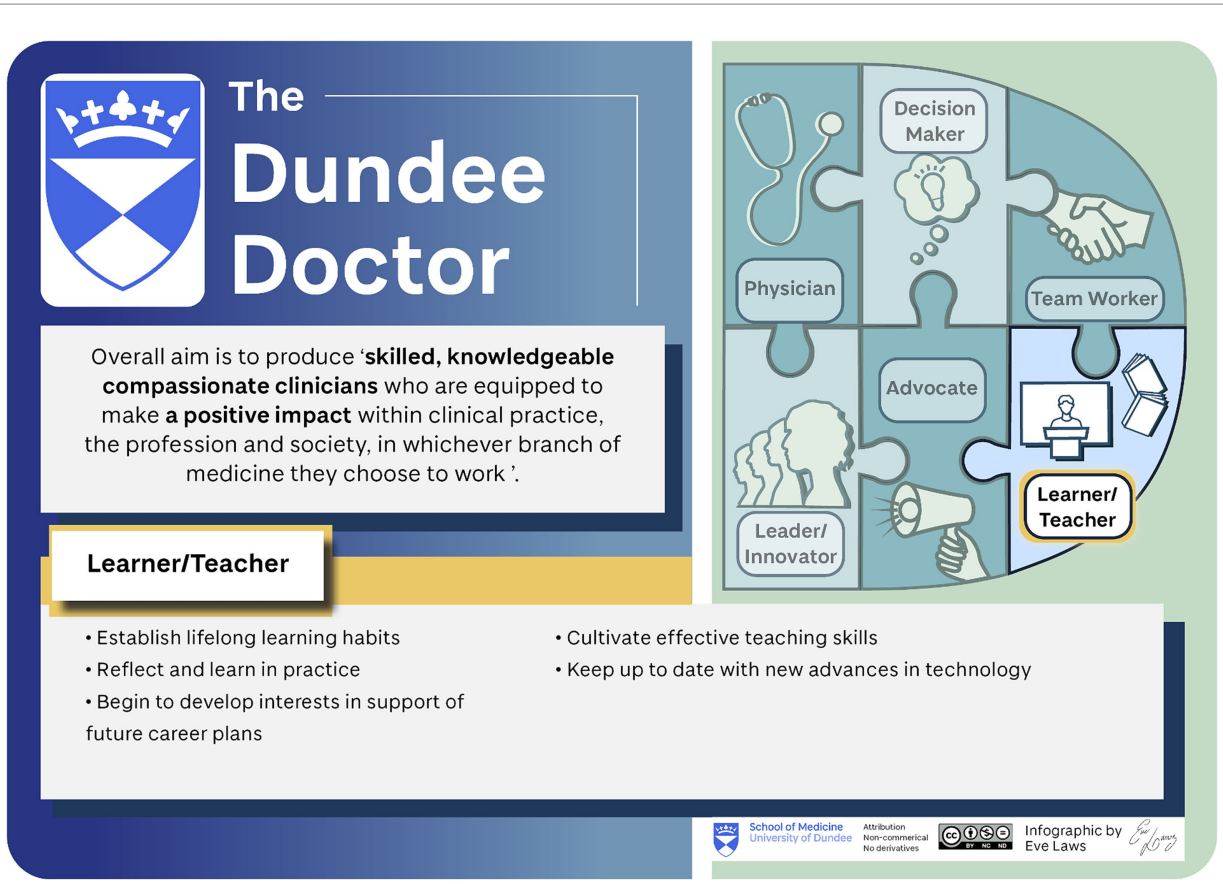


FIGURE 2
The Dundee Doctor. Designed by Eve Laws for University of Dundee.

3 Challenges faced

Implementing change to a curriculum as full and constrained as undergraduate medicine is enormously challenging. There is little margin for error due to the need for patient safety and the ongoing confidence of the public. The implementation of a new national exam means there is organizational anxiety about meeting those externally mediated academic objectives. Additionally, we knew that the previous program was well respected and produced excellent doctors. Consequently, every effort has been made to make the changes to the program as unobtrusive as possible, bringing reform through "quiet revolution" rather than disruption. This can be mistaken for inaction without a clear and consistent message from leaders.

The combination of core and elective elements of the new curriculum strands can be viewed as both a strength and a weakness of the course. If every element was core, there would be increased exposure and consistent coverage across the cohort. However, the topics covered are so wide ranging and diverse, it felt inappropriate to the curriculum design team to make all elements compulsory. Additionally, the amount of time that would take would be impractical given the other demands of the course. Through the Bigger Picture, learners have exposure to a wider range of content, allowing their curiosity and personal interest to guide them where they are most motivated. Allowing learners this opportunity may in turn directly improve academic achievement (36).

Formal evaluation of these curriculum elements has not been carried out at this time, at least in part due to the need to roll the changes out across three academic years, but this will be possible soon. Anecdotally student and staff have welcomed the changes, but student satisfaction may be a poor indicator of long-term impact, so a wider evaluation program is in development.

4 Discussion

It is posited that there is a decline in medical student empathy during the course of their studies (37). It may be that the current curricular emphasis on biomedical models of disease, and cure rather than prevention augments this. Certainly there is an overall decline in medical student understanding of social determinants of health during their studies (38, 39), persistent through decades of medical education, despite overt attempts to change this trajectory (40). Internationally, this area remains challenging, whether attempting to address antibiotic stewardship (41), climate change and environmental damage (42), lifestyle medicine (43, 44). Current approaches create overloaded curricula and do not create the adaptable, socially conscious doctors that are needed.

The introduction of new assistive technologies relating in particular to medical decision making and clinical reasoning, in the form of so-called artificial intelligence and machine learning emphasize the need for this adaptability. It is currently unclear what the role of the doctor will be in years to come, but we can be reasonably confident it will change rapidly, and significantly. We need to push our schools to develop programs that are "continuously renewing" (44), adapting to the future just like our students will. We have tried to bring that spirit to the new curriculum in Dundee, and look forward to the next steps.

Author contributions

EH: Conceptualization, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

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

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Exploring psychosocial factors influencing sexually transmitted infection intention testing among medical students: a cross-sectional study in two universities

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Background: Despite the significant global burden of sexually transmitted infections (STI), detection rates are poor. Acceptance of these tests is influenced by several factors that have not been explored among Colombian medical students.

Objectives: The aim of this study was to describe the behaviors and psychosocial factors toward STI screening among medical students of two universities in Pereira, Colombia, between March and June 2020.

Methods: An observational, cross-sectional study was conducted with 284 medical students in the first 3 years of undergraduate at two universities. An online, self-administered survey was conducted between March 2020 and June 2020, using an instrument from the "STI Testing Questionnaire," to assess behaviors and psychosocial factors toward STI testing. Frequencies and percentages were used for descriptive analysis. The association between characteristics and psychosocial factors with STI testing intention was obtained using a logistic regression model. A p-value <0.05 was accepted as statistically significant for all analyses.

Results: A total of 284 medical students participated in this study. The majority were female (56.7%), and 53.2% were from private universities. Eighty-four point 5% (84.5%) had risky sexual behaviors, and only 32.4% reported intentions to be tested for STIs. Among the psychosocial factors, 64.1% reported high social pressure, and 43.0% reported social fear. An association with the intention to undergo STI testing was identified in those who had been previously tested (OR = 2.486; 95% CI: 1.492–4.142) and in those who engaged in risky sexual behaviors (OR = 3.537; 95% CI: 1.437–8.704).

Conclusion: Medical students exhibit a high prevalence of risky sexual behaviors but show a disturbing lack of intention to undergo STI screening. Prior experiences significantly influence screening intentions, while social pressure and fear also play a role. These insights can serve as a basis for targeted interventions

to improve STI screening rates and enhance sexual health education among Colombian medical students.

KEYWORDS

perceptions, previous experiences, psychosocial factors, sexually transmitted infections, medical students

1 Introduction

Sexually Transmitted Infections (STIs) represent a significant public health issue due to their high transmissibility, continuous and exponential growth, consequences in terms of morbidity and mortality, costs associated with the health system, and short-, medium-, and long-term complications (1). According to the World Health Organization (WHO), more than 1 million people between the ages of 15 and 49 contract an STI every day, most of them asymptomatic. Projections for 2020 indicated 374 million new infections from one of the four treatable STIs (chlamydia, gonorrhea, syphilis, and trichomoniasis) (2). Recent data indicates that HIV, viral hepatitis, and STIs cause 2.5 million deaths each year, with deaths from hepatitis-related causes increasing to 1.3 million in 2022, compared to 1.1 million in 2019. Increased notifications of STI cases are occurring in many WHO regions, which, together with the decrease in new HIV infections and viral hepatitis, indicate that STI control is not advancing fast enough to meet the Sustainable Development Goals for 2030 (3).

During the COVID-19 pandemic in 2020, there was a reported reduction in medical consultations and STI testing in countries like Spain due to lockdowns and social isolation measures (4). However, after the restrictions were lifted, there was a significant rebound in STIs in 2021, a phenomenon reported in various sources (4, 5). The greatest burden of STIs globally is found among adults aged from 15 to 49 years, including university students, who tend to underestimate the risk of contracting STIs and engage in high-risk behaviors such as inadequate condom use (2, 6, 7).

In Colombia, according to the National Institute of Health (INS), HIV has shown an increasing trend year after year, reaching 26.6 cases per 100,000 inhabitants in 2019 (8). The National Demographic and Health Survey showed that only three out of 10 young people have sufficient information about STIs (9). Additionally, the department of Risaralda in Colombia has the third-highest HIV incidence rate (40.9 cases per 100,000 inhabitants), with the infection affecting mostly the population of the municipality of Pereira between 20 and 34 years of age (10).

Screening tests are one of the pillars of STI management and control, bringing benefits for both individual and collective health by ensuring timely access to appropriate treatments and encouraging safer sexual behaviors (6). Cultural influences play a significant role in the area of secondary prevention of STIs. Cultural norms and values can affect attitudes toward sexual health and willingness to be screened. In many cultures, the stigma associated with STIs can be a major barrier to early detection and treatment (11).

Studies on STIs have shown that screening rates can be influenced by factors such as age, gender, ethnicity, education level, knowledge level, and systemic factors (8). Social and psychological factors such as perceptions of susceptibility and severity have also been shown to be predictors of STI testing behavior (12, 13). Research on behavioral theories has demonstrated their potential effect on various sexual behaviors, including the theory of planned behavior, the health belief model (HBM), and social cognitive theory (SCT) regarding barriers to STI testing (13). In this context, research has shown that self-esteem, shame, peer pressure, and lack of knowledge act as barriers that delay or impede the willingness to undergo testing for timely detection (14). In Colombia, stigma and discrimination in the workplace, family, and health services have been identified as the main barriers to accessing STI testing (15).

It is crucial to focus on the college student population and medical students. University students, due to their youth and high-risk behaviors, are a vulnerable group to STIs. Additionally, medical students, being in training to become health professionals, have a dual responsibility: managing their own health and promoting healthy practices in their future professional practice (16). However, the possible psychosocial factors associated with STI screening tests in undergraduate medical students in Colombia have not been evaluated so far. Therefore, the objective of this research was to identify and describe the demographic, academic, sexual behavior, and psychosocial factors associated with the intention to undergo STI screening tests in medical students from two universities in Pereira, Colombia.

2 Methods

2.1 Study design

We conducted a cross-sectional observational study through a self-administered online survey.

2.1.1 Setting, population, and sample

Pereira is a Colombian municipality, the capital of the department of Risaralda located in the Eje Cafetero region. Online data were collected from students officially enrolled between the first and sixth semester in medical schools of two universities (one public and one private) located in the municipality of Pereira, between March and June 2020.

A non-probabilistic convenience sampling was used for the data collection process. Participants between 18 and 25 years of age, of both sexes, with a history of an active sexual life (having had at least one sexual relationship prior to filling out the questionnaire), who agreed to voluntarily participate in the survey through an electronic informed consent form were included in the research. Responses from participants outside the age ranges, with no sexually active life, or who did not accept the electronic informed consent were not included.

2.2 Study size

The required sample size was calculated using the following equation, designed to calculate samples in infinite or unknown populations (17):

$$n = \frac{Z^2 \cdot (p \cdot q)}{e^2}$$

Starting with a confidence level of 95% ($Z = 95\%$), a margin of error of 6% ($e = 6\%$), and an expected positive (p) and negative (q) distribution of 50%, a minimum of $n = 267$ completed questionnaires were obtained.

2.3 Data measurement and questionnaire

A survey developed from the STI Testing Questionnaire, based on the theory of planned behavior (TPB), the HBM, and the SCT theories (18–21), and previously validated by Martin-Smith et al. with UK university students, was used, demonstrating a Cronbach's alpha coefficient > 0.7 (22).

An online, self-reported, survey-type questionnaire, adapted from the STI Testing Questionnaire was utilized (22). The tool was validated through pilot testing among 21 participants from the medical schools of the two participating universities, followed by feedback that included the development of relevant corrections related to understanding terminology and wording. Once the errors were corrected, a structured and uniform questionnaire consisting of 91 questions was obtained. Additionally, the final version of the questionnaire demonstrated an internal consistency with a Cronbach's alpha coefficient of 0.67. A version of the final questionnaire translated into English was included as a Supplementary file.

The online questionnaire consisted of eight sections: (1) Informed consent; (2) Sociodemographic data made up of 11 questions that assessed variables such as sex, age, year of study, type of university, religion, sexual risk behaviors, and intention to be tested for STIs; (3) Knowledge about STIs made up of 17 questions; (4) Social pressure for STI testing made up of 8 questions; (5) Direct attitudes toward STI testing comprised of 8 questions; (6) Indirect attitudes toward STI testing comprised of 21 questions; (7) Social fear toward STI testing comprised of 8 questions; (8) Self-efficacy with 17 questions related to medical students' confidence toward STI testing.

2.4 Variables

The type of university was classified into public and private according to the university's source of funding. To assess sexual behavior, sexual risk behaviors were measured based on four questions about sexual activity without condom use, with casual or regular partners. If at least one of the questions indicated a risk behavior, the participant was categorized as having sexual risk behavior. Additionally, the history of STI testing and the intention to undergo STI testing were explored.

To evaluate psychosocial factors, six variables (indicators) were studied:

- Knowledge about STI testing, defined as the information and understanding about STI transmission, symptoms, and prevention, was assessed through the evaluation of questions on STI transmission, symptoms, and prevention of STIs. To define the level of knowledge, a value of 1 point was assigned for each correct answer and 0 points for incorrect answers. This resulted in a maximum score of 17 points and a minimum score of 0 points (participants who answered all questions incorrectly). Thus, three categories of STI knowledge level were defined: high knowledge level (scores between 12 and 17 correct answers), medium knowledge level (scores between 7 and 11 correct answers), and low knowledge level (for scores between 6 and 0 correct answers).
- Social pressure, defined as the influence exerted by society or peers to conform to certain behaviors or attitudes regarding STI testing, was assessed subjective norms, i.e., perceived pressure to perform or not to perform an STI test in relation to four groups: partners, friends, family, and health professionals. For each question, the belief score was based on a 5-category Likert-type scale (completely disagree, somewhat disagree, neither disagree nor agree, somewhat agree, and completely agree) through which an overall score between −40 and + 40 was obtained and classified into three categories, where −40 to −13 represent low perceptions of social pressure to have an STI test, from −13 to 13 moderate perceptions of social pressure, and between 13 and 40 for a high perception of social pressure.
- Attitudes toward STI testing were measured through two approaches including direct attitudes and indirect attitudes. Direct attitudes, defined as explicit expressions of approval or disapproval toward a behavior, were evaluated the participants' stance by means of a Likert-type scale of 5 categories (completely disagree, somewhat disagree, neither disagree nor agree, somewhat agree, and completely agree) through a possible score between 8 and 35, finding three possible categories: positive direct attitude (between 35 and 27), moderate direct attitude (between 17 and 26), and negative direct attitude (between 8 and 16). Indirect attitudes defined as subtle or implied expressions of approval or disapproval, were measured using a Likert-type scale with five categories (completely disagree, somewhat disagree, neither disagree nor agree, somewhat agree, and completely agree). The scores of the questions were summed to obtain a maximum score of 55 and a minimum of 11, measuring the indirect attitude in three categories: positive perceptions (between 55 and 41), neutral perceptions (between 40 and 26), and negative perceptions (between 25 and 11).
- Social fear, defined as the apprehension of negative consequences or stigma from others impacting decisions like STI testing, was explored using a 5-category Likert-type scale (completely disagree, somewhat disagree, neither disagree nor agree, somewhat agree, and completely agree) toward situations you would face with STI testing. The question scores were summed to create a composite score ranging from 8 to 40, with low perceived social fear ranging from 8 to 19, moderate perceived fear toward STI testing ranging from 20 to 29, and high perceived social fear with scores ranging from 30 to 40.

- Self-efficacy, defined as the belief in one's ability to successfully perform a behavior, was measured using a 5-category Likert-type scale questions of confidence (0% confidence, 25% confidence, 50% confidence, 75% confidence, 100% confidence). Item scores were summed to create a composite score ranging from a minimum of 12 to a maximum of 60. From this, self-efficacy was organized into three categories, where a score between 12 and 27 represents low self-efficacy to undergo STI testing, between 28 and 44 represents moderate self-efficacy, and high self-efficacy between 45 and 60.

2.5 Data collection and management

The online platform Google Forms facilitated data collection. Participants accessed the survey through a unique link disseminated on social networks, including "Facebook" and "WhatsApp." The survey link was distributed by the research team in the official Facebook and WhatsApp groups for medical students at the participating universities. Once participants entered the questionnaire, the survey preamble briefly described the objectives of the study, promised confidentiality, and requested informed consent. Participants had to accept the Participation Agreement to access the survey through an electronic informed consent question, reinforcing anonymity.

To maintain a high degree of data integrity, the researchers meticulously examined all responses for possible errors or inconsistencies, such as respondents choosing all available responses or duplicate responses and excluded these questionnaires from the final sample. Initially, we had 325 survey responses. After rigorous filtering, 41 responses were excluded mainly due to systematic errors, such as participants completing the questionnaire despite indicating they had not had sexual intercourse, surveys with inconsistent age ranges, or surveys that only contained demographic data. A total of 284 valid responses were obtained and included in the study.

2.6 Bias

To control for possible biases during data collection and management, we implemented several strategies. To avoid duplicate submissions, the Google Forms platform was configured to limit one response per IP device. In addition, our questionnaire design was intentionally selected to avoid collecting identifiable information such as IP addresses. To further minimize bias during the analysis phase, each member of the research team reviewed the results independently. When discrepancies arose, they were collaboratively resolved to ensure that only valid and genuine responses were incorporated into our final findings. These measures significantly strengthened the reliability and credibility of our research results.

2.7 Statistical analysis

Our study used descriptive statistical measures to analyze the responses to each categorical item of the questionnaire, including the calculation of frequencies and percentages. In addition, a logistic regression model was used to estimate the association between participant characteristics, knowledge, and psychosocial factors with the intention to screen for STIs, expressed by Odds Ratio (OR) and 95% confidence intervals (95% CI). The tests were two-tailed, and we considered statistical significance with p values less than 0.05. For both descriptive and inferential analyses, we used IBM SPSS Statistics for Windows, version 26.0 (IBM Company, Chicago, IL, United States).

TABLE 1 Demographic characteristics and sexual behaviors of medical students.

		n	%
Demographic characteristics			
Sex	Female	161	56.7
	Male	123	43.3
Age (years)	≤ 20	199	70.1
	> 20	85	29.9
Univesity type	Private	151	53.2
	Public	133	46.8
Year of study	First	108	38.0
	Second	116	40.8
	Third	60	21.1
Religion	Believer	225	79.2
	Nonbeliever	59	20.8
Sexual behaviors			
STI pre-screening	No	151	53.2
	Yes	133	46.8
Intention to screen for STIs	No	192	67.6
	Yes	92	32.4
Sexual risk behaviors	No	44	15.5
	Yes	240	84.5

3 Results

3.1 Demographic characteristics

A total of 284 medical students were included, the majority being 56.7% ($n = 161$) female, with 70.1% ($n = 199$) aged 20 years or younger, and 79.2% ($n = 225$) considering themselves believers in some religion. Additionally, slightly more than half (53.2%) reported studying at a private university, and the majority of participants were in their second year of medical school (40.8%; Table 1).

Regarding sexual behaviors, 53.2% ($n = 151$) of the participants reported not having been previously tested for STIs, and only 32.4% ($n = 92$) reported an intention to undergo testing for asymptomatic STIs (Table 1). However, 84.5% ($n = 240$) were identified as having risk sexual behaviors. Within this group, the most prevalent risk behavior was having ever had vaginal intercourse without condom use with a regular partner, reported by 91.3% ($n = 219$), followed by having ever had vaginal intercourse without condom use with an occasional partner, reported by 35% ($n = 84$).

3.2 Psychosocial factors

3.2.1 Knowledge

Regarding the knowledge of the participants with STI testing, it was evident that the features with the greatest lack of knowledge, defined by the percentage of incorrect answers, were related to the diagnosis of diseases such as chlamydia (65.8%), gonorrhea (70.4%), and syphilis (59.9%). The questions with the highest knowledge were related to the probability of infection if a condom is not used (92.6% correct answers), symptoms of STIs (89.8%), and treatment of some STIs (82.7%; Supplementary Table 1). However, the overall assessment of knowledge showed that 76.1% ($n = 216$) of participants had a high level of knowledge (Table 2).

3.2.2 Social pressure

The evaluation of social pressure toward STI testing showed that participants were influenced by the pressure exerted by others, particularly sexual partners (48.2%), family members (35.2%), and doctors and health professionals (55.6%; Supplementary Table 2). In this context, the overall assessment of the influence that social pressure can exert on the development of STI screening tests found a high degree of social pressure in 64.1% ($n = 182$) of the participants (Table 2).

3.2.3 Direct attitudes

Direct attitudes toward STI screening tests showed a predominant stance in favor, as the majority of students disagreed with negative characteristics of screening tests, such as considering them a waste of time, painful, harmful, or being unimportant (Supplementary Table 3). Consequently, the overall estimate of direct attitudes toward STI testing revealed a completely positive stance in 100.0% ($n = 284$) of participants (Table 2).

3.2.4 Indirect attitudes

Indirect attitudes, on the other hand, showed that the aspects most likely to influence a negative stance against STI screening tests included viewing them as something shameful (37.0%), believing they could affect the future and relationships (56.7%), or considering them detrimental to career prospects (59.2%; Supplementary Table 4). Overall, indirect attitudes were defined by a neutral or indifferent stance toward STI screening tests in 79.9% ($n = 227$) of the participants (Table 2).

3.2.5 Social fear

Regarding social fear, the main factors in the screening tests that could lead to social fear were concern about sexual partner reaction (50.5%), concern about parental reaction (40.0%), and feeling puzzled (35.9%; Supplementary Table 5). In this context, social fear toward STI testing and its results showed a significant influence on students, with 44.0% ($n = 125$) having a moderate level of social fear and 43.0% ($n = 122$) experiencing a high level of social fear (Table 2).

3.2.6 Self-efficacy

The self-efficacy events that generated the greatest insecurity in the participants were that they considered that they would be the greatest in the waiting room (20.7%) and that the result would be made public (42.3%), while among the factors to which they seemed to attach no importance were related to the time available for testing, such as weekends or in the evenings (Supplementary Table 6). Thus, a high self-efficacy effect is evident in 83.5% ($n = 237$) of students (Table 2).

TABLE 2 Characteristics of psychosocial factors toward STI screening in medical student.

Psychosocial factors		*n*	%
Knowledge	Low	6	2.1
	Moderate	62	21.8
	High	216	76.1
Social pressure	Low	10	3.5
	Moderate	92	32.4
	High	182	64.1
Direct attitudes	Positive	284	100.0
Indirect attitudes	Negative	2	0.7
	Neutral	227	79.9
	Positive	55	19.4
Social fear	Low	37	13.0
	Moderate	125	44.0
	High	122	43.0
Self-efficacy	Low	1	0.4
	Moderate	46	16.2
	High	237	83.5

3.3 Factors associated with the intention to be tested for STIs

Within the demographic characteristics of the respondents, only those related to education showed effects on the intention to be tested for STIs, showing that participants from public universities would be less inclined to be screened (OR = 0.418; 95% CI 0.248–0.703). While participants in the second year of undergraduate medical school would be more inclined (OR = 1.790; 95% CI 1.017–3.150; Table 3).

For their part, sexual behaviors exhibited a significant association with intent to be screened, as there was an association toward positive intent in those who had been previously screened for STIs (OR = 2.486; 95% CI 1.492–4.142) and in those with risky sexual behaviors (OR = 3.537; 95% CI 1.437–8.704; Table 3).

Most of the psychosocial factors did not show significant effects on the participants' intention to be tested for STIs. However, within the indirect attitudes, apparently having positive direct attitudes was associated with the intention to be screened (OR = 2.187; 95% CI 1.198–3.992; Table 4).

4 Discussion

This study evaluated psychosocial factors associated with intention to undergo STI screening in medical students. To our knowledge, this is the first exploration in medical students in South America. Using an online questionnaire, we gathered data from a sample of 284 sexually active medical students, predominantly women, with a significant inclination toward religious beliefs.

TABLE 3 Association between demographic and sexual behavior characteristics and the intention to undergo STI screening in medical students.

		Intention to undergo STI screening				
		No (n = 192)		Yes (n = 92)		OR (CI 95%)
		n	%	n	%	
Sex	Female *ref.*	113	70.2	48	29.8	
	Male	79	64.2	44	35.8	1.311 (0.795–2.161)
Age (years)	≤ 20 *ref.*	141	70.9	58	29.1	
	> 20	51	60.0	34	40.0	1.621 (0.953–2.756)
University type	Private *ref.*	89	58.9	62	41.1	
	Public	103	77.4	30	22.6	**0.418 (0.248–0.703)**
Year of study	First *ref.*	79	73.1	29	26.9	
	Second	70	60.3	46	39.7	**1.790 (1.017–3.150)**
	Third	43	71.7	17	28.3	1.077 (0.532–2.178)
Religion	Nonbeliever *ref.*	41	69.5	18	30.5	
	Believer	151	67.1	74	32.9	1.116 (0.600–2.075)
STI pre-screening	No *ref.*	116	76.8	35	23.2	
	Yes	76	57.1	57	42.9	**2.486 (1.492–4.142)**
Sexual risk behaviors	No *ref.*	38	86.4	6	13.6	
	Yes	154	64.2	86	35.8	**3.537 (1.437–8.704)**

Statistically significant associations are marked in bold.

TABLE 4 Association between psychosocial factors and intention to undergo STI screening among medical students.

		Intention to undergo STI screening				
		No (n = 192)		Yes (n = 92)		OR (CI 95%)
Psychosocial factors		n	%	n	%	
Knowledge	Low *ref.*	5	83.3	1	16.7	
	Moderate	46	74.2	16	25.8	1.739 (0.188–16.031)
	High	141	65.3	75	34.7	2.659 (0.305–23.183)
Social pressure	Low *ref.*	9	90.0	1	10.0	
	Moderate	72	78.3	20	21.7	2.500 (0.298–20.923)
	High	111	61.0	71	39.0	5.756 (0.713–46.421)
Indirect attitudes	Neutral *ref.*	161	70.9	66	29.1	
	Negative	2	100.0	0	0.0	0.485 (0.023–10.254)
	Positive	29	52.7	26	47.3	**2.187 (1.198–3.992)**
Social fear	Low *ref.*	23	62.2	14	37.8	
	Moderate	92	73.6	33	26.4	0.589 (0.271–1.278)
	High	77	63.1	45	36.9	0.960 (0.449–2.051)
Self-efficacy	Low *ref.*	1	100.0	0	0.0	
	Moderate	37	80.4	9	19.6	0.760 (0.028–20.175)
	High	154	65.0	83	35.0	1.621 (0.065–40.244)

Statistically significant associations are marked in bold.

However, neither gender nor religious beliefs showed significant associations with the intention to get tested for STIs. Previous research has highlighted the effect of gender on testing for different STIs, often finding differences in favor of women and men in various infections (23–25). This difference is mostly attributed to health promotion efforts focused on women, especially in cases of diseases such as chlamydia and gonorrhea (26, 27). In our sample, however, we believe that both men and women are equally exposed to academic information about STIs, which may mitigate the effect of gender on the intention to test for STIs.

Academic variables showed an influence on participants' intention to undergo STI testing. For example, studying at a public university was associated with a lower intention to undergo testing. This can be explained by several factors, including the socioeconomic disparities

to which students at public universities in Colombia are exposed (28), which may result in financial barriers that affect access to medical consultations and STI testing (29). Additionally, our findings showed an association between students who have progressed further in their year of study and their intention to undergo STI testing. Although this was not statistically significant among third-year students, it shows a trend similar to those observed in other studies on college students (22). In this context, this inclination could be attributed to increased exposure to sexual health and STI-related topics in the curriculum, which raises awareness of STI risks and consequences, thereby increasing student's intention to undergo testing (14).

Regarding sexual behavior, 84.5% of medical students reported engaging in risky sexual behaviors, such as having multiple sexual partners and unprotected intercourse. This rate is comparable to findings among university students in 2019 in Barranquilla, Colombia (87.0%) (30), and Polish university students (87%) (31), but significantly higher than rates reported among Ethiopian university students (44.0%), female medical students in Cuba (74.5%), and Nigerian medical students (6.1%) (32–34). Despite the high prevalence of risky behaviors, the proportion of students who had undergone previous STI screening or intended to do so in the future was notably low. This discrepancy could hinder infection detection and increase the likelihood of transmission and complications (27). However, in this context, curiously, we found that previous STI screening and risky sexual behaviors were the factors most associated with the intention to undergo STI screening (OR = 2.486; 95%CI 1.492–4.142, OR = 3.537; 95%CI 1.437–8.704, respectively). These findings somewhat contrast with the HBM, which suggests that individuals, based on their perceived vulnerability or susceptibility, take certain actions (35). In this scenario, those who perceive themselves to have a lower risk of contracting a disease are more likely to engage in riskier behaviors, including not intending to undergo screening tests. We believe this contradiction could be significantly influenced by the environment—specifically, university medical students who have a high level of knowledge about STIs. Despite understanding the potential consequences of their actions, they may still engage in risky sexual behaviors and be more willing to undergo screening tests.

On the other hand, psychosocial factors have been shown to have important effects on the intention to be tested for STIs in college students (22). Although most of the psychosocial factors did not show a statistically significant association with the intention to be tested for STIs in our research, the evaluation of psychosocial factors showed important details. For example, in most of the sample, the effects of the opinion of individuals in the close environment such as friends or family members marked an important effect on the social pressure that medical students may feel about STI testing. This is complemented by evidence that the reaction of parents and partners mainly makes up the social fear that participants may feel about STI testing and its outcome. In this regard, previous research has found that increased social pressure significantly affects intention and behavior toward early testing (6), as well as that fear, stigma, and clinical environment were critical to whether people would participate in screening services (36). This is explained in light of TPB theory, which posits that social pressure (subjective norms, behavioral control) is a modulator of people's behavior (37).

The levels of knowledge about STIs among participants were encouraging, as only 21.8% demonstrated moderate knowledge and only 2.1% showed low knowledge about the transmission, symptoms, and prevention of STIs. These findings align with previous studies that identified high levels of knowledge about STIs in medical students in other regions of Colombia (38, 39). Although the level of knowledge was predominantly high and did not have a statistically significant effect on the intention to undergo STI screening among students, significant error rates were found related to the diagnosis of different STIs. These findings highlight the need to improve the knowledge of medical students in these areas, especially in the diagnosis of STIs.

Regarding the participants' attitudes, although direct attitudes appeared to be completely positive, aspects within the participants' indirect attitudes influence to stop medical students from getting tested for STIs, especially related to the possible repercussion of the result on their future life, evidencing a complex influence on the factors that revolve around STI screening. This idea is reinforced given that positive indirect attitudes demonstrated a positive association (OR = 2.187; 95%CI 1.198–3.992) toward getting tested for STIs, and this is consistent with research by Shepherd et al., in which it was evident that having an unfavorable attitude toward visiting a clinic negatively predicted screening (40), so such attitudes may deter young people from routine screening.

Although this research was conducted during the initial stage of the COVID-19 pandemic, we believe that the self-report design allowed us to explore the opinions of medical students without the quarantine affecting their views on STI screening tests. This is particularly relevant since data on risky sexual behaviors were collected for 1 year prior to data collection.

Furthermore, this research sheds light on a previously underexplored area concerning the detection of STIs among medical students in Colombia and South America. It reveals the challenges and factors that directly influence STI screening policies in sexually active and high-risk groups.

Regarding risky practices, we emphasize the importance of these findings in shaping health strategies within the Colombian and South American contexts. The goal is to include young populations, including university students, in strategies that promote the avoidance of risky sexual behaviors and highlight the importance and benefits of STI detection tests for personal health.

5 Limitations

This study had several limitations, including selection bias due to the use of convenience sampling and self-administered questionnaires. This was primarily because of the COVID-19 health crisis, which made it impossible to collect responses in person. Consequently, the results of this research may exhibit selection bias, as students less concerned about STIs might have been less interested in responding to the survey. Although the distribution aimed to use the platforms most commonly used by students, the response rate could have been affected by excluding students with limited access to the Internet or the social networks used for questionnaire distribution. This limitation could impact the sample size and the representativeness of the results. Additionally, to prevent duplicate responses, the number of responses was restricted to one per device using the features of the Google Forms platform.

Moreover, explorations of phenomena associated with STIs, such as this one, are susceptible to social acceptability bias. This bias could arise from students fearing to answer truthfully due to concerns about the anonymity of their responses. In this context, the researchers made efforts to reassure students about strict anonymity, including the use of an anonymous questionnaire in which none of the responses included identifiable participant information such as names, email addresses, or telephone numbers. Additionally, the survey included a statement

guaranteeing the confidentiality of the responses to be collected, so participants felt secure about their privacy. Furthermore, the acceptance of a mandatory informed consent by each participant emphasized that responses would be anonymous and confidential, and stressed the importance of honesty in completing the instrument.

6 Conclusion

Medical students from two universities in Pereira, Colombia exhibited a high prevalence of risky sexual behaviors. However, there is a concerning trend of low intention to undergo screening for STIs, putting this group at a higher risk of STI transmission and associated complications.

Previous experiences, including previous screening tests and engagement in risky sexual behaviors, showed a significant effect on the intention to undergo STI screening.

While many psychosocial factors did not show associations with STI testing intentions, the influence of environmental factors was evident through the impact of social pressure and social fear on STI screening behaviors.

The findings of this study provide valuable insights into the underlying factors and enable the development of targeted interventions aimed at addressing barriers to STI screening. These interventions can promote a more comprehensive approach to sexual health education and promotion within the medical student in Pereira, and other Colombian localities.

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

This study strictly complied with the ethical standards described in the Declaration of Helsinki. Additionally, its development adhered to ethical protocols and was approved through an exemption granted by the Research Ethics Committee (CEISH) of the Fundación Universitaria Autónoma de las Américas. Participants that were included in the research, voluntarily participated in the survey and provided an electronic informed consent form.

Author contributions

VL-G: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft. MA: Conceptualization, Data curation, Investigation, Resources, Validation, Visualization, Writing – original draft. AÁ: Conceptualization, Data curation, Investigation, Methodology, Resources, Validation, Writing – original draft. VM: Conceptualization, Investigation, Methodology, Resources, Visualization, Writing – original draft. MM: Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft. AR: Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft. JI-C: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing – review & editing.

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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.

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Supplementary material

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The knowledge, training, and willingness of first year students in Xuzhou, China to perform bystander cardiopulmonary resuscitation: a cross-sectional study

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Background: Bystander Cardiopulmonary Resuscitation (CPR) can significantly improve the rate of return of spontaneous circulation in patients with cardiac arrest. Since first year students with no specific academic background are energetic and quick to learn, many Chinese schools offer first-aid training course including CPR to them before they start school. However, data on CPR knowledge, training, and willingness among first year students are lacking in most regions of China, which makes the effectiveness of CPR training unknown.

Objectives: To evaluate first year students' knowledge level, training experience and rescue willingness for CPR of first year students in Xuzhou, and to analyze the influencing factors of CPR knowledge level and rescue willingness of first year students in Xuzhou.

Design: A cross-sectional study.

Participations: A total of 9,887 first year students from three universities in Xuzhou city were selected by multi-stage random cluster sampling method.

Methods: A self-designed five-part structured questionnaire was used to investigate the knowledge, training and willingness of CPR among first year students. Independent sample *t*-test, χ^2-test and Logistic regression were used for data analysis.

Results: The average score of CPR knowledge was 2.44 ($\pm$1.60), 99.13% of the respondents were willing to participate in CPR training, and 66.25% had received CPR training. Respondents with rural household registration, relatives who had suffered from serious diseases, relatives engaged in the medical profession, good self-rated quality of life, CPR training, and willing to CPR training had higher CPR knowledge levels. 76.77% of the respondents were willing to perform bystander CPR. Women, those who had received CPR training, and those who were willing to receive CPR training were more willing to help patients with sudden cardiac arrest. Lack of first aid knowledge and skills (82.61%) was the biggest obstacle hindering respondents from performing rescue.

Conclusion: Most of the first year students of Xuzhou University in China have CPR training experience and have a strong willingness to train. Most are willing to perform bystander CPR, but have a low knowledge level. Colleges and universities can adopt diversified training methods, make plans for regular CPR retraining and other strategies to improve the quality and effect of CPR training for college students.

KEYWORDS

cardiopulmonary resuscitation, knowledge, training, willingness, first year students

1 Introduction

Out-of-hospital cardiac arrest (OHCA) is a prevalent issue in global health (1). A meta-analysis, encompassing 67 studies from diverse countries and regions indicates that the global incidence of OHCA varies between roughly 20 to 140 cases per 100,000 individuals. Correspondingly, the survival rate spans about 2 to 11% (2). As per the "China Cardiovascular Health and Disease Report 2022," an estimated 330 million individuals in China were affected by cerebrovascular disease (often abbreviated as CVD), highlighting its immense impact in that region. Furthermore, CVD remains the primary cause of mortality among both urban and rural residents in China (3). Owing to the substantial prevalence of CVD patients, the annual occurrence of cardiac arrest in China is considerably high (4). As stated in the "China Cardiac Arrest and Cardiopulmonary Resuscitation Report (2022 edition)," the overall incidence of cardiac arrest in China in 2022 was approximately 97.1 per 100,000 individuals. Research has demonstrated that bystander Cardiopulmonary Resuscitation (CPR) serves as a significant determinant in enhancing the survival rate of OHCA cardiac arrest patients, and the rate of return of spontaneous circulation was significantly higher among patients who received bystander CPR compared to those who did not (5–7). Despite the increasing participation rate of bystander CPR in China in recent years (from 10.41% in 2013 to 19.36% in 2017), attributed to collaborative efforts by the Chinese government, medical institutions, and relevant social groups (8), it remains comparatively low when compared to other countries or regions, such as the United States, the United Kingdom, Australia and so on (9–11). The performance and quality of CPR are influenced by the level of CPR knowledge and CPR training experience possessed by bystanders (12, 13). Compared to other occupational groups, such as workers, farmers, and freelancers, college students exhibit a higher level of knowledge and a greater inclination to engage in bystander CPR (14). Consequently, comprehending the present state of training experience, training willingness, CPR knowledge level and rescue willingness among college students in China is essential. By encouraging college students to disseminate CPR knowledge to their peers and community, we can effectively promote the widespread adoption of emergency rescue practices.

The majority of prior research has primarily concentrated on college students residing in major urban centers such as Beijing with a population of over 21 million (15), Chongqing with nearly 31 million (16), and Wuhan with approximately 11 million residents (17). However, there is a scarcity of data on college students in non-major cities like Xuzhou, which has a significant population, with over 9 million residents, including a substantial student population of more than 240,000 across 13 universities (18). This survey takes first year students as the research object because they do not a have professional background. This uniformity helps to minimize potential biases that might arise from pre-existing professional knowledge or skills, such as those possessed by students in health-related fields. For instance, students with a medical or paramedical background might have a higher baseline of CPR knowledge and a different perspective on performing out-of-hospital CPR, which could skew the results if not accounted for. By focusing on first year students, we aim to capture a more accurate representation of CPR knowledge and willingness among individuals at the very start of their higher education journey, providing a solid baseline for CPR training needs and effectiveness. This is also the innovation of our topic selection. Therefore, this study aims to conduct a cross-sectional investigation into the existing levels of CPR knowledge, training experiences, training willingness and rescue willingness among first year students in Xuzhou. Simultaneously, we will also endeavor to explore the influencing factors of first year students' CPR knowledge level and rescue willingness, to explore the factors affecting the behavior intention of bystander CPR and to provide a basis for further improving the knowledge level of college students' CPR, improving the participation rate of bystander CPR, and improving the quality of bystander CPR.

2 Methods

2.1 Study setting and data collection

Our study was conducted from September to November 2022 among first year students in Xuzhou, China. Xuzhou is home to 13 universities, which include a variety of educational institutions ranging from research-oriented universities to vocational colleges, each offering different levels of higher education.

This study employed a multi-stage random whole-group sampling method to ensure a diverse representation (Figure 1). In the initial stage, based on the different governing bodies, the 13 universities in Xuzhou were categorized into three groups: subordinate universities of ministry, subordinate universities of provincial government and vocational institute. To minimize potential biases or data interference that could arise from the unique characteristics of each university, such as their academic focus or student demographics, one university was randomly selected from each of the three categorized groups. In the subsequent stage, five

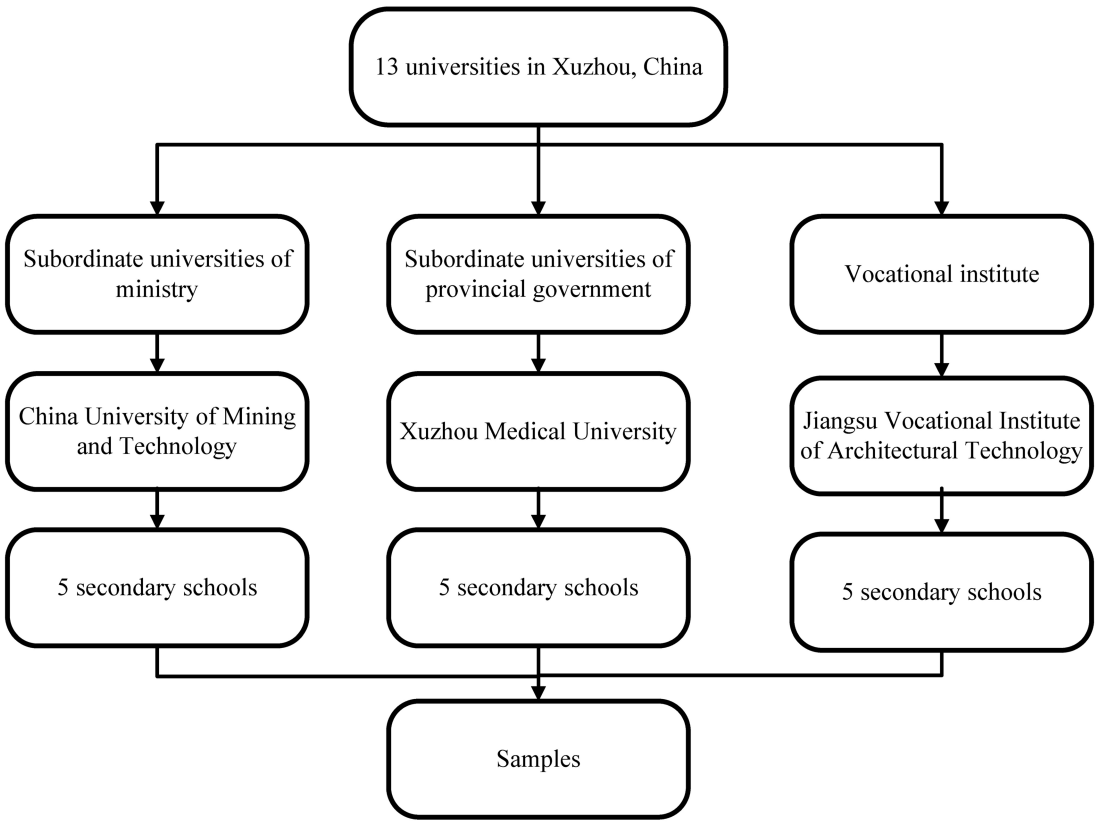


FIGURE 1
Sampling method.

secondary schools from each selected university were chosen randomly. First year students from these secondary schools underwent cluster sampling.

The CPR training referenced in this study adhered to the guidelines set forth by the American Heart Association (AHA), which is a widely recognized standard in CPR education. This curriculum, which includes the latest recommendations for chest compressions, rescue breaths, and the use of Automated External Defibrillators (AEDs), was consistently applied to all participants in the study to ensure uniformity in training quality and content. The use of a standardized curriculum also facilitated the comparison of participants' knowledge and skills against established benchmarks.

Data collection was facilitated via the 'Questionnaire Star' platform. Participants accessed and completed the electronic questionnaire by scanning the QR (Quick Response) code. Importantly, all respondents were apprised of the purpose of the study's objectives and provided their consent to partake in the study. For quality assurance, any questionnaire that was either incomplete or presented contradictory responses was deemed invalid.

2.2 Measures

A self-administered structured questionnaire was used for this survey, which was divided into five distinct sections, each designed to assess different aspects of the participants' CPR knowledge and experiences (Table 1).

Section one focused on demographic information, establishing a baseline profile of the respondents. Section two evaluated the participants' prior CPR training experiences, including the type and time of training received. Section three gauged the participants' willingness to undergo CPR training and their preferences for training methods. Section four assessed the respondents' knowledge of CPR through a series of factual questions. Finally, section five explored the participants' attitudes toward performing bystander CPR and the barriers they perceived to providing such aid.

The questionnaire underwent a rigorous process of content validation by a panel of experts in the field of emergency medicine and public health, demonstrating a high level of reliability and validity (Cronbach's $\alpha = 0.936$, KMO = 0.967).

2.3 Data analysis

Data were analyzed using IBM SPSS 20.0 with the test level set at $\alpha = 0.05$ and $P<0.05$ was considered a significant difference.

Continuous variables are described using means and standard deviations; counts and composition ratios represent categorical variables. The CPR knowledge section consisted of 7 questions, with 1 point for each correct answer and no points for incorrect answers, out of a total of 7 points. The respondents' CPR knowledge score was calculated, and the results showed that the scores of the respondents presented a skewed distribution. Since the results showed poor CPR

knowledge in the population as a whole, the level of CPR knowledge of the respondents was defined as the relative level of CPR knowledge in the population. Therefore, we classify a score > median as high and a score ≤ median as low. The χ^2 test was employed to examine the disparities in categorical outcomes between respondents who received CPR training and those who did not. Logistic regression analysis investigated factors influencing individuals' willingness to engage in CPR training.

3 Results

A comprehensive number of 9,976 questionnaires were completed for this survey. Following the elimination of 89 questionnaires due to their lack of responses or the presence of conflicting information, 9,887 questionnaires were deemed suitable for the final analysis.

3.1 Characteristics of the participants

The respondents had an average age of 18.20 ± 0.764, with a majority (over 99%) falling within the age range of 16 to 20 years old. Of the respondents, 60.99% (6030) identified as male. Additionally, 42.01% (4154) came from urban households, while 115 (1.16%) belonged to well-off families, 84.03% (8308) were from average family economic conditions, and 14.81% (1464) were classified as poor. Furthermore, 81.02% (8010) of the subjects reported having relatives with a history of major illness, and 36.77% (3635) of these relatives were employed in the medical profession (Table 2).

3.2 CPR training experience

66.25% of the respondents (6550) received CPR training (Table 2). There were significant differences in CPR training rates between respondents of different genders, household registration, family economic condition, self-rated quality of life, history of major illness in relatives, and relatives in the medical profession ($p \leq 0.05$) (Table 2).

Among respondents who had CPR training experience, 71.89% (4709) had attended CPR training 1 to 2 times, 21.33% (1397) had attended 3 to 4 times and 6.78% (444) had attended five times or more; 19.00% (1879) had participated in CPR training at primary school level, 43.76% (4327) at junior secondary school level, 52.23% (5164) at Senior high school level and 14.82% (1465) at undergraduate (or tertiary) level; 71.50% (4683) had attended CPR training in the form of face-to-face lectures, 57.31% (3754) had attended CPR training by watching online courses and 75.73% (4960) had attended CPR simulation exercises; schools (89.80%) were the main place where respondents attended CPR training. Respondents without experience of CPR training indicated that the biggest barrier to attending CPR training was not knowing how to attend (68.41%), followed by not having time to attend due to heavy academic commitments (27.81%), not seeing the need to attend (2.49%), and a small percentage (1.29%) not attending CPR training for other reasons.

3.3 CPR training willingness

Most respondents (99.13%) expressed willingness to participate in CPR training, while a negligible proportion (0.87%) indicated their lack of interest. Among those who were willing to attend CPR training, the majority (40.92% or 4,011 individuals) expected to receive training through regular simulation exercises, followed by face-to-face lectures (70.48%), online courses (51.33%), reading books and newspapers (36.40%), and accessing internet information (32.79%). Furthermore, it was found that 40.92% (4011) of the participants who were willing to attend CPR training anticipated receiving such training every month. Additionally, 45.01% (4111) of the respondents expected to have access to CPR training once per semester, while 14.48% (1419) believed that receiving CPR training once per school year would be satisfactory.

3.4 CPR knowledge

The proportion of correct answers on CPR knowledge is presented in Table 3. The mean score for CPR knowledge was 2.44 (±1.60), with a median score of 2, and the interquartile range was 3. The average score rate of CPR knowledge was 34.86% (2.44/7). Only 0.17% of respondents answered all questions correctly. Respondents with

TABLE 1 Structure of the questionnaire sections.

Part	Questions
Characteristics of respondents	Gender
	Household registration
	Self-rated of the family financial situation
	History of major illness in relatives
	Relatives in the medical profession
CPR training status	CPR training experience
	When to participate in CPR training
	What organization conduct CPR training
	Forms of CPR training to attend
	Reasons for not having attended CPR training
CPR training willingness and requirements	Willingness to participate in CPR training
	What type of CPR training you would like to attend
	Desired frequency of CPR training
CPR knowledge	The role of automated external defibrillators
	Measures to take for respiratory and cardiac arrest
	The correct steps for CPR
	The ratio of CPR chest compressions to artificial respirations
	The correct hand position for chest compressions during CPR
	The depth of chest compressions during CPR
	The duration of a CPR cycle
CPR willingness	Willingness to perform bystander CPR
	Obstacles to perform bystander CPR

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TABLE 2 Distribution of demographic characteristics of respondents' CPR training experience.

	Total, *n*	Trained, *n* (%)	Untrained, *n* (%)	χ^2	*p*-value
Gender				10.635	0.001
Male	6,030	3,920 (65.01)	2,110 (34.99)		
Female	3,857	2,630 (68.19)	1,227 (31.81)		
Household registration				62.202	<0.001
Urban	4,154	2,935 (70.65)	1,219 (29.35)		
Countryside	5,733	3,615 (63.06)	2,118 (36.94)		
Self-rated of the family financial situation				19.363	<0.001
Well-off	115	83 (72.17)	32 (27.83)		
Average	8,308	5,568 (67.02)	2,740 (32.98)		
Poor	1,464	899 (61.41)	565 (38.59)		
Self-rated quality of life				57.188	<0.001
Very Good	2045	1,463 (71.54)	582 (28.46)		
Good	3,745	2,532 (67.61)	1,213 (32.39)		
Normal	3,687	2,297 (62.45)	1,381 (37.55)		
Poor	316	198 (62.66)	118 (37.34)		
Very Poor	103	60 (58.25)	43 (41.75)		
History of major illness in relatives				10.407	0.001
No	1,877	5,366 (66.99)	2,644 (33.01)		
Yes	8,010	1,184 (63.08)	693 (36.92)		
Relatives in the medical profession				80.863	<0.001
No	6,252	3,938 (62.99)	2,314 (37.01)		
Yes	3,635	2,612 (71.86)	1,023 (28.14)		
Total	9,987	6,550 (66.25)	3,337 (33.75)		

TABLE 3 Proportion of correct answers on CPR knowledge.

CPR knowledge	Total (*n*)	Percentage
The role of an AED	3,579	36.17
Measures to take in respiratory and cardiac arrest	5,487	55.50
The correct steps for CPR	2,736	27.67
The ratio of chest compressions to artificial respirations	2,601	26.31
The correct hand position for chest compressions during CPR	3,550	35.91
The depth of chest compressions during CPR	4,238	42.86
The duration of a CPR cycle	3,456	35.95

previous CPR training had a mean score of 2.717 (±1.505), significantly higher than those without CPR training (mean score = 1.899, $t = -24.835$, $p < 0.001$).

A total of 46.86% ($n = 4,633$) of the participants demonstrated a high level of CPR knowledge (CPR knowledge score > 2 points), while 53.14% ($n = 5,234$) exhibited a low level of CPR knowledge (CPR knowledge score ≤ 2 points). Logistic regression analysis revealed that individuals with family members who had experienced a major illness, those with relatives employed in the medical profession, those who had better self-rated quality of life are better, those who had received CPR training, and those who expressed a willingness to undergo CPR training displayed a higher level of CPR knowledge (Table 4).

3.5 Willingness to perform bystander CPR

A significant majority of respondents, 76.77% (7590), expressed their willingness to perform bystander CPR on a patient experiencing sudden cardiac arrest, provided they possessed adequate mastery of CPR techniques. Conversely, a notable

TABLE 4 Logistic regression analysis: influence of demographic characteristics, CPR training experience and willingness on CPR knowledge level.

Characteristics	High level, *n* (%)	OR value (95%CI)	*P*-value
Gender			
Male	2,769 (45.92)	1.0	
Female	1,864 (48.33)	1.059 (0.975 to 1.151)	0.176
Household registration			
Countryside	2,566 (44.76)	1.0	
Urban	2,067 (49.76)	1.080 (0.991 to 1.178)	0.079
History of major illness in relatives			
No	3,703 (46.23)	1.0	
Yes	930 (49.55)	1.217 (1.096 to 1.352)	<0.001
Relatives in the medical profession			
No	2,750 (44.99)	1.0	
Yes	1,883 (51.80)	1.234 (1.133 to 1.345)	<0.001
Self-rated of the family financial situation			
Poor	647 (44.19)	1.0	
Average	3,921 (47.20)	0.930 (0.818 to 1.058)	0.464
Well-off	65 (56.52)	1.164 (0.777 to 1.746)	0.269
Self-rated quality of life			
Very poor	33 (32.04)	1.0	
Poor	116 (36.71)	1.166 (0.718 to 1.894)	0.536
Normal	1,642 (44.64)	1.682 (1.088 to 2.601)	0.019
Good	1,790 (47.80)	1.805 (1.163 to 2.803)	0.009
Very Good	1,052 (51.44)	2.001 (1.283 to 3.121)	0.002
CPR training experience			
No	1,094 (32.78)	1.0	
Yes	3,539 (54.03)	2.347 (2.149 to 2.562)	<0.001
CPR training willingness			
No	24 (27.91)	1.0	
Yes	4,609 (47.03)	2.163 (1.331 to 3.517)	<0.001

proportion of 23.23% exhibited hesitancy or diminished willingness to extend such assistance. Logistic regression analyses revealed that respondents who identified as female, possessed prior CPR training, had a high level of CPR knowledge, and were willing to undergo further CPR training displayed a higher inclination toward performing bystander CPR on a patient in sudden cardiac arrest (Table 5).

The lack of first aid knowledge and skills was the biggest obstacle that hindered respondents from performing bystander CPR followed by fear of secondary injury, practice, and dispute. Only a minority of respondents said it is none of their business. Meanwhile, some respondents expressed that they were willing to actively rescue at any time without hesitation (Table 6).

4 Discussion

This study was to determine the China Xuzhou first year students' CPR training experience, training will, knowledge level and the current situation of rescue will. The results showed that more than half of the respondents had received CPR training, and more than 70% of them had attended CPR training only once or twice. Most of them were willing to participate in CPR training, but the level of CPR knowledge was low, with an average score of only 2.44 (out of 7). In addition, most respondents said they would be willing to perform bystander CPR if they had CPR skills.

In this survey, it was found that 66.25% of the respondents had participated in CPR training, surpassing the rates observed in Chongqing (33.6%) (16), Wuhan (14.6%) (17), and Xinjiang (44.9%) (19), while being comparable to the United States (65%) (20). However, it fell short of the rates observed in the United Kingdom (90%) (21) and Norway (89%) (22). Participation in CPR training is a prerequisite for acquiring CPR knowledge and proficiency in CPR skills. Studies have confirmed that individuals who have received CPR training are more inclined to perform CPR (23). Consequently, enhancing the proportion of individuals who have undergone CPR training stands is crucial to improving bystander CPR rates. Due to the concerted efforts of the Chinese government and relevant social

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TABLE 5 Logistic regression analysis: influence of demographic characteristics, CPR knowledge level, CPR training experience and willingness on Willingness to perform bystander CPR.

Characteristics	Willing to rescue, *n* (%)	OR value (95%CI)	*P*-value
Gender			
Male	4,575 (75.87)	1.0	
Female	3,015 (78.17)	1.120 (1.016 to 1.235)	0.022
Household registration			
Urban	3,181 (76.58)	1.0	
Countryside	4,409 (76.91)	1.091 (0.987 to 1.206)	0.088
History of major illness in relatives			
No	6,174 (77.08)	1.0	
Yes	1,416 (75.44)	0.941 (0.835 to 1.062)	0.326
Relatives in the medical profession			
No	4,761 (76.15)	1.0	
Yes	2,829 (77.83)	1.051 (0.951 to 1.163)	0.330
Self-rated of the family financial situation			
Poor	1,103 (75.34)	1.0	
Average	6,396 (76.99)	1.009 (0.871 to 1.168)	0.907
Well-off	91 (79.13)	1.032 (0.634 to 1.680)	0.900
Self-rated quality of life			
Very poor	80 (77.67)	1.0	
Poor	221 (69.94)	0.555 (0.323 to 0.956)	0.034
Normal	2,795 (76.99)	0.704 (0.428 to 1.158)	0.166
Good	2,833 (75.65)	0.678 (0.410 to 1.121)	0.130
Very good	1,661 (81.22)	0.941 (0.565 to 1.568)	0.816
CPR training experience			
No	2,472 (74.08)	1.0	
Yes	5,118 (78.14)	1.186 (1.072 to 1.311)	0.001
CPR training willingness			
No	4,761 (76.15)	1.0	
Yes	2,829 (77.83)	5.641 (3.599 to 8.841)	<0.001
CPR knowledge level		1.	
Low level	3,927 (74.74)	1.0	
High level	3,663 (79.06)	1.205 (1.094 to 1.328)	<0.001

TABLE 6 Obstacle that hindered respondents from performing bystander CPR.

Obstacles	Total (%)
Lack of CPR knowledge and skills	8,168 (82.61%)
Fear of secondary injury	7,293 (73.76%)
Fear of practice	6,228 (62.99%)
Fear of dispute	5,185 (52.44%)
None of my business	1,433 (14.49%)
No scruples	1,500 (15.17%)

entities (23), schools have emerged as the primary hub for comprehensive CPR training across all educational stages in China, fostering a continuous drive toward widespread dissemination of CPR technology and scientific knowledge. While commendable progress has been achieved, a discernible disparity remains compared to Europe, America and other developed countries. The respondents

who had not participated in CPR training in this survey said that they did not know how to participate in CPR training was the biggest obstacle. Activities such as CPR week can be carried out to strengthen publicity and education, so as to increase the proportion of the population participating in CPR training.

In terms of the willingness aspect of CPR training, over 99% of the participants expressed their willingness to engage in CPR training, surpassing the survey of CPR training willingness among Chinese adults in 2019 (73.4%) (24), as well as previous research conducted in other countries (25). These findings indicate that college students, known for their strong learning abilities, exhibit the highest level of willingness to acquire CPR knowledge. Therefore, prioritising CPR training for college students is crucial in enhancing the overall CPR knowledge and skills within society. In addition, most respondents preferred CPR training through passive learning methods, such as simulation exercises, face-to-face lectures, and online courses. A minority of respondents indicated a desire for CPR training through active learning approaches, such as reading books, newspapers, and magazines and accessing network data. Several studies have demonstrated that traditional face-to-face CPR training (26), online computer-based CPR training (27), and virtual reality (VR) technology for CPR training (28) each possess distinct advantages. Therefore, embracing diverse methods of CPR training is conducive to enhancing the effectiveness and efficiency of such training.

Compared with the high rate of CPR training participation and the rate of willingness to participate in CPR training, the level of CPR knowledge in this survey was low. Only less than half of the respondents had a relatively high level of CPR knowledge, and the average score of CPR knowledge was only 34.86% (2.44/7). Less than 1 % of the respondents could answer all the questions correctly, similar to the results of a survey of college students in Chongqing (1%) (16). The correct answer rate for CPR knowledge showed the lowest percentage of respondents who could accurately identify the compression ventilation rate, aligning with findings from a study conducted on the general population in Turkey (29). Even for the question "Measures to take for respiratory and cardiac arrest" with the highest correct rate, only slightly more than half of the respondents could answer correctly, indicating that the overall CPR knowledge level of the respondents in this survey was low. The influencing factors of CPR knowledge level included "History of major illness in relatives," "Relatives in the medical profession," "Self-rated quality of life," "CPR training experience" and "CPR training willingness." A study of older adult respondents who were being treated in emergency wards found that most patients understood all components of CPR (30). As the results of our analysis show, the level of CPR knowledge is higher in those whose relatives have serious diseases. Since patients with serious diseases are more likely to have sudden cardiac arrest, doctors and nurses usually pay more attention to the popular science and training of CPR knowledge for such patients and their relatives. At the same time, out of concern and care for the relatives of the serious illness, the family members usually pay more attention to understanding the relevant knowledge. CPR is a required skills for medical practitioners (31), and even the CPR knowledge level of junior medical students is higher than that of non-professionals. Therefore, it is common sense that respondents with relatives engaged in the medical profession have higher CPR knowledge level. Some studies have found that self-rated health negatively correlates with depression (32), and self-rated health is an effective measure of quality of life (33). Therefore, people with better self-rated health are more likely to perform well in mental health and thus achieve better quality of life. This may explain why our analysis showed that participants with better self-rated quality of life were likelier to have a higher level of CPR knowledge. To give help to others is associated with better mental health (34); therefore, the self-rated a better quality of life were more willing to give help to others are more likely to focus on and take the initiative to learn CPR-related knowledge and skills, and therefore have higher CPR knowledge level. Several studies have confirmed that people who have been trained in CPR, whether in the medical profession or laypersons, have a higher level of CPR knowledge than those who have not (35, 36). At the same time, some studies also pointed out that even medical practitioners' CPR knowledge and skill levels will decline after a period of CPR training (37, 38). Lack of regular CPR retraining May be one of the reasons for the low CPR knowledge level of the respondents in this survey, so it is particularly important to maintain a certain frequency of CPR retraining. The survey revealed that over 40% of the respondents expressed an expectation for monthly CPR training, while a similar proportion indicated a desire for CPR training on a semesterly basis. The findings of a randomized trial study aimed at determining the optimal frequency for high-quality CPR skills training demonstrated that CPR training once per month significantly improved CPR performance (39).

Although there is a limited overall understanding of CPR, over 70% of respondents indicated their willingness to perform bystander CPR if they were more proficient in CPR techniques. This is consistent with findings from surveys conducted among healthcare professionals in China (73.9%) (40) and community populations in the U.S. (77.8%) (41). Our study showed that women, those with prior CPR training experience, individuals open to further CPR education, and those with a higher CPR knowledge were more inclined to perform bystander CPR. Such trends echo results from prior surveys among medical staff in China. The predominant barrier hindering respondents from engaging in bystander CPR was a first-aid knowledge and skills deficiency.

Additionally, a significant majority expressed concerns about causing secondary harm during rescue efforts and potential disputes arising as a result, which closely mirror those obtained from a survey conducted in Taiwan (42). Over 60% of respondents admitted lacking confidence and fear regarding practical application. Notably, another survey involving Chinese students highlighted that the main hindrance to performing CPR on family members was fear of practice, whereas, for strangers, it was primarily driven by apprehension regarding potential conflicts stemming from secondary injuries incurred during resuscitation attempts (17). Only a small minority chose to perform bystander CPR without consideration indicating most respondents would carefully consider whether or not to administer assistance based on the specific circumstances encountered when faced with cardiac arrest patients to avoid unnecessary disputes.

The concerns most respondents expressed highlight a critical area where public perception is influenced by external factors. While our study did not specifically measure the impact of media exposure on first year students' knowledge and willingness to perform CPR, existing literature suggests that media platforms, including social media, television, and movies, play a significant role in disseminating health information and influencing attitudes, particularly among

younger demographics (43, 44). Media often serves as a primary source of information for the public, and its portrayal of CPR can either educate or mislead. For example, television and movies sometimes depict dramatic and inaccurate CPR scenarios that May exaggerate the risks of performing CPR, thereby increasing the apprehension of causing harm. On the other hand, responsible and accurate media coverage can demystify the process, reduce misconceptions, and encourage a more informed public response to cardiac arrest situations.

Given the influence of media, it is vital for educational institutions and healthcare organizations to partner with media professionals to promote accurate CPR knowledge and techniques. This can be achieved through educational campaigns, public service announcements, and engaging content that addresses common misconceptions and emphasizes the importance of CPR in life-saving situations., Considering the high level of media consumption among young people, it would be valuable to assess the extent to which first-year students are influenced by media in their understanding and attitudes toward CPR and assess the impact of such content on their knowledge, attitudes, and willingness to perform CPR in future research.

4.1 Limitation

The limitation of this investigation is that, first of all, this study takes first year students in Xuzhou as the research object, which cannot reflect the situation of the whole first year students, nor can it represent the situation in other regions of China. In addition, this study is a cross-sectional study, and it is not certain whether CPR training affects on improving the CPR knowledge level of the respondents. Further studies are needed to confirm this. Finally, the self-designed questionnaire used in this survey May still not be perfect enough to reflect the participants' situation fully.

5 Conclusion

Most of first year students in Xuzhou, China, with CPR training experience and strong training willingness are willing to implement the bystander CPR. However, most of them only received one or two CPR trainings; due to a lack of periodic CPR training, their knowledge level is relatively low. This also leads to the lack of first-aid knowledge and skills as the main obstacle to implementing bystander CPR. Colleges and universities should further promote the popularization of CPR knowledge and skills based on the achievements so far, adopt diversified training methods, and formulate plans for regular CPR retraining to improve the quality and effect of CPR training for college students. At the same time, based on the experience of college students' CPR training for the whole population to improve the efficiency and effect of large-scale CPR training.

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 Ethics Committee of Xuzhou Medical 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

ZQ: Conceptualization, Funding acquisition, Methodology, Project administration, Writing – review & editing. SZ: Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. CL: Data curation, Investigation, Writing – review & editing. YR: Investigation, Software, Writing – review & editing. RW: Investigation, Validation, Writing – review & editing. SZ: Data curation, Investigation, Writing – review & editing. XG: Data curation, Investigation, Writing – review & editing. YL: Investigation, Supervision, Writing – review & editing. XY: Project administration, Resources, Supervision, Writing – review & editing. TX: Resources, Supervision, Writing – review & editing.

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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.

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The influence of perceived formative assessment on the learning autonomy of medical students: the chain mediating role of psychological empowerment and positive academic emotions

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Introduction: Medical students' autonomous learning is a cornerstone of their educational journey. Formative assessment is defined as a process to enhance learning and improve academic performance, and the key to the effectiveness of formative assessment is the students' perceptions of it. The present study investigates the impacts of perceived formative assessment on the learning autonomy of medical students, explores the chain mediating role of psychological empowerment and positive academic emotions, and offers strategies for facilitating medical students' autonomous learning.

Methods: A cross-sectional investigation was conducted using a convenience sampling method involving 713 medical students (mean age 19.72 ± 1.18 years; 207 male and 506 female students; the proportion of participants is 93.69%) in Shandong Second Medical University. Perceived formative assessment was performed using a self-designed questionnaire of Perceived Formative Evaluation for Medical Students, learning autonomy using the Autonomy in Learning Rating Scale for College Students, positive academic emotions using the General Academic Emotion Questionnaire for College Students, and psychological empowerment of medical students using the Chinese version of Psychological Empowerment Scale (PES). The data were analyzed using descriptive statistics, Pearson's correlation, multiple regression, and mediation analysis using the SPSS26.0 program and PROCESS3.1.

Results: Perceived formative assessment significantly predicted learning autonomy (β = 0.06, p < 0.05). It also positively predicted psychological empowerment (β = 0.20, p < 0.001), and psychological empowerment positively predicted the learning autonomy of medical students (β = 0.36, p < 0.001). Psychological empowerment also positively predicted positive academic emotions (β = 0.64, p < 0.001), and positive academic emotions positively predicted learning autonomy (β = 0.44, p < 0.001). The direct effect value of perceived formative assessment on learning autonomy was 0.18, while the total indirect effect was 0.43. The mediation effect of psychological empowerment on the relationship between perceived formative assessment and learning

autonomy was 0.22, and the chain mediation effect of psychological empowerment and positive academic emotions was 0.18, accounting for 30%, 70%, 36%, and 30% of the total effect, respectively.

Conclusion: Perceived formative assessment directly enhances medical students' learning autonomy. This relationship is partially mediated by psychological empowerment and positive academic emotions. The results suggest that formative evaluation boosts psychological empowerment, which fosters positive academic emotions and further promotes learning autonomy.

KEYWORDS

perceived formative assessment, learning autonomy, psychological empowerment, positive academic emotions, medical students

1 Introduction

Rapid changes in demographics, epidemiology, environmental and behavioral risks, and increasingly complex health issues are creating unprecedented health challenges, which in turn place higher demands on health professionals, necessitating continuous improvement in their professional competence. Nurturing autonomy in learning among medical students is essential for their continuing professional development (1, 2). Autonomy refers to intrinsic motivation and self-governance or self-regulation (3). It is the capacity to take control of one's own learning process (4) and is also considered a cornerstone of lifelong learning (5). Some research has successfully demonstrated that high learning autonomy plays an important role in increasing medical students' academic achievement, learning strategies, and study efforts, as well as in reducing students' exhaustion during the learning process (6, 7). Autonomy also helps build confidence by increasing their clinical decision-making responsibility, which enhances their educational experience (8). Fostering medical students' autonomous motivation may help deliver healthcare in a humanistic manner by encouraging their use of an autonomy-supportive style of relating to patients (9–11). Learners' autonomy has primarily been examined within the context of language learning, but research about learning autonomy in medical settings is limited (12). Furthermore, the literature indicates that the factors influencing medical students' autonomous learning remain relatively unexplored (13). Therefore, investigating the factors influencing medical students' learning autonomy and offering insights for nurturing their learning autonomy is a meaningful endeavor.

The learning benefits of formative assessment have made it a key consideration in educational reform worldwide (14), and it is also widely used in medical teaching practice and research with the ongoing educational reform in China (15). However, how perceived formative assessment improves learning autonomy in medical students has been less demonstrated. Self-determination theory (SDT) (16, 17) is an organismic-dialectical theory that views human beings as proactive organisms whose intrinsic functioning can be either facilitated or impeded by their social context. This support or hindrance is mediated by the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. According to SDT, autonomy-supportive contexts in which medical students' basic psychological needs are satisfied will improve their wellbeing and promote intrinsic motivations and self-regulation of extrinsic motivations, leading to more volitional engagement and effectiveness in medical learning. Furthermore, cognitive evaluation theory (CET) (18, 19) hypothesized that social-contextual events (e.g., feedback, communications, and rewards) that promote feelings of competence will not enhance intrinsic motivation unless they are accompanied by an internal perceived locus of causality. In other words, medical students will only experience them as controllers of their learning behavior, leading to intrinsic motivation and learning engagement. Psychological empowerment, as a kind of intrinsic task motivation reflecting a sense of control in relation to one's work, has been suggested to play a mediating role between supportive management and both employee performance and positive emotions (20). There are still two questions that remain unanswered: Whether psychological empowerment plays a mediating role in the relationship between supportive educational practices and learning autonomy among medical students? How does formative assessment influence learning autonomy through the interaction of psychological empowerment and positive academic emotions? This research, based on self-determination theory (SDT) and cognitive evaluation theory (CET) as a framework, aimed to elucidate the influence of supportive educational practices on medical students' learning autonomy. It selected formative assessment, the most commonly used method in current medical students' academic evaluation, as the independent variable, and incorporated psychological empowerment and positive academic emotions into the model to explore the deeper mechanisms underlying the relationship from both cognitive and emotional perspectives. This research will help better understand the mechanisms of formative assessment on the learning autonomy of medical students and provide some implications for fostering medical students' learning autonomy.

1.1 Perceived formative assessment and learning autonomy

One study has shown that formative assessment plays a crucial role in promoting learners' autonomy (21). Formative assessment is defined as encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged (22, 23). Since formative assessment is highly student-focused and interactive, provides quality feedback and feed-forward, and is adaptive, it allows students to autonomously learn problem-solving procedures and enables them to take an active role in their own learning by challenging them (17, 24, 25). Therefore, it has been recognized as a beneficial strategy for enhancing their self-regulation and empowering them to become autonomous learners (23, 26–30). A growing body of research provides extensive evidence that, if well perceived by students, formative assessment has the potential to

contribute to improving students' learning. According to Harks et al. (31), formative assessment affects students' engagement in learning through students' perception of its usefulness. Kyaruzi et al. (32) found that students' perceptions of the quality of teacher feedback delivery and perceived scaffolding positively predicted students' feedback use, whereas perceived monitoring negatively predicted feedback use. Based on this, we propose the following hypothesis:

> *Hypothesis I*: Perceived formative assessment can positively predict learning autonomy in medical students.

1.2 Perceived formative assessment, psychological empowerment, and learning autonomy

Psychological empowerment is defined as intrinsic task motivation reflecting a sense of control in relation to one's work and cognitive orientation to one's work role (33), and it is shaped by the contextual environment and contributes to enhancing feelings of self-efficacy and autonomy (34–37). Extant theoretical and empirical studies suggested that psychological empowerment may be an important mediator between organizational environment and work performance, commitment, and engagement (20, 38–43). According to CET, people must experience their behavior as self-determined for intrinsic motivation to be evident. This requires inner resources that are typically the result of prior developmental supports for autonomy and competence (44). Relevant research confirmed the mediating effect of psychological empowerment in the relationship between perceived formative assessment and learning. Studies showed that formative assessment improves students' feeling of empowerment to take control of their own learning processes (45–47) and intrinsic motivation (48). Previous research has also revealed that psychological empowerment is related to autonomy. For example, Watkins' study found a significant relationship between psychological empowerment and professional autonomy (49). Myrick suggested that psychological empowerment fosters autonomy, choice, control, and responsibility, which, in turn, creates empowered schools (50). Psychological empowerment will be more influential in beliefs about one's own skills and efforts when it involves exercising control, participating in decision-making, or engaging in problem-solving (51).

Based on the above, we propose the following hypothesis:

> *Hypothesis II*: Psychological empowerment plays a mediating role in the relationship between perceived formative assessment and learning autonomy.

1.3 Perceived formative assessment, positive academic emotions, and learning autonomy

An extensive body of research has revealed that positive academic emotions are considered a potential mediating variable of the relationship between formative assessment and learning autonomy. Pekrun's (52) cognitive and motivational model postulates that positive emotions have a positive influence on learners' self-regulation. The relationship between positive academic emotions and learning autonomy has been well-established in research. Some studies have shown how positive emotions are related to a range of autonomy-related variables such as competency beliefs (53), mastery and performance approach goals (54, 55), study effort, learning strategies, self-regulation (56), and engagement (57, 58). Studies show that perceived teacher's supportive feedback was positively related to individual levels of academic enjoyment (53) and emotional resilience (59). Recently, a longitudinal study showed that perceived learning control has positive effects on academic enjoyment (60). Thus, we propose the following hypothesis:

> *Hypothesis III*: Positive academic emotions play a mediating role in the relationship between perceived formative assessment and learning autonomy.

The chain mediating model hypothesis model is shown in Figure 1.

1.4 The chain mediating role of psychological empowerment and positive academic emotions on perceived formative assessment and learning autonomy

Psychological empowerment may mediate the relationship between perceived formative assessment and positive academic emotions of medical students. A meta-analysis of psychological empowerment has revealed that perceived support in an organization is one of the antecedents of psychological empowerment and that psychological empowerment acts as a motivational factor that may generate emotional reactions (20). Furthermore, positive academic emotions may mediate the relationship between psychological empowerment and learning autonomy of medical students. A longitudinal study showed that positive affect mediates the relationship between psychological empowerment and employee outcomes (61). According to SDT, when an individual is given an opportunity for self-direction, basic psychological needs are fulfilled and then intrinsic motivation is enhanced, thus leading to self-integration (44).

Drawing from the above framework and findings of related studies, we propose the following hypothesis:

> *Hypothesis IV*: Psychological empowerment and positive academic emotions together play a chain mediating role in the relationship between perceived formative assessment and learning autonomy.

The theoretical model used in this study is shown in Figure 1.

2 Materials and methods

2.1 Participants

We estimated the sample size using a prior analysis using G*Power 3.1, selecting the multiple linear regression method (62) and setting the effect size at a medium level ($f^2 = 0.15$), the statistical power ($1\text{-}\beta$) = 0.95, and type I errors (α) = 0.001. Based on these parameters,

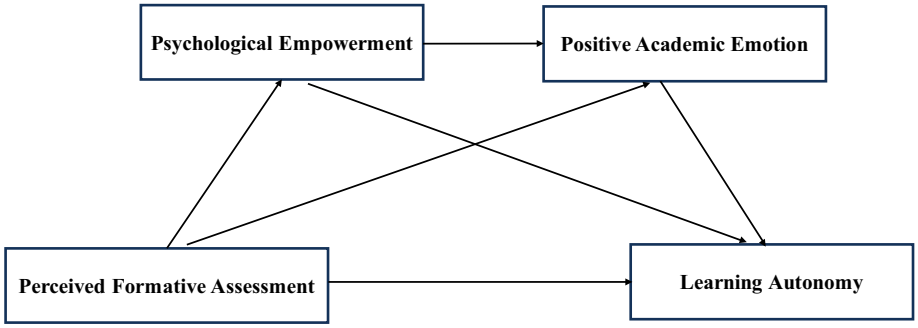


FIGURE 1
Chain mediating model hypothesis of psychological empowerment and positive academic emotions in the relationship between perceived formative assessment and learning autonomy of medical students.

the estimated sample size is not less than 208. A cross-sectional survey via the online survey website Wenjuanxing was conducted using the convenience sampling method to investigate medical students at Shandong Second Medical University located in Shandong Province. A total of 761 questionnaires were collected. After excluding invalid questionnaires (i.e., failed to complete all answers, options are inconsistent, and item responses were quicker than the reasonable rate of 2 s per item), 713 questionnaires were considered valid (93.69% valid response rate) (63). All subjects were between the ages of 18 and 23 years of age (M = 19.72; SD = 1.18). The sample included 207 men (29.03%) and 506 women (70.97%). Of these, 351 were first-year students (49.23%), 189 were second-year students (26.51%), and 173 were third-year students (24.26%). Participants were enrolled in majors related to clinical medicine (437, 61.29%), medical technology (185, 25.95%), and other fields (91, 12.76%).

2.2 Measures

2.2.1 Perceived formative evaluation questionnaire for medical students

This study measured medical students' perceived formative assessment using a self-designed questionnaire of Perception of Formative Evaluation for Medical Students. The questionnaire was constructed following the standardized procedure of questionnaire development. The questionnaire consists of 41 items, which are divided into two subscales: perception of assessment and perception of feedback. Each item was rated using a Likert scale ranging from "1" (never perceived) to "4" (often perceived). The higher the score, the higher the level of perceived formative assessment. Confirmatory factor analysis showed that the CMIN/DF value of the questionnaire was 3.067, the CFI value was 0.880, and the RMSEA value was 0.083, indicating acceptable structural validity. Cronbach's α of the questionnaire was 0.95.

2.2.2 Autonomy in learning rating scale for college students

The Autonomy in Learning Rating Scale for College Students used in this study was developed by Yuan (64). This scale consists of 61 items and includes four dimensions: self-regulation, learning strategies, content and environment, and learning motivation. The scale uses a 5-point Likert scoring method (from 1 = "Not like me at all" to 5= "very much like me"); a higher score indicates a higher level of learning autonomy. Cronbach's α of the scale was 0.98 for this study.

2.2.3 General academic emotion questionnaire for college students

The General Academic Emotion Questionnaire for College Students was developed by Ma (65). The questionnaire consists of 88 items and four dimensions: negative activating emotions, positive activating emotions, negative deactivating emotions, and positive deactivating emotions. It uses a 5-point Likert scale rating method (from 1 = "strongly disagree" to 5 = "strongly agree"). A higher dimension score indicates a higher level of experienced academic emotion. This study used the positive emotions items (38 items) to evaluate the academic positive emotions of medical students. Cronbach's α of the scale was 0.95 for this study.

2.2.4 Psychological empowerment scale

The Psychological Empowerment Scale (PES) was originally constructed by Spreitzer (33), and the Chinese version was revised by Li-Chaoping et al. (66). To better adapt the scale to the learning context, some expressions were modified. For instance, "work" was changed to "learning" and "department" was changed to "class." The scale consists of four dimensions including meaning, self-efficacy, self-determination, and impact, with a total of 12 items. It adopts a 5-point Likert scoring method (from 1 = "strongly disagree" to 5 = "strongly agree"). A higher score indicates a higher level of psychological empowerment. The scale has been shown to have good reliability and validity. Cronbach's α of the scale was 0.93 for this study.

2.3 Date analysis

Data analysis was performed using the SPSS26.0 program and PROCESS3.1. Harman's single-factor analysis was first conducted to check for potential common method bias. The reliability of each of the scales used in the current study was evaluated using Cronbach's α coefficient. Pearson's correlation analysis was conducted to explore the association among variables. Subsequently, PROCESS 3.1 (Model 6) was used to test the chain mediation effect of PE and PAE. The bias-corrected percentile bootstrap method was used to estimate the 95% confidence interval with 5,000 repeated sampling (67). The effects are considered to be statistically significant if the CI does not contain zero.

3 Results

3.1 Multicollinearity and common method variance

An exploratory factor analysis was used to test for possible common method bias by incorporating all questionnaire items. The results showed 21 factors with eigenvalues greater than 1. The first factor accounted for 30.16%, which is less than 40% (68), indicating no serious common method deviation in the data of this study.

3.2 Correlation between variables

A significant correlation was found between formative assessment, psychological empowerment, positive academic emotions, and learning autonomy of medical students (Table 1), and the results supported conducting a further mediating effects analysis (69).

3.3 The mediating effects of psychological empowerment and positive academic emotions

PROCESS 3.1 was used to analyze the mediating role of psychological empowerment and positive academic emotions between perceived formative assessment and learning autonomy of medical students, controlling the variables such as major and hometown. The results of the regression analysis (Table 2) showed that perceived formative assessment had a significant positive predictive effect on learning autonomy ($\beta = 0.06$, $p < 0.05$), confirming hypothesis I; perceived formative assessment positively predicted psychological empowerment ($\beta = 0.20$, $p < 0.001$), and psychological empowerment positively predicted the learning autonomy of medical students ($\beta = 0.36$, $p < 0.001$), confirming hypothesis II; and psychological empowerment positively predicted positive academic emotions ($\beta = 0.64$, $p < 0.001$), and positive academic emotions positively predicted learning autonomy ($\beta = 0.44$, $p < 0.001$), confirming hypothesis IV. The effect of perceived formative assessment on positive academic emotions was not significant when the chain mediating effect was tested ($\beta = 0.02$, $p > 0.05$).

The bootstrap method was used to test the chain mediating effect of psychological empowerment and positive academic emotions between perceived formative assessment and learning autonomy in medical students. Table 3 shows the 95% confidence intervals of the bootstrap sampling test for each path, and none of the bootstrapped 95% confidence intervals for these indirect effects contained a value of 0, indicating that the indirect effects are significant. Specifically, the total indirect effect was significant, with an indirect effect value of 0.43; the mediating effect of psychological empowerment on perceived formative assessment and learning autonomy in medical students was significant, with a mediating effect value of 0.22; and the chain mediating effect of psychological empowerment and positive academic emotions in the relationship between perceived formative assessment and learning autonomy in medical students was also significant, with a mediating effect value of 0.18, accounting for 70, 36, and 30% of the total effect, respectively. The detailed pathway model is shown in Figure 2.

TABLE 1 Correlation analysis of study variables ($N = 713$).

	Mean	*SD*	PFA	PE	PAE	LA
PFA	126.90	12.60	—			
PE	43.91	7.66	0.20**	—		
PAE	134.03	19.93	0.12**	0.64**	—	
LA	204.49	39.36	0.18**	0.65**	0.68**	—

PFA, perceived formative assessment; PE, psychological empowerment; PAE, positive academic emotions; LA, learning autonomy. *$p < 0.05$, **$p < 0.01$.

4 Discussion

This study explored the chain mediating effects of psychological empowerment and positive academic emotions in the relationship between perceived formative assessment and learning autonomy of medical students by constructing a chain mediation model. The results indicate a significant positive correlation between perceived formative assessment, psychological empowerment, positive academic emotions, and learning autonomy of medical students. Further regression analysis results also indicate a significant positive predictive effect of perceived formative assessment on the learning autonomy of medical students, confirming our first hypothesis. When psychological empowerment and positive academic emotions entered into the equation, the direct effect of perceived formative assessment on the learning autonomy of medical students changed. The findings of the mediation test revealed that psychological empowerment and positive academic emotions partially mediated the effect of perceived formative assessment on the learning autonomy of medical students. The literature revealed that limited studies have investigated the specific pathways between perceived formative assessment and learning autonomy in medical students. This study provided empirical evidence supporting the impact of formative assessment on learning autonomy and extended these findings to the education of medical students. The results help to a better understanding of the mechanisms between formative assessment and learning autonomy in medical students from both cognitive and emotional perspectives. Since this study is a cross-sectional study, it cannot confirm causality.

4.1 The relationship between perceived formative assessment and learning autonomy in medical student

The results of this study showed that perceived formative assessment significantly predicted the learning autonomy of medical students, which is consistent with the findings of previous studies (21, 70). Although supporters of formative assessment agree that it improves students' learning autonomy, research has found that students and teachers have different perceptions of formative assessment (70, 71), and teachers' autonomous teaching predicted students' autonomous learning through students' perceptions of it (72). Therefore, students' perception and utilization of formative assessment provided by teachers play an important role in enhancing learning autonomy. More perceived use of formative assessment is associated with more feelings of autonomy (73).

TABLE 2 Regression model of the effect of PFA on LA in medical students ($N = 713$).

Variables	β	t	P	$LLCI$	$ULCI$	R^2	F
PFA → PE	0.20	5.47	0.00***	0.08	0.17	0.04	10.84***
PFA → PAE	0.02	0.70	0.49	−0.57	0.12	0.42	126.30***
PE → PAE	0.64	21.78	0.00***	1.51	1.81		
PAE → LA	0.44	13.23	0.00***	0.74	1.00	0.55	172.69***
PE → LA	0.36	10.70	0.00***	1.50	2.17		
PFA → LA	0.06	2.23	0.03*	0.02	0.34		

PFA, perceived formative assessment; PE, psychological empowerment; PAE, positive academic emotions; LA, learning autonomy. *$p < 0.05$, ***$p < 0.001$.

TABLE 3 The mediating effects of PE and PAE ($N = 713$).

		Effect	Boot SE	Boot LLCI	Boot ULCI	Ratio to total effect
Direct effect		0.18	0.08	0.02	0.34	0.30
Indirect effect	Total indirect effect	0.43	0.09	0.27	0.60	0.70
	PFA PE LA	0.22	0.05	0.14	0.32	0.36
	PFA PE PAE LA	0.18	0.04	0.11	0.26	0.30
Total effect		0.61	0.11	0.38	0.83	

PFA, perceived formative assessment; PE, psychological empowerment; PAE, positive academic emotions; LA, learning autonomy.

According to th self-determination theory (SDT), students have basic psychological needs for autonomy, competence, and relatedness. When students perceive that their behavior emanates from the self and is self-authored, they experience it as volitional, and it fulfills their basic psychological needs, thus enabling them to develop autonomous motivation (44, 74). Formative assessment is very student-centered and supportive, fulfilling students' basic psychological needs when perceived well by students (24, 25). This perception and fulfillment allow students to exert control over their learning, make their own decisions, and then enable students to become autonomous learners.

4.2 The chain mediating role of psychological empowerment and positive academic emotions in the relationship between perceived formative assessment and learning autonomy in medical students

The results of this study showed that perceived formative assessment impacts the learning autonomy of medical students through the chain of psychological empowerment and positive academic emotions. This is the main contribution of this research. The results showed that perceived formative assessment indirectly affects the learning autonomy of medical students through two pathways: psychological empowerment and the chain mediating effect of psychological empowerment and positive academic emotions.

First, the results of this study found that perceived formative assessment positively predicts psychological empowerment, and psychological empowerment positively predicts the learning autonomy of medical students. This path accounts for 36% of the total effects, indicating that psychological empowerment is an important mediating factor in the relationship between perceived formative assessment and learning autonomy in medical students. Research into psychological empowerment has reported strong evidence confirming its role as a mediating and motivational factor in organizational and community psychology (20, 75). Based on previous research, Llorente-Alonso et al. (20) posited that high-performance managerial practices, oriented toward offering workers greater access to support, resources, and learning, act as empowering elements. In addition, individuals' perception of real rewards and support enables workers to feel empowered. Formative assessment is precisely a practice that "encourages students and gives them a greater sense of ownership" by deeply involving them in strategies such as personal goal-planning, monitoring, and reflection, thus giving learners "the power to oversee and steer their own learning" (76). Cauley and McMillan (48) also discovered that formative assessment encourages students and gives them a greater sense of ownership in instructional activities. Psychological empowerment positively predicted the learning autonomy of medical students. This result is consistent with previous studies (49, 50), suggesting that psychological empowerment plays an important role in motivating and activating students to regulate and be responsible for their own learning. Psychological empowerment can be viewed as a cognitive and motivational process by which students develop learning autonomy based on perceived formative assessment (20, 33, 37).

Second, the result of this study showed that positive academic emotions mediated the relationship between psychological empowerment and learning autonomy of medical students. This path (perceived formative assessment→psychological empowerment→positive academic emotions→learning autonomy) accounts for 30% of the total effect, indicating that perceived formative assessment influences learning autonomy through the chain of psychological empowerment and positive academic emotions. On the one hand, psychological empowerment positively predicted positive academic emotions, indicating that students who experience higher levels of psychological empowerment also

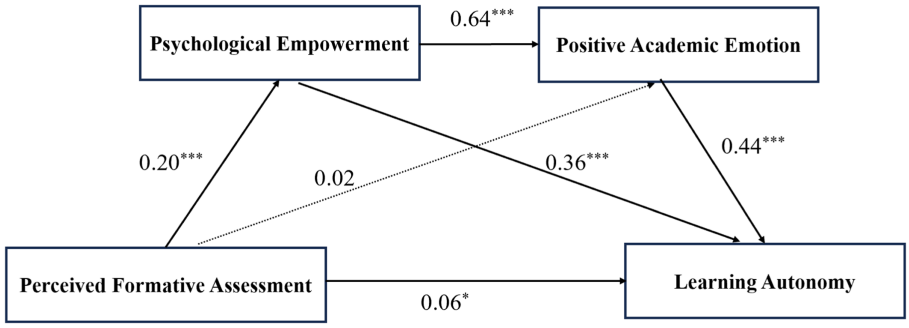


FIGURE 2
Illustrated pathway showing the chain mediating effect.

experience more positive academic emotions. Previous studies found that learning engagement of university students, which is led by psychological empowerment (77), mediates the relationship between perceived assessment and learning satisfaction (78).

On the other hand, the result of this study showed that positive academic emotions positively predict the learning autonomy of medical students. This result is consistent with previous findings (56, 57). Many studies have confirmed that achievement emotions affect the cognitive, motivational, and regulatory processes mediating learning and achievement (52, 56). Positive academic emotions can help focus attention, strengthen intrinsic and extrinsic motivation, facilitate students' self-regulation of learning (56), and enhance students' learning autonomy. This result indicates that educators need to value positive academic emotions in teaching, especially for medical students who face a heavier burden of schoolwork coupled with high standards of performance, making them more susceptible to experiencing negative emotions (79, 80), even burnout (81).

Interestingly, the results of this study found that perceived formative assessment does not predict positive academic emotions directly. This is inconsistent with previous studies (53). This result can be explained by Pekrun's control-value theory of achievement emotions, which postulates that the affective impact of social environments is mediated by control and value appraisals (82). This insignificant result may also be due to our exclusive focus on positive emotions. Future research could include both positive and negative emotions together to illustrate this question. This result illustrated that the influence of perceived formative assessment on positive academic emotions is completely mediated by psychological empowerment.

5 Contributions and limitations

These findings revealed the relationship among perceived formative assessment, psychological empowerment, positive academic emotions, and learning autonomy in medical students. The findings of this study provide insight into the psychological mechanisms underlying the influence of perceived formative assessment on learning autonomy. They extend the findings into medical education and enrich the existing literature on formative assessment and learning autonomy. This finding indicates that educators and teachers should consider the design of formative assessment from the perspectives of both teachers and students, pay attention to promoting students' psychological empowerment, and value positive academic emotions. These findings provide empirical evidence about the relationship among perceived formative assessment, psychological empowerment, positive academic emotions, and learning autonomy in medical students, which may provide some useful insights for further exploration of the relationship between these four variables.

Despite its contributions to the existing literature, this study also has several limitations. First, this study used a cross-sectional questionnaire method, which makes it impossible to clarify the causal relationship between variables. A longitudinal research design should be applied to further validate the findings of this research in the future. Second, the mediation variables in this research were only psychological empowerment and positive academic emotions and did not include other possible factors. Third, this research only studied the factors from the perspective of individuals, without considering environmental factors and the individual-environmental interactions.

6 Conclusion

The finding of this study demonstrated the relationship between perceived formative assessment and learning autonomy in medical students and the chain mediated effect of psychological empowerment and positive academic emotions. Specifically, perceived formative assessment has a direct positive impact on the learning autonomy of medical students and an indirect positive impact through the chain mediating factors of psychological empowerment and positive academic emotions.

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 Ethics Committee of Shandong Second Medical 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

JW: Formal analysis, Methodology, Writing – original draft. GZ: Data curation, Investigation, Writing – review & editing. JG: Writing – review & editing. XS: Conceptualization, Writing – review & editing. LS: Methodology, Writing – review & editing.

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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.

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COVID-19 drives medical education reform to promote "healthy China 2030" action plan

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In June 2019, the Chinese government proposed the Healthy China Action Plan (2019–2030) development strategy, which focuses on disease prevention and health promotion. It is expected that by 2030, the national health literacy level will be significantly improved, premature mortality caused by major chronic diseases will be significantly reduced, the average healthy life expectancy will be greatly improved, and the main health indicators of residents will enter the ranks of high-income countries. Unfortunately, at the end of 2019, COVID-19 began to break out in Wuhan, China, which had a huge impact on China's economy and people's health. A series of problems in China's health care and medical education were exposed in the prevention and treatment of the epidemic. How to reform medical education and build a medical talent training system with Chinese characteristics is the key to achieving China's Health 2030 strategy. This article will explore the direction of medical education reform in China under the background of the "Healthy China 2030" strategy and the post pandemic era.

KEYWORDS

COVID-19, public health, medical education, talent cultivation, healthy China 2030

1 Introduction

"Healthy China 2030" is an important strategic plan proposed by China, aimed at promoting the construction of a healthy China, improving the health level of the entire population, and promoting sustainable economic and social development (1). It is expected that by 2025, China's health system will become more perfect, the ability to prevent and respond to major epidemics and public health emergencies will be significantly enhanced, the innovation ability of health technology will be significantly strengthened, and the average life expectancy of health will increase proportionally (2–4). The implementation of this strategy coincides with the outbreak of the COVID-19, which exposed the weaknesses of public health system and current medical education in China (5–7). Therefore, the Chinese government and educational institutions have introduced a series of measures to address these issues. After years of education reform, the training mode, educational philosophy, and innovative practical ability of medical students have undergone significant changes. However, for responding to sudden public safety and health emergencies, achieving the national health strategy, and cultivating medical talents with both modern medical technology and innovation capabilities, medical education reform still needs to be continuously explored.

1.1 Impact of COVID-19 on Chinese medical education

The outbreak of the COVID-19 epidemic has undoubtedly exposed some weaknesses in China's medical education model. Firstly, the training of emergency response ability is insufficient. Medical education often focuses more on the diagnosis and treatment of routine diseases in daily life, with relatively weak training in emergency response to public health emergencies. At the beginning of the COVID-19 epidemic, many medical students and medical staff showed a lack of experience and strategies to deal with it (8). Secondly, the integration of interdisciplinary education is not deep enough. The response to the COVID-19 epidemic requires multidisciplinary knowledge and skills, such as epidemiology, statistics, sociology, psychology, etc. However, in the traditional medical education model, the boundaries between disciplines are relatively clear, and interdisciplinary integration education has not been fully developed, resulting in difficulties in achieving interdisciplinary collaboration in epidemic prevention and control (9). Furthermore, the preparation of online education resources and platforms is insufficient. During the epidemic, offline teaching was restricted and forced to switch to online teaching on a large scale. However, some medical education institutions lack in the construction of online education resources and the adaptability of teachers and students to online teaching, which affects the teaching effectiveness and quality (10). Finally, professional ethics and humanistic care education need to be strengthened. Some studies have investigated the humanistic care ability of Chinese medical staff, but the results are not satisfactory (11, 12). The existing medical education may not have sufficient training in this area, resulting in some medical staff experiencing difficulties in psychological adjustment or insufficient care for patients when facing enormous pressure and difficulties. A cross sectional study showed that during the COVID-19, medical staff in Wuhan experienced tremendous mental pressure and serious mental health problems. The mental state of medical staff was directly related to the patient's nursing experience (13, 14).

2 Medical education reform in the context of the "Healthy China 2030" strategy

The implementation of the Healthy China strategy is the foundation for achieving the Chinese Dream of rejuvenation of the Chinese nation. The development of medical education in China is currently at a special historical juncture. It is necessary to consider the future of medical education and clarify the direction of medical education reform to better cope with new challenges.

2.1 Reforming teaching methods to promote digitalization of education

During the COVID-19 pandemic, offline teaching was limited, which prompted the rapid development of online teaching in medical education. Major medical schools have set up online teaching platforms, conducting live courses, recorded courses, and online interactive discussions. This not only breaks the limitations of time and space, allowing students to access learning resources anytime and anywhere, but also cultivates their ability to learn independently. Through years of development, the blended learning model of online and offline has been greatly promoted (Figure 1).

2.1.1 Challenges of blended learning mode

The blended learning model of online and offline is the integration of traditional classroom teaching in offline and learning in online network environment. With the development of information technology, products related to education such as MOOCs, micro courses, various learning apps, and mobile learning platforms have emerged. While effectively expanding educational time and space, their advantages such as flexibility, accuracy, richness, fun, and personalization have also been widely recognized by educators and learners. Students transition from passive learning to active learning and from individual learning to team collaboration through online resource previews, extracurricular assignments, group case discussions, and other teaching activities (15–17). At the same time, online teaching has also promoted innovation in educational technology, such as the application of virtual laboratories, simulated clinical scenarios, etc. However, the blended learning model of online and offline also faces many challenges. It should follow the law of knowledge dissemination and the students' development. Teachers need to make full use of internet technology to carry out the integrated design of online and offline teaching, rather than a simple mechanical combination of online and offline teaching content and teaching mode. The design of integrated teaching mode needs to fully consider the cognitive level of students, the progressive nature of teaching content, the class hour allocation and classroom activities of online and offline teaching. In addition, teachers should also make full use of the network platform and internet technology after class to understand students' online learning data, summarize students' online learning, and give responses in offline face-to-face teaching to optimize online teaching design (18, 19).

2.1.2 The development of digital education in China

In addition, information technology should be deeply integrated with curriculum teaching to promote digitalization of education. Modern information technology is the core force driving curriculum and teaching reform (20). By utilizing its fast transmission speed and strong information processing capabilities, high-quality and diverse curriculum resources are categorized and aggregated in specialized cyberspace or designated cloud platforms to solve the problem of course resource sharing. Secondly, utilizing cloud computing and cloud services, big data analysis, human-computer interaction and other technologies to record the learning process, perceive learning status, and conduct real-time statistics and analysis, intelligent learning guidance and assistance are provided for students' learning. At present, China's digital education is developing rapidly. By the end of 2023, 519,000 educational institutions across China had linked to the national

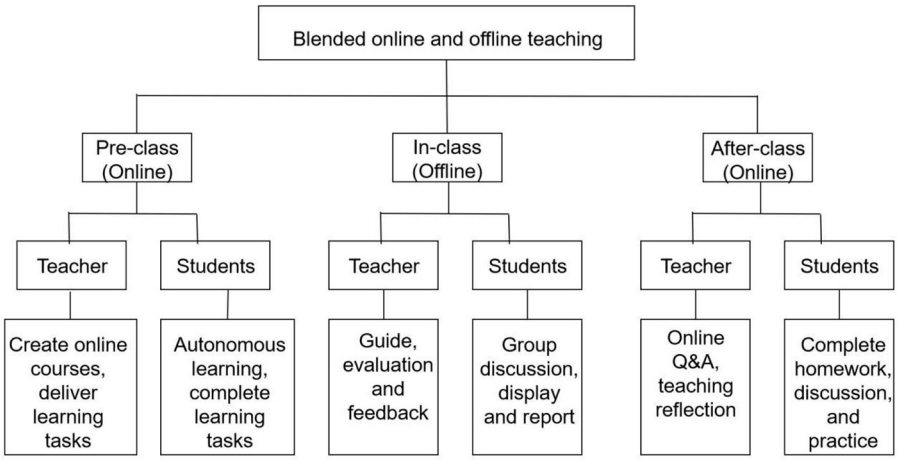


FIGURE 1
Blended online and offline teaching mode.

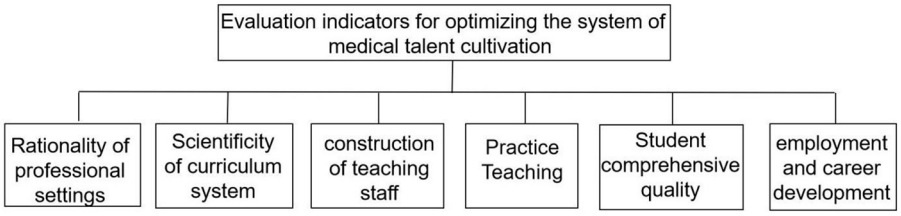


FIGURE 2
Evaluation indicators for optimizing the system of medical talent cultivation.

smart education platform, benefiting 18.8 million teachers and 293 million learners. It had over 100 million registered users from 200 countries, with 36.7 billion visits. The platform has incorporated a vast treasure trove of digital resources, including 27,000 university courses, and nearly 500 courses on innovation and entrepreneurship, effectively improving students' innovation and knowledge transfer abilities (21). China's modern higher education also cannot do without cooperation with countries around the world. The internationalization of digital education is an important trend in the development of education, which has also brought new opportunities and challenges to Chinese education. China still needs to further promote the construction of a global digital education cooperation platform and promote the exchange and integration of educational resources, educational models and educational concepts through digital technology and internet platforms worldwide.

2.2 Optimize the system of medical talent cultivation and promote access to medical innovation

The COVID-19 has exposed a series of problems in China's medical talent training system, which are mainly manifested in the large enrollment scale of medical education, but the overall level is low (22). The current hierarchical structure and quality level of medical talents are not in line with the development of the economy and society. There is a significant shortage of general practitioners and high-level public health talents (23, 24).Therefore, optimizing the system of medical talent cultivation and accelerating the development of medical innovation are crucial for the "Healthy China 2030" strategy. In addition, it is necessary to establish relevant evaluation indicators to guide and promote medical education reform and scientific research innovation development (Figure 2). In terms of medical talent cultivation, it can be evaluated from multiple dimensions such as the rationality of professional settings, the rationality of hierarchical structure, the construction of teaching staff, and employment and career development. For example, examining whether the professional settings are in line with the needs of the health industry, whether the proportion of medical talents at different levels is reasonable, whether students' clinical skills, research and innovation abilities, and humanistic literacy levels have been effectively improved, whether the teaching staff has rich teaching experience and professional literacy, and what the employment rate and career development prospects of graduates are. In terms of medical innovation development, it can be evaluated from the aspects of scientific research investment, scientific research output, technology transformation efficiency, and innovative enterprise development.

2.2.1 Strengthen the training of general practitioners

At present, the number of general practitioners in China is <9% of the total number of clinical doctors, and the education level of general practitioners is low, with insufficient ability to diagnose, treat, and prevent diseases (25). High level composite specialist doctors, including professionals in infectious diseases, respiratory diseases, public health, etc., are lacking, and their ability to respond to major outbreaks of infectious diseases is weak. The Chinese government should increase its efforts in cultivating comprehensive medical talents, gradually expand the scale of targeted free comprehensive medical student training for grassroots services. At the same time, educational institutions should systematically plan the general practice teaching system, strengthen general practice education for all medical students, establish demonstration bases for general practice teaching, accelerate the reform of the general practitioner salary system, and expand the career development prospects of general practitioners.

2.2.2 Strengthen the construction of public health service system

China need to accelerate the construction of a high-level public health talent training system, establish a number of high-level public health colleges. However, the teaching, research, and practical implementation functions of China's public health system are divided between public health colleges and disease prevention and control centers, resulting in a separation between the development of public health theory and practice. Therefore, it is necessary to strengthen practical teaching and enhance the cooperation between medical colleges, disease prevention and control centers, and infectious disease hospitals in medical research and teaching. Through practical teaching, such as clinical internships, public health internships, etc., medical students can apply theoretical knowledge to practical work, improve their practical and problem-solving abilities (26). Medical education institutions should also collaborate with public health institutions in scientific research, cultivating students' research abilities and innovative thinking, enabling them to have the ability to prevent and control infectious diseases, as well as comprehensive qualities to respond to public health emergencies (27).

2.2.3 Promote the inheritance, innovation, and development of traditional Chinese medicine

Traditional Chinese medicine has played a unique role in the prevention and control of the COVID-19, and demonstrated the value and role of traditional Chinese medicine in responding to major public health events (28). Similarly, traditional Chinese medicine plays a very important role in China's health strategy. It has significant advantages in disease prevention and chronic disease management (29). Therefore, traditional Chinese medicine plays an irreplaceable role in China's health strategy. However, for a long time, there have been problems and bottlenecks in the cultivation of traditional Chinese medicine talents, such as long cycles, insufficient medical innovation, and prevention and treatment capabilities for major diseases. Therefore, the cultivation of traditional Chinese medicine talents needs to follow the basic laws of the development of traditional Chinese medicine, establish a thinking mode with Chinese medicine characteristics, and organically integrate traditional Chinese medicine disciplines with interdisciplinary fields. It is also necessary to comprehensively apply new technologies and methods such as artificial intelligence to meet the needs of modern medical development and public health.

2.2.4 Strengthen the cultivation of interdisciplinary talents in medicine

Multidisciplinary integration has become a trend in global medical research and healthcare services. With the aging population and changes in lifestyle, diseases are becoming increasingly complex and diverse. To cultivate interdisciplinary talents who can integrate knowledge and methods from different disciplines, conduct in-depth research on the pathogenesis, diagnosis, and treatment of diseases from multiple perspectives, and provide more comprehensive and effective solutions for solving complex diseases. Secondly, modern healthcare is shifting from disease centered to health centered. This requires the intersection of medicine with public health, environmental science, nutrition, and other disciplines, focusing on disease prevention and health promotion, and achieving full life cycle health management (30). In 2024, the Chinese Ministry of Education added five "cross fusion" majors to meet major national needs and serve the new development trend of the health industry. These 5 majors are: Medical Device and Equipment Engineering, Geriatric Medicine and Health, Health and Medical Security, Pharmaceutical Economics and Management, and Biomedical Data Science. These majors promote the cross disciplinary integration of medical engineering, medical science, and medical humanities, which is conducive to the cultivation of comprehensive talents. However, new requirements have been put forward for the reform of curriculum, teaching, faculty, and teaching evaluation.

2.3 Improve the quality of medical student training and cultivate innovative medical talents

High quality medical talents are an important foundation and guarantee for building a healthy China. How to better cultivate high-level and top-notch medical innovation talents that meet the needs of the new era? How to make Chinese medical talents have stronger international competitiveness? These are the major issues currently facing the reform of medical education in China.

2.3.1 Humanistic education for medical students

Medical students should possess good humanistic qualities. Having humanistic literacy can enable medical students to better understand patients' psychological, emotional, and social backgrounds, thereby establishing a relationship of trust and respect, improving patient compliance and treatment effectiveness (31). At present, many medical colleges in China still adhere to the traditional concept that doctors only treat diseases and

save lives, and only focus on imparting professional knowledge, neglecting the education of humanities and the cultivation of students' comprehensive qualities. But the modern medical model is shifting from a simple biomedical model to a biopsychosocial medical model, requiring medical students to have the ability to comprehensively consider patients' physiological, psychological, and social factors. Humanistic literacy is the key to achieving this transformation. Therefore, in order to improve the level of humanistic education for medical students, schools must incorporate humanistic courses into the curriculum system and make them reach a certain proportion and offer more public elective courses in humanities to enhance students' cultural literacy. In addition, clinical reception and doctor-patient communication skills training courses should be offered to enable students to systematically learn doctor-patient communication skills. The volunteer practical activities should be carried out to improve the professional ethics of medical students (32).

2.3.2 Leadership in medical education

With the increasing complexity of the healthcare system, the continuous advancement of medical technology, and the diversification of patient needs, the healthcare industry urgently needs talents with strong leadership to cope with various challenges. Medical professionals with leadership skills can effectively coordinate medical teams, optimize the allocation of medical resources, promote interdisciplinary cooperation, drive the development of medical research and education, and thus enhance the overall level of the medical industry (33, 34). So, how to cultivate leadership in medical education? Firstly, it is necessary to provide students with comprehensive knowledge of leadership theory. Incorporate leadership related courses into the curriculum to help students understand the concepts, principles, and methods of leadership. Through teaching methods such as case analysis and group discussions, help students master effective leadership strategies and communication skills. Medical education should provide rich practical opportunities for students to exercise their leadership skills in a real medical environment. For example, organizing students to participate in the planning and implementation of medical projects, encouraging them to play a leadership role in the team, and solving practical problems.

2.3.3 Scientific research and innovation in medical education

Medicine is a constantly evolving discipline, with new disease challenges and health needs constantly emerging. Medical students with research and innovation abilities can actively engage in medical research, explore unknown fields, and provide new ideas and methods for solving medical problems. They are able to use innovative thinking to optimize medical processes, introduce new technologies and methods, improve the accuracy of disease diagnosis, and treatment effectiveness. For the China's health strategy, the research and innovation capabilities of medical students are of great value in responding to major public health events. For example, innovative scientific research achievements in infectious disease prevention and control, chronic disease prevention and control, and emergency response to sudden health emergencies can provide scientific basis for policy formulation and measure implementation. In order to better cultivate the research and innovation abilities of medical students, the medical education system needs to increase research practice courses, provide more opportunities to participate in research projects, strengthen mentor guidance, establish interdisciplinary communication platforms, and create an academic atmosphere that encourages innovation (35, 36). At the same time, the government and society should increase investment in medical research, support innovative research by medical students, and promote the transformation and application of scientific research results.

2.3.4 Mental health and medical education

In the process of medical education reform, the cultivation of mental health qualities among medical students plays a crucial and far-reaching role. The study of medical knowledge is arduous and complex, and clinical practice requires high precision and responsibility, which puts enormous academic pressure on medical students. Medical students with mental health have stronger resilience and emotional regulation abilities, and can cope with difficulties and challenges in learning with a positive attitude, thereby improving learning efficiency and quality (37, 38). Medical students with mental health are often more confident and empathetic, able to establish harmonious doctor-patient relationships and teamwork. To strengthen mental health education for medical students, the first step is to optimize the curriculum design. Incorporate mental health education into compulsory courses, systematically impart mental health knowledge and coping skills, so that medical students can self identify and deal with common psychological problems. At the same time, diversified teaching methods such as case analysis, group discussions, role-playing, etc. should be adopted to enhance the attractiveness and practicality of the course. Schools should establish specialized psychological counseling centers equipped with professional counselors to provide individual and group counseling services for medical students.

3 Conclusion

The COVID-19 epidemic has not only brought challenges to China's public health and medical education, but also brought new development opportunities. On the one hand, the epidemic has promoted the innovation of medical education model. The development of online teaching platforms and the abundance of digital teaching resources have provided a broader space and more diverse means for medical education, making personalized, and lifelong learning possible. On the other hand, the epidemic has prompted medical education to pay more attention to interdisciplinary training. The interdisciplinary integration of public health, clinical medicine, information technology, and other fields provides a higher quality training platform for new medical education, which will cultivate medical talents with comprehensive abilities and better serve China's health strategy. In the post pandemic era, the public's demand for health

services is increasing day by day. However, compared with other countries, factors such as China's economic development level, population structure, socio-cultural background, and healthcare system result in certain differences in healthcare demand. The healthcare needs of economically developed countries are more diversified and high-end, including the demand for advanced medical technology, drugs, and medical services. China may place greater emphasis on the popularization and accessibility of basic healthcare. The aging population in China is gradually increasing, and the demand for long-term care, rehabilitation, and chronic disease management is growing. Sociocultural background can also affect people's perception of health and their demand for healthcare. China and some other Asian countries have a high demand for traditional Chinese medicine. The healthcare systems of different countries can also lead to differences in healthcare needs. China implements a universal medical insurance system, mainly to ensure the basic medical needs of residents. The demand for healthcare is increasingly showing characteristics of diversification, personalization, and high quality. New challenges and requirements have been put forward for medical education. Strengthening international exchanges and cooperation in the field of healthcare, drawing on advanced medical education systems and healthcare models from abroad, will help promote China's healthcare level. Under the Healthy China (2019–2030) strategy, the medical and health industry is entering a new stage of development. Medical education reform can cultivate more high-quality medical talents that meet the needs of the times, improve the overall quality and ability of the medical and health team, which will help strengthen the construction of the public health system, enhance the ability to respond to public health emergencies, improve the disease prevention and control system, promote fairness, accessibility, and quality improvement of medical services, thereby comprehensively and cyclically safeguarding people's health, effectively promoting the implementation of China's health strategy.

Data availability statement

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

Author contributions

LH: Conceptualization, Writing – original draft. FW: Conceptualization, Funding acquisition, Writing – review & editing.

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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.

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Pathway analysis of clinical nurse educator's intention to use virtual reality technology based on the UTAUT model

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Purpose: This study aims to investigate the willingness of clinical nurse educator to adopt virtual reality technology, while also examining the underlying mechanisms that influence this willingness through the lens of the Unified Theory of Acceptance and Use of Technology (UTAUT).

Methods: A convenience sampling method was employed to select 225 clinical nurse educator, all of whom possess a professional qualification certificate as nurse practitioners, from a tertiary hospital in Wuhan City, Hubei Province. The study utilized an adapted UTAUT model theory-based design to develop several questionnaires: the performance expectancy questionnaire (11 items), the effort expectancy questionnaire (4 items), the social influence questionnaire (6 items), the facilitating conditions questionnaire (7 items), and the behavioral intention questionnaire (4 items). These instruments were designed to assess the clinical nurse educators' willingness to adopt VR technology. Furthermore, a regression model was established to analyze the factors influencing this willingness, utilizing SPSS 26.0 for statistical analysis and validating the model through path analysis with AMOS 24.0, where a p-value of less than 0.05 was considered statistically significant.

Results: The questionnaire demonstrated strong reliability and validity, yielding a total of 222 valid samples, comprising 209 females (94.14%) and 13 males (5.86%). Among the clinical nurse educators, 163 (73.42%) reported a willingness to use virtual reality technology, with scores of 4 or higher. Pearson correlation analysis revealed positive correlations between performance expectancy, effort expectancy, social influence, and facilitating conditions with behavioral intention ($p < 0.05$). Furthermore, regression analysis indicated that performance expectancy, effort expectancy, social influence, and facilitating conditions had a positive impact on behavioral intention ($p < 0.05$). The path model exhibited a good fit, and the results were consistent with the regression analysis, showing that the effects of performance expectancy, effort expectancy, and social influence on the behavioral intention to use virtual reality technology were 0.231, 0.150, 0.236, and 0.247, respectively.

Conclusion: Clinical nurse educators exhibit a robust willingness to engage with VR technology. Moreover, improving factors such as performance expectancy, effort expectancy, social influence, and facilitating conditions can substantially enhance their readiness to adopt this technology.

KEYWORDS
virtual reality, behavioral intention, clinical nurse educator, UTAUT, pathway analysis

1 Introduction

Nursing education serves as a cornerstone of the healthcare system, playing a vital role in public health and improving the quality of nursing services. However, traditional approaches to nursing education often prioritize the transmission of theoretical knowledge at the expense of developing practical skills. In clinical environments, students frequently face obstacles in obtaining sufficient hands-on experience due to resource constraints, as well as encountering occupational hazards such as exposure to infectious diseases and needlestick injuries (1). As a result, the investigation of innovative teaching methods and technologies has become an essential focus within the modern landscape of nursing education.

Virtual Reality (VR) technology, as an emerging innovation, has been extensively utilized in nursing education during the 21st century. It not only offers a safe and controlled learning environment but also simulates real clinical scenarios, enabling students to overcome the limitations inherent in traditional classrooms and clinical internships (2). This approach aids in enhancing their practical skills and their ability to navigate complex situations. Through VR technology, students can engage in various nursing procedures within a simulated context, which decreases the error rate in actual clinical settings while bolstering their self-confidence and professional competencies (3). Despite the promising prospects for VR's application in nursing education, its widespread adoption faces several challenges. These challenges primarily include the reluctance of nursing educators to embrace new technologies, the high costs associated with VR systems, and the absence of comprehensive evaluation and feedback mechanisms that are essential for guiding the optimization and enhancement of this technology (4).

In response to these shortcomings, this study used the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine the key factors affecting the intention to use virtual reality (VR) technology from the perspective of clinical nurse educators. This approach aims to increase acceptance of virtual reality among clinical nurse educators and promote its use in nursing education (5). The UTAUT model offers a comprehensive theoretical framework that elucidates and predicts individual technology acceptance provides behavior through four core constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. Performance expectancy refers to the anticipated benefits derived from the technology, while effort expectancy emphasizes the ease of use associated with the technology, Social influence relates to the perceptions of others regarding technology adoption, and facilitating conditions encompass the organizational and technological infrastructure that supports technology usage. Together, these constructs significantly impact an individual's behavioral intention, subsequently influencing their actual intention to utilize the technology (6).

This study is based on the UTAUT model and aims to explore the potential mechanisms that influence clinical nurse educators: willingness to adopt VR technology. It aims to promote the comprehensive integration of VR technology into nursing education, thereby improving the quality and efficiency of the entire nursing education field. We hope to integrate more innovative elements into nursing education through research, promote the modernization of nursing education, and ultimately improve the quality of nursing services.

2 Methods

2.1 Participants

To reduce sampling costs and ensure the acquisition of sufficient and representative samples, the convenience sampling method was employed to select the clinical nurse educator who had obtained the professional qualification certificate of nurse practitioner from a tertiary hospital in Wuhan City, Hubei Province as the research object. Inclusion criteria for this study comprised in-hospital clinical nurse educators who possess a nurse professional qualification certificate and who provided informed consent to voluntarily participate. Exclusion criteria included individuals who have not engaged in any teaching activities within the past year and those who withdrew from the study midway. Breckler's study indicates that a sample size exceeding 200 can be utilized to construct a more stable equation model (7). The survey was distributed via the Questionstar platform, with a total of 225 questionnaires being disseminated.

2.2 Instruments

2.2.1 Demographic information

A total of five entries were included in the study, comprising information on gender, age, levels of education, years of work experience, and whether or not the participants had been exposed to VR technology.

2.2.2 Clinical nurse educators' willingness to use virtual reality technology questionnaire

This questionnaire was adapted from the questionnaire designed by Dandan Lu et al. (8),based on the Unified Theory of Acceptance and Use of Technology (UTAUT), namely "Clinical Nurse Educators' Willingness to Use Virtual Simulation Technology." The adapted questionnaire consists of five parts, each employing the forward scoring method and utilizing a 5-point Likert scale. The scoring ranges from 5 to 1, reflecting responses from 'completely agree' to 'completely disagree.' The overall Cronbach's α coefficient is 0.964, which exceeds the acceptable threshold of 0.700, indicating high internal consistency. Furthermore, the KMO value is 0.960, also above the threshold of 0.700, and the results of Bartlett's sphericity test yield a significance level of $p < 0.01$, confirming the questionnaire's robust reliability and validity. Selected variables and measurement items are detailed in Table 1, while a comprehensive list of all measurement items is provided in Appendix 1.

(1) Performance expectancy, consisting of 11 items, delineate the advantages that clinical nurse educators can derive from the application of VR technology in their practice. A higher score indicates greater perceived utility in their work. In this study, Cronbach's $\alpha = 0.954 > 0.700$, KMO value $= 0.966 > 0.700$, Bartlett sphericity test $p < 0.01$.
(2) Effort expectancy, consisting of 4 items, reflects the ease of utilizing virtual reality technology, including the challenges

TABLE 1 Variables and partial sample measurement questions.

Variables	Meaning	Measurement questions
Performance expectancy	The benefits of using VR technology for your own work	1. It makes my teaching more interesting
		2. I am satisfied with the use of virtual reality in nursing education
		3. It gives me a sense of fulfillment at work
Effort expectancy	Ease of using VR technology	1. My search for virtual reality based teaching materials is not very difficult
		2. It is not difficult for me to design the content of teaching virtual reality technology that fits the speciality of my profession
		3. I learnt that teaching operations using virtual reality technology is not difficult
Social influence	Degree of support for one's use of virtual reality technology from individuals or groups that one considers important to oneself	1. My colleague suggested that I use virtual reality technology in my teaching
		2. Students expect me to use virtual reality in teaching and learning
		3. Schools, students and others rate the use of virtual reality technology in nursing education highly
Facilitating conditions	Level of support for hardware, finance, technical training, etc. to promote the use of VR technology	1. I have the hardware equipment and facilities to use virtual reality technology in teaching and learning, e.g., computers, networks, venues, virtual glasses, etc.
		2. I was able to get funding and other support for teaching virtual reality technology
		3. My college or department has a better team for teaching and researching virtual reality technology
Behavioral intention	Behavioral tendencies to use VR technology	1.I prefer the use of virtual reality in nursing education
		2.I would like to use virtual reality in nursing education
		3.I would recommend the use of virtual reality technology in nursing education to colleagues in my neighborhood

associated with locating teaching materials and performing technical operations. A higher score indicates greater ease of use, while a lower score suggests increased difficulty. In this study, Cronbach's $\alpha = 0.894 > 0.700$, KMO value $= 0.846 > 0.700$, Bartlett's sphericity test $p < 0.01$.

(3) Social influence, consisting of 6 items, refers to the level of support for the use of virtual reality technology by individuals or groups that clinical nurse educators deem significant. This support may manifest as mutual encouragement among colleagues. A higher score indicates a greater degree of support. In this study, Cronbach's $\alpha = 0.932 > 0.700$, KMO value $= 0.929 > 0.700$, Bartlett sphericity test $p < 0.01$.

(4) Facilitating conditions, consisting of 7 items, refers to the level of support perceived by clinical nurse educators regarding hardware, funding, technical training, and other resources necessary to promote the use of VR technology. Higher scores reflect greater levels of support. In this study, Cronbach's $\alpha = 0.933 > 0.700$, KMO value $= 0.941 > 0.700$, Bartlett sphericity test $p < 0.01$.

(5) Behavioral intention, consisting of 4 items, refers to the behavioral tendency of clinical nurse educators to adopt virtual reality technology. This tendency is evidenced by their willingness to utilize virtual reality technology, their intention to increase its usage, and their readiness to recommend it to colleagues. A higher score indicates a greater propensity to use virtual reality technology. The willingness to use is categorized into two groups based on a cut-off value of 4 points: a score of $\geq$4 points signifies a high willingness to use and is classified as the high group, while a score of <4 points indicates a generally low willingness to use. In this study, Cronbach's $\alpha = 0.883 > 0.700$, KMO value $= 0.831 > 0.700$, Bartlett sphericity test $p < 0.01$.

3 Data collection

The questionnaire designed for this study includes demographic information and five measurement variables based on the UTAUT theoretical model: performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention. The production of the questionnaire is facilitated by the Questionstar platform, and the questionnaires are distributed online. Each respondent is allowed to submit only one questionnaire.

4 Statistical analyses

To ensure the reliability of the data and the accuracy of the results, we eliminated incompletely filled questionnaires and those with unchanged responses prior to data analysis. The coded data were analyzed using SPSS 26.0 and AMOS 24.0 statistical software. Initially, we conducted basic reliability and validity tests on the questionnaire, employing Cronbach's α coefficient to assess reliability. Bartlett's test of sphericity and the KMO value were used to evaluate validity. Subsequently, demographic and sociological data, along with general information, were analyzed using descriptive statistics. Measurement data were reported as mean ± standard deviation, while categorical data were expressed as frequency and percentage. To assess the factors influencing the willingness to utilize virtual reality technology, we first categorized the willingness scores into high and low groups based on a 4-point cutoff. Following this, we performed a multi-factor logistic regression analysis to examine the relationship between demographic and sociological factors and the willingness to use virtual reality technology. To investigate the relationship between the variables based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and willingness to use, we tested the data for normality to ascertain the

distribution of performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention. If the data exhibited a normal distribution or was approximately normal, we employed Pearson correlation analysis to examine the correlations among performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention. Conversely, if the variables did not meet the normality condition, we opted for Spearman correlation analysis to further investigate the impact of UTAUT-based variables on usage intention. We also performed a multicollinearity test (Variance Inflation Factor, VIF) on the variables. If no multicollinearity was detected among performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention, we included the variables related to intention to use in the stepwise regression analysis. In cases where multicollinearity was present, we employed Ridge regression analysis. Finally, to further identify the variables affecting usage intention, we constructed a path model following confirmatory factor analysis using AMOS 24.0 statistical software to validate the effectiveness of the regression model. $p < 0.05$ was considered statistically significant.

5 Results

A total of 225 electronic questionnaires were distributed through questionnaire star, excluding 3 questionnaires whose response time was too short, 222 valid questionnaires were recovered, with an effective recovery rate of 98.67%. This meets the requirements for basic data analysis and the analysis was conducted by using SPSS 26.0 and AMOS 24.0. The results are as follows:

5.1 General information about clinical nurse educators

In terms of gender, there were 209 (94.14%) female teachers and 13 (5.86%) male teachers. More than half of the clinical nurse educators were under 40 years of age, 122 (55%). There were 54 (24.32%) senior nurse teachers with 5 and less years of experience, 99 (44.60%) with 6 to 15 years of experience, 49 (22.07%) with 16 to 30 years of nursing experience and 20 (9.01%) with 31 and more years of nursing experience. There were 138 (62.16%) who had been exposed to VRT and 84 (37.84%) who had not been exposed to VRT, and detailed data are shown in Table 2.

5.2 Analysis of the current status of clinical nurse educators' willingness to use virtual reality technology

Following the normality test, the data performance expectancy, effort expectancy, social influence, facilitating conditions exhibited a kurtosis close to 3, a skewness close to 0, and a data distribution that was approximately normal. The means and standard deviations of the scores for each variable were as follows: the highest scoring variable was behavioral intention, with a mean and standard of 3.87 ± 0.85; effort expectancy score was the lowest with a mean and standard of 3.54 ± 0.89. A total of 163 (73.42%) scored a behavioral intention score of ≥4, indicating that 73.42% of clinical nurse educators in this sample exhibited a higher willingness to use VR technology. This is illustrated in Table 3.

5.3 Multifactor logistic regression analysis of demographic and sociological characteristics on willingness to use VR technology

The following variables were used as independent variables: gender, age, education levels, years of work experience, and whether or not they had been exposed to virtual reality technology. Multifactorial logistic regression analysis was performed with

TABLE 2 General information on clinical nurse educators ($N = 222$).

Variables		Number	%
Gender	Female	209	94.14
	Male	13	5.86
Age (Years)	≤30	51	22.97
	31–40	71	31.98
	41–50	71	31.98
	≥51	29	13.06
Education level	Bachelor's degree or other	133	59.91
	Master's degree or PhD	89	40.09
Years of working experience (Years)	≤5	54	24.32
	6 ~ 15	99	44.60
	16 ~ 30	49	22.07
	≥31	20	9.01
Whether exposed to virtual reality technology	Yes	138	62.16
	No	84	37.84

TABLE 3 Current status of clinical nurse educators' willingness to use VR technology.

Variables	Number of entries	Score($\bar{x} \pm s$)
Behavioral intention	4	3.87 ± 0.85
Facilitating conditions	7	3.57 ± 0.88
Social influence	6	3.79 ± 0.92
Effort expectancy	4	3.54 ± 0.89
Performance expectancy	11	3.76 ± 0.83

TABLE 4 Results of multifactor logistic regression analysis of sociological characteristics of the population and behavioral intention.

Variables	B	SE	Wald	*P*	Exp(B)	EXP(B) 95% CI	
						lower limit	limit
Gender (as reference: male)							
Female	0.318	0.653	0.238	0.626	1.375	0.382	4.942
Age (as reference: ≥51)							
≤30	1.183	1.012	1.368	0.242	3.265	0.450	23.715
31–40	0.711	0.772	0.848	0.357	2.036	0.448	9.249
41–50	0.895	0.871	1.056	0.304	2.448	0.444	13.504
Education level (as reference: Master's degree or PhD)							
Bachelor's degree or other	−0.160	0.376	0.181	0.670	0.852	0.408	1.780
Years of working experience (as reference: ≥31)							
6–15	−0.533	0.961	0.307	0.580	0.587	0.089	3.864
16–30	−0.688	0.834	0.681	0.409	0.503	0.098	2.575
≤5	−1.147	1.144	1.006	0.316	0.317	0.034	2.988
Whether exposed to virtual reality technology (as reference: Yes)							
No	−0.253	0.316	0.643	0.423	0.776	0.418	1.442

behavioral intention as the dependent variable, with scores greater than or equal to 4 being classified as a high group and less than 4 as a low group. The results demonstrated that there was no statistically significant difference in the willingness to use virtual reality technology among clinical nurse educators of different genders, ages, levels of education, and years of experience ($p > 0.05$). Furthermore, the impact of prior exposure to virtual reality technology on the willingness to use VR technology was not statistically significant ($p > 0.05$), as shown in Table 4.

5.4 Analysis of the impact of variables on behavioral intention based on the UTAUT model

5.4.1 Person-related analyses

Following the normality test, the data performance expectancy, effort, expectancy, social influence, facilitating conditions and behavioral intention were found to be approximately normally distributed. The results of correlation analyses demonstrated that performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention were positively correlated, $p < 0.05$, with R-values of 0.58, 0.59, 0.54, and 0.57, respectively, as shown in Figure 1.

5.4.2 Stepwise regression analysis of variables and behavioral intention in the UTAUT model

After multicollinearity testing, the VIF values are all less than 3. There is no multicollinearity problem between variables, and the data is good. In order to clarify the relationship between performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention in the UTAUT model, multiple stepwise regression analysis was employed. Performance expectancy, effort expectancy, social influence, and facilitating conditions were used as independent variables, and behavioral intention was used as the dependent variable in the stepwise regression analysis. After four iterations, the best model 4 was obtained, and four factors entered the regression equation, as detailed in Table 4. The final regression equation was established as follows: behavioral intention = 0.783 + 0.22*social influence +0.239*facilitating conditions+0.236*performance expectancy+0.144*effort expectancy. See Tables 5, 6.

5.4.3 Path analysis of variables and behavioral intention of UTAUT model

5.4.3.1 Confirmatory factor analysis

As illustrated in Figure 2, the AMOS software was utilized to create the confirmatory factor analysis measurement model

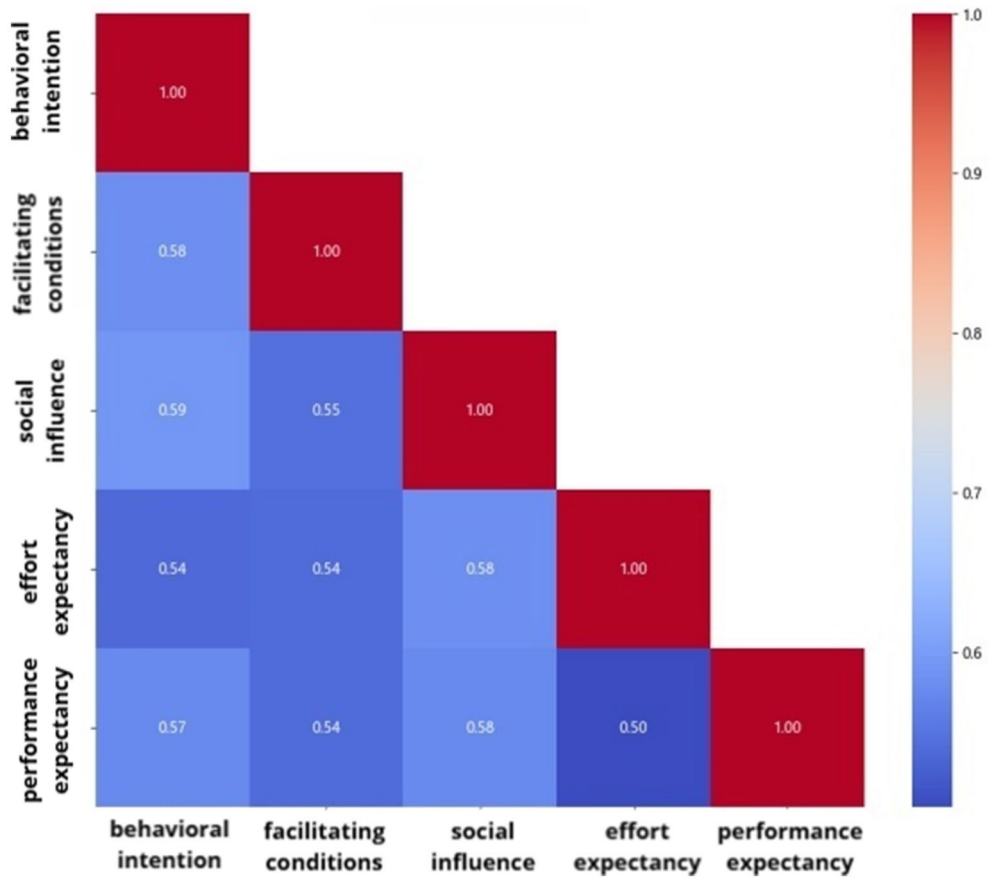


FIGURE 1
Correlation analysis results of each variable in the study on the willingness of clinical nurse educator to use virtual reality technology.

TABLE 5 Results of stepwise regression model analysis.

Model	R	R2	Adjusted R2	SE	Durbin Watson	F	*p*
1	0.591[b]	0.350	0.347	0.688	1.990	118.301	0.000[b]
2	0.667[c]	0.445	0.440	0.638		87.749	0.000[c]
3	0.695[d]	0.484	0.477	0.616		68.084	0.000[d]
4	0.705[e]	0.497	0.487	0.610		53.549	0.000[e]

[b]Predictor variable: (constant), Social influence.
[c]Predictor variables: (Constant), Social influence, Facilitating conditions.
[d]Predictor: (Constant), Social Influence, Facilitating conditions, Performance expectancy.
[e]Predictor variables: (Constant), Social Influence, Facilitating conditions, Performance expectancy, Effort expectancy.

diagram. In this model, the CMIN/DF = 1.135 and the RMSEA = 0.025, which is below the threshold of 0.08, indicating a well-constructed model. At a significance level of $p < 0.001$, the factor loadings of all observed variables are significant, with standardized factor loading coefficients exceeding 0.7 and average variance extracted (AVE) values greater than 0.5. Consequently, this measurement model demonstrates strong convergent validity, as shown in Table 7. The square roots of the AVE for performance expectancy, effort expectancy, social influence, facilitating conditions, and behavioral intention variables are 0.812, 0.826, 0.837, 0.817, and 0.819, respectively. All of these values surpass the Pearson correlation coefficients among the variables, thereby confirming that this measurement model possesses high discriminant validity, as presented in Table 7.

5.4.3.2 Path analysis

To further validate the regression model, we established a path depicting the factors influencing nursing clinical teachers' willingness to use virtual reality technology, as illustrated in Figure 3. The model demonstrates a good fit, with RMR = 0.00 < 0.08, CFI = 1.00 > 0.90, and IFI = 1.00 > 0.90. The effect sizes of performance expectancy, effort expectancy, social influence, and facilitating conditions on the behavioral intention are 0.231, 0.150, 0.236, and 0.247, respectively. Notably, facilitating conditions exert the largest impact, followed by

TABLE 6 Regression coefficient test.

Variables	Unstandardized coefficient		Standardized coefficient beta	*t*	Sig.	95.0% CI		collinearity statistics	
	B	standard error				lower limit	limit	Tolerance	VIF
(Constant)	0.783	0.216		3.623	<0.001	0.357	1.209	0.526	1.900
Social influence	0.220	0.062	0.236	3.560	<0.001	0.098	0.341	0.584	1.712
Facilitating conditions	0.239	0.061	0.247	3.919	<0.001	0.119	0.359	0.581	1.722
Performance expectancy	0.236	0.065	0.231	3.651	<0.001	0.109	0.364	0.575	1.738
Effort expectancy	0.144	0.061	0.150	2.370	0.019	0.024	0.264	0.526	1.900

social influence. The standardized path coefficients of the model are consistent at 0.231, 0.150, 0.236, and 0.247, with all *p* values being less than 0.05, as detailed in Table 8.

6 Discussion

6.1 There are no discernible differences in the willingness of clinical nurse educators with varying demographic and sociological characteristics to utilize virtual reality technology

The results of this study indicate that there is no statistically significant difference in the willingness to use VR technology among clinical nurse educators based on gender, age, education level, or years of experience. In the study conducted by Hyun et al., it was found that gender significantly influences consumers' enjoyment and willingness to replay VR games, with men exhibiting a greater propensity to enjoy and replay these games compared to their female counterparts (9). This discrepancy may be attributed to the specific application context of virtual reality technology. The virtual reality nursing context of the present study is not gender-biased, aligning with the findings that gender does not impact the willingness of nursing clinical teachers to utilize virtual reality. Nevertheless, future research should thoroughly investigate the factors influencing the willingness to adopt virtual reality. Given the research context, it is recommended that additional demographic and sociological factors, as well as sample characteristics, be incorporated to better understand the individual traits that may affect the willingness to use VR technology. This study did not find evidence that prior exposure to virtual reality technology affects individuals' willingness to use it. This finding is consistent with the conclusion drawn by Cao Xiao-yue in her research on the willingness of virtual reality game players, which similarly indicates that prior exposure does not significantly influence their willingness to engage with the technology (10). However, this contrasts with the findings of Lu Dandan et al., who investigated the impact of virtual simulation technology in medical education and found that it does affect medical teachers' willingness to adopt such technology (8). The differing outcomes regarding the influence of exposure to virtual reality technology on willingness to use it may be attributed to the specific contexts in which the technology is utilized. Efiloğlu Kurt et al. (11) demonstrated that students' willingness to use virtual reality technology varies between Turkish and British learning environments, with distinct influencing factors in each context. Furthermore, Riva et al. (12) highlighted that individuals experience different emotions or values in varied environments. It is possible that these diverse experiences contribute to the differing results regarding the impact of exposure on the intention to use VR. Therefore, future research on the intention to use virtual reality technology should consider the specific contexts of its application to better understand how varying usage scenarios affect willingness to use before and after exposure to virtual reality, ultimately enhancing the research model on the intention to use this technology.

6.2 Performance expectancy and effort expectancy influence clinical nurse educators' willingness to use VR technology

In this study, performance expectancy positively influence the intention to use VR technology. This finding aligns with the results of previous research and is consistent with the UTAUT model, which suggests that clinical nurse educators are more inclined to adopt virtual reality technology if they perceive it as beneficial for their work (13). The implementation of VR technology can effectively mitigate risks, such as needle sticks and infections, that clinical nurse educators and students encounter in actual clinical settings. Furthermore, enhancing the nursing operational skills of both teachers and students through virtual training represents a crucial advancement in nursing clinical safety education. Additionally, compared to traditional teaching methods, VR technology training not only enhances students' learning performance more efficiently but also makes the learning process more engaging. Therefore, VR technology, characterized by its high efficiency and safety, is increasingly appealing to both teachers and students for educational purposes. However, the full potential of VR technology has yet to be realized, particularly in the context of clinical teaching hospitals, where its application remains limited. To enhance the willingness to adopt VR technology and to promote its integration into clinical education, a teaching plan can be developed that facilitates collaborative observation and engagement between teachers and students. This approach would allow them to experience the enjoyment and effectiveness that VR technology offers, thereby enhancing their perception of its potential benefits (14).

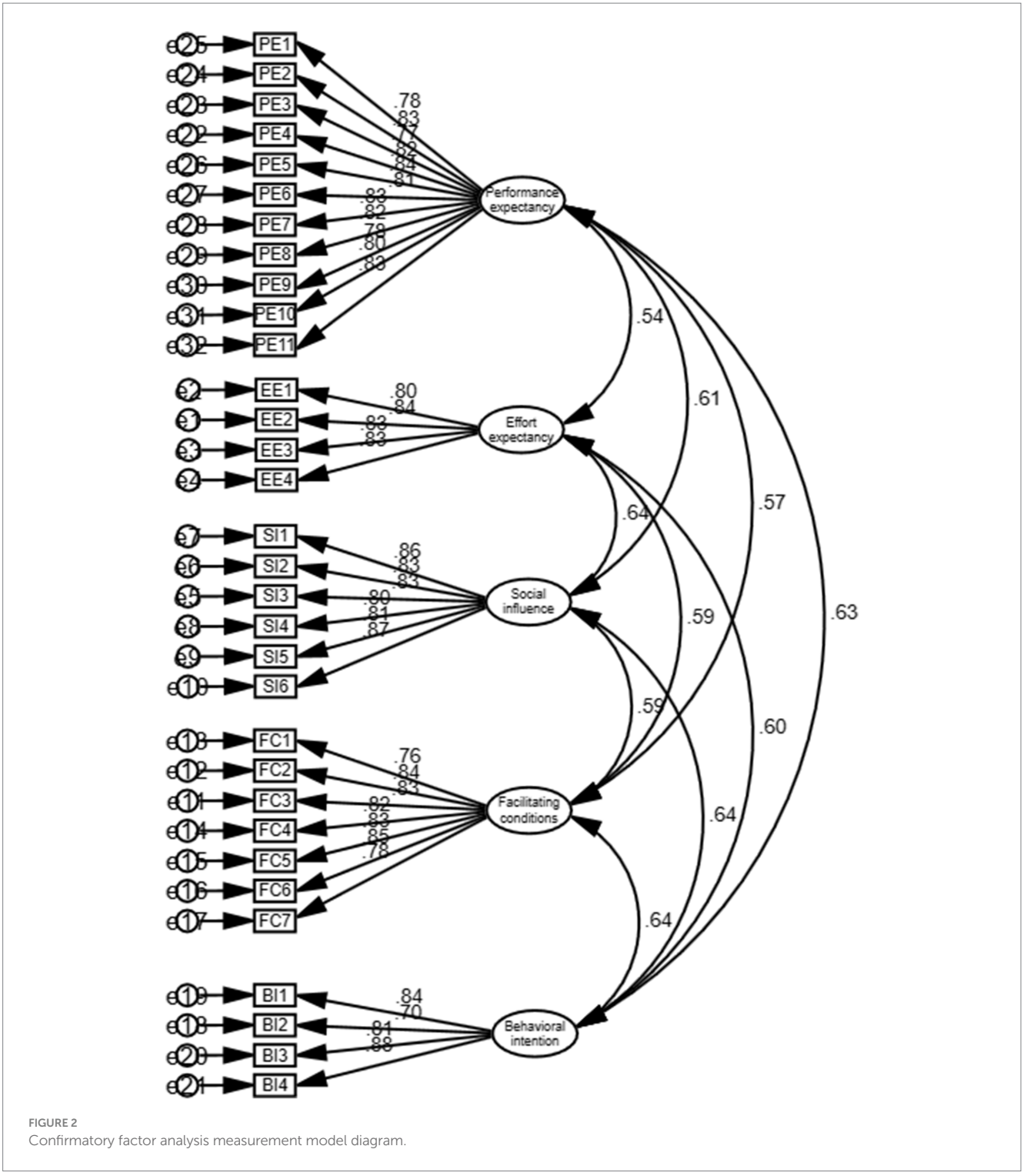


FIGURE 2
Confirmatory factor analysis measurement model diagram.

Additionally, developers of VR equipment could increase awareness by implementing promotional strategies and offering free trial programs, providing more teachers and students with opportunities to explore and understand this technology. By implementing these measures, the acceptance and willingness of both teachers and students to embrace VR technology can be significantly improved, ultimately fostering its broader application in clinical education.

Effort expectancy positively influences the behavioral intention of using VR technology. This research finding aligns with the model proposed by Cao Ruiyang et al., which examines factors affecting learners' acceptance of virtual experiment platforms based on the UTAUT model (15). Effort expectancy serves as an indicator of the ease of using technology; in this study, a higher effort expectancy score correlates with greater ease of operation and use of VR technology. The simplest form of human-computer interaction can be achieved through a computer and mouse. However, for highly immersive virtual reality experiences, specialized display helmets are also utilized. As VR technology continues to evolve, the interaction and operation will become increasingly

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TABLE 7 Confirmatory factor analysis results.

Path name	Factor loading coefficient	S.E	*p*	CR	AVE
Performance expectancy→PE1	0.776			0.955	0.659
Performance expectancy→PE2	0.831	0.077	***		
Performance expectancy→PE3	0.770	0.071	***		
Performance expectancy→PE4	0.824	0.074	***		
Performance expectancy→PE5	0.841	0.078	***		
Performance expectancy→PE6	0.806	0.078	***		
Performance expectancy→PE7	0.828	0.079	***		
Performance expectancy→PE8	0.823	0.083	***		
Performance expectancy→PE9	0.781	0.078	***		
Performance expectancy→PE10	0.800	0.083	***		
Performance expectancy→PE11	0.834	0.082	***		
Effort expectancy→EE1	0.802			0.895	0.682
Effort expectancy→EE2	0.840	0.070	***		
Effort expectancy→EE3	0.830	0.065	***		
Effort expectancy→EE4	0.835	0.072	***		
Social influence→SI1	0.858			0.933	0.700
Social influence→SI2	0.830	0.060	***		
Social influence→SI3	0.830	0.060	***		
Social influence→SI4	0.798	0.058	***		
Social influence→SI5	0.814	0.062	***		
Social influence→SI6	0.874	0.064	***		
Facilitating conditions→FC1	0.760			0.933	0.668
Facilitating conditions→FC2	0.843	0.082	***		
Facilitating conditions→FC3	0.831	0.087	***		
Facilitating conditions→FC4	0.822	0.087	***		
Facilitating conditions→FC5	0.825	0.085	***		
Facilitating conditions→FC6	0.845	0.086	***		
Facilitating conditions→FC7	0.781	0.078	***		
Behavioral intention→BI1	0.843			0.889	0.671
Behavioral intention→BI2	0.705	0.066	***		
Behavioral intention→BI3	0.810	0.073	***		
Behavioral intention→BI4	0.877	0.073	***		

***represents $p < 0.001$.

user-friendly, and virtual reality teaching software will become more accessible, particularly with the growth of computer expertise. Consequently, educators are more likely to adopt this technology. Nonetheless, certain technical barriers remain, necessitating deeper collaboration and strengthened technical exchanges and resource sharing between teaching hospitals and universities. Furthermore, partnerships between educational institutions and development units are essential; these initiatives are critical for advancing the application of virtual reality technology in nursing education.

In related research on the acceptance of VR technology, performance expectancy is typically the decisive factor influencing willingness to accept such technology (16). In this study, effort expectancy ($\beta = 0.150$) demonstrates the smallest impact on the behavioral intention, whereas performance expectancy has a greater impact ($\beta = 0.231$); however, it is not the sole decisive factor in the intention to use VR technology. Despite the significant advantages of VR technology in educational and teaching applications, challenges persist regarding teacher adaptation and technological integration during the implementation process (17). These challenges may contribute to the relatively low influence of performance expectancy on the behavioral intention. Conversely, this outcome could also be linked to individuals' exposure to various types of VR systems, as differing levels of immersion and ease of operation can lead to varied experiences, thereby affecting perceptions of the enjoyment and effectiveness of virtual reality technology. Future research should incorporate additional factors relevant to the research context in order to investigate the

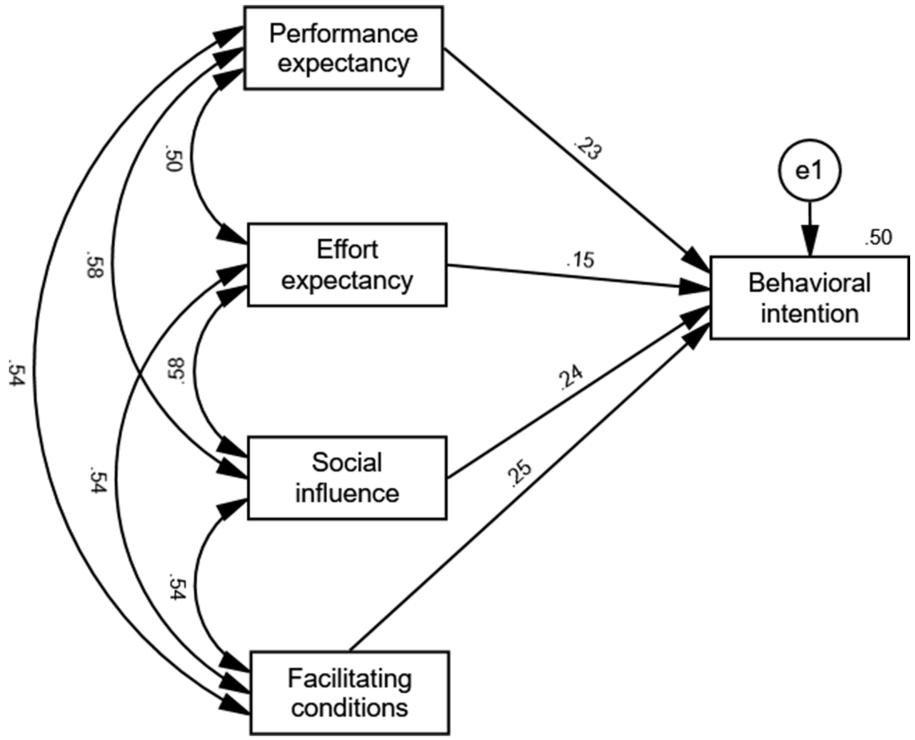


FIGURE 3
Path structure diagram.

TABLE 8 Table of path coefficients.

Path name	Estimate	S.E.	C.R.	*p*
Performance expectancy→behavioral intention	0.231	0.064	3.684	<0.001
Effort expectancy→behavioral intention	0.150	0.060	2.392	0.017
Social influence→behavioral intention	0.236	0.061	3.593	<0.001
Facilitating conditions→behavioral intention	0.247	0.060	3.955	<0.001

elements that influence performance expectancy, effort expectancy, social influence, and facilitating conditions. This approach will contribute to a more comprehensive understanding of how clinical nurse educators utilize VR technology. In light of the adaptation and technical challenges associated with integrating VR technology into nursing education, it is essential for nursing clinical teachers to participate in the development process of nursing VR technology. This involvement will enable teachers to gradually adjust to new teaching methodologies and become proficient in system operation during the development phase. Furthermore, an operational training system designed in this manner can better align with the clinical application scenarios in nursing, thereby enhancing the acceptance and practicality of VR technology within nursing education.

6.3 Social influence and facilitating conditions influence clinical nurse educators' willingness to use VR technology

Social influence positively affects the behavioral intention of using virtual reality technology. This finding aligns with the research results of other scholars (18) and is consistent with the UTAUT model. It indicates that the greater the support an individual receives from significant individuals or groups regarding the use of virtual reality technology, the stronger their intention to adopt it (19). Such support may stem from recommendations and encouragement from colleagues, as well as from policies enacted by the country, educational institutions, and teaching hospitals. The influence of facilitating conditions on the intention to use is both significant and positive. This result mirrors the findings of Zhang Yingjie et al. (20) and Gunasinghe et al. (21), suggesting that the more external resources—such as hardware, funding, and technical support—an individual receives, the greater their willingness to utilize virtual reality technology. In this study, facilitating conditions exhibited the most substantial impact on the willingness to use virtual reality technology ($\beta = 0.247$), followed closely by social influence. Whether through volitional support or material encouragement, the degree of support remains a critical factor in the willingness to adopt VR technology. In the context of increasing informatization and intelligent education, VR technology has garnered significant attention not only in universities but also in large tertiary hospitals, where the application of virtual surgery and 3D anatomy is thriving. The advancement of medical VR technology can facilitate the integration of VR into nursing education to a considerable extent. Concurrently, educational authorities at all levels have introduced policies that provide financial support and

establish related initiatives to promote the application of VR technology in educational settings. Consequently, as societal developments continue, facilitating conditions and social influence are expected to rise, thereby enhancing the willingness of clinical nurse educators to adopt VR technology. It is essential for clinical nurse educators to strengthen collaboration in experience sharing, teaching, and other areas to cultivate a positive community atmosphere. Furthermore, organizations that implement incentive mechanisms and offer hardware, financial, and other forms of support represent effective strategies to bolster educators' willingness to utilize virtual reality technology, thereby further advancing its application in clinical teaching.

7 Conclusion

This study found that clinical nurse educators exhibit a high willingness to utilize virtual reality technology, with 73.42% of participants scoring 4 points or above on their willingness assessment. The research draws upon the classic variables of the UTAUT model to design its variables, exploring the factors that influence clinical nurse educators' willingness to adopt VR technology and establishing a path model. Consequently, enhancing performance expectancy, effort expectancy, social influence, and facilitating conditions for clinical nurse educators can significantly increase their willingness to use virtual reality technology. This, in turn, may assist teaching hospitals in fostering greater acceptance of VR technology among clinical nurse educators, thereby providing a foundation for the further promotion of this innovative technology. Additionally, the study offers reference opinions on the application of VR technology in clinical nurse education.

8 Limitations and future prospects

The respondents of this study were all from a tertiary teaching hospital, which may limit the generalizability of the study results. Future research should aim to expand the sample size, validate findings across multiple regions, and consider incorporating interviews or other qualitative research methods to gain a deeper understanding of the mechanisms underlying each variable. Additionally, this study employed a convenience sampling method, which may introduce certain biases. Future investigations should utilize more rigorous sampling techniques, such as random or stratified sampling, to obtain more representative data from various hospitals across different regions. This study utilized a cross-sectional design, which precludes the determination of causal relationships or trends. To address this limitation, future research could adopt a longitudinal design to track changes within the same group of participants, thereby enhancing our understanding of the behavioral development of clinical nurse educators using VR technology. The demographic information collected in this study is relatively limited; future research should include a broader range of demographic data, such as age, gender, educational background, and technology proficiency, to explore how these factors influence clinical nurse educators' acceptance of virtual reality technology. Furthermore, this study is grounded in a specific technology acceptance model. Future research could integrate additional relevant theoretical frameworks of technology acceptance to develop a more comprehensive model that elucidates clinical nurse educator's willingness to utilize VR technology.

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 Ethical Review Board of the Hubei University of Chinese Medicine in Wuhan City, Hubei Province (Protocol reference number: 2024009). 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. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

LM: Conceptualization, Methodology, Writing – review & editing. FD: Writing – original draft. LL: Writing – review & editing. CY: Data curation, Writing – review & editing HH: Supervision, Project administration, Writing – review & editing. ZS: Writing – review & editing. YD: Investigation, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1437699/full#supplementary-material

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Assessment of acceptance and associated factors of HIV pre-exposure prophylaxis among commercial female sex workers in drop-in centers selected sub-cities of Addis Ababa, Ethiopia

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Background: Globally, female sex workers (FSWs) face high risk of HIV, particularly in regions like sub-Saharan Africa. In Ethiopia and Addis Ababa, the impact is significant. Implementing WHO-recommended measures, such as pre-exposure prophylaxis (PrEP), is crucial to reducing new HIV infections and addressing service access disparities among FSWs. Thus this study aimed to assess the acceptance of Pre-Exposure Prophylaxis (PrEP) among commercial female sex workers in selected sub-cities of Addis Ababa, Ethiopia, 2022.

Method: Institution-based cross-sectional study design was conducted on three randomly selected sub-cities of Addis Ababa from June 20 to July 30, 2022. All (358) commercial sex workers available during the study period were included. A structured, pretested, and interviewer-administered questionnaire was used to collect the data. Logistic regression was used to identify factors associated with acceptance of pre-exposure prophylaxis and statistical significance was determined at p-value <0.05. An odds ratio with a 95% confidence interval was used to measure association estimates.

Result: A total of 358 female sex workers responded, 67.9% (95% CI: 63.7, 73.2%) were willing to take pre-exposure prophylaxis. Acceptability of pre-exposure prophylaxis was significantly associated with the accessibility of pre-exposure prophylaxis at easily reachable areas (AOR3.786; 95%CI: 1.449, 9.894) and knowledge about pre-exposure prophylaxis (AOR 3.270; 95%CI: 1.336, 8.001).

Conclusion: Acceptability of pre-exposure prophylaxis among female sex workers was 67.9% which is low. Accessibility of pre-exposure prophylaxis is an easily reachable area and knowledge of about it could significantly affect its acceptability.

KEYWORDS

acceptance, Addis Ababa, Ethiopia, female sex worker, HIV, pre-exposure prophylaxis

1 Introduction

HIV remains a major public health concern, disproportionately affecting female sex workers (FSWs) worldwide (1). FSWs are among the most vulnerable populations due to factors such as inconsistent condom use, multiple sexual partners, and limited access to health services, which contribute to their heightened risk of HIV infection. In Ethiopia, this issue is particularly concerning. A systematic review conducted in 2019 estimated that there are approximately 200,000 FSWs in the country, with the majority (57.5%) being 24 years old or younger, and 14% aged 19 or younger (2). This indicates that a significant number of FSWs are in the younger age group, highliting the urgency to address HIV prevention strategies for this population. Addis Ababa hosts one of the largest populations of female sex workers (FSWs) in Ethiopia, significantly exceeding the numbers found in other regions (3). The impact of HIV remains severe, especially among FSWs, with the highest prevalence observed in this group (4). According to studies done by the Central Statistics Agency and IMF in 2016, HIV prevalence among the general population in Ethiopia ranges from 0.8 to 4.8% (5). A national surveillance study on Most Risk Populations revealed a significantly higher HIV prevalence of 23.8% among female sex workers in all regional capitals (6). Female sex workers (FSWs) globally face a substantial HIV burden and encounter challenges in accessing health services, particularly pronounced in high-prevalence regions like sub-Saharan Africa (7). Despite declines in HIV prevalence, the 2016 Global AIDS update reveals persistently high rates among FSWs (8). They are considered a hard-to-reach population, with limited uptake of HIV services in Ethiopia, prompting a recognized need for targeted interventions (9, 10). Ethiopia, in alignment with global goals, aims to reduce new HIV infections and end AIDS as a public health threat by 2030, as reflected in national strategies (1, 6). Evidence suggested comprehensive HIV prevention for sex workers, led by their communities, is crucial (11, 12). The recent introduction of pre-exposure prophylaxis (PrEP) for high-risk populations, including female commercial sex workers, highlights the importance of adherence and acceptability for its effectiveness in reducing new HIV infections. Ethiopia is actively working on preventive measures to align with the global goal of ending AIDS by 2030, particularly focusing on the well-being of female sex workers and sero-discordant HIV-negative individuals (1, 4, 6).

Various studies among different populations, including female sex workers (FSWs), reveal substantial interest in PrEP. Participants in Guangxi, China, expressed willingness if proven safe and effective, while studies in Dar es Salaam, Tanzania, Harare, Zimbabwe, and Kolkata, India, demonstrated high acceptance rates, especially if PrEP was provided free of cost (13–16).

Studies in a high-risk Peruvian population and Zambia and Uganda emphasized factors impacting PrEP use, such as out-of-pocket costs, efficacy, potential side effects, and stigma (17, 18). WHO recommends offering PrEP to those at substantial risk, making it crucial for FSWs' needs to be addressed to achieve Ethiopia's 2030 HIV/AIDS elimination goal (19).

One such prevention strategy is the use of pre-exposure prophylaxis (PrEP), which has proven highly effective in reducing HIV transmission among high-risk groups, including FSWs (8). However, for PrEP to be successful, high levels of awareness, acceptability, and adherence are required (20, 21). While studies in other countries such as China, Tanzania, Zimbabwe, and India have shown substantial interest in and acceptance of PrEP among FSWs (13–16), research on the awareness, perceptions, and uptake of PrEP among FSWs in Ethiopia remains limited.

This study aims to fill this gap by specifically assessing the acceptance and associated factors influencing PrEP uptake among FSWs in Addis Ababa. Unlike previous studies that focused on broader or different populations, this research centers exclusively on FSWs in drop-in centers, offering new insights into their attitudes and behaviors regarding PrEP use. The findings from this study will provide critical baseline data for future interventions and policy formulation, supporting Ethiopia's national strategy to reduce new HIV infections among key populations.

2 Methods and materials

2.1 Study area and period

The study was conducted at Drop-in Centers (DICs) in Addis Ababa, Ethiopia, from June 20 to July 30, 2022. Addis Ababa, the capital city of Ethiopia and a major diplomatic hub in Africa, is divided into 11 sub-cities and hosts 12 Drop-in Centers. These centers play a critical role in supporting key populations, such as female sex workers, by providing essential HIV prevention and treatment services. Addis Ababa, as the largest city in Ethiopia, is a key destination for migrants from other regions, which contributes to the high number of female sex workers. The outflow of people, combined with the city's economic opportunities and its role as a tourist destination, further increases the demand for commercial sex work.

The selected sub-cities for the study Akaki, Yeka, and Kirko are densely populated and represent areas with diverse socio-economic dynamics, including significant migrant populations. As of 2024, the population of Addis Ababa was estimated at 5.7 million, growing annually at 4.45%, which accounts for approximately 20% of Ethiopia's urban population (22). Estimates show that the city has one of the highest concentrations of female sex workers in Ethiopia (23). The study specifically focused on female sex workers selected from Drop-in Centers located in these three sub-cities.

In terms of HIV prevention, diagnosis, and treatment, Addis Ababa has a well-established healthcare infrastructure. The Drop-in Centers provide community-based comprehensive HIV services, offering essential support to female sex workers. Services include free condoms, HIV testing, counseling, antiretroviral therapy (ART), and other sexual and reproductive health services. In addition to the DICs, numerous public health facilities, such as health centers and hospitals, are available across the city to provide further HIV care and treatment. Both the government and non-governmental organizations are actively working to reduce HIV transmission through broad preventive measures and improved access to healthcare services.

2.2 Study design

Institution-based cross-sectional study design was conducted to assess the acceptance of pre-exposure prophylaxis among female sex workers coming to drop-in centers in Addis Ababa, Ethiopia, 2022.

Abbreviations: DIC, Drop in center; PrEP, Pre-exposure prophylaxis.

2.3 Source of population and study population

The study population consisted of all female commercial sex workers who visited the drop-in centers in the selected sub-cities of Addis Ababa, Ethiopia, during the study period for various reasons. Given the limited number of female sex workers accessing these centers, we employed a census approach rather than a sample size calculation, which allowed us to include all 358 individuals who met the inclusion criteria.

2.4 Eligibility criteria

This study included female sex workers residing in the selected sub-cities of Addis Ababa during the data collection period, who were HIV-negative at that time, eligible for PrEP, and willingly provided consent to participate.

2.5 Variables

The acceptability of PrEP was the dependent variable.

Commercial female sex workers' awareness, Accessibility of PrEP, FSW knowledge about PrEP, FSW Stigma, and discrimination, socio-demographic characteristics like age, marital status, educational status, place of birth, income, engaging in sex work before arriving in Addis Ababa, total years of experience, in engaging in sex work, reasons for becoming a sex worker, substance use, alcohol use, and condom use were Independent variables.

2.6 Data collection tool and procedure

Structured interviewer-administered questionnaire was developed to collect socio-demographic, socioeconomic, and clinical characteristics of female sex workers (FSWs) in Addis Ababa. This questionnaire was designed by integrating relevant questions from established guidelines and previous literature (23–25).

To ensure the reliability and validity of the instrument, a pretest was conducted with a sample representing 5% of the target population and based on the feedback the questioner was modified. Training was given for data collectors and supervisors for 1 day on the objective, significance of the study, data collection tool, procedures and detailed instructions on how to administer the questionnaire effectively. To facilitate the recruitment process, collaboration was established with health providers at the Drop-In Center (DIC), ensuring that the data collectors were familiar with the study environment and the target population.

Female sex workers identified as HIV-negative and eligible for pre-exposure prophylaxis (PrEP) were recruited during the data collection phase. Informed consent was obtained from each participant prior to their inclusion in the study, provided that they understood the purpose of the research and their rights as participants.

The data collection process was supervised by the principal investigator along with two field supervisors, who monitored the data collectors to maintain adherence to the study protocol and ethical standards throughout the duration of the study.

2.7 Data analysis

The collected data were entered into Epi-data version 3.1 to reduce entry errors and avoid inappropriate values by fixing the range of values coded in the software. The data were analyzed using SPSS version 23. For the first objective, descriptive statistics were used, and findings were presented in a frequency table. For the second objective, which focused on identifying associated factors influencing PrEP acceptance, binary logistic regression analysis was performed. The selection of independent variables was guided by theoretical frameworks and empirical evidence from existing literature on HIV prevention, specifically tailored to the context of commercial female sex workers. Initially, each independent variable was assessed in a bivariate analysis with the dependent variable (PrEP acceptance), and those with a p-value <0.25 were considered for inclusion in the multivariate logistic regression model. In the multivariate analysis, variables with a p-value ≤0.05 were deemed statistically significant. To ensure robustness, criteria such as the Akaike Information Criterion (AIC) and Variance Inflation Factor (VIF) were utilized to check for multicollinearity, with a VIF value greater than 10 indicating high collinearity. The Wald test was employed to assess the significance of each predictor, ensuring that only statistically significant variables contributed to the final model. Adjusted Odds Ratios (AOR) with a 95% Confidence Interval (CI) were reported.

2.8 Data quality management

Before data collection the questionnaire was translated into the local language Amharic and then back into English to ensure consistency. Before data collection, the questionnaire was pre-tested on 5% of the total study population at Bole sub-city. During data collection: the data collection and interviewing mechanism was strictly supervised throughout the data collection period by the assigned supervisors and the principal investigator. Questionnaires were checked for completeness and consistency at the site of the data collection by the principal investigator.

2.9 Ethical approval and consent to participants

Prior to data collection, ethical clearance was obtained from Yekatit 12 Hospital Medical College (Ethical Clearance Number 399/2022) and subsequently submitted to the Addis Ababa Health Bureau. The Addis Ababa Health Bureau then issued support letters to the sub-cities of Yeka, Akaki Kality, and Kirkos, which in turn provided further support letters to the respective designated areas (Drop-in Centers). To ensure confidentiality, all data were anonymized by assigning unique codes to participants, and any personal identifiable information was removed during the data collection process. Data were stored securely in password-protected files, with access restricted to authorized research team members only. Additionally, all interviews were conducted in private settings to ensure participant confidentiality. Written and verbal informed consent was obtained from all participants, and they were assured of their right to withdraw at any stage without any consequences. The

study procedures strictly adhered to the principles outlined in the Declaration of Helsinki.

2.10 Operational definition and measurements

2.10.1 Commercial female sex worker

Commercial FSW" refers to women who engage in sex work primarily for financial remuneration. Participants were identified as commercial FSW based on their self-reported occupation status. A survey tool was employed that categorized employment as commercial sex work.

2.10.2 Acceptability

This refers to the extent to which female sex workers were willing and able to use PrEP consistently and correctly. Participants were asked to report their intention using yes/no questions, such as "Would you be willing to start taking PrEP if it were offered to you?" and "Would you be willing to take PrEP daily as prescribed?" (16). Those who answered "yes" were scored as 1, indicating they accepted PrEP, while those who answered "no" were scored as 0, indicating they did not accept PrEP.

2.10.3 PrEP accessibility

We assessed PrEP accessibility through a combination of self-reported factors, including physical proximity to health facilities that provided PrEP services, awareness of PrEP among female sex workers, and barriers to accessing PrEP, such as cost, stigma, and healthcare availability. This variable referred to the extent to which PrEP medication was accessible to individuals at a nearby location, whether the area was easily reachable, and whether the medication was available free of cost. Participants were asked to report on these aspects using yes/no questions, such as "Is there a healthcare facility offering PrEP medication near your location?," "Is the location where you can get PrEP easily reachable for you?" Based on the World Health Organization's recommendation that individuals should live within a 5 km radius of a health facility for optimal access (26), and "Is the PrEP medication available to you free of cost?" (24). Those who answered "yes" were scored as 1, indicating positive availability, while those who answered "no" were scored as 0, indicating negative availability. The data were collected via structured surveys and interviews with participants, and PrEP accessibility was categorized into different levels (Yes and NO).

2.10.4 Educational status

In this study, the educational status of commercial sex workers was categorized based on established classifications from the Ethiopian Demographic and Health Survey (47). The categories are defined as follows: *Cannot Read and Write* refers to individuals who lack any literacy skills; *Can Read and Write* describes those who possess basic reading and writing abilities but have not completed any formal education; *Primary Level* includes individuals who have completed their primary education, typically covering grades 1 to 8; and *Secondary Level* encompasses those who have finished secondary education, which includes lower secondary (grades 9 and 10) and upper secondary (grades 11 and 12).

2.10.5 Knowledge about PrEP prophylaxis

This refers to the extent to which individuals understand the purpose, effectiveness, and usage of Pre-Exposure Prophylaxis (PrEP) as a preventive measure against HIV infection. Participants were asked to report their knowledge using yes/no questions, such as "Do you know that PrEP is used to prevent HIV infection?," "Are you aware that PrEP must be taken daily to be effective?," and "Do you know that PrEP is recommended for people at high risk of HIV infection?" (24). Those who answered "yes" were scored as 1, indicating they had correct knowledge about PrEP, while those who answered "no" were scored as 0, indicating a lack of knowledge. Respondents who had answered ≥ 4 /7 labeled as knowledgeable and $\leq 3/7$, not knowledgeable (16, 24, 25).

3 Results

3.1 Socio-demographic characteristics of the study participant

A total of 358 female sex workers were interviewed, resulting in a response rate of 98%. The median age of the participants was 28 years, with the majority belonging to the age group of 25–29 years (38.5%). In total, 69.3% of the study participants were born outside of Addis Ababa, while 30.7% were born in Addis Ababa. Among those born outside of Addis Ababa, only 6.5% had a previous history of sex work.

The majority of female sex workers had a primary level of education (33.2%), and most participants (47.2%) were not married. Additionally, 55.6% of participants came to Addis Ababa to work as house servants, while 17.7% came to visit relatives. Among all participants, 61% became female sex workers due to financial problems, followed by 21.5% who were influenced by their peers. Among the total participants, the majority (57%) had a monthly income of 3,001–6,000 ETB. Among all participants, the majority (34.1%) had been engaging in sex work for 0–3 years. Female sex workers born outside Addis Ababa began engaging in sex work at an earlier age (13 years) compared to those born in Addis Ababa (14 years). Their maximum age at the start of engaging in sex work was 44 years and the minimum was 13 years, but the mean age at the start was the same for both groups at 22.18 years (Table 1).

3.2 Assessment of awareness and accessibility of PrEp

Among the total interviewed clients (358), 294 (82%) heard about PrEP. Among these 294 female sex workers, 132 (45%) were informed about its advantages, 44 (15%) about how it could be taken, 29 (10%) about its accessibility, and 89 (30%) about all the above information.

From these 294 female sex workers, 172 (59%) received information from healthcare providers, 53 (18%) from community mobilizers, 40 (14%) from friends, 16 (5%) from media, and 13 (4%) from peer educators among all interviewed commercial female sex workers (358), 74.6% reported that they received PrEP in their nearest area. All of the female sex workers reported that they received it free of cost. Additionally, 72.9% of them said it is easily reachable. Among the total 358 female sex workers, 296 (82.7%) knew about pre-exposure prophylaxis (PrEP) (see Table 2).

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TABLE 1 Socio-demographic characteristics of commercial female sex workers in drop-in centers of Addis Ababa, Ethiopia, July 2022.

Demographics characteristic	Frequency (*n*)	Percentage (%)
Age group		
18–24	93	26.0
25–29	138	38.5
30–34	78	21.8
35–39	37	10.3
>40	12	3.4
Income		
≤1,000	19	5.3
1,001–3,000	118	33.0
3,001–6,000	204	57.0
>6,000	17	4.7
Education		
Cannot read and write	81	22.6
Can read and write	109	30.4
Primary level	119	33.2
Secondary level	49	13.7
Marital status		
Married	61	17.0
Never married	169	47.2
Separated	102	28.5
Other (widow and divorced)	26	7.2
Place of birth		
Addis Ababa	110	30.7
Out of Addis Ababa	248	69.3
Engaging in sex work before Addis Ababa (*N* = 248)		
Yes	16	4.5
No	232	64.8
Experience in commercial sex activities		
0–3 years	122	34.1
4–5 years	110	30.7
6–10 years	89	24.9
>10 years	37	10.3
Reason for coming to Addis Ababa (*n* = 248)		
House servant	138	55.7
Education	33	13.3
To visit my relatives	44	17.7
To work as FSW	25	10.1
Disagreement with those I live with	8	3.2
Reason for becoming a commercial sex worker		
Financial problems	219	61.2
Loss of parents	33	9.2
Peer pressure	77	21.5
Conflict with those I live with	20	5.6
Divorce	9	2.5

TABLE 2 Commercial female sex workers' awareness and source of information and accessibility of drop in centers about PrEP in drop-in centers in Addis Ababa, July 2022.

Awareness and accessibility	Frequency	Percentage
Heard about PrEP		
Yes	284	79%
No	74	21%
What do you hear about PrEP(n = 294)		
How it can be taken	44	15%
Its advantages	132	45%
Its accessibility	29	10%
All	89	30%
Source of information (*n* = 294)		
Media	16	5%
Health care provider	172	59%
Friends (PrEP user)	40	14%
Community-based mobilizer	53	18%
Peer educator	13	4%
Near to their home(5 km) (Drop-in center)		
Yes	262	74.6%
No	96	25.4%
Free		
Yes	358	100%
Reachable		
Yes	262	72.9%
No	96	27.1%
Knowledge about PrEp		
Not knowledgeable	62	17.3
Knowledgeable	296	82.7

3.3 Alcohol and substance use

Among all interviewed 358 female sex workers (FSWs), 274 (76.5%) had consumed alcohol. Of those who consumed alcohol, 52.8% had taken it during their last sexual intercourse, and 21.5% were intoxicated. Additionally, 64% of the total interviewed FSWs had used substances. Among the 229 substance users, 149 (65%) had chewed khat, 61 (27%) had used shisha, and the remaining 19 (8%) had used cigarettes (Table 3).

3.4 Acceptance of PrEP

Among the 358 interviewed female sex workers (FSWs), 243 (67.9%) [95% CI 63.7 to 73.2%] accepted pre-exposure prophylaxis (PrEP). Various reasons were reflected by those 115(32.1%) study participants who refused 34 (29.56%) cited fear of stigma and discrimination, 21 (18%) were concerned about drug side effects, 16 (13.9%) lacked information about the drug, 14 (12.1%) preferred using condoms, 9 (7.8%) believed God keeps them safe, 8 (6.95%) said they are HIV negative, 7 (6%) felt confident in their protective

TABLE 3 Alcohol and substance use among female sex workers in drop-in centers of Addis Ababa, July 2022.

Alcohol and substance use	Frequency	Percentage
Alcohol consumption	274	76.5%
Alcohol consumption during last sex work	189	52.8%
Intoxicated during last sex work	77	21.5%
Substance use	229	64%
Type of substance used (n = 229)		
Khat	149	65%
Shisha	61	27%
Cigarette	19	8%

TABLE 4 Commercial female sex workers' acceptance of PrEP in drop-in centers, Addis Ababa, July 2022.

Acceptance	Frequency	Percentage
PrEP acceptance (N = 358)		
Yes	243	67.9
No	115	32.1
Reasons for not accepting PrEP (N = 115)		
Fear of stigma and discrimination	34	29.6
Concerns about drug side effects	21	18.3
Lack of information about the drug	16	13.9
Preference for using condoms	14	12.2
Reliance on religious belief (God keeps me)	9	7.8
Belief that being HIV-negative is sufficient	8	7
Confidence in personal protective measures	7	6.1
Other reasons (dislike of the drug, inconvenience of daily pills)	6	5.2

measures, and 6 (5.2%) mentioned other reasons (dislike of the drug, inconvenience of daily pills; Table 4).

3.5 Factors associated with acceptability of pre-exposure prophylaxis

Using binary logistic regression, an association between the acceptance of pre-exposure prophylaxis (PrEP) and socio-demographic characteristics (age, marital status, educational level, place of birth, income), as well as other variables (easily reachable, heard about PrEP, knowledge about PrEP), were examined. Variables with a p-value less than 0.25 in the binary logistic regression were then included in a multivariable logistic regression model. After performing multivariable logistic regression, predictor variables with a p-value ≤0.05 were identified as significantly associated with PrEP acceptance.

The results indicated that there was a highly significant association between the ease of reachability of the PrEP service area and PrEP acceptance. Individuals who had easy access to PrEP services were 3.7 times more likely to accept PrEP compared to those who did not have easy access (AOR = 3.786, 95% CI: 1.50–9.56).

Moreover, a significant difference was observed between those who were knowledgeable about PrEP and those who were not. Those who knew about PrEP were 3.2 times more likely to accept PrEP than those who were not knowledgeable (AOR = 3.27, 95% CI: 1.30–8.23).

However, socio-demographic factors including age, marital status, educational level, place of birth, income, and having heard about PrEP, did not show a significant association with PrEP acceptance in the multivariable logistic regression model (Table 5).

4 Discussion

The study was conducted to determine the level of acceptance of pre-exposure prophylaxis (PrEP) and associated factors among female sex workers in Addis Ababa. In this study, more than two-thirds (67%) of female sex workers accepted PrEP. This finding is consistent with studies conducted in other regions of sub-Saharan Africa, such as Kampala, Uganda, where 71% of female sex workers accepted PrEP (27). Similarly, in Xinjiang, China, the acceptance rate was 69.29% (28). Additionally, a study in Uganda found a similar PrEP acceptance rate of 66% among female sex workers (18).

However, the current study's PrEP acceptance rate is significantly lower than the 80.4% reported in Kolkata, India (14), 76.1% in Ho Chi Minh City, Vietnam (29), 92.2% in South-Central Uganda (30),91% in Zambia (18) and another cross-sectional study done in US show high acceptance rate (74%) (31).

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TABLE 5 Associated factors for PrEP acceptance among sex workers at drop-in centers in Addis Ababa, July 2024.

Variable	Category	PrEP Acceptance (Yes)	PrEP Acceptance (No)	COR (95% CI)	AOR (95% CI)
Age					
	15–24	64	29	1.036 (0.78, 1.38)*	1.777 (1.12, 2.82)
	25–29	96	42	1.02 (0.72, 1.45)	2.308 (1.45, 3.67)
	30–34	54	24	0.595 (0.35, 1.01)	2.083 (1.12, 3.88)
	35–39	21	16	0.906 (0.48, 1.71)	1.258 (0.54, 2.91)
	≥40	8	4		
Education					
	Cannot read and write	53	28	1.687 (0.97, 2.93)*	1.231 (0.53, 2.85)
	Can read and write	83	26	0.934 (0.53, 1.65)	1.602 (0.73, 3.50)
	Primary level	76	43	0.91 (0.52, 1.57)*	0.85 (0.40, 1.81)
	Secondary level	31	18	1	1
Marital status					
	Married	37	24	1.589 (0.89, 2.82)*	1.496 (0.66, 3.37)
	Never married	120	49	1.297 (0.80, 2.10)	1.688 (0.80, 3.56)
	Widowed	12	5	1.557 (0.52, 4.67)*	1.741 (0.42, 7.15)
	Divorced	6	3	1	1
Experience					
	0–3	87	35	0.939 (0.57, 1.55)	0.792 (0.38, 1.64)
	4–5	77	33	0.753 (0.43, 1.31)*	0.524 (0.23, 1.18)
	6–10	58	31	0.528 (0.29, 0.96)	0.408 (0.16, 1.03)
	>10	21	16	1	1
Income					
	>1,000	18	1	0.076 (0.01, 0.54)*	1.496 (0.66, 3.37)
	1,001–3,000	68	50	0.137 (0.08, 0.24)	1.688 (0.80, 3.56)
	3,001–6,000	145	59	0.133 (0.08, 0.22)	1.741 (0.42, 7.15)
	>6,000	12	5	1	1
Heard about PrEP					
	Yes	208	76	1.596 (0.95, 2.68)	0.279 (0.11, 0.72)
	No	35	39	1	1
Source of awareness					
	Media	9	7	1.898 (0.69, 5.20)	0.496 (0.13, 1.89)
	Provider	122	50	2.051 (1.25, 3.38)	1.019 (0.46, 2.28)
	Friend	29	11	2.657 (1.39, 5.06)	1.383 (0.54, 3.56)
	Mobilizer	41	12	2.593 (1.36, 4.95)	1.265 (0.49, 3.27)
	Peer educator	10	3	1	1
Reachable					
	Yes	192	63	3.107 (1.98, 4.83)	3.786 (1.50, 9.56)
	No	51	51	1	1
Near to their Home(5 km) (Drop-in center)					
	Yes	193	69	2.573 (1.62, 4.08)	2.179 (1.11, 4.30)**
	No	50	46	1	1
PrEP Knowledge					
	Yes	216	80	3.5 (2.21, 5.56)*	3.27 (1.30, 8.23)**
	No	27	35	1	1

*$p < 0.2$; **$p < 0.05$.

This disparity might be due to the reasons for refusal among the 115 (32.1%) participants who did not accept PrEP. The most common reasons for non-acceptance were fear of stigma and discrimination (29.56%), concerns about drug side effects (18%), lack of information about the drug (13.9%), and preference for condoms (12.1%). Additionally, 7.8% believed that God keeps them safe, 6.95% thought they were HIV negative, 6% felt confident in their protective measures, and 5.2% cited other reasons such as dislike of the drug and inconvenience of daily pills. Furthermore, this disparity might also stem from cultural and economic differences in the study areas. The healthcare infrastructure in Ethiopia poses significant barriers to accessing pre-exposure prophylaxis (PrEP), particularly when compared to countries with more integrated and efficient healthcare systems. In nations where access to preventive services is streamlined, individuals are more likely to encounter fewer obstacles when seeking PrEP, thereby fostering higher acceptance rates (32). Furthermore, the level of training that healthcare providers receive regarding PrEP is crucial in influencing acceptance rates. In environments where providers are well-informed and actively engage in discussions about PrEP, patients are likely to feel more comfortable and empowered to consider this preventive option (33). Additionally, the overarching policy environment significantly shapes the effectiveness of health interventions. Countries that implement supportive policies and allocate adequate funding for PrEP programs create conducive environments that facilitate uptake. Conversely, Ethiopia faces various challenges within its policy framework that may impede the effective implementation of PrEP, limiting its availability and accessibility to those at risk (34). These reasons are similar to those reported in a study in Dares Salaam, Tanzania, where 46% of female sex workers were not interested in a daily pill for HIV prevention (35). Similarly, in a high-risk Peruvian population, potential side effects and stigma had the greatest impact on PrEP use (17), while concerns about side effects and low self-perceived risk were the most common reasons for PrEP non-acceptance (36). The leading barrier to PrEP acceptance in the current study was stigma and discrimination (29.56%), which is consistent with findings from other studies (37, 38).

The current research revealed that the acceptance of Pre-Exposure Prophylaxis (PrEP) was significantly and positively associated with both the accessibility of the drug at easily reachable locations and the level of knowledge about PrEP. This finding is consistent with the study conducted by Cornell et al. (39) in South Africa, which demonstrated that increasing the availability of PrEP through community-based distribution points significantly improved uptake among high-risk populations. Similarly, Harrison et al. (40) found that expanding PrEP services to local health centers and community clinics in Kenya resulted in increased PrEP adherence among key populations. Moreover, Harling et al. (35) highlighted in their study in Tanzania that accessibility measures, such as the presence of mobile clinics and local health initiatives, significantly influenced PrEP uptake among female sex workers. Their research emphasized that localized service delivery improved accessibility and consequently led to higher acceptance rates.

Additionally, there was a highly significant difference between individuals who were knowledgeable about PrEP and those who were not. Those who were informed about PrEP were 3.2 times more likely to accept it than those who lacked this knowledge (AOR = 3.27, 95% CI: 1.30–8.23). This finding is consistent with studies from other regions that emphasize the importance of PrEP education. For instance, Cornell et al. (39) found that increasing awareness and understanding of PrEP through educational programs in South Africa significantly improved PrEP uptake among high-risk populations. Similarly, Nabunya et al. (41) demonstrated that community-based educational interventions in Uganda effectively enhanced PrEP knowledge and increased acceptance among high-risk groups. Furthermore, Musa et al. (42) showed that educational interventions in Nigeria also significantly improved PrEP knowledge and acceptance among high-risk individuals. These studies collectively highlight that effective educational strategies are crucial for increasing PrEP acceptance and uptake. Even though the success of PrEP intervention is heavily dependent on the user's willingness and the compliance with prescribed PrEP regimen lack of awareness and insufficient knowledge regarding this technique by both healthcare providers and subjects are major barriers to its optimal benefit (43–46).

4.1 Strengths and limitations of this study

- The study addresses HIV susceptibility among high-risk female sex workers in Addis Ababa, Ethiopia, contributing valuable insights to public health interventions in sub-Saharan Africa.
- Provides a more comprehensive understanding of the factors influencing PrEP acceptance within the target population.
- Given the sensitive nature of the topic (sex work and HIV prevention), participants may be inclined to provide responses they perceive as socially acceptable rather than expressing their true attitudes and behaviors.

5 Conclusion

Acceptability of pre-exposure prophylaxis among female sex workers at selected sub-cities (Yeka, Akakikality, and Kirkose) of Addis Ababa Ethiopia is 67.9% which was low. Easily reachability of the area where PrEP is given and female sex workers knowledge about PrEP could be significantly associated with high acceptance. A comprehensive mix of multiple interventions is necessary for the successful implementation of a PrEP program among this population in Addis Ababa.

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

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. EA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. GT: Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

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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.

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Knowledge, attitude, and practice toward foodborne disease among Chinese college students: a cross-sectional survey

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Background: More than 200 diseases are caused by eating food contaminated and the burden of foodborne disease is considered to be high worldwide. Foodborne diseases are an important public health issue, and the knowledge, attitudes and practices among college students are crucial in preventing outbreaks.

Objective: This study aimed to evaluate the current knowledge, attitudes, and practices (KAP) toward foodborne diseases among Chinese college students and to identify the factors influencing practice actions.

Methods: A cross-sectional study was conducted from April to November in 2023. A cluster random sampling method was used to enroll participants at Xihua University. The questionnaire including 47 items was used to collect the foodborne diseases information. An offline questionnaire was used to generate the surveys. Multiple linear regression was used to analyze the factors associated with foodborne disease knowledge, attitudes and practices.

Results: A total of 445 college students with a mean age of 19.76 $\pm$ 1.24 years were included in the study. The majority of participants were female (59.1%), of Han Chinese (95.1%), and nearly two-thirds were lower-year undergraduates (66.7%). Most participants (78.9%) were non-medical students, and 64.7% of participants were from rural areas. The KAP score of foodborne diseases was 79.21 $\pm$ 6.84. The knowledge, attitudes, and practices scores toward foodborne diseases were 8.76 $\pm$ 0.95, 10.50 $\pm$ 1.63, and 59.94 $\pm$ 6.48, respectively. In particular, there was a notable decrease in practice scores toward foodborne diseases among male students, ethnic minority students, and non-medical students. The significant predictors of practices were included gender (β = 0.11, $p < 0.05$), nationality (β = −0.12, $p < 0.05$), specialization type (β = −0.13, $p < 0.05$), residence (β = −0.11, $p < 0.05$).

Conclusion: These results revealed gaps in knowledge, attitudes, and practices regarding foodborne diseases, and the knowledge was at an insufficient level, the attitude was positive and practice was at a moderate and acceptable level. In general, the level of KAP was at a moderate and acceptable level. Gender, nationality, education level, specialization type, and residence were identified as crucial influencers on practices toward foodborne diseases. It is necessary to provide foodborne disease health education targeting this population in western areas, which can help improve students' knowledge, attitudes, and practices.

KEYWORDS

foodborne diseases, China, knowledge, attitudes, practices, students

Introduction

Foodborne diseases (FBDs) are infections of the digestive system caused by foodborne pathogens such as parasites, viruses, bacteria, and fungi, which are a public health threat, leading to loss of lives and hindering socioeconomic development (1, 2). Over 250 different types of microbial agents and unconventional agents such as prions are linked to foodborne illnesses in humans (3). Microbial infections were the most common cause of outbreaks worldwide. In particular, bacteria such as Salmonella, Shigella species, pathogenic *Escherichia coli*, and *Listeria monocytogenes* are the most commonly infection sources of foodborne disease (4). Those agents of foodborne disease are from cross-contamination or contaminated food including poultry, eggs, meat, vegetables and ready-to-eat foods, and can affect individuals of all ages (5, 6).

It was estimated that unsafe foods led to 600 million cases of foodborne illness, 420,000 deaths, and the loss of 33 million years of healthy life globally (7). In the United States, approximately100,939 cases of foodborne illnesses, 5,699 hospitalizations, and 145 deaths were reported between 2009 and 2015, and the proportion of foodborne illnesses attributed to food-producing animals was 10.4–14.1% from 1999 to 2017 (8, 9). In Europe, 23 million people are affected by foodborne illnesses, leading to approximately 5,000 deaths annually (8). According to the data from the China National Foodborne Disease Outbreaks Surveillance System, a total of 5,493 outbreaks of foodborne disease were reported in 2021, resulting in 117 deaths and 32,334 illnesses from 30 provinces, and the incidence rate of foodborne diseases is 2.43 per one hundred thousand (10).

The location where food raw materials and its products were contaminated, allowing pathogens to survive and multiply, varied in each outbreak. Food raw materials and their products are contaminated during processing, preparation, preservation, and consumption, resulting in an outbreak of foodborne diseases. A study showed that foodborne disease outbreaks in China occurred mainly in food service establishments, homes and schools in 2021 (10). Although the majority outbreaks of foodborne-disease are caused by various food service facility providers, schools and homes are important sites where foodborne diseases have been reported to occur frequently and can affect students of all ages. In the post-COVID-19 pandemic era, takeaway food services are an emerging business in China and have become one of the potential options for college students' campus foods (11). Notably, the takeaway ordering services and food delivery around the school are gaining popularity among students due to their affordability, convenience, and easy accessibility from takeaway platforms, attracting them as a preferred meal option for college students (12). For college students, while it is convenient to eat takeaway foods, there is also a potential impact on both college student health and campus food safety (13, 14).

The majority of foodborne diseases reported cases occur in commercial food service institutions, so food consumers and handlers play a fundamental role in preventing foodborne diseases. Most instances of foodborne disease can be prevented if food consumers and handlers follow the principles of food safety (15, 16). Numerous studies have been focused on the impact assessment of various education and training interventions on the food safety knowledge, attitudes, and actions of food handlers in food service establishments. A meta-analysis of 18 randomized controlled trials and 29 nonrandomized trials has shown that food safety education and training interventions are effective strategies for improving the behaviors and behavioral precursors (e.g., knowledge and attitudes) of food handlers (17).

However, consumer surveys revealed different levels of understanding of foodborne diseases, and the application of this knowledge was also found to be inconsistent. Studies on consumers have shown that foodborne diseases outbroke, attributing to improper food preparation practices, decreased personal hygiene, and a lack of food safety knowledge among consumers (18, 19). In China, college students are a special group of people who are usual both food preparation practices and consumers at school. Common improper practices include long-term storage at room temperature for consumption, cross-contamination of raw ingredients, inadequate cold-holding temperatures, insufficient time and temperature during reheating, inadequate cleaning of utensils, and using of undercooked foods etc. (9, 20, 21).

Student knowledge and practices related to food safety can play a fundamental role in the prevention of foodborne diseases (22). In order to enhance the oversight and control of foodborne disease, the Chinese government enacted the food safety law in 2009, with the second amendment taking place in 2021 (23). Subsequently, the Ministry of Education of the People's Republic of China, the State Administration for Market Regulation of the People's Republic of China, and the National Health Commission of the People's Republic of China all together promulgated regulations on the management of food safety and nutrition and health in schools in 2019 (24).

It is stipulated that the school food processing practices must comply with the school's food safety and nutrition health management regulations. It should guide college students in developing healthy eating habits and good personal hygiene, as well as to improve their awareness and knowledge of food safety, with which is to reduce the risk of food contamination and reduce the occurrence of foodborne illness for themselves (23, 24). Despite a series of action plans in the food safety field including school-food safety in China, the knowledge and practices of students regarding foodborne diseases and food safety were found unsatisfactory. Especially in western China, there was no significant decrease in the overall reporting of foodborne illness among school students (25).

Therefore, it is crucial to evaluate college students' knowledge, attitudes, and practices toward foodborne diseases in order to find ways to reduce the risk of foodborne diseases. However, most foodborne illness studies in China have focused on epidemiology (26, 27), public food establishments (28, 29), investigation of middle schools in rural areas (30), without addressing the knowledge, attitudes, and practices among students in higher education in recent years. In China, the article on foodborne illness studies among the college students was limited to the Henan in 2015 and Chongqing in 2019. In the post-COVID-19 pandemic era, the eating habits of young people have changed significantly, and they are paying more attention to healthy living and food safety. While this study did not obtain a nationally representative sample, it still offered insight into the knowledge, attitudes, and practices of college students in western China, and contributed important data to regional studies in the area in the post-pandemic. This study used the knowledge, attitudes, and

Abbreviations: KAP, Knowledge, attitude and practice; FBDs, Foodborne diseases; SD, Standard Deviations; ANOVA, Analysis of Variance; CI, Confidence Interval; RC, Reference Category.

practices (KAP) tool to assess the KAP level toward foodborne diseases among college students in the western of China, and to identify the factors that influence practice actions.

Materials and methods

Study design and setting

In order to evaluate students' knowledge, attitudes, and practices (KAP) concerning foodborne diseases, a cross-sectional survey was conducted at Xihua University in China from the spring semester to the fall semester, which took place between April and November 2023. The report of this study followed the STROBE checklist for observational studies (Supplementary Table S1).

A cluster random sampling method was used to enroll participants at our university, a public research university with a population of ~41,000 undergraduate students located in Chengdu. Three classes of students from general education courses were randomly selected and included in the study. Then all students in each selected class from freshmen to seniors were included to participate in the study.

Seniors are fourth-year students, juniors are third-year students, sophomores are second-year students, and freshmen are first-year students in university. Freshmen and sophomores are the lower-year undergraduates; juniors and seniors are the upper-year undergraduates. An offline questionnaire was used to generate the surveys. The survey took about 5–8 min to complete, and students who answered fewer than 95% of the questions were excluded from the study.

The inclusion and exclusion criteria of participants

The inclusion criteria for the study were as follows: (a) voluntary participation of all students (b) un-occurred of foodborne diseases in the past 2 months, (c) and no limited to grades and majors including medical students and non-medical students. The exclusion criteria were as follows: (a) unwillingness to participate in the study and (b) the occurrence of foodborne diseases in the past 2 months.

Sample size calculation

A sample size of participants was calculated using Cochran's formula (31), $N = Z^2pq/e^2$. Test significance level was set $\alpha = 0.05$, e is the margin of error at 5% (standard deviation of 0.05), Z is 1.96 at 95% confidence interval, and $q = 1 - p$. According to previous studies on this topic have been conducted in China, the anticipated frequency p has been established at 50% (32). In this study, a minimum sample size of participants was 384. Considering potential dropouts, 450 students were selected for the study.

Ethics

The current study was conducted in accordance with the guidelines of the Declaration of Helsinki. We provided assurances regarding respondents' confidentiality and emphasized the study's voluntary nature. Those participants were assured that the data would be used only for research purposes and informed consent was obtained from all participants (Supplementary Table S2).

Questionnaire design

A questionnaire used to gather data on KAP was based on a literature review of previous studies (33–35). The questionnaire was presented in a Chinese version and then the content validity was evaluated by a microbiologist and two public health experts from the university. The questionnaire included all 47 items, which were divided into four domains (36) (Supplementary Table S3).

The first domain with 9 questions collected sociodemographic data from participants. The sociodemographic variables included gender, age, nationality, educational level, monthly living expenses, specialization type, residence, training on foodborne diseases, and onset within 2 months. The second domain with 10 items assessed participants' knowledges toward foodborne diseases, which included the knowledges of foodborne diseases, food contamination pathways and control. The knowledge section of the questionnaire consisted of "true or false" questions for each item, and a correct response got 1 point for a total of 10 points. The scores of participants who correctly answered the questions were calculated in the knowledge domain. The third domain with 13 items evaluated participants' attitudes toward foodborne diseases in the three-point scale pattern, ranging from agree (positive) to disagree (negative), and a positive attitude got 1 point for a total of 13 points. The scores of participants who positively answered the questions were calculated in this domain. In the fourth domain, a five-point scales with 15 questions was used to assess participants' practices toward foodborne diseases. This section required respondents to indicate whether they never, sometimes, neutral, often, or always engaged in specific behaviors. The score ranged from one (never), two (sometimes), three (neutral), four (often) to five (always) for items of 1, 2, 3, 4, 9, 12, 13, 14, 15, while the score assigned 5 to never, 4 to sometimes, 3 to neutral, 2 to often, and 1 to always for items of 5, 6, 7, 8, 10, 11, and then total practices scores were calculated.

Data analysis

IBM SPSS Statistics version 22 (IBM Corp., Armonk, NY, United States) was used to analyze the data. All data of students' KAP (knowledge, attitudes, and practices) scores were presented as means and standard deviations (SD). The knowledges content and validity were confirmed by experts in their corresponding fields. Cronbach's α was utilized to assess the internal consistency (i.e., reliability), the Kaiser-Meyer-Olkin coefficient and Bartlett's test of sphericity were used to assess the construct validity of the questionnaires (attitudes and practices domains), 0.6 ~ 0.7 or higher is acceptable level (37, 38) and statistical significance was set at $p < 0.05$. The Chi-square test was used to analyze the differences in categorical variables, and the independent sample T-test and one-way analysis of variance (ANOVA) were used to analyze the differences in continuous variables among demographic characteristics. Multiple linear regression was utilized to determine the factors linked to knowledge, attitudes, and

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practices scores regarding foodborne disease. Regression coefficients (β) with 95% CI were employed to measure these associations.

Results

Participants demographic characteristics

A total of 448 (the response rate of 97%) students participated in the study (Table 1). After excluding 3 incomplete questionnaires, 445 questionnaires were included, resulting in an effective recovery rate of 99.3%. The majority of the participants were female (59.1%) and Han Chinese (95.1%). The age of the participants was between 18 and 24 years. Almost two-thirds of the participants (66.7%) were the lower-year undergraduates (freshman and sophomore), and 33.3% were the upper-year undergraduates (junior and senior). Almost four-fives of participants' (87%) monthly living expenses were ranging from 1,000 Yuan to 2,000 Yuan. Most of participants (78.9%) were non-medical students and only 21.1% were medical students. Around 35.3% of the participants were from cities or towns and 64.7% of the participants were from rural area. A majority (91.8%) of participants did not receive any training on foodborne diseases and/or food safety, and only 9.2% of the participants completed any food safety training or courses. All students did not have a foodborne illness in 2 months (Table 1).

Cronbach's alpha coefficient in this study was 0.61 and 0.65 for students' attitudes and practices toward foodborne diseases respectively, which was acceptable level. The Kaiser-Meyer-Olkin coefficient was 0.67 for students' attitudes and Bartlett's test of sphericity was statistically significant ($p < 0.001$, $\chi^2 = 646.39$, and df. = 78), and the Kaiser-Meyer-Olkin coefficient was 0.70 for students' practices and Bartlett's test of sphericity was statistically

TABLE 1 Demographic characteristics and KAP score analysis of the participants.

Variables	Proportion (N = 445)	Frequency (%)	Scores of KAP (mean ± SD)	Statistical value
Gender				
Male	182	40.9%	78.47 ± 7.41	$t = 1.32$, $p = 0.18$
Female	263	59.1%	79.72 ± 6.37	
Age, years				
18 ~ 20 years	313	70.3%	79.38 ± 6.58	$t = 0.01$, $p = 0.99$
≥20 years	132	29.7%	78.81 ± 7.41	
Nationality				
Ethnic minority	22	4.9%	75.63 ± 6.09	$t = -2.53$, $p = 0.01$
Han Chinese	423	95.1%	79.39 ± 6.83	
Educational level				
Lower-year undergraduate	297	66.7%	78.75 ± 6.80	$t = -2.01$, $p = 0.04$
Upper-year undergraduates	148	33.3%	80.13 ± 6.83	
Monthly living expenses				
<1,000 yuan	16	3.6%	77.50 ± 4.95	$F = 6.90$, $p = 0.001$
1,000 ~ 2000 yuan	387	87.0%	78.89 ± 6.71	
>2000 yuan	42	9.4%	82.80 ± 7.57	
Type of specializations				
Non-medical field	351	78.9%	78.64 ± 6.86	$t = -3.43$, $p = 0.001$
Medical field	94	21.1%	81.34 ± 6.34	
Residence				
Cities and towns	157	35.3%	80.62 ± 7.10	$t = 3.24$, $p = 0.001$
Rural area	288	64.7%	78.44 ± 6.57	
Training on foodborne diseases				
Yes	41	9.2%	82.48 ± 6.04	$t = 3.25$, $p = 0.001$
No	404	90.8%	78.88 ± 6.83	
Onset within 2 months				
Yes	0	0	–	
No	445	100%	78.79 ± 6.63	–

Scores of knowledge, attitudes and practices (KAP) were calculated. Independent sample t-test and one-way ANOVA test used for KAP scores toward foodborne diseases. Lower-year undergraduate (freshman + sophomore) and upper-year undergraduate (junior and senior).

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significant ($p < 0.001$, $\chi^2 = 1403.76$, and df. = 105), indicating the acceptable validity of the scale section. The mean score of foodborne diseases KAP was 79.21 ± 6.84 out of 98 (range = 60 to 96). Of the 445 students, 234 students (52.6%) had a high KAP level and scored over 80 points toward foodborne diseases. The study findings showed a significant difference in foodborne diseases KAP score based on the nationality, educational level, monthly living expenses, specialization type, residence, and training on food safety (all, $p < 0.05$) (Table 1).

Knowledge toward foodborne diseases

An assessment of foodborne diseases knowledge of students is summarized in Table 2. 80% ~ 89% of the students were able to accurately comprehend foodborne diseases-related knowledge (Supplementary Table S4). Out of 10 foodborne diseases-related questions, a large proportion (89.3%) of the college students can answer correctly about 7 questions. The mean score of foodborne diseases knowledge was 8.76 ± 0.95 ranging 6 to 10. Of the 455 participants, almost two-thirds of students (65.2%, $n = 290$) had a moderate knowledge level with scores >80%. Most of the participants showed moderate knowledge of foodborne diseases including food contamination pathways and control ways, personal hygiene and habits. But poor knowledge was mainly related to cross-contaminating food with the same knife to cut raw meat and vegetables (Figure 1).

In the demographic characteristics variable comparison, the mean score of foodborne diseases knowledge in the upperclassman (junior/senior) (8.95 ± 0.94) was visible higher than that of the underclassmen (freshman/sophomore) (8.67 ± 0.95) ($p < 0.05$). The mean score of foodborne diseases knowledge in students from the rural areas (8.84 ± 0.90) was noticeable higher than that of students form the cities and towns (8.62 ± 1.04) ($p < 0.05$).

TABLE 2 The scores of foodborne diseases-related knowledge, attitudes and practices among participants.

Variables	Proportion ($N = 445$)	Knowledge scores (mean ± SD)	*p*-value	Attitudes scores (mean ± SD)	*p*-value	Practices scores (mean ± SD)	*p*-value
Gender							
Male	182	8.84 ± 0.89	0.19	10.56 ± 1.71	0.54	59.08 ± 6.93	**0.02**
Female	263	8.71 ± 0.99		10.46 ± 1.58		60.54 ± 6.09	
Age, year							
<20	313	8.73 ± 0.96	0.32	10.44 ± 1.73	0.17	59.61 ± 6.05	0.19
≥20	132	8.83 ± 0.95		10.65 ± 1.37		59.30 ± 6.85	
Nationality							
Ethnic minority	22	8.91 ± 0.81	0.40	10.81 ± 1.13	0.35	55.91 ± 7.00	**0.003**
Han nationality	423	8.76 ± 0.96		10.48 ± 1.66		60.15 ± 6.83	
Educational level							
Freshman+ Sophomore	297	8.67 ± 0.95	**0.005**	10.40 ± 1.77	**0.046**	59.27 ± 6.35	0.21
Junior+ Senior	148	8.95 ± 0.94		10.70 ± 1.31		60.02 ± 6.17	
Monthly living expenses							
<1,000 yuan	16	8.75 ± 1.00	0.12	10.37 ± 1.45	**0.009**	58.37 ± 5.41	**0.003**
1,000 ~ 2000 yuan	387	8.80 ± 0.96		10.42 ± 1.67		59.66 ± 6.35	
>2000 yuan	42	8.48 ± 0.86		10.23 ± 1.12		63.09 ± 7.24	
Type of specializations							
Non-medical field	351	8.73 ± 0.94	0.14	10.42 ± 1.72	**0.015**	59.49 ± 6.86	**0.004**
Medical field	94	8.89 ± 1.02		10.80 ± 1.23		61.63 ± 6.34	
Residence							
Cities and towns	157	8.62 ± 1.04	**0.029**	10.62 ± 1.51	0.25	61.37 ± 6.74	**0.001**
Rural area	288	8.84 ± 0.90		10.43 ± 1.70		59.16 ± 6.24	
Training on foodborne diseases							
Yes	41	8.88 ± 0.90	0.42	10.82 ± 1.33	0.18	62.78 ± 5.59	**0.003**
No	404	8.75 ± 0.96		10.47 ± 1.66		59.65 ± 6.50	

Bold indicates significance at $p < 0.05$, Scores of knowledge, attitudes and practices were calculated, respectively. Independent sample *t*-test and one-way ANOVA test used for knowledge, attitudes and practices scores toward foodborne diseases. For knowledge toward foodborne diseases, each correct answer that was addressed as "True" was marked as 1 point, while "False" responses were given 0 points in this section. For attitudes toward foodborne diseases, each positive response that was addressed as "agree" was marked as 1 point, while "neutral" and "disagree" responses were given 0 points in this section. For practices toward foodborne diseases, 1 = never, 2 = sometimes, 3 = neutral, 4 = often, 5 = always for items 1,2,3,4,9,12,13,14,15 and 5 = never, 4 = sometimes, 3 = neutral, 2 = often, 1 = always for item 5,6,7,8,10,11.

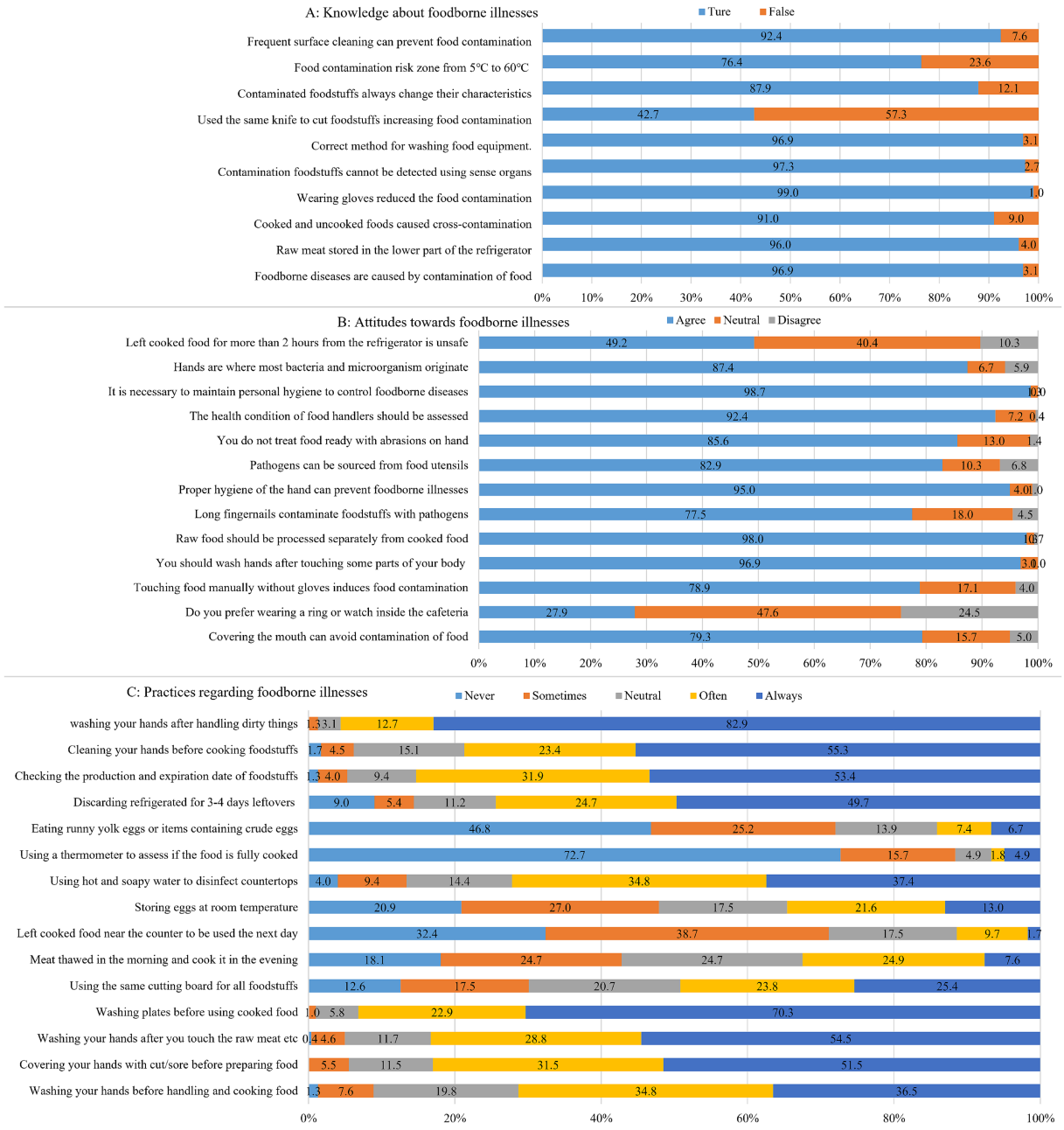


FIGURE 1
Responses to questions related to KAP (knowledge, attitude, and practice) toward foodborne diseases (n = 445). **(A)** Knowledge about foodborne illnesses; **(B)** Attitude toward foodborne illnesses; **(C)** Practice regarding foodborne illnesses.

However, there was no statistical difference in students' knowledge toward foodborne diseases in the variables of gender, age, nationality, monthly living expenses, specialization type and training on food safety (all, $p > 0.05$) (Table 2).

Attitudes toward foodborne diseases

Most of the students (78% ~ 86%) showed positive attitudes toward foodborne diseases (Supplementary Table S5). On a 3-point scale, the overall average score of the questions on attitudes was 10.50 ± 1.63 out of 13, ranging 1 to 13. Among the study participants, 4.9% responded negatively, 14.3% were neutral, and 80.8% had positive attitudes toward foodborne diseases. Only 27.9% of participants believed that wearing a ring or watch would cause food contamination inside the cafeteria. Nearly half of the respondents (49.2%) agreed that leaving cooked food out of the refrigerator for more than 2 h was unsafe. Approximately 78.9% of participants believed that touching food manually without gloves would induce a cross-contamination of foods, and 77.5% of participants expressed that pathogens such as bacteria could contaminate food through long and painted fingernails (Figure 1).

In the demographic characteristics variable comparison, the mean score of attitudes toward foodborne diseases in the upperclassman (junior/senior) (10.7 ± 1.31) was significantly higher than that of the underclassmen (freshman/sophomore) (10.4 ± 1.77) ($p < 0.05$). The average score for attitudes toward foodborne diseases among medical students (10.80 ± 1.23) was significantly higher than that of non-medical students (10.42 ± 1.72) ($p < 0.05$). The attitudes of students with a monthly living expense of 1,000–2000 toward foodborne diseases are more positive, with the highest significant score (10.42 ± 1.67) ($p < 0.05$). There was no statistical difference in students' attitudes toward foodborne diseases in the variables of gender, age, nationality, residence and training on food safety (all, $p > 0.05$) (Table 3).

Practices toward foodborne diseases

Less than half of the students (35% ~ 54%, always) had varied adequate practice, and about one-thirds of the students had inadequate practice toward foodborne diseases (Supplementary Table S6). The mean score of the practices toward foodborne diseases was 59.94 ± 6.48 out of 75, ranging from 41 to 75. Of the 445 participants, slightly more than half (52%, $n = 230$) of students had a better level of practices toward foodborne diseases with scores >80%. As shown in Figure 1, almost 82.9% of the students wash hands after handling dirty things. Before serving cooked food, 70.3% of the students wash bowls and plates used for seafood, poultry and raw meat. Nearly half of the students never eat runny yolk eggs or items containing crude eggs (46.8%), and

TABLE 3 The multiple linear regression of knowledge, attitudes, and practices scores toward foodborne diseases.

Variables	Knowledge level				Attitudes level				Practices level			
	β	*p*-value	95%CI		*β*	*p*-value	95%CI		*β*	*p*-value	95%CI	
			Lower	Upper			Lower	Upper			Lower	Upper
Gender												
Male	RC											
Female	−0.07	0.16	−0.31	0.05	0.01	0.99	−0.30	0.32	0.11	**0.024**	0.18	**2.58**
Age, year												
<20	RC											
≥20	−0.08	0.20	−0.43	0.09	0.01	0.90	−0.41	0.47	−0.14	0.26	−3.61	−0.24
Nationality												
Ethnic minority	0.04	0.40	−0.24	0.59	0.04	0.40	−0.41	1.00	−0.12	**0.012**	−6.15	−0.77
Han nationality	RC											
Educational level												
Freshman+ Sophomore	RC											
Junior+ Senior	0.19	**0.008**	0.10	0.67	0.01	0.85	−0.44	0.53	0.08	0.25	−0.79	2.94
Monthly living expenses												
<1,000 yuan	RC											
1,000 ~ 2000 yuan	0.02	0.86	−0.44	0.53	−0.01	0.86	−0.90	0.76	0.02	0.86	−2.88	3.45
>2000 yuan	−0.09	0.29	−0.87	0.26	0.13	0.13	−0.22	1.70	0.17	0.05	0.05	7.43
Type of specializations												
Non-medical field	0.01	0.89	−0.25	0.29	−0.07	0.25	−0.73	0.19	−0.13	**0.024**	−3.82	−0.27
Medical field	RC											
Residence												
Cities and towns	RC											
Rural area	0.09	0.07	−0.02	0.36	−0.06	0.23	−0.52	0.13	−0.11	**0.015**	−2.80	−0.30
Training on foodborne diseases												
Yes	0.04	0.35	−0.16	0.45	0.06	0.20	−0.19	0.86	0.11	**0.013**	0.53	4.54
No	RC											
Knowledge score	–				0.15	**0.002**	0.10	0.42	−0.04	0.43	−0.87	0.37
Attitudes score	–				–				0.03	0.52	−0.24	0.48
Practices score	–				–				–			

Bold indicates significance at $p < 0.05$. "–"Not included. The R^2 for the model of knowledge score, attitudes score and practice score were 0.05 ($F = 2.42$, $p = 0.011$), 0.06 ($F = 2.71$, $p = 0.003$), and 0.12 ($F = 5.45$, $p < 0.001$), respectively. *β*, Regression coefficient; CI, confidence interval; RC, reference category.

always discard refrigerated leftovers after 3–4 days (49.7%). About 53.4% of the students always check the production date and expiration date and never ate food that deteriorated and expired. However, one quarter of students (25.4%) always use the same cutting board for raw meat, poultry, seafood and vegetables, and 13.0% of the students always long store eggs at room temperature.

In the demographic characteristics variable comparison, the average score of practices toward foodborne diseases was significantly varied by participants' gender, nationality, monthly living expenses, specialization type, residence and training on food safety (all, $p < 0.05$) (Table 2). Male students (59.08 ± 6.93), students from ethnic minorities (55.91 ± 7.00), students with low monthly living expenses (58.37 ± 5.41), non-medical students (59.49 ± 6.86), students from rural areas (59.16 ± 6.24), and students without food safety training, those scored lower in the practices toward foodborne diseases. However, there was no significant difference in students' practices toward foodborne diseases in the variables of age and educational level (all, $p > 0.05$) (Table 2).

Assessment of the variables associated

The multiple linear regression of knowledge, attitudes, and practices scores toward foodborne diseases was showed in Table 3. Data of Pearson correlation showed that students' attitudes regarding foodborne diseases improved as their knowledges of foodborne diseases increased ($p < 0.05$). The data of regression indicated that knowledge of participants was positively associated with their attitudes ($\beta = 0.15$, $p < 0.05$), but not with their practices ($\beta = -0.04$, $p > 0.05$). The regression models showed that upperclassmen (junior and senior) had high knowledge levels on foodborne diseases compared to the underclassmen (freshman and sophomore) ($\beta = 0.19$, $p < 0.05$), which showed that educational level was the significant predictor of knowledge on foodborne diseases. One meaningful factor of attitudes toward foodborne diseases was the knowledge ($\beta = 0.15$, $p < 0.05$). Students with high knowledge levels were appreciably more likely to have a positive attitude toward foodborne diseases. On the other hand, the significant predictors of practices were included gender ($\beta = 0.11$, $p < 0.05$), nationality ($\beta = -0.12$, $p < 0.05$), specialization type ($\beta = -0.13$, $p < 0.05$), residence ($\beta = -0.11$, $p < 0.05$), and training on foodborne diseases ($\beta = 0.11$, $p < 0.05$).

Discussion

Foodborne illnesses continue to be a major public health issue in developing countries (39), and understanding the knowledge, attitudes, and practices (KAP) of individuals, particularly college students, is also crucial for preventing foodborne illnesses. The present study provided valuable insights into the knowledge, attitudes, and practices of foodborne diseases among college students. Overall, this study found a moderate KAP score level among college students in western areas.

The role of college student food consumers plays a crucial part in reducing foodborne diseases. Previous studies have indicated that health literacy levels could effectively assist individuals in preventing and controlling disease (40). Students with adequate health literacy may have higher KAP scores for foodborne diseases, and were more likely to be aware of their responsibility to prevent foodborne diseases and then to adopt beneficial health practices. Students with low health literacy may lack access to valuable health knowledge and struggle to adopt beneficial health practices (41). Although China has made considerable progress in improving health literacy in the last decades (42), foodborne disease health education for college students remains an important means for improving population health. In the study, the identification of only 47.4% of students with a low KAP level suggests that there is still a significant portion of the students that may benefit from targeted educational interventions to improve their understanding and practices related to foodborne diseases.

The study results revealed that participants with differences in nationality, educational level, specialization type, and residence had a substantial variation in overall KAP scores for foodborne diseases ($p < 0.05$). There was a meaningful decline in the KAP score toward foodborne diseases among ethnic minority students, freshman and sophomore students, non-medical students, rural students and students who were not trained in foodborne diseases. However, the findings for demographic characteristics variables are not fully consistent with previous studies in Jordan (43), Greek (44), Kuwait (45), Canadian (46), Bulgaria (47), Saudi Arabia (48), and Ethiopia (33), which may be attributed to differences in study design, questionnaire format, study period, social support, and demographic characteristics. Overall, this suggests that interventions and educational programs targeting foodborne diseases should be tailored to address the specific needs and characteristics of these younger cohorts. Efforts to enhance and promote foodborne diseases training programs are crucial in equipping college students with the necessary knowledge and skills to mitigate foodborne disease risks.

The study found that the participants displayed a moderate level of knowledge regarding foodborne diseases, with the majority answering the knowledge-related questions correctly. The average knowledge score of foodborne diseases varied significantly across different sociodemographic characteristics, consistent with findings in other studies (46–48) on food safety knowledge. However, there were specific areas of poor knowledge, particularly concerning practices such as cross-contaminating food with the same knife to cut raw meat and vegetables, and long-storing eggs at room temperature. Additionally, the study revealed that upperclassmen (junior and senior students) had a higher knowledge level on foodborne diseases compared to the underclassmen (freshmen and sophomore students), indicating that educational level was a significant predictor of knowledge on foodborne diseases.

Attitude is an important factor that can influence perceptions and practices related to foodborne diseases, ultimately leading to a decrease in the occurrence of foodborne illnesses (49, 50). The results showed that students with a high level of knowledge about foodborne diseases were appreciably more likely to have a positive attitude toward foodborne diseases practices. Based on the attitude of all questions, 81% of college students had a positive response toward foodborne diseases, higher than previously estimated levels from an evaluation of food safety education on college students in Henan Province, China, in 2014 (51). This difference might be due to the implementation of regulations on the management of food safety, and nutrition and health in schools in 2019 (24) and improvement in health literacy in the last decades in China (42). This finding underscores the importance of knowledge in shaping individuals' attitudes and perceptions toward foodborne diseases. It also highlights

the potential for targeted educational interventions to improve attitudes and promote safer food practices among college students.

In the current study, there was a moderate level of practices toward foodborne diseases among college students, which aligns with several previous studies in Jordan (52) and Bangladesh (53). Additionally, the study also revealed that individuals with higher monthly living expenses were more inclined to adhere to positive attitudes and good food hygiene practices. Most students showed good habits of avoiding food kept at room temperature for a long time and refusing to eat expired food, which is in line with a prior survey conducted among students from China Chongqing's nursing, education, and medical colleges (32). However, there were areas for improvement, for example, one quarter of students reported practices such as using the same cutting board for vegetables, seafood, and raw meat, and long storing eggs at room temperature, which are known foodborne diseases risks. In particular, male students, ethnic minority students, non-medical students, and students from rural areas showed a lower score in the practices toward foodborne diseases, which suggests the need for targeted interventions to improve specific foodborne diseases practices among college students.

Multiple linear regression analyses (Table 3) showed that gender, nationality, education level, specialization type, residence and training on foodborne diseases were identified as key influencers on foodborne diseases practices, which are consistent with previous studies in China (32), Saudi Arabia (48), Ethiopia (33) and Bangladesh (54). The study found that knowledge of foodborne diseases provokes positively attitudes toward foodborne diseases, consistent with a study on Bangladesh students (47). This underscores the importance of considering these factors when developing interventions to improve foodborne diseases practices among Chinese college students. Targeted educational programs that address specific knowledge gaps and promote positive attitudes toward foodborne diseases practices could be instrumental in improving overall food safety behaviors among this population.

In general, although the participants had a positive attitude, their practice was still sometimes lower than expected. Students should be aware of the importance of good practices in preventing foodborne illness. For example, when buying food, check the production date and shelf life. Wash hands before handling or cooking food and after contact with raw meat, poultry, seafood, or contaminated items. Discard leftovers after 3–4 days in the refrigerator. Use separate cutting boards for raw meat, poultry, seafood, and vegetables. Use clean plates for cooked foods and do not mix raw and cooked foods. Bandage any cuts on your hands before preparing ingredients, etc.

Nonetheless, this study has several limitations. Firstly, the selection of universities utilized a non-probability sampling technique, which could potentially bias the study's findings. Secondly, the sample was obtained from only one university, with a limited number of college students included in the study. Thirdly, the ethnic minority sample used in this study was significantly smaller compared to the Han nationality group, and a more diverse ethnic minority sample should be included in future research. Fourthly, it employed a cross-sectional design, and thereby could not claim causality among the variables studied. Furthermore, given the self-report nature of the measurements employed in this study, there is a risk of social desirability and reporting biases from the respondents. Due to these limitations, the findings of this study cannot be generalized to the entire student population in China.

Conclusion

The present study revealed the insufficient level of knowledge, moderate and acceptable level of practices, but high attitude toward foodborne diseases among these college students in western areas of China. Knowledge, attitudes, and practices varied based on demographic characteristics. To enhance knowledge, attitudes, and practices toward foodborne diseases, factors such as gender, nationality, education level, specialization type, and residence should be considered. Specifically, targeted courses or training on foodborne diseases should be increased for college students to improve their knowledge and practices for reducing foodborne diseases. Subsequent research could also employ qualitative methodologies to obtain a more profound insight into the factors that influence foodborne disease practices.

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 approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. 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

XM: Conceptualization, Funding acquisition, Writing – original draft. LB: Formal analysis, Investigation, Methodology, Writing – review & editing. XZ: Formal analysis, Investigation, Methodology, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1435486/full#supplementary-material

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Knowledge of obstetric danger signs and its associated factors among husbands residing in the Raya Kobo district, Ethiopia

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Background: The term "danger signs" refers to any symptoms or indicators that suggest a pregnant woman may be at risk during pregnancy. Mothers are often burdened with responsibilities, and the majority of them do not even receive treatment for potential complications, which can ultimately lead to the loss of their lives. This situation highlights the barriers that prevent them from being properly prepared for potential risks. In Ethiopia, various studies have been conducted on male involvement in pregnancy, but none have assessed knowledge of obstetric danger signs (ODS). While a few studies have focused on husbands' knowledge of obstetric danger signs, there is still variation in the variables examined.

Objectives: The objective of the study was to assess the level of knowledge about obstetrical danger signs and the associated factors among husbands whose wives were pregnant and gave birth within the last 12 months in the Raya Kobo district, North Wollo, Amara Ethiopia, in 2023.

Methods: A community-based cross-sectional study was conducted from 29 April to 30 May 2023 in the Raya Kobo district. A multi-stage stratified random sampling technique was used to select 626 samples. The data were analyzed using SPSS version 26.00 statistical software. Independent variables with a p-value of ≤0.25 in the bivariate analysis were considered candidates for multivariate analysis, and a p-value of ≤0.05 was considered statistically significant.

Results: Regarding knowledge about obstetric danger signs, 46.3% (95% CI: (42.6 to 50.3%)) of the respondents had good knowledge. The variables significantly associated with knowledge about obstetric danger signs included husbands who attended secondary school (adjusted odds ratio (AOR) = 4.77, 95% CI, (1.42–16.04)), those living in urban areas (AOR = 3.00, 95%CI = (1.59, 7.57)), those with an average monthly income between 3,001 and 5,000 birr (AOR = 3.35, 95% CI = (1.58, 7.12)), and those with more than five children (AOR = 0.15, 95% CI = (0.05–0.46)).

Conclusion and recommendations: The knowledge of obstetric danger signs among husbands in the Raya Kobo district was limited. The educational status of the husband, average family income, residence, and number of children were significantly associated with the husbands' knowledge of obstetric danger signs.

Therefore, these findings highlight the importance of addressing knowledge gaps through targeted educational programs aimed at improving awareness of obstetric danger signs.

KEYWORDS

husbands' knowledge, obstetrical danger signs, cross-sectional, Raya Kobo district, Ethiopia

Introduction

The term "danger signs" refers to any symptoms or indicators that suggest a pregnant woman may be at risk during pregnancy. They are referred to as obstetric danger signs (ODS) and include symptoms such as loss of consciousness, persistent vomiting, severe persistent abdomen pain, vaginal bleeding, swelling of the face, fingers, and feet, blurred vision, severe recurring frontal headache, and high-grade fever (1, 2).

Every pregnant woman is at risk of experiencing unanticipated, sudden problems related to ODS (1, 3). Pregnancy and its related complications remain one of the major causes of maternal morbidity and mortality worldwide, with over half a million women dying each year due to pregnancy-related causes. Almost all of these (87%) maternal deaths occur in low-income countries (3, 4). Direct obstetric factors, such as severe bleeding, pregnancy-induced hypertension, unsafe abortion, labor and delivery difficulties, and maternal infections, account for approximately 73% of all maternal deaths (3).

Developing countries experience a maternal mortality rate that is 15 times higher than that of developed countries, and the global burden of maternal mortality is concentrated in these regions, with sub-Saharan Africa accounting for 56% of all reported maternal deaths (5). Maternal mortality remains a significant public health concern in low- and middle-income countries, particularly in sub-Saharan Africa, where Ethiopia is located. One of the most effective strategies for reducing maternal mortality is the early identification and management of obstetric danger signs, which are critical indicators of potential complications during pregnancy, childbirth, and the postpartum period (6). Timely recognition of obstetric danger signs allows for prompt intervention, preventing life-threatening complications such as preeclampsia, obstructed labor, and hemorrhage (7).

The Sustainable Development Goal 3 (SDG 3) aims to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030. In addition to this target, each country has the responsibility and commitment to achieve a target of no more than 140 maternal deaths per 100,000 live births (8, 9). Although the maternal mortality ratio is decreasing globally, its reduction in sub-Saharan countries is occurring at a much slower rate. According to the 2019 Ethiopia Demographic Health Survey (EDHS) mini-report, the maternal mortality and morbidity ratio in Ethiopia was 402 per 100,000 live births. Of these deaths, 30% were related to obstetrical danger signs during pregnancy (4).

Abbreviations: ANC, Antenatal Care; AOR, Adjusted Odds Ratio; BSc, Bachelor of Science; CI, Confidence Interval; CM, Clinical Midwife; COR, Crude Odd Ratio; EDHS, Ethiopia Demographic Health Survey; HEWs, Health Extension Workers; ICPD, International Conference on Population and Development; ODS, Obstetric Danger Signs; OR, Odd Ratio; RH, Reproductive Health; SBA, Skilled Birth Attendant; SDG, Sustainable Development Goal; SPSS, Statistical Package and Services Solution; WHO, World Health Organization.

Maternal mortality remains a critical health challenge in Ethiopia, particularly in rural areas where access to healthcare services is limited. One of the key factors contributing to the high maternal mortality rate is the delay in recognizing and responding to obstetric danger signs. These signs serve as early warning of potential complications during pregnancy, childbirth, and the postpartum period (10).

In the majority of developing countries, including Ethiopia, the underlying cause of maternal death during pregnancy is attributed to three crucial delays, even when ODS occur: delay in identifying danger signs and making the decision to visit the health facility, delay in reaching the health facility, and delay in receiving appropriate and adequate care at the health facility (1, 2).

The majority of women in Ethiopia have a low social status, and the decision-making power regarding access to and use of care is dominated by men. This factor can significantly contribute to adverse pregnancy outcomes (11, 12). A study conducted by Mbizvo and Say analyzed the factors that reduced maternal mortality in Bangladesh, Morocco, and Rwanda. The findings revealed that maternal mortality rates decreased by 20–50% through increased skilled birth attendance and efforts to educate husbands about obstetric danger signs (30).

Several studies conducted in various regions of Africa (including Nigeria, Tanzania, Kenya, and Ethiopia) showed that male partners had a low level of knowledge about obstetric danger signs during pregnancy and childbirth. Only 22.4 to 56.2% of them were able to identify at least two or more of the listed danger signs (2, 13–15).

When husbands fail to recognize the danger signs during pregnancy, it can affect the health of both the mother and the fetus, leading to conditions such as anemia, infections, prematurely ruptured membranes, neonatal morbidity and mortality, abortion, antepartum hemorrhage, and illness or death of the mothers (5, 16). Moreover, a lack of knowledge regarding obstetric danger signs is associated with a delay in the utilization of skilled care, which contributes to an increase in maternal mortality and morbidity (17).

Husbands, particularly in rural Ethiopia, play a key role in influencing the first two delays. As primary decision-makers in many households, they are often responsible for determining when and whether their wives should seek medical care during pregnancy and childbirth (18). If husbands lack knowledge about obstetric danger signs, such as severe vaginal bleeding, convulsions, and prolonged labor, it can lead to significant delays in recognizing complications and deciding to seek timely care, thereby contributing to poor maternal and neonatal outcomes (10).

The World Health Organization (WHO) advocates for the inclusion of men in maternal health strategies as their participation can lead to better care-seeking behaviors, timely interventions, and improved overall maternal well-being (19). Limited awareness of obstetric danger signs among husbands contributes to delays in seeking care, which is a known factor in increasing the risk of maternal

mortality in rural Ethiopia. However, maternal deaths are influenced by multiple factors (10, 19).

In Ethiopian cultural practices, men are at the top of the decision-making hierarchy, including decisions regarding the healthcare of their spouses. Therefore, they become a major factor in determining where, when, why, and how many pregnant women can access antenatal care, delivery services, and postpartum care. Husbands' knowledge of obstetric danger signs, such as severe headache, severe bleeding, convulsions, and prolonged labor, can directly impact the timeliness of seeking care. Husbands with insufficient knowledge of obstetric danger signs may fail to recognize when their wives are in need of urgent medical attention, leading to delays that could result in adverse maternal or neonatal outcomes.

Various studies have been conducted in Ethiopia on male involvement during pregnancy. Despite the acknowledged importance of male involvement in maternal health, there is limited research on husbands' knowledge of obstetric danger signs. In addition, there is still considerable variation in the variables studied, and no research has been conducted specifically in rural districts such as Raya Kobo.

This study aimed to assess husbands' knowledge of obstetric danger signs in the Raya Kobo district and to identify the factors associated with this knowledge. Understanding these factors can guide public health interventions aimed at improving male engagement in maternal health and help design targeted educational programs to increase husbands' awareness of obstetric danger signs, ultimately reducing delays in care-seeking and improving maternal outcomes.

Therefore, incorporating variables, such as distance from nearby health facilities, and sources of information would help assess husbands' knowledge of obstetric danger signs and the associated factors in the Raya Kobo district.

Methodology

Study area

This study was conducted in the Raya Kobo district, North Wollo Zone, Amara Regional state, Ethiopia, which is 570 Km away from Addis Ababa, the capital city of Ethiopia, and 409 km from Bahir Dar, the capital of the regional state. According to the 2007 Census conducted by the Central Statistical Agency (CSA) of Ethiopia, the district had a total population of 221,958. There were 2,659 pregnant women in the district. The district consists of 37 rural and five urban kebeles. It has 1 hospital, 7 health centers, and 42 health posts. Each health post has two health extension workers (HEWs) (20).

Study design and period

A community-based cross-sectional study was conducted from 29th April to 30th May 2023.

Participants

The source population included all husbands living in the Raya Kobo district whose wives were pregnant or had given birth within the 12 months prior to the study period. The study population consisted of all husbands living in the selected 11 kebeles whose wives were pregnant or had given birth within the 12 months prior to the study period.

Eligibility criteria

Inclusion criteria: all husbands living in the Raya Kobo district for 6 months and above were included in this study.

Exclusion criteria: husbands who were critically ill and unable to participate in the interview during the data collection period were excluded from the study.

Sample size determination

The sample size was determined using a single population proportion formula based on the levels of husbands' knowledge (p = 44%) from a previous study in the Amara region's Andede district (35). The sample size was calculated as follows:

$$\text{vn1} = (Za/2)2\text{p}.qd2 = z2x(1-p)d2$$
$$= \left((1.96)2^{*}\left(0.44^{*}0.56\right)\right)/(0.05)2 = 379$$

Considering a 1.5 design effect and a 10% non-response rate, the total sample size was calculated to be 626.

The second largest sample size was calculated using EP Info V.7, with a maximum result of 189. Therefore, the overall final sample size was determined by considering the first objective, which was 379, a 1.5 design effect, and a 10% non-response rate, resulting in a total sample size of 626.

Sampling technique and procedure

A multi-stage stratified random sampling technique was used to select participants. The district was divided into urban and rural areas, with nine kebeles selected from the rural area and two kebeles from the urban area using random sampling and considering a minimum sample size of 25%. Data on husbands whose wives were pregnant or had given birth within the past 12 months were collected through a survey before the actual data collection. Husbands of mothers who were single, divorced, or widowed in the selected kebeles were excluded from the study. After determining the number of participants, the sample size for each kebele was proportionally allocated, and eligible women were selected using a systematic sampling technique. The interval was determined by dividing the total number of eligible women in the study area, which was estimated to be 1,337, by the sample size of 626, resulting in an interval of 2 (K=N/n, 1,337/626 = 2). The eligible women were initially selected using the lottery method from a list of folders, and after selecting these women, the researchers then proceeded to approach their husbands to administer the questionnaire (Figure 1).

Data collection method

Data were collected using face-to-face interview techniques and structured questionnaires adapted from various studies

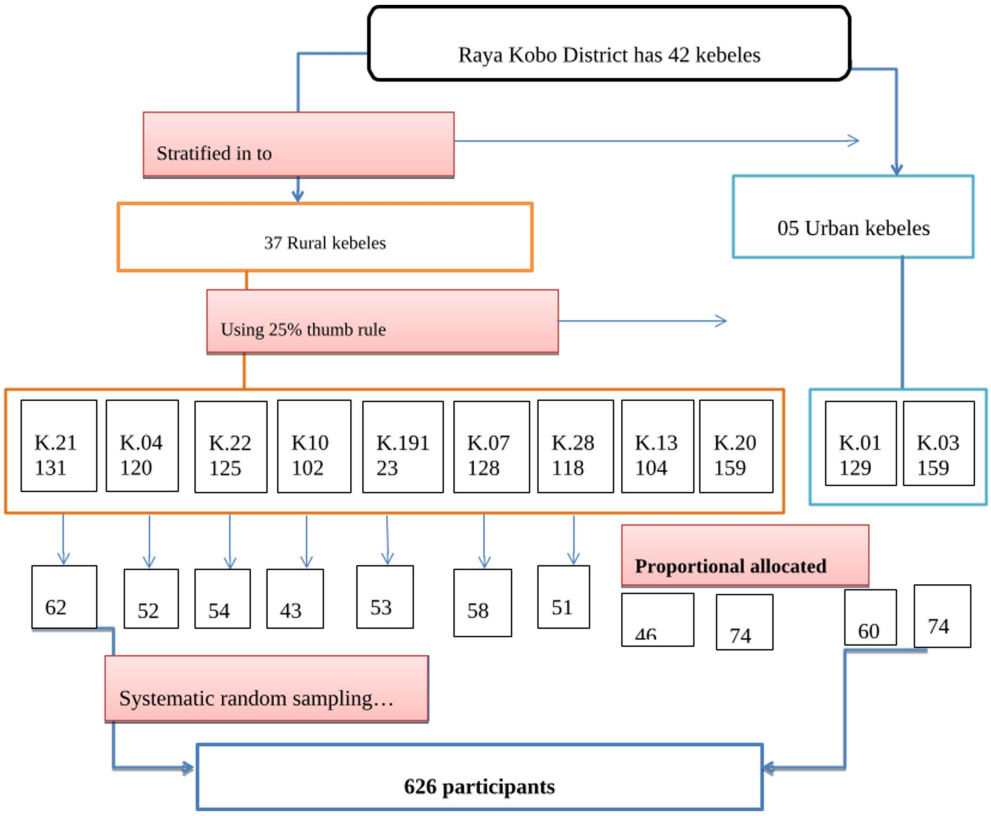


FIGURE 1
Schematic presentation of the sampling procedure.

(19, 21). The information collected included sociodemographic and economic characteristics (maternal age, husband's age, residence, income, educational status of the woman/husband, and occupational status), infrastructure (availability of health facilities and distance from a health facility), obstetrical characteristics (gravidity, parity, and place of delivery), and husbands' awareness of danger signs of obstetric complications at three stages. A total of eight female HEWs and three BSc midwifery graduates were hired as data collectors and were supervised by two MPH students.

Dependent variable: the dependent variable was the husbands' knowledge of obstetric danger signs.

Independent variables: the independent variables included sociodemographic and socioeconomic characteristics (maternal age, husband's age, residence, educational status of the woman/husband, occupational status of the woman/husband, and family income), obstetrical characteristics (gravidity, parity, place of delivery, previous history of danger signs, and male involvement in antenatal care (ANC) follow-up), infrastructure (availability of health facilities and distance from a health facility), and sources of information (radio, TV, decision-making by the husband, and health professionals).

Husbands' good knowledge of obstetrical danger signs: this refers to men who responded to 26 questions about obstetric danger signs during any of the three phases (pregnancy, childbirth, or the post-partum period) and scored above or equal to the median score (20, 22).

Data processing and analysis

Each completed questionnaire was checked manually for completeness before data entry. The data were coded and entered into EpiData (V.4.6), cleaned to check for accuracy and consistency, and any errors identified were corrected. The final data were exported to SPSS (IBM-26) for further cleaning and analysis. Logistic regression was performed, and the variables with a 95% CI and a p-value of <0.05 were considered significant. The strength of the statistical association was determined by the adjusted odds ratio (AOR) and 95% CI. The assumptions of multiple logistic regression were fulfilled, and the goodness of fit was tested using the Hosmer–Lemeshow statistical test (0.12). Multicollinearity was assessed based on the maximum number of variables. The important findings' frequencies, proportions, means, and standard deviations were summarized and presented using tables, figures, and narratives.

Data quality assurance

To maintain the data quality, a reliability test was performed using Cronbach's α, which yielded a value of 0.787. A validity test was conducted by a senior expert, and the Pearson correlation coefficient was calculated using SPSS software. Data collectors received training to further uphold the quality of data. A pretest was conducted on 5% of the study participants from a similar population in the Guba Lafto district, located outside the study area. Based on the pretest feedback,

some questions were rephrased and inappropriate skipping patterns were corrected. The questionnaires were initially prepared in English, then translated into Amharic (the national language), and subsequently translated back into English by two different language experts to ensure consistency and clarity.

Results

Sociodemographic and socioeconomic characteristics of the husbands

Data collection was planned for 626 participants, and 620 completed the interviews, resulting in a resonse rate of 99.04%. The mean age of the respondents was 34.68 (SD ± 6.46) years. A total of 270 (43.5%) respondents were between the ages of 26 and 35 years. Among the study participants, 209 (33.7%) had primary education, while only 55 (8.9%) had attended college or higher education. A total of 408 (65.8%) respondents lived in rural areas (Table 1).

Obstetric characteristics of the respondents

The obstetric characteristics of the respondents were determined based on the condition of their wives, as reported by the husbands. Among the respondents' wives, 492 (79.4%) were pregnant during the data collection. Regarding the number of pregnancies, 511 (82.4%) of

TABLE 1 Distribution of the respondents and their wives by socio-demographic and economic characteristics in the Raya Kobo district, April 2023 (n = 620).

Variable	Characteristic	Frequency	Percentage (%)
Age of the respondent	25 and below	66	10.7
	26–35	270	43.5
	36–45	217	35.0
	46 and above	67	10.8
Age of the wife	24 and below	145	23.4
	25–29	303	48.9
	30–34	92	14.8
	35 and above	80	12.9
Educational status of the husband	Unable to read and write	45	7.3
	Able to read and write	159	25.6
	Primary school	209	33.7
	Secondary school	152	24.5
	College and above	55	8.9
Educational status of the wife	Unable to read and write	86	13.8
	Able to read and write	147	23.7
	Primary school	267	43.1
	Secondary school	81	13.1
	Collage and above	39	6.3
Occupational status of the husband	Farmer	346	55.8
	Governmental employee	155	25.0
	Merchant	60	9.7
	Daily labor	59	9.5
Occupational status of the wife	Housewife	412	66.5
	Governmental employee	93	15.0
	Merchant	107	17.2
	Daily labor	8	1.3
Average family income	1,500 birr and below	145	23.4
	1,501–3,000 birr	268	43.2
	3,001–500 birr	102	16.5
	5,001 birr and above	105	16.9
Residence	Urban	212	34.2
	Rural	408	65.8

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TABLE 2 Distribution of the respondents and their wives by obstetric characteristics in the Raya Kobo district, April 2023.

Variable	Characteristics	Frequency	Percentage (%)
Current status of their wives (n = 620)	Pregnant	492	79.4
	Breastfeeding	128	20.6
Husbands' involvement during the ANC visit (n = 620)	Yes	376	60.6
	No	244	39.4
Number of gravidity (n = 620)	Primigravida	109	17.6
	Multigravida	511	82.4
Place of birth of the last delivery (n = 449)	Home	91	20.27
	Health facility	358	79.73
History of obstetric complication (n = 511)	Yes	155	30.33
	No	356	69.67
Number of children (n = 620)	2 and below	282	45.5
	3 and 4	227	36.6
	5 and above	111	17.9

TABLE 3 Availability of a health facility and the time it takes to reach it in the Raya Kobo district, 2023.

Variable	Character	Frequency	Percentage
Availability of a health facility (620)	Yes	600	96.8%
	No	20	3.2%
The time it takes to reach the nearest health facility (600)	30 min and below	216	36%
	>30 min above	384	64%

the respondents' wives were multigravida, and 376 (60.6%) husbands helped their wives comply with the instructions received at health institutions during ANC visits. The majority of the respondents, 600(98.6%), reported that there was a health facility available in their kebeles, but only 99 (16.0%) of them lived within 30 min of a health facility. Similarly, 108 (17.4%) of the respondents needed to walk distances greater than 90 min (Table 2).

Infrastructure-related factors

Of the respondents, 600 (96.8%) reported that health facilities were available in their kebeles, and only 216 (36%) of the respondents reported that it took them less than 30 min to reach the nearest health facility (Table 3).

Sources of information

The findings of this study indicated that the majority of the participants, 247(39.8%), who gathered information about obstetric danger signs received it from health professionals (Figure 2).

Knowledge of obstetric danger signs

The knowledge of obstetric danger signs among the respondents was calculated for each period using the median score cut-off point of 34. It was categorized as "good knowledge" when the average score was above the median score, and it was categorized as "poor knowledge" when the average score was below the median score. Of all respondents, 46.3% (95% CI: 42.6–50.3) had good knowledge (Figure 3).

Knowledge of obstetric danger signs during pregnancy, delivery, and postpartum periods

When computing the phase one variable to identify those above the median score, 261 (42.1%) of the respondents, with a 95% CI of (38.1, 46.0), had good knowledge during the postpartum period. In this phase, severe vaginal bleeding after delivery was reported to be a high-scoring obstetric danger sign, mentioned by 348 (56.1%), while severe weakness was reported to be a lower-scoring obstetric danger sign, mentioned by 185 (29.8%). In another computed variable, 36.6% of the respondents had good knowledge throughout pregnancy. A total of 422(68.1%) respondents mentioned membrane rupture before labor and 411 (66.3%) respondents mentioned severe vaginal bleeding as high-scoring obstetric danger signs, while 92 (14.8%) mentioned difficulty breathing as a lower-scoring obstetric danger sign. Lastly, during delivery, 26% of the husbands mentioned in phase two had a median score. A total of 301 (48.1%) identified placenta retention (placenta not detaching before 30 min) as the highest-scoring obstetric danger sign, while 106 (17.1%) mentioned high-grade fever as a lower-scoring danger sign (Table 4).

Factors associated with the husbands' knowledge of obstetrical danger signs

To identify the factors associated with the husbands' knowledge of obstetric danger signs, binary and multivariable logistic regression analyses were conducted with the dependent and independent variables. In the binary logistic regression, the age of the husband, the occupation of the husband, the level of education of the husband,

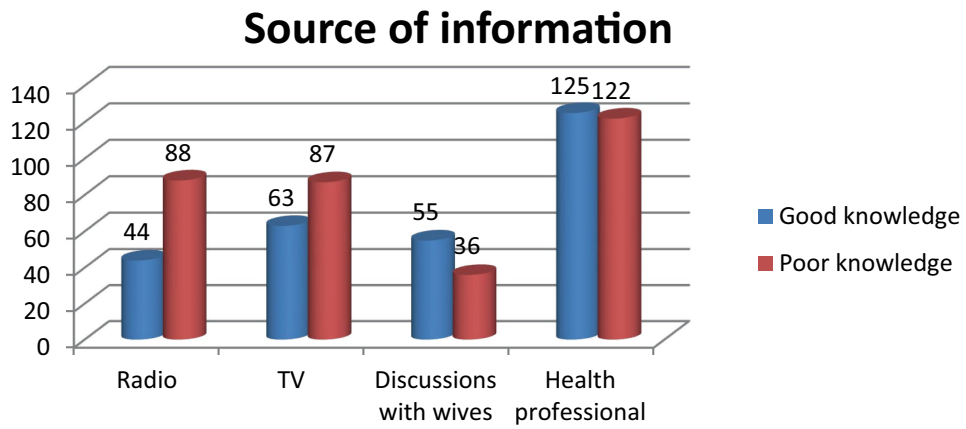


FIGURE 2
Source of information for the husband on ODS in Raya Kobo district, April (2023).

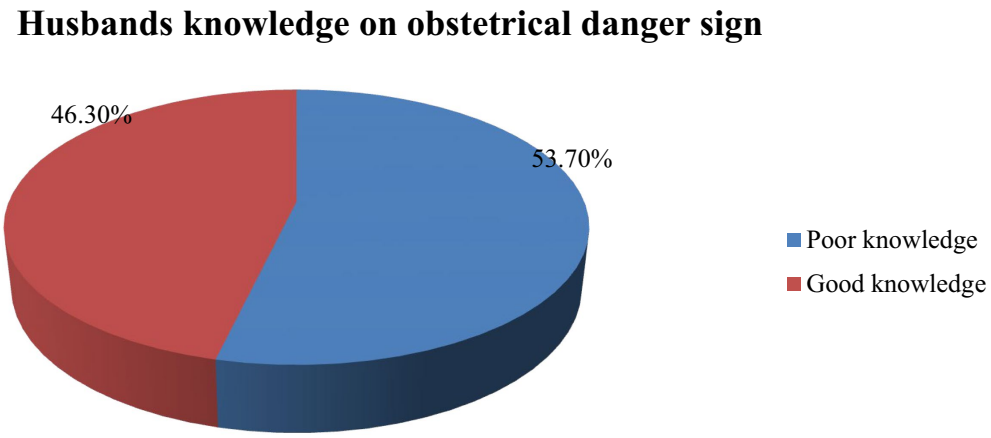


FIGURE 3
Knowledge of obstetric danger signs among husbands in the Raya Kobo District April 2023.

family income, residence, the husband's involvement in ANC visits, the wife's history of bad obstetric signs, number of children, and the level of education of the wife were significantly associated with the husbands' knowledge of obstetric danger signs.

The multivariable analysis was performed to identify independent predictors of the husbands' knowledge regarding obstetrics danger signs. After controlling for possible confounders, the husband's education, residence, number of children, and family income were identified as the independent predictors of the husbands' knowledge of obstetrics danger signs in the Raya Kobo district. These results also showed that the husbands who had secondary school education were 4.8 times (AOR = 4.77, 95% CI, (1.42–16.04)) more likely to have good knowledge of obstetrics danger signs than those who were unable to read and write.

The husbands in families with more than five children were 85% (AOR = 0.15: 95% CI; (0.05–0.46)) less likely to have good knowledge of obstetric danger signs compared to those with fewer than two children. The husbands with an average monthly income of 3,001–5,000 birr were 3.4 times (AOR = 3.35, 95% CI = (1.58, 7.12)) more likely to have good knowledge compared to those with an average monthly income of less than 1,500 birr. The husbands living in urban areas were 3 times (AOR = 3.00, 95%CI = (1.59, 7.57)) more likely to have good knowledge than those living in rural areas (Table 5).

Discussion

The findings of this study indicated that the magnitude of the husbands' knowledge of obstetric danger signs in the overall combination of three phases (prenatal period, childbirth, and postnatal period) was 46.3%, with a 95% CI of 42.6 to 50.3%. This finding is lower than that in Nigeria, where research conducted in two different study areas found that 53.8 and 51.9% of men had good knowledge of obstetric danger signs in pregnancy, as well as 53.3% in Dessie (12, 21, 22). This variation may be due to socio-economical differences between the studies conducted in Nigeria and this study, where the majority of the participants lived in rural areas that had less access to sources of information about obstetric danger signs and a lower likelihood of wives attending ANC follow-up visits, which would provide opportunities for sharing knowledge on danger signs.

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TABLE 4 Knowledge of obstetric danger signs during pregnancy, delivery, and postpartum periods among the husbands in the Raya Kobo district, April 2023.

Variable	Frequency (Yes)	Percentage (%)
Part 1: during pregnancy		
Severe vaginal bleeding	411	66.3%
Severe headache	280	45.2%
Blurring of vision	216	34.8%
Convulsion	204	32.9%
Swelling of hand and face	153	24.7%
High-grade fever	101	16.3%
Difficulty breathing	92	14.8%
Severe weakness	100	16.1%
Severe abdominal pain	243	39.2%
Reduced fetal movement	243	39.2%
Membrane rupture	422	68.1%
Part 2: during delivery		
Vaginal bleeding	205	33.1%
Severe headache	129	20.8%
Convulsion	111	17.9%
High-grade fever	106	17.1%
Labor >12 h	266	42.9%
Placenta not detached after 30 min	301	48.5%
Part 3: during postpartum		
Severe vaginal bleeding	348	56.1%
Severe headache	226	36.5%
High-grade fever	187	30.2%
Offensive vaginal discharge	229	36.9%
Convulsion	203	32.7%
Severe weakness	185	29.8%
Blurring of vision	197	31.8%
Swelling of hand and face	199	32.1%
Difficulty breathing	236	38.1%

However, this finding was higher than the findings of studies conducted in the Musoma district, Mara region, Tanzania (32%) and southern Ethiopia (42.2%) (23).

Possible reasons for the higher prevalence and the differences observed might include healthcare system disparities between the countries, especially the utilization of community mobilization on maternal health in Ethiopia by health extension workers. Additionally, the time gap between studies may have contributed, as wives' utilization of maternal care may have improved, which in turn could have led to an increase in husbands' knowledge of danger signs. The study found that the husbands who had completed secondary school were 4.8 times (AOR = 4.77, 95% CI, (1.42–16.04)) more likely to have good knowledge of obstetric danger signs than those who were unable to read and write. This finding is in line with a study conducted in Southwest Nigeria (24). This may be due to the fact that education is an important tool for increasing understanding and access to information about obstetric danger signs and their outcomes through various electronic media. In addition, closer collaboration between schools and local health services may enhance the delivery of reproductive health education. The place of residence was significantly associated with the husbands' knowledge of obstetric danger signs. The husbands living in urban areas were 3 times (AOR = 3.00, 95%CI = (1.59, 7.57)) more likely to have good knowledge than those living in rural areas. This finding is similar to a study conducted in the Andede district (25). This could be because the respondents living in urban areas in the present study had greater access to information compared to those in rural areas, as most messages are transmitted through various media available in urban settings. However, this finding is in contradiction with a study conducted in the Chencha district, Gamo Gofa Zone, southern Ethiopia, which showed that husbands living in rural areas were 8.4 times more knowledgeable than those living in urban areas (11). This discrepancy may be due to the fact that the husbands living in rural areas in this study had limited sources of information and lower educational backgrounds compared to those living in urban areas.

The number of children in this study was a significant factor associated with the husbands' awareness. The husbands in families with more than five children were 85% times (AOR = 0.15; 95% CI: 0.05–0.46) less likely to have good knowledge of obstetric danger signs compared to those with fewer than two children. The finding is consistent with a study conducted in Tanzania (26).A possible reason for this is that husbands with many children tend to prioritize income generation, leading to longer working hours and multiple sources of employment (27). This situation leaves them with limited time to attend antenatal care (ANC) visits or to recognize and respond to obstetric danger signs, such as prolonged labor, severe bleeding, or reduced fetal movement, all of which require immediate attention. However, a study conducted in Nigeria showed no significant difference in the knowledge of danger signs regarding the number of children in the family (28). The reason for this discrepancy may be the large sample size used as larger sample sizes increase the probability of detecting associations between variables.

The total average monthly income of the family was also a factor associated with the husbands' knowledge of obstetric complications. The husbands with an average monthly income of 3,001–5,000 birr were 3.4 times (AOR = 3.35, 95% CI = (1.58, 7.12)) more likely to have good knowledge compared to those with an average monthly income of less than 1,500 birr. This finding is in line with studies conducted in South Ethiopia and Uganda, where economic status was also significantly associated with men's awareness of danger signs of obstetric complications (28, 29). This may be because men with higher economic status are more likely to be exposed to health education provided by health institutions. In addition, they can afford radios, TVs, and other media to access more information about maternal health. Higher-income households tend to exhibit better health-seeking behaviors and greater engagement in maternal health, as they are less constrained by financial limitations. This access to information and services enables them to pay more attention to their wives' pregnancies, increasing the likelihood of early recognition and intervention in the case of obstetric danger signs.

Strengths and limitations of this study

The study was community-based, which allowed it to reflect the experiences of the husbands during the study period. It also utilized a

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TABLE 5 Multivariate and bivariate logistic regression analyses showing factors independently associated with the husbands' knowledge of obstetrics danger signs in the Raya Kobo district, 2023.

Characteristic with Variable		Knowledge		COR (95% CI)	AOR (95% CI)
		Good knowledge	Poor knowledge		
Age of the respondent	25 and below	34 (51.5)%	32 (48.5)%	1	1
	26–35	141 (52.2)%	129 (47.8)%	1.03 (0.60–1.67)	0.82 (0.35–1.95)
	36–45	93 (42.9)%	124 (57.1)%	0.71 (0.41–1.23)	1.20 (0.44–3.29)
	46 and above	19 (29.4)%	48 (71.6)%	0.34 (0.18–0.76)	1.96 (0.51–7.54)
Husbands' education	Unable to read and write	15 (33.4%)	30 (66.6%)	1	1
	Able to read and write	43 (27%)	116 (73%)	0.74 (0.36–1.51)	1.43 (0.55–3.71)
	Primary school	74 (35.4%)	135 (64.6%)	1.09 (0.55–2.17)	1.79 (0.59–5.42)
	Secondary school	117 (75%)	38 (25%)	**6.16 (3.24–13.8)**	**4.77 (1.42–16.04)***
	Collage and above	38 (69.1%)	17 (30.9)	4.47 (1.92–10.39)	1.65 (0.45–6.05)
Husbands' occupation	Farmer	96 (27.7)%	250 (72.3)%	1	
	Government employee	109 (69.3)%	46 (29.7%)	6.17 (4.06–9.37)	1.57 (0.81 to 3.05)
	Merchant	44 (73.3)%	16 (26.7)%	7.16 (3.86–13.3)	2.16 (0.9 to 5.17)
	Daily labor	38 (64.4)%	21 (35.6)%	4.7 (2.63–8.44)	1.23 (0.54 to 2.8)
Residence	Urban	159 (75)%	53 (25)%	**6.56 (4.51–9.54)**	**3.00 (1.59–5.57)****
	Rural	128 (21.4)%	280 (68.6)%	1	1
Husbands' involvement in the ANC visit	No	85 (34.8%)	159 (65.2%)	1	1
	Yes	202 (53.7%)	174 (46.3%)	2.17 (01.56–3.02)	1.73 (0.81 to 3.68)
History of obstetric danger signs	No	150 (42.4%)	206 (57.6%)	1	1
	Yes	78 (49.4%)	80 (50.6%)	0.78 (0.53–1.13)	1.22 (0.54 to 2.74)
Number of children	2 and below	168 (59.9)%	114 (40.2)%	1	1
	3 and 4	94 (41.4)%	133 (58.6)%	0.48 (0.34–0.68)	0.79 (0.45–1.41)
	5 and above	25 (22.5)%	86 (77.5)%	**0.20 (0.12–0.33)**	**0.15 (0.05–0.46)***
Family income	1,500 birr and below	37 (24.5)%	108 (74.5)%	1	1
	1,501–3,000 birr	92 (34.3)%	176 (65.7)%	1.53 (0.97–2.39)	1.15 (0.67–1.99)
	3,001–500 birr	76 (74.5)%	26 (25.5)%	**8.53 (4.77–15.26)**	**3.35 (1.58–7.12)***
	5,001 birr and above	82 (78.1)%	23 (21.9)%	10.41 (5.74–18.85)	1.68 (0.66–4.26)

*significant at p value < 0.05, **significant at p value < 0.01.

large sample size, making the findings more representative. However, a limitation of the study is the potential for recall bias, even though the recall period was reduced to 1 year. The husbands were asked to remember events that occurred up to 1 year before the study, and the data were collected by having them mention the obstetric danger signs they knew and the activities they had undertaken, without providing them with options to choose from.

Conclusion

The husbands' knowledge of obstetric danger signs in the Raya Kobo district was limited. Severe vaginal bleeding was the most frequently identified obstetric danger sign during the antepartum, intrapartum, and postpartum periods. The educational status of the husband, average family income, residence, and number of children were significantly associated with the husbands' knowledge of obstetric danger signs. These findings highlight the importance of addressing knowledge gaps through targeted educational programs aimed at improving awareness of obstetric complications. Enhancing this awareness among husbands could play a crucial role in promoting timely healthcare-seeking behaviors and improving maternal health outcomes in the study area.

Data availability statement

The data sets used or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics statement

The studies involving humans were approved by the Institutional Review Board (IRB) of Debre Berhan University,

Asrat Woldeys Health Science Campus, who granted ethical approval under reference number IRB01/74/2015. The Official letter was written for Amara Public Health Institute to Raya Kobo District health offices and informed verbal consent was taken from individual participants. No form of identifier was included in the questionnaires to maintain confidentiality. Participation was voluntary and participants were informed that they could withdraw from the study at any stage if they desired, without any penalty. At the end of the interview, information was given about the danger signs of obstetric complications at three stages (during pregnancy, labor and childbirth, and the postpartum period). 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

JD: Data curation, Project administration, Visualization, Writing – original draft, Writing – review & editing. AY: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. AMi: Conceptualization, Formal analysis, Methodology, Software, Validation, Writing – original draft, Writing – review & editing. AA: Conceptualization, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. AMo: –. NS: Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. BM: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing.

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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.

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Awareness of lung cancer among urban residents in Sichuan Province and its impact on their willingness to choose medical institutions for cancer screening

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Introduction: This study aimed to investigate the current level of knowledge about lung cancer among urban residents in Sichuan Province and to assess its influence on their willingness to choose county-level or lower-level medical institutions for cancer screening.

Methods: A total of 31,184 urban residents of Sichuan Province were included in the cross-sectional study. Binary logistic regression and propensity score matching (PSM) were used to assess the influence effect.

Results: The results showed that (1) only 23.88% of the residents self-reported having good knowledge about lung cancer. They mainly acquired knowledge from the media (43%) and medical staff (42%). Only 33.5% of the participants had undergone lung cancer screening, with the main reasons being periodic physical examinations (54%) and physician recommendations (23%). (2) Binary logistic regression analysis revealed that knowledge of lung cancer was significantly associated with the participants' willingness to undergo lung cancer screening at county-level or lower-level medical institutions [OR = 1.185, 95% CI (1.113 -1.263), $p < 0.001$]. (3) Using PSM, it was found that the willingness of residents who had good knowledge of lung cancer-related topics increased by 2.8% after using kernel matching, by 3.1% after using one-to-one nearest neighbor matching, and by 2.4% after using radius matching with a caliper size of 0.001. (4) After stratifying by psychological status, we found that among residents with unstable psychological status, the willingness of those who had good knowledge of lung cancer increased by 5.3% after using kernel matching, by 3.6% after using one-to-one nearest neighbor matching, and by 4.9% after using radius matching with a caliper size of 0.001.

Discussion: Improving urban residents' understanding of the disease could help improve the current situation of hierarchical diagnosis and treatment.

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KEYWORDS

awareness of lung cancer, cancer screening, county or below medical institutions, hierarchical diagnosis and treatment system, propensity score matching

1 Introduction

Cancer is one of the leading causes of death and economic burden in China (1). The combination of early detection, diagnosis, and treatment is key to achieving higher efficiency in China's healthcare system, particularly in the context of limited resources (2). Currently, the majority of cancer screening techniques are simple, and common cancer screening modalities are available at all levels of medical institutions. For instance, the ThinPrep cytology test for cervical cancer screening and the fecal occult blood test for colorectal cancer screening are commonly available in county-level or lower-level medical institutions (3, 4). Encouraging patients to seek medical services at these institutions could play a significant role in regulating patients' therapeutic plans, controlling medical and healthcare expenditures, and improving the efficiency of medical and healthcare services (5–7). Moreover, enhancing the capacity of county-level or lower-level medical institutions for cancer screening can reduce the burden on larger hospitals and ensure coverage for the majority of residents.

Lung cancer is the leading cause of cancer-related morbidity and mortality in China (8, 9). It has the highest incidence rate in China, placing a significant social and economic burden on the public health system. Numerous studies have shown that low-dose spiral CT (LDCT) is associated with significantly lower lung cancer mortality and all-cause mortality rates in China (10–12). However, due to China's large population, implementing lung cancer screening programs requires substantial efforts. Lung cancer screening in county-level or lower-level medical institutions can significantly reduce the burden on high-level hospitals by targeting high-risk groups. This approach also improves the allocation of medical resources.

In October 2014, Sichuan Province officially implemented the hierarchical medical system, aiming to address the structural imbalance in the allocation of medical and healthcare resources. However, some studies have indicated that the proportion of primary care visits has not significantly increased since the implementation of the policy (13). Upon reviewing the recent literature on the hierarchical medical system, we found that few studies have examined the impact of residents' disease awareness on their choice of medical institutions. Numerous behavioral theories suggest that cognition is closely related to behavior (14–17). Based on this, we proposed a hypothesis that residents' awareness of the disease may influence their choice of clinical medical institutions. According to the Appraisal-Tendency Framework (ATF), anxious individuals exhibit distinct behavioral preferences in decision-making, often opting for more conservative and safer strategies to reduce uncertainty and minimize potential negative outcomes (18, 19). Therefore, we hypothesized that residents with different mental states may make different medical treatment decisions.

To test our hypothesis, this study aimed to explore how urban residents' awareness of lung cancer influences their choice of medical institution for screening. In addition, it assessed the participants' willingness based on their psychological stability.

2 Materials and methods

2.1 Participants

This study was cross-sectional, and convenience sampling was employed, with each participant completing a questionnaire. From March to November 2021, a simple random sampling method was used to select residents from physical examination centers in hospitals across various municipalities in Sichuan Province. Sichuan Province has 21 municipalities; however, due to the limited population in Ganzi Prefecture and Aba Prefecture, participants were randomly selected from the remaining 19 municipalities based on the total resident count. The resident population data were obtained from the *Sichuan Provincial Health Statistical Yearbook 2020* (20). The paper version of the questionnaire was sent to the residents by the investigators. After removing some missing values, 31,184 participants remained. Criteria were as follows: (1) age greater than 18 years; (2) voluntary participation; and (3) availability of CT equipment and professional imaging physicians for lung cancer screening at county-level or lower-level medical institutions, where the residents live.

2.2 Data collection

This study used a self-assessment questionnaire to collect data on the following: age, sex, ethnicity, education level, occupation, type of medical insurance, commercial insurance status, average income per person per month, acceptable screening costs, smoking status, family history of cancer, knowledge about lung cancer, willingness to undergo lung cancer screening at county-level or lower-level medical institutions, and psychological status. In this study, the acceptable screening costs for lung cancer screening were measured by the question: "How much is the most you are willing to pay for lung cancer screening?" The responses were categorized into the following five levels: less than 100 yuan, 101–200 yuan, 201–300 yuan, 301–400 yuan, and more than 400 yuan. Their knowledge about lung cancer was measured by the following yes–no question: "Do you know about lung cancer?" Their willingness to undergo lung cancer screening at a county-level medical community institution was measured by the following yes–no question: "Are you willing to choose county-level or lower-level medical institutions for lung cancer screening?" The psychological status was measured by the following yes–no question: "Do you feel anxious because of abnormal physical examination results?"

2.3 Statistical analysis

SPSS version 23 was used for data analysis. Data with a normal distribution were presented as mean ± SD. Student's *t*-test was used to compare two independent samples. Qualitative features were presented as frequencies and percentages and compared using the chi-squared test. Binary logistic regression was used for multi-factor analysis.

After the binary logistic regression analysis, propensity score matching (PSM) was performed for robustness testing using Stata 15.0. The propensity score (PS) for an individual is defined as the probability of being assigned to the "treatment" group, given all relevant covariates. The PS is typically estimated using a logistic regression model that incorporates all variables that may be related to the outcome and/or the treatment decision (21, 22). In this study, knowledge of lung cancer was treated as an independent variable. We grouped the residents according to this variable. The outcome was a willingness to undergo lung cancer screening at county-level or lower-level medical institutions. The covariate factors included age, sex, ethnicity, education level, occupation, type of medical insurance, commercial insurance, average

income per person per month, acceptable screening cost for lung cancer screening, smoking status, and family history of cancer.

We used kernel matching as the main method. To verify whether different matching methods affected the results, 1:1 nearest neighbor matching and radius matching with a caliper size of 0.001 were applied. Finally, psychological status was used as a stratification variable, and the participants were grouped based on their psychological status.

TABLE 1 Basic situation of awareness about lung cancer.

Variable	Frequency (*n*)	Percentage (%)
Good understanding of lung cancer		
Yes	7,446	23.88
No	23,738	76.12
Lung cancer screening experience		
Yes	10,436	33.5
No	20,748	66.5
Total	31,184	100.0

3 Results

3.1 Awareness of lung cancer-related knowledge

A total of 31,184 respondents were included in this study. Based on their responses, only 7,446 (23.88%) participants had a good understanding of lung cancer (Table 1). The main sources of their knowledge about lung cancer were the media (43%) and medical staff (42%; Figure 1). Of the 31,184 respondents, 10,436 (33.5%) had undergone low-dose spiral CT (LDCT) screening for lung cancer (Table 1). Among these 10,436 respondents, the main reasons for undergoing LDCT screening were regular physical examinations (54%), followed by medical staff recommendations (23%; Figure 2).

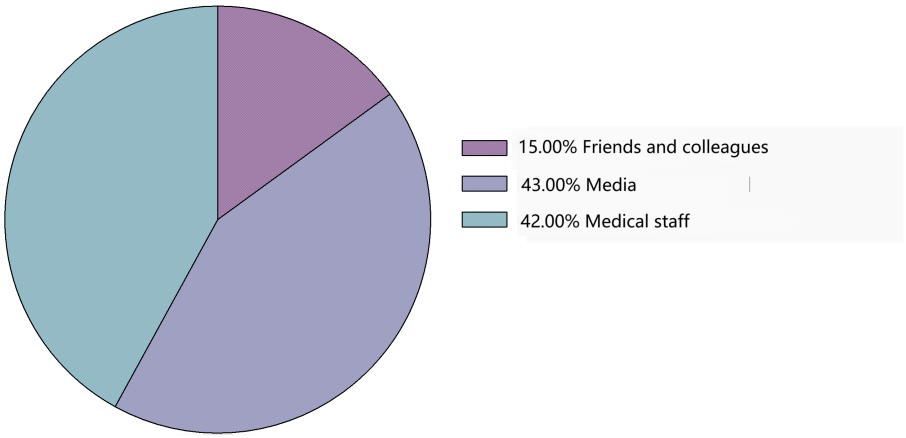


FIGURE 1
Sources of knowledge about lung cancer.

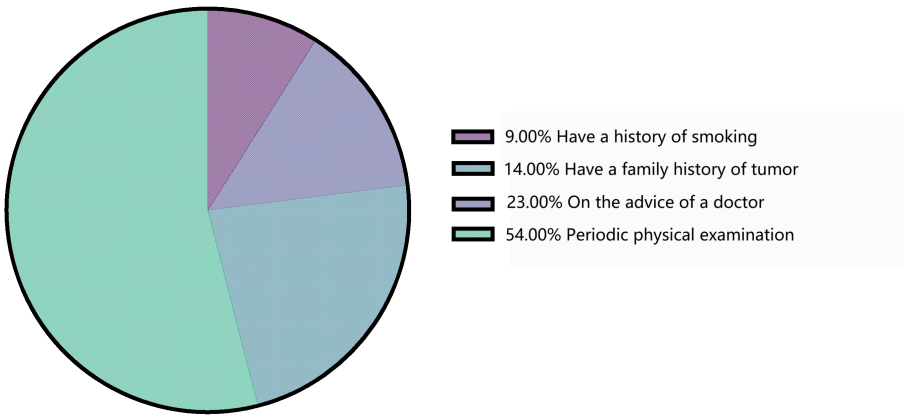


FIGURE 2
Reason for lung cancer screening.

TABLE 2 Characteristics of the participants.

Variables	County-or lower-level hospitals (n = 7,198)	Higher-level hospitals (n = 23,986)	χ^2/T	p-value
Age	40.45 ± 14.209	40.69 ± 13.640	−1.301	0.193
Sex [n (%)]			2.329	0.127
Male respondents	3,791 (23.4)	12,387 (76.6)		
Female respondents	3,407 (22.7)	11,599 (77.3)		
Ethnicity [n (%)]			3.665	0.056
Han	6,963 (23.0)	23,307 (77.0)		
Minority	235 (25.7)	679 (74.3)		
Education [n (%)]			408.130	<0.001
High school or lower	2,202 (30.9)	4,935 (69.1)		
College /Junior college	4,421 (21.9)	15,740 (78.1)		
Master's degree or higher	575 (14.8)	3,311 (85.2)		
Occupation [n (%)]			132.733	<0.001
Government or public institution	2,752 (24.5)	8,460 (75.5)		
Private enterprises	3,481 (21.2)	12,702 (78.8)		
Self-employed entrepreneur	273 (19.7)	1,111 (80.3)		
Student or jobless	755 (30.6)	1713 (69.4)		
Medical insurance [n (%)]			6.164	0.013
Medical insurance for urban and rural residents	1944 (22.1)	6,838 (77.9)		
Basic medical insurance for urban workers	5,254 (23.5)	17,148 (76.5)		
Commercial insurance [n (%)]			97.808	<0.001
Yes	576 (16.4)	2,926 (83.6)		
No	6,622 (23.9)	21,060 (76.1)		
Monthly income [n (%)]			727.526	<0.001
<3,000 yuan	1,344 (34.5)	2,554 (65.5)		
3,000–4,000 yuan	1,650 (29.5)	3,938 (70.5)		
4,000–5,000 yuan	1,574 (24.7)	4,801 (75.3)		
≥5,000 yuan	2,630 (17.2)	12,693 (82.8)		
Acceptable screening costs [n (%)]			100.926	<0.001
<100 yuan	1,137 (32.3)	2,386 (67.7)		
101–200 yuan	1802 (28.1)	4,620 (71.9)		
201–300 yuan	2,250 (25.2)	6,671 (74.8)		
301–400 yuan	1,061 (20.9)	4,016 (79.1)		
>400 yuan above	948 (13.1)	6,293 (86.9)		
Smoking [n (%)]			0.135	0.713
Yes	1896 (23.2)	6,266 (76.8)		
No	5,302 (23.0)	17,720 (77.0)		
Family history of tumors [n (%)]			16.335	<0.001
Yes	1,142 (21.0)	4,300 (79.0)		
No	6,056 (23.5)	19,686 (76.5)		
Psychological status [n (%)]			19.583	<0.001
Stable	2,332 (24.8)	7,074 (75.2)		
Unstable	5,178 (23.8)	16,600 (76.2)		

TABLE 3 Factors associated with the choosing willing on lung cancer screening in situations.

Variables	Experimental group	Comparative group	OR (95%CI)	*P* value
Understanding of lung cancer	Good understanding	Bad understanding	1.182 (1.110,1.259)	<0.001
Psychological status	Unstable status	stable status	0.849 (0.800,0.902)	<0.001
Education	College school/Junior college	High school or lower	0.713 (0.669,0.761)	<0.001
	Master's degree or higher		0.523 (0.469,0.584)	<0.001
Occupation	Private enterprises	Government or public institution	0.812 (0.765,0.862)	<0.001
	Self-employed entrepreneurs		0.694 (0.600,0.802)	<0.001
	Student/jobless		1.036 (0.935,1.147)	0.502
Type of health insurance	Basic medical insurance for urban workers	Medical insurance for urban and rural residents	1.107 (1.041,1.178)	0.001
Commercial insurance	Yes	No	0.826 (0.749,0.911)	<0.001
Monthly income	3001~4000 yuan	<3000 yuan	0.884 (0.807,0.967)	0.007
	4001~5000 yuan		0.759 (0.693,0.832)	<0.001
	≥5000 yuan		0.578 (0.530,0.631)	<0.001
Family history of lung cancer	Yes	No	0.976 (0.907,1.051)	0.526
Acceptable screening costs	101~200 yuan	<100 yuan	0.826 (0.755,0.905)	<0.001
	201~300 yuan		0.726 (0.666,0.792)	<0.001
	301~400 yuan		0.592 (0.536,0.645)	<0.001
	>400 yuan		0.381 (0.345,0.422)	<0.001

TABLE 4 Sample balance test after stratification by psychological status.

		Stable Psychological Status			Unstable Psychological Status		
Variable		Deviation Reduction (%)	T	*p*	Deviation Reduction (%)	T	*p*
Age	Unmatched	82.3	2.05	0.041	83.3	1.04	0.301
	Matched		0.29	0.77		0.15	0.884
Sex	Unmatched	58.7	0.2	0.84	84.7	−1.47	0.143
	Matched		−0.07	0.947		−0.19	0.852
Ethnicity	Unmatched	11.9	−0.24	0.812	87.4	−0.75	0.454
	Matched		−0.17	0.866		−0.08	0.936
Education	Unmatched	76.3	5.75	<0.001	88	7.57	<0.001
	Matched		1.13	0.26		0.77	0.443
Occupation	Unmatched	89.4	−6.73	<0.001	99.5	−6.77	<0.001
	Matched		0.61	0.544		−0.03	0.975
Medical insurance	Unmatched	30.9	−1.93	0.054	67.9	−2.72	0.007
	Matched		−1.06	0.288		−0.71	0.478
Commercial insurance	Unmatched	60.3	0.53	0.594	69.5	1.12	0.262
	Matched		0.17	0.866		0.28	0.781
Monthly income	Unmatched	80.1	3.12	0.002	90.1	4.92	<0.001
	Matched		0.5	0.617		0.42	0.678
Acceptable screening costs	Unmatched	78.7	5.68	<0.001	88.7	5.77	<0.001
	Matched		0.99	0.324		0.55	0.584
Smoking	Unmatched	64.2	3.25	0.001	78.6	2.91	0.004
	Matched		0.92	0.359		0.51	0.611
Family history of tumors	Unmatched	45.3	8.94	<0.001	66.7	6.3	<0.001
	Matched		0.37	0.714		1.62	0.105

TABLE 5 Average treatment effect on the treated (ATT) of lung cancer knowledge on the choice of medical institutions for screening, stratified by psychological status.

	Matching method	ATT	S. E	*Z*
All study participants	Unmatched	0.013*	0.006	3.10
	Kernel matching	0.028*	0.006	4.94
	1:1 nearest neighbor matching	0.031*	0.008	3.73
	Radius matching with caliper size 0.001	0.024*	0.005	5.32
Stable psychological status	Unmatched	−0.008	0.009	−0.81
	Kernel matching	0.007	0.009	0.78
	1:1 nearest neighbor matching	0.014	0.014	0.98
	Radius matching with caliper size 0.001	0.008	0.009	0.91
Unstable psychological status	Unmatched	0.032*	0.007	4.56
	Kernel matching	0.039*	0.007	5.62
	1:1nearest neighbor matching	0.053*	0.01	5.02
	Radius matching with caliper size 0.001	0.042*	0.007	5.98

In the kernel matching, the kernel function and broadband use default values. ATT, Average Treatment Effect on the Treated.
*Denotes statistically significant.

3.2 Characteristics of the participants

Table 2 shows that the majority of variables exhibited significant differences between the two groups. The residents who were willing to choose county-level or lower-level medical institutions for lung cancer screening were more likely to have lower educational backgrounds, more stable careers, no commercial insurance, urban workers' medical insurance, a lower monthly income, a negative family history of cancer, lower acceptable screening costs, and stable psychological status ($p<0.05$).

3.3 Multivariate analysis

We included significant indicators from the univariate analysis in the multivariate analysis. The results of the binary logistic regression analysis are presented in Table 3. The participants with a strong understanding of lung cancer were more willing to undergo lung cancer screening at county-level or lower-level medical institutions (odds ratios = 1.182, 95%CI 1.110 to 1.259). The residents with unstable psychological status were less willing to choose these institutions (odds ratios = 0.849, 95%CI 0.800 to 0.902). In addition to a family history of lung cancer ($p > 0.05$), factors such as education, occupation, basic medical insurance, commercial insurance, monthly income, and acceptable screening costs were all significantly associated with the residents' willingness to undergo lung cancer screening at county-level or lower-level medical institutions ($p < 0.05$).

3.4 Propensity score matching

We considered that binary regression could not infer causality as the regression results only represented the correlation. Since our study was cross-sectional, we used PSM to simulate the principles of a quasi-experiment to obtain results that closely aligned with causal inference. This approach allowed us to examine the effect of having knowledge of the disease on cancer screening decisions.

3.4.1 Balance test in PSM

As mentioned above, psychological states can significantly influence decision-making behavior, a perspective confirmed by numerous studies (18, 19). During the propensity score matching process, we initially conducted a matching analysis on the overall population to validate the findings presented in Table 3. Subsequently, we divided the participants into groups based on their psychological states to assess the influence of lung cancer-related knowledge on the choice of medical institutions.

After using psychological status as a stratification variable, the two groups showed no significant differences in covariates following propensity score matching ($p > 0.05$). For the residents with unstable psychological status, the matched Pseudo-R^2 value decreased from 0.008 to 0.002, the LR chi^2 from 185.40 to 28.58, the mean bias from 5.6 to 2.0, and the median bias from 5.1 to 1.2, all indicating significant improvement. For the residents with stable psychological status, the matched Pseudo-R^2 value decreased from 0.016 to 0.0021, the LR chi^2 from 171.71 to 4.43, the mean bias from 8.7 to 1.4, and the median bias from 6.7 to 1.1. These results collectively suggest that the sample matching was successful (Table 4).

3.4.2 Average treatment effect on the treated

Table 5 shows the average treatment effect on the treated (ATT) of lung cancer knowledge on the respondents' willingness to undergo lung cancer screening at county-level or lower-level medical institutions. The willingness percentage increased by 2.8% in the treated group after using kernel matching, 3.1% after using 1:1 nearest neighbor matching, and 2.4% after using radius matching.

We then stratified the analysis by mental health status. Among the individuals with stable psychological status, the results were not statistically significant across the matching methods. In contrast, among those with unstable psychological status, the percentage of residents with good lung cancer knowledge willing to undergo screening at county-level medical institutions increased by 3.9% after using kernel matching, 5.3% after using 1:1 nearest neighbor matching, and 4.2% after using radius matching.

We used a bootstrap simulation with 500 replications to estimate the standard error of the propensity score for each unit.

4 Discussion

First, this study revealed that the residents' knowledge about lung cancer in Sichuan Province was limited, with only 23.88% of the urban residents having a good understanding of the disease. In addition, 33.5% of the respondents reported having undergone lung cancer screening using LDCT. A multicenter, population-based, prospective cohort study in China conducted between 19 February 2013 and 31 October 2018 found that of the 1,016,740 participants enrolled, 79,581 high-risk participants underwent an LDCT scan, accounting for a proportion of only 7.8% (10). This proportion is significantly lower than that observed in the present study. We found that Sichuan Province has been vigorously publicizing the benefits of LDCT screening through many medical institutions and media channels since 2016. In addition, several lung cancer community screening programs have been organized by West China Hospital since 2019. This shows that Sichuan Province may be at the forefront in China in promoting LDCT screening for lung cancer among high-risk populations. Furthermore, our patients' characteristics may also have caused the large difference between our results and those of previous studies. According to the findings of the National Lung Screening Trial, screening for lung cancer with LDCT is the most effective method for reducing lung cancer mortality (23). Therefore, there is an urgent need to improve patients' knowledge about lung cancer, particularly by medical staff, as this may help to increase the lung cancer screening rate in high-risk populations.

Second, the multivariate and PSM analyses indicated that the residents with a strong understanding of lung cancer were more likely to choose county-level or lower-level medical institutions for screening. Their understanding of the disease reflects their health literacy. As one of the social determinants of health, health literacy represents the cognitive and social skills that motivate individuals to gain access to, understand, and use information to promote and maintain good health (24). Therefore, health literacy is essential for individuals to make informed healthcare decisions and benefit from healthcare services. Inadequate health knowledge is associated with high healthcare expenditures and the irrational use of healthcare services, as proven by several studies (25–27).

Finally, the stratified PSM analysis results suggested that psychological status may also influence residents' choice of medical institutions. We found that the impact of lung cancer knowledge was more pronounced among those with unstable psychological status compared to the participants with stable psychological status. Previous research indicates that individuals with anxiety disorders exhibit significantly greater risk aversion (19). In our study, this result may be explained by the tendency of the anxious residents to choose institutions with lower rates of misdiagnosis or missed diagnoses in lung cancer screening to alleviate anxiety related to uncertain examination outcomes. This explanation aligns with the ATF theory introduced in the background (18, 19). The more substantial effect may also suggest that anxious residents have greater potential for improvement and that psychological status may play a positive mediating role between lung cancer knowledge and the choice of county-level hospitals. However, this hypothesis requires further validation through more detailed follow-up research. The findings suggest that measures to alleviate patient anxiety may play a role in enhancing the effectiveness of the hierarchical medical system and promoting rational patient flow.

This study has several potential limitations. It relied on self-reports to measure the residents' knowledge of lung cancer, which may have introduced measurement errors. In addition, as the survey sites were mainly hospital-based physical examination centers, there may have been a population selection bias. Future studies should incorporate additional research design elements to address these limitations.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Ethics Committee of West China Hospital, Sichuan University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

QC: Data curation, Formal analysis, Methodology, Software, Writing – original draft, Writing – review & editing. RL: Data curation, Funding acquisition, Investigation, Project administration, Resources, Writing – original draft, Writing – review & editing. TB: Writing – original draft. ZY: Writing – original draft. QL: Investigation, Writing – review & editing. FC: Conceptualization, Investigation, Methodology, Resources, Validation, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1388140/full#supplementary-material

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Half of the mothers had poor delivery referral practices in public hospitals of Bahir Dar City Northwest, Ethiopia

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Background: Policy makers and stakeholders may benefit from understanding maternal delivery referral practices as they develop efficient mechanisms to implement appropriate referral linkage. However, the practice of maternal delivery referral is not well known. This study aims to assess the maternal referral practices and associated factors among laboring mothers referred to public hospitals of Bahir Dar City, Northwest, Ethiopia.

Method: In the hospitals of the city of Bahir Dar, a facility-based cross-sectional survey was carried out from March 1 to March 30, 2021. A total of 358 mothers who came by referral to give birth at the public hospitals in Bahir Dar were interviewed using a pre-tested questionnaire that was presented by an interviewer. Data was coded, and inputted to Epi-data version 3.1 software, and after being transferred, analyzed using SPSS version 25. The associated factors linked to poor maternal referral practices were identified using bi-variable and multivariable logistic regressions. The p-value cutoff of 0.05 was ultimately determined to be statistically significant.

Results: A total of 353 study participants took part in the study. The level of poor maternal referral practice was 52.7% (95% CI 47%, 58%). The mean age of the respondents was 26.73 (± 5.45) years. Twenty eight percent of the mothers were illiterate. Unable to read and write (AOR = 2.38, 95%CI: 1.15, 4.94), read and write only (AOR = 6.59, 95%CI: 2.53, 17.17), monthly income < 1,527 birr (AOR = 4.55, 95%CI: 1.91, 10.84), monthly income between 1,527 and 3,000 birr (AOR = 4.29, 95%CI: 1.76, 10.50), and monthly income between 3,001 and 5,305 birr (AOR = 3.73, 95%CI: 1.49, 9.33), referred from referral hospitals (AOR = 4.63, 95%CI: 1.94, 11.07), gave birth via cesarean section (AOR = 2.06, 95%CI: 1.22, 3.47), gave birth via assisted delivery (AOR = 4.77, 95%CI: 1.64, 13.91), and time spent more than 1 h to arrive to Bahir Dar City public hospitals (AOR = 2.15, 95%CI: 1.07, 4.34) were significantly associated with poor maternal referral practice.

Conclusion: Poor maternal referral practices were widespread. The use of maternal referrals was influenced by obstetric, social, environmental, and demographic factors. The poor maternal referral practices during labor should receive the most attention from mothers who have low monthly incomes and do not attend formal education.

KEYWORDS

referral practice, laboring mother, poor practice, Bahir Dar City, Ethiopia

Background

A referral is a two-way communication process in which a healthcare professional at one level of the healthcare system requests the assistance of a better or differently resourced facility at the same or higher level to assist in, or take over, the management of the client's case because they lack the resources (drugs, equipment, skills) to do so (1). Initiating a referral can shorten treatment delays, prevent system overload, and allow the use of expertise at advanced clinical hubs by communicating the reasons for the recommendation with the receiving hospital.

The goal of the maternity referral system is to identify pregnant women who are at a high risk of obstetric difficulties and refer them to more specialized delivery care at a higher level. Risk screening throughout pregnancy is part of this strategy.

Evidence from the United States (USA) revealed that 19.8% of referrals lacked a specific justification. Additionally, just 6.4% of referrals were ruled inappropriate (2).

Only 3% of sick children who were seen at a referral hospital in Tanzania, according to a research, were referred (3). Similar to this, a research conducted in Ghana found that only 11% of the children hospitalized to the referral facility were referred, and only one outpatient department (OPD) care seeker in every 34 OPD care seekers (3%) seen at a referral institution was referred (4).

According to the Kenya National Bureau of Statistics, 2011 data showed that referral forms used to refer patients varied by province. The higher proportion of this referral was seen in western (78%), and in Nairobi providences (73%). However, the lower was recorded in rift valley (38%) and North Eastern provinces [28%; (5)].

Evidence suggested that the referral system may be impacted by lack of knowledge about referrals, inadequate information provided by doctors who refer patients, delayed or poor quality of consultations with medical professionals. The severity of the sickness, the requirement for permission to travel to the clinic and pay associated expenditures, balancing child care obligations, the perceived quality of hospital care, and the communication skills of health personnel are all significant variables, according to the studies (6, 7).

Results showed that information between medical institutions is inadequately communicated, delayed medical record transfers may result in repeated testing, and doctors have restricted authorization to prescribe certain medications, all of which have an impact on how successful the referral system is (8–11).

Inadequate obstetric transfer was the cause of nearly half of maternal deaths (48.38%; 11) between 2008 and 2013 despite the Ethiopian women's access to basic delivery care services having increased dramatically by ~48% (10-fold to 2001) by 2019. Referral practices for maternity deliveries are still up for debate (12). However, Ethiopian maternal referral linkage has little empirical support. There for, the aim of this study was to evaluate the maternal delivery referral practice and the factors that contribute to it in the public hospitals of Bahir Dar City, Ethiopia.

Abbreviations: CI, confidence interval; CS, cesarean section; PHI, Pregnancy induced hypertension; AOR, Adjusted Odds Ratio; USA, United States of America; WHO, World Health Organization; OPD, Outpatient department; Kms, Killo meters; BSc, Bachelor of Science; ETB, Ethiopian Birr; ANC, Ante natal care; SPSS, Statistical Package for social science; OR, Odds Ratio; SD, Standard deviation.

Methods and materials

Study setting and period

March 1 and March 30 of 2021, the study was carried out in the public hospitals of the city of Bahir Dar. The city, which serves as the Amhara Regional State's capital, lies 480 kilometers Northwest of Addis Ababa. There are 10 health clinics and three public hospitals in the city. Felege-hiwot Hospital, Tibebe-ghion Hospital, and Adis-alem Hospital are the public hospitals that offer delivery care services. These three public hospitals provided 1, 875 maternal delivery care services in total, according to the department of maternity reports from the preceding 3 months in the hospitals involved in this study. Of which, 131 delivered mothers were sent to Adis-alem hospitals, 953 were sent to Felege-hiwot hospitals, and 791 were sent to Tibebe-ghion hospitals.

Study design and population

A cross-sectional study with a focus on healthcare facilities was conducted. During the time of data collection, all women who requested better delivery care at one of the three public hospitals in Bahir Dar City and were willing to participate in the study were taken into account. Women with severe medical conditions, mental health issues, or those who refused to participate in the study were not included.

Sampling size and sampling procedure

Using a single population percentage formula, the sample size was calculated under the following presumptions: The proportion of obstetric referrals recorded in Addis Ababa was 30.3%, a 95% level of confidence and a 5% margin of error (13). The sample size was computed using a population adjustment formula and by including a 10% non-response rate because the source population, or 1, 875, was less than 10,000. As a result, the final sample size was calculated to be 358. According to proportional to size allocation, the required sample size from each public hospital was determined. Every five intervals, participants were chosen from each facility using a systematic random sample technique equal to the volume of maternal referrals to the hospitals. The sampling interval was determined using the anticipated 3-month gestational referral. The first case was chosen using a lottery system. Following the completion of the services, an exit interview was done with a total of 358 delivery women.

Operational definitions

Laboring mother: is used to describe any mother who gives birth to a child and delivers the placenta, membranes, and umbilical cord to the outside world through the vagina (14).

Maternal referral practice: is a situation when a mother has been referred by a health professional to higher-level health care facilities and has gotten a good maternal referral practice when she responded to greater or equal to mean and above of the thirteen-referral practice assessing questions as correctly. Otherwise, she was considered as having poor maternal referral practice.

Knowledge: 10 questions were used to measure the knowledge of referred mothers with regard to Ethiopian healthcare referral systems. If the delivered mother answered more than the mean score of the knowledge questions, she was considered as having adequate knowledge, otherwise, she was considered as having inadequate knowledge.

Quality of care: In this study quality of maternal care was considered when a laboring mother gained service with respect, privacy maintained and given necessary medications as per the health professionals order.

Data collection, studied variables and data analysis: Structured questionnaires adapted from various studies (15–19) were used to collect the data. The survey included questions assessing socio-demographic characteristics, obstetrics-related, knowledge, environmental factors, health facility-related factors, and maternal referral practice (outcome variable). Independent translators translated the questionnaire from English to Amharic before the data collection to ensure consistency. The study's aims, data collection techniques, and the significance of the study in relation to the studied objectives were covered in a one-day training session for the four BSc midwives and the two supervisors. The responders were interviewed shortly after giving birth, just as they were getting some rest before leaving the hospital ward.

The investigators verified the consistency and completeness of the data collected. The data was coded and entered into the EPI-DATA program version 3.1 before being exported for cleaning up and analysis in SPSS version 20.0. The frequency, proportion, means, and standard deviations of descriptive statistics were computed. In order to examine the relationship between explanatory and outcome variables, a binary logistic regression model was used. For the multivariable logistic regression analysis, variables having a p-value of <0.2 in the bi-variable analysis were regarded as candidates. The strength of the relationship between explanatory factors and the maternal referral practice was assessed using an adjusted odds ratio (OR) with a 95%. Variables with a p-value of 0.05 were considered as statistically significant predictors of maternal referral practice. The Hosmer and Lemeshow goodness of fit test was used to evaluate the model's fitness ($P > 0.05$).

Ethical consideration

Ethical clearance for this study was obtained from the Ethical Review Board of Bahir Dar University, College of Medicine and Health Sciences. Letters of support were received from the Amhara regional public health institute. The oral consent was obtained from medical directors of each hospital. Before collecting the data, the written informed consent was obtained from delivered mothers. Anonymity and confidentiality were considered. The study adhered to tenets of the Declaration of Helsinki.

TABLE 1 Socio-demographic characteristics of the study participants in public hospitals of Bahir Dar City, Ethiopia, 2021 ($n = 353$).

Variables	Maternal delivery referral practice		X^2, P-Value
	Good	Poor	
Age groups (Years); $\mu = 26.73 \pm 5.45$ years			
15–19	10 (41.7)	14 (58.3)	1.865, 0.393
20–30	130 (49.4)	133 (50.6)	
31–43	27 (33.3)	39 (66.7)	
Maternal educational status			
Unable to read and write	37 (38.1)	60 (61.9)	26.021, 0.0001*
Able to read and write	9 (20.9)	34 (79.1)	
Grade 1–8	28 (56)	22 (44)	
Grade 9–10	39 (55.7)	31 (44.3)	
Grade 11–12	6 (42.8)	8 (57.2)	
Diploma and above	48 (60.8)	31 (39.2)	
Religion			
Orthodox Christian	149 (48.4)	159 (51.6)	2.030, 0.566
Others¥	18 (40)	27 (60)	
Occupation			
Governmental employee	51 (46.8)	58 (53.2)	0.854, 0.931
Merchant	21 (50)	21 (50)	
Housewife	74 (46.3)	86 (53.7)	
Others¥¥	21 (50)	21 (50)	
Marital status			
Currently married	148 (46.4)	171 (53.6)	3.145, 0.370
Currently unmarried	19 (55.9)	15 (44.1)	
Husband educational status			
Unable to read and write	15 (25.8)	43 (74.2)	25.772, 0.0001*
Able to read and write	17 (34)	33 (66)	
Grade 1–4	16 (66.7)	8 (33.3)	
Grade 5–8	21(50)	21 (50)	
Grade 8–10	12 (37.5)	20 (62.5)	
Grade 11–12	33 (57.9)	24 (42.1)	
Diploma and above	34 (60.7)	22 (39.3)	
Husband occupation			
Student	9 (47.4)	10 (52.6)	8.261, 0.082
Government employee	42 (55.3)	34 (44.7)	
Private employee	45 (51.7)	42 (48.3)	
Merchant	35 (41.2)	50 (58.8)	
Farmer	17 (32.7)	35 (67.3)	
Ethnicity			
Amhara	162 (48.2)	174 (51.8)	3.201, 0.362
Others¥¥¥	5 (29.4)	12 (70.6)	

(Continued)

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TABLE 1 (Continued)

Variables	Maternal delivery referral practice		X^2, *P*-Value
	Good	Poor	
Residence			
Urban	131 (50.8)	127 (49.2)	4.621, 0.032**
Rural	36 (37.9)	59 (62.1)	
Average monthly income			
<1,527 ETB	58 (41.7)	81 (58.3)	14.454, 0.002 ***
1,527–3,000 ETB	41 (41.4)	58 (58.6)	
3,001–5,305 ETB	35 (50.7)	34 (49.3)	
>5,305 ETB	33 (71.7)	13 (28.3)	

Others¥ (Muslim, protestant and catholic), ¥¥ (student, daily laborer), ¥¥¥ (Oromo, Tigrie, Agew).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research. The authors intend to disseminate this research to the public through social media, press releases, and media departments and websites of authors' institutions.

Results

Socio-demographic characteristics

A total of 353 women were enrolled in the study, and 98.6% of them responded. The mean age of respondents was 26.73 years (+ 5.45 SD). In the age range of 31–43 years, two thirds of respondents who perceived poor maternal referral practices were found. The majority of respondents lived in urban areas, including both the poor (76.4%) and those who believed that good maternal referral practices were in place (62.96%). The variables age, religion, occupation, marital status, and ethnicity did not show variation between the poor and good maternal referral practices, but maternal and husband educational status, residence, and monthly income did show a significant difference between the good perceived maternal referral practice and the poor one (Table 1).

Obstetric-related characteristics

The majority (64.9%) of the current born babies was male, and 49.3% of these male babies had good maternal delivery referral practices. However, 50.7% of them born from women who did not practice good maternal referral. Nearly 94% of mothers who received poor delivery referral practice gave birth to a live fetus, while 96% of mothers who received poor referral treatment experienced stillbirth. With maternal delivery referral practice, there are considerable variations in gestational age and delivery method for the most recent birth. However, there was little correlation between the amount of maternal delivery referral practice and the parity, cause for referral, fetal outcome, ANC follow-up, and history of bleeding before and after birth (Table 2).

TABLE 2 Obstetric-related characteristics of the respondents in public hospitals of Bahir Dar City, Ethiopia, 2021 ($n = 353$).

Variables	Maternal delivery referral practice		X^2, *P*-Value
	Good	Poor	
Parity			
Primipara	93 (44.7)	115 (55.3)	1.370, 0.242
Multipara	74 (51.03)	71 (48.97)	
Reason for referral			
Previous C/S	22 (46.8)	25 (53.2)	7.845, 0.097
Hypertension/PIH	38 (57.6)	28 (42.4)	
Cephalo-pelvic disproportion	31 (38.3)	50 (61.7)	
Abnormal presentation/position	31 (41.3)	44 (58.7)	
Others	45 (53.6)	39 (46.4)	
The current pregnancy wanted			
Yes	142 (46.1)	166 (53.9)	1.407, 0.236
No	25 (55.6)	20 (44.4)	
Gestational age			
Preterm	58 (40.3)	86 (59.7)	7.282, 0.026*
Term	101 (54)	86 (46)	
Post term	8 (36.4)	14 (63.6)	
Mode of delivery of the current birth			
Spontaneous vaginal delivery	107 (55.2)	87 (44.8)	12.456, 0.002**
Assisted delivery	7 (25.9)	20 (74.1)	
Cesarean delivery	53 (40.2)	79 (59.8)	
The fetal outcome of the current birth			
Alive	160 (93.6)	11 (6.4)	0.539, 0.463
Stillbirth	7 (3.8)	175 (96.2)	
Sex of the current baby			
Male	113 (49.3)	116 (50.7)	1.084, 0.316
Female	54 (43.5)	70 (56.5)	
Did you have ANC follow-up of the current birth			
Yes	150 (46.7)	171 (53.3)	0.478, 0.490
No	17 (53.1)	15 (46.9)	
Did you face bleeding before the birth of this current baby			
Yes	30 (42.9)	40 (57.1)	0.694, 0.405
No	137 (48.4)	146 (51.6)	
Did you face bleeding during delivery or later of this birth			
Yes	55 (44.7)	68 (55.3)	0.509, 0.475
No	112 (48.7)	118 (51.3)	

TABLE 3 Knowledge of delivered mothers about Ethiopian healthcare referral system in public hospitals of Bahir Dar City, Ethiopia, 2021 ($n = 353$).

Variables	Frequency (*f*)	Percentage (%)
Adequate knowledge	87	24.6
Inadequate knowledge	266	75.4
Ever heard about maternal delivery referral system	187	52.9
Directionality affects the referral system in Ethiopian context ($n = 187$)	145	77.5
Distance of facilities from one another can affect the obstetric referral practice	239	67.7
Availability of referral forms/slips and other communication networks can influence the referral system	157	44.5
Availability of ambulance in the referring health facility has a role in the referral system	149	42.2
Social/family support has role to play in the referral system	143	40.5
Preference of the client has a role to play in the referral system	204	57.8
Counseling role of the referral officer could influence the referral system	181	51.3
Community participation is important in referral system	183	51.8
Financial ability of the client is a factor to be considered in the referral system	186	52.4

Knowledge of delivered mothers about Ethiopian healthcare referral system

According to the survey, 187 (52.9%) of the respondents had heard about maternal delivery referral systems, and 86 (44.9%) of those respondents cited health personnel as their sources of information. About 77.5, 67.7, 44.5, 42.2, 51.8, and 52.4% of respondents were aware that the maternal delivery referral system in Ethiopia is influenced by factors such as directionality, distance from the facility and between facilities, availability of referral forms, ambulance availability, community involvement, and clients' financial capacity, respectively. Accordingly, 87 (24.6%) of the respondents had sufficient understanding of the Ethiopian healthcare referral system (Table 3).

Health facility and healthcare access related characteristics

The villages where the mothers who gave birth had functional health development army for maternal delivery referral in about 31.4% of the cases. With a maternal delivery referral practice, there are significant variations in the amount of time spent by mothers to be seen by a health worker, the mode of transportation used during referral of a maternal delivery, the type of the referring health facility, the level of the referring health facility, and the distance from the nearest hospital in kilometers (Table 4).

Level of maternal delivery referral practice

The level of poor maternal delivery referral practice among women was 52.7% (95% CI: 47, 58) after taking 13 maternal delivery referral practice assessment questions, calculating the composite index value, and dichotomizing the composite value.

Factors associated with maternal delivery referral practice

The final model for maternal delivery referral practice comprised maternal educational status, residency, monthly income, level of referring health facility, mode of delivery of current birth, and travel time to closest hospital. The multivariable logistic regression analysis revealed that women with unable to read and write (AOR = 2.4, 95%CI: 1.2, 4.9), with able to read and write (AOR = 6.6, 95% CI: 2.5, 7.2); monthly income <1,527 ETB (AOR = 4.6, 95%CI: 1.9, 10.8), income between 1,527 and 3,000 ETB (AOR = 4.3, 95%CI: 1.8, 10.5), and between 3,001 and 5,305 ETB (AOR = 3.7, 95%CI: 1.5, 9.3); who referred from referral hospital (AOR = 4.6, 95% CI:1.9, 11.1), delivered using assisted delivery (AOR = 4.7, 95% CI: 1.7, 13.9), delivered using cesarean (AOR = 2.1, 95% CI: 1.2, 3.5), and >1 h travel time to nearby hospital (AOR = 2.2, 95% CI:1.1, 4.3) had increased likelihood of being good maternal delivery referral practice (Table 5).

Discussion

To our knowledge is concerned, this is the first study assessing referral practices among delivered mothers. The study confirmed that the poor maternal delivery referral practice could be higher in magnitude in the variable of interest of most socio-demographic and economic factors, obstetrics, over all knowledge about referral system and health facility and characteristics related to health access. However, the majority of obstetric traits and skills had no relationship with maternal delivery referral practice and were left out of the final regression model.

The WHO has designed a framework or one of the standards known as the referral system, which specifies that all women with any conditions that cannot be adequately treated with the resources available be appropriately referred. This has been done to improve the quality of care for mothers at time of delivery (21). However, compared to a study done in Tanzania, the proportion of poor

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TABLE 4 Health facility and healthcare access related characteristics and maternal referral practice in public hospitals of Bahir Dar City, Ethiopia, 2021 ($n = 353$).

Variables	Maternal delivery referral practice		X^2, *P*-Value
	Good	Poor	
Distance from nearest hospital in Kms			
<5	155 (50.5)	152 (49.5)	4.585, 0.032*
≥5	31 (67.4)	15 (32.6)	
Functional village health developmental army for maternal delivery referral			
Present	91 (81.9)	20 (18.1)	2.770, 0.096*
Absent	95 (39.3)	147 (60.7)	
Level of the referring health facility			
Health center	25 (39.7)	38 (60.3)	12.952, 0.005****
Primary hospital	108 (54.8)	89 (45.2)	
General hospital	19 (42.2)	26 (57.8)	
Referral hospital	34 (70.8)	14 (29.2)	
Type of the referring health facility			
Public	168 (55.5)	135 (44.5)	13.499, 0.001*
Others¥	18 (20)	32 (64)	
Time spent to be seen by a health worker			
<10 min	111 (57.5)	82 (42.5)	7.273, 0.026*
10–30 min	56 (51.9)	52 (48.1)	
>30 min	19 (36.5)	33 (63.5)	
Means of transportation during referral of maternal delivery			
Ambulance	147 (72.1)	57 (27.9)	72.726, 0.0001*
Other	39 (26.2)	110 (73.8)	

TABLE 5 Factors associated with maternal delivery referral practice in public hospitals of Bahir Dar City, North West Ethiopia, 2021.

Variable	Maternal delivery referral practice		COR (95%CI)	AOR (95%CI)
	Good	Poor		
Maternal educational status				
Unable to read and write	37	60	2.5 (1.4, 4.6)	2.4 (1.2, 4.9)*
Able to read and write	9	34	5.9 (2.5, 13.9)	6.6(2.5, 7.2)***
Grade 1–8	28	22	3.1 (0.5, 17.9)	3.1 (0.5,19.2)
Grade 8–12	45	39	1.2 (0.6, 2.4)	1.2 (0.6, 2.6)
Diploma and above	48	31	1.00	1.00
Monthly income				
< 1,527 birr	58	81	3.5 (1.7, 7.3)	4.6 (1.9,10.8)***
1,527–3,000 birr	41	58	3.6 (1.7, 7.6)	4.3 (1.8, 10.5)***
3,001–5,305 birr	35	34	2.5 (1.1, 5.45)	3.7 (1.5, 9.3)**
>5,305-birr	33	13	1.00	1.00
Level of the referring health facility				
Health center	38	25	1.00	1.00
Primary hospital	89	108	1.8 (1.0, 3.3)	1.5 (0.8, 2.9)
General hospital	26	19	1.1 (0.5, 2.4)	1.4 (0.6, 3.5)
Referral hospital	14	34	3.7 (1.7, 8.2)	4.6 (1.9, 11.1)***
Mode of delivery of the current birth				
Spontaneous vaginal delivery	107	87	1.00	1.00
Assisted delivery	7	20	3.5 (1.4, 8.7)	4.7 (1.7, 13.9)**
Cesarean delivery	53	79	1.8 (1.2, 2.8)	2.1 (1.2, 3.5)**
Time taken to arrive to nearby hospital				
<30 min	120	112	1.00	1.00
30–60 min	29	32	1.2 (0.7, 2.1)	1.0 (0.6, 1.9)
>60 min	18	42	2.5 (1.4, 4.6)	2.2 (1.1, 4.3)*

* Significant at $p < 0.05$, ** significant at $P < 0.01$, *** significant at $P < 0.00$.

maternal referral practices in the current study was 52.7% (95% CI: 47%, 58%; 3). The differences in the state of maternal health system practices that may be identified in various nations, such as the policy of maternal referral systems and different measuring instruments, may be the possible explanation for this greater level of bad maternal referral practices. The various sample size estimates, the study's context, and sociocultural norms were also likely contributors to this degree of variation. Similar to other studies, the current study was carried out in the regional capital city of the Amhara state referral hospitals, which include tertiary and specialized comprehensive hospitals with a large number of different patient flows that deteriorate the standard of the maternal referral system (22, 23). The referral healthcare facility's lower level of quality of care is another explanation for the low compliance of mothers to adhere to the referral system (22, 23). In this study, mothers who were referred from lower-level facilities, including health centers had poor referral practices for maternal delivery, consistent with other studies (24). Policymakers must therefore focus on capacitating the referral tier system not only in the upper level of health system but also strongly give emphasis in the lower levels of healthcare wings.

The knowledge, skills, and educational experiences of healthcare professionals, as well as the maternal educational status, which is characterized by late referrals, have a significant impact on the referral system in general and the maternal referral system in particular (24–27). In line with other study, the current study found an association between maternal educational status and maternal delivery referral patterns (26). Some mothers may have believed that all levels of further care provided were in the same practices of care as those of the lower level of care due to their lower educational enrollment, which is one of the misconceptions that stifled good delivery referral practices, especially in resource-constrained settings like Ethiopia. The hierarchy, capabilities, and restrictions of each healthcare institution, as well as the need for referral, were not understood by the laboring women. Therefore,

the governments should take an assignment on implementing educational interventions that focus on the women who are in the reproductive age range with little literacy coverage. Moreover, health professionals must also undergo continuous professional development in order to identify complications during any stage of labor, manage them, and quickly refer women during delivery.

The fact that physical accessibility and distance to healthcare settings are the primary reasons why mothers did not adhere to the referral system in many resource-limited settings (28–31) is similar to the findings of the current study, which found that longer travel times to nearby higher level healthcare facilities caused delivered mothers to poorly adhere to the referral linkage. This may be explained by the fact that longer travel times for newly delivered mothers to the next level of care resulted in both direct and indirect costs for food, transportation, and production day loss. This is the most common phenomenon that explains why mothers in low-income nations like Ethiopia did not accept the recommendations of healthcare professionals and prefer to seek care from traditional healthcare providers at home rather than seeking more advanced care. Another studies have also confirmed that one of the three delays that contribute to maternal deaths is a delay in transportation (28, 31, 32).

Also, one of the obstacles preventing most mothers from following the referral system to higher level healthcare institutions during labor was the prevalent false perception of assisted delivery, such as cesarean section (24). A significant percentage of mothers connected the referral system to needing a cesarean delivery (4, 29–31). In a similar vein, the current study found a strong correlation between poor maternal referral practices and cesarean birth. Most often, assisted and cesarean section deliveries require a swift decision and skill in handling emergency procedures, but most Ethiopian professionals, particularly those working in the lower levels of the health system, are not well equipped to handle such services, which is why maternal referrals are delayed in the absence of an adequate facility for such a procedure. On the other hand, childbirth professionals irresponsibly referred the mothers without paying enough attention to the referral processes, which were characterized by confusion, dilemmas, and dread of problems after the mothers had already exhausted. Additionally, avoiding responsibility in the event that the outcome of the mother's delivery would be poor led to poor maternal referral practices. Therefore, the ministry of health and women should reinforce the legal system's due process and protection of women's rights.

Given that most government facilities in Ethiopia do not charge for maternal healthcare-related services, and that motherhood income is a known impediment to referral systems (20, 32–34), the study found that poor maternal delivery referral practices were significantly associated with low monthly income. One social factor of health, poverty, made it more likely for women to have babies with poor maternal referral practices and birth outcomes. This level of referral practice might be exacerbated mainly the weak functionality of the ambulance services and free of indirect medical costs. In the lines share of rural health facilitates, ambulance services were politicized and not actively serving the intended users such as mothers which intern forced them to use public transport out-of-pocket which is neither fast, sheep or healthy. The poor efficiency of the ambulance services may be also the main cause of this poor referral practice. This study had certain constraints, of course. Since the study was cross-sectional, it is impossible to conclude causation because the components do not show a temporal link. The study's findings might only be applicable to those mothers with history of healthcare facility attendance for delivery. The most prevalent bias was recall bias. To lessen the impact of this bias, probing techniques were used. It can also be challenging to gather self-reported data on sensitive topics like motherhood income because these topics can be extremely private and frequently relate to self-image and personality.

Conclusion

Maternal delivery referral practices were generally found to be poor and delivery referral standards are not adequately complied because of the fact that low levels of motherhood income, low educational attainment, lack of transportation options, and a longer travel time to a higher-level healthcare facilities. The healthcare accessibility and mode of delivery were also belonged to those important factors that independently influenced maternal delivery referral practice. Maternal delivery referral practice could be improved through mass maternal education. In order to ensure that services were more client-centered; the study strongly suggested that greater efforts has to be made in constructing facilities close to the direct points of use by mothers. Low-cost transport is also needed to mitigate barriers to referral by availing ambulance. To ensure quality maternal referrals, district-level health managers should be trained and equipped with the skills needed to monitor and evaluate referral documentation, including the quality and efficiency of maternal referrals. It is also important to conduct additional qualitative research on maternal referrals, namely concentrating on the implications of policy in improving the referral tier system.

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 Ethical Review Board of Bahir Dar University, College of Medicine and Health Sciences. 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

DA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft. AF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original

draft. HG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft.

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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.

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Analyzing the perception of happiness among Korean medical students using a concept mapping methodology: a cross-sectional study

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Introduction: Happiness differs according to population groups and cultures. For medical students, more studies have focused on negative emotions than on happiness. This study explored the overall perceptions and standards of medical students to analyze the concept of happiness from various perspectives in the Korean context.

Methods: A concept mapping analysis comprising five stages was conducted with medical students at Yonsei University's Wonju College of Medicine in South Korea. Focus questions were generated in Phase 1, and 23 students participated in individual brainstorming in Phase 2. Fifty statements were confirmed in Phase 3. Sixteen students assigned an importance score to each statement and participated in the individual sorting of statements and naming of categories in Phase 4. Finally, the concept maps were interpreted using multidimensional scaling and hierarchical cluster analysis.

Results: The medical students' perception of happiness was divided into two dimensions, "Study–Life" on the X-axis and "Self–Relationship" on the Y-axis, and was expressed in three categories and five sub-categories. The subcategories of "Self-management" and "Quality of life" were grouped under "Personal development," "Social support" was named as a single category, and "Guaranteed future" and "Academic achievement" were grouped as "Professional fulfillment." The most important sub-category for medical students was "Social support." Among the statements generated in these categories, the most important was "When I have a healthy body and stamina," which belonged to "Quality of life."

Discussion: This study showed that to enhance the happiness of medical students, a system that supports their social relationships, careers, learning, and individual efforts is required. The results of this study can provide information for the development of student support programs that allow medical educators and institutions to promote medical students' happiness.

KEYWORDS

happiness, quality of life, multidimensional scaling analysis, concept mapping, medical students

1 Introduction

Happiness is difficult to define in a single word, and its definition may change depending on the context. It is sometimes used interchangeably with quality of life, subjective well-being, and life satisfaction and is highly correlated with these concepts. In previous studies, happiness has been defined as an individual's overall assessment of their quality of life according to their own standards (1, 2), which differ by individual. The perception of happiness varies across different cultural contexts and academic disciplines among university students (3). For example, American and Korean college students perceived their happiness differently (4, 5), while medical students demonstrated lower psychological well-being scores compared with non-medical students (6).

Quantitative studies on negative emotions such as stress, burnout and depression are sufficiently reported in previous studies (7–9). For instance, in a systematic review, Rotenstein et al. reported that the prevalence of depressive symptoms among medical students was 27.2% (10). However, studies on the overall perception of happiness targeting medical students are lacking, leaving happiness a positive and relatively underexplored domain.

Tools such as the Oxford Happiness Questionnaire (OHQ) have been widely used to measure happiness; however, this is a one-dimensional scale consisting of items on positive and negative emotions, life satisfaction, and happiness characteristics (1, 11). Therefore, since respondents only answer the items given in the survey, other concepts of happiness remain difficult for researchers to identify.

The happiness of medical students is likely to involve unique contextual factors. In fact, the rigorous academic workload, evaluation systems, and identity formation process as future professionals may be critical factors defining their happiness. However, more research needs to address the overall perception and concept of happiness among medical students. China, Korea, and Japan are representative of nations with a confusion culture (12). While studies exist on mental health and positive psychology among Chinese medical students (13, 14), there is limited research on positive psychological aspects such as happiness among medical students in Japan and Korea. As Korean researchers, we recognized the necessity of studying happiness among Korean medical students. Although we found recent research, most was restricted to analyzing only the correlation between the educational environment in medical schools and happiness, their study shows limitations in defining and exploring happiness as a multidimensional concept (15).

By employing concept mapping analysis to identify and derive the concepts and criteria of happiness that medical students perceive, this study aims to overcome the limitations of previous quantitative survey-based research. The conceptual mapping analysis is a desirable research method for exploring specific phenomena based on the subjective experiences of participants in fields that lack a pre-established theoretical system (16, 17). We believe that it is possible to analyze medical students' perception of happiness by examining the concept of happiness. Therefore, the purpose of this study was to identify medical students' concepts and standards of happiness using concept-mapping analysis. These results can provide an opportunity for medical educators and institutions to better understand the happiness of medical students and implement appropriate student support programs.

This study's specific research questions are follows. First, what is happiness as perceived by medical students? Second, what do medical students think is the relative importance of happiness?

2 Materials and methods

2.1 Study design

This single-center, cross-sectional study explored the concept of happiness among medical students. Concept mapping analysis is a structured conceptualization process that explores and describes the hidden side of specific phenomena. It allows researchers to objectively understand the perception or concept of a phenomenon in a specific group by visually representing it (18).

2.2 Ethical considerations

This study was approved by the Institutional Review Board of the Yonsei University Wonju Christian Severance Hospital (CR322034). Participation was voluntary, and all of the participants provided informed written consent.

2.3 Participants

The participants of this study were medical students at Yonsei University's Wonju College of Medicine. As for inclusion criteria, we selected medical students who had been in medical college for at least one semester, who understood the purpose and methods of the study, and who voluntarily agreed to participate in the study. Responses that could not be included in the research data analysis because they did not agree to participate in the study or were insincere were excluded. Because it is possible for the participants who generate the ideas and those who sort and rate them to be different when using this methodology (19).

Participants were recruited separately for these two phases. In a concept mapping study, research participants should be opportunistically sampled in a potential conceptual universe, considering heterogeneity.

2.4 Sample size

Although there is no limit to the number of research participants in a concept mapping study, more than ten participants are required to fully generate ideas (18). In previous studies using concept mapping, the number of participants has varied from 20 to 629 in the brainstorming stage, depending on the research theme (20). However, as medical students voluntarily participated in the brainstorming stage in this study, we determined that response collection would be complete when the saturation of the description of the concept of happiness was confirmed. In the next step (sorting and rating), approximately 15 participants are recommended (21). In a review of concept mapping studies, the average number of participants in this stage was approximately 14 (20). Therefore, we planned to recruit 16–17 participants in this study, considering that 10% of the participants may drop out.

2.5 Data collection

The concept mapping research procedure proposed by Kane and Trochim was used in this study (18). Participants were categorized by sex and grade.

First, in the preparation step, the following focus questions were created to collect students' thoughts on the concepts of happiness. Two authors (JL and KHP) made the questions to stimulate the general happiness concepts of the students.

- Who is a happy medical student?
- What do you need for a happy medical school life?
- Describe a specific experience in which you felt happy after becoming a medical student.

Second, ideas were generated. Medical students were asked to freely express their thoughts on the focus questions using a questionnaire hosted on SurveyMonkey. The survey link was listed on a recruitment notice that was posted on a bulletin board in the medical college building, which students could access if they wished to participate. Responses to the survey were collected between June and September 2022. Sixty statements were generated after qualitative analysis using the participants' ideas (JL and KHP).

Third, statements were structured. All of the researchers evaluated the statements, classified them into temporary categories. Each statement should contain one idea that does not overlap with another. All participants were able to accurately understand the statements' contents. All statements were expressed in short phrases, such as "When I do…" or "When I am…" Finally, 50 statements were confirmed.

Fourth, in the representation step, the medical students who rated the statements and created a similarity matrix were recruited via another notice in the medical college building. They visited one of the researchers' offices where they received an orientation on how to rate statements and create similarity matrix tables. The rating and sorting of statements took place in October and November 2022. The participants grouped similar statements into the same group and named them accordingly. The importance of each statement was indicated on a 5-point scale (1 = relatively unimportant, 5 = extremely important).

2.6 Instruments

To guide the generation of ideas during the preparation step, three open-ended focus questions were developed. As a next step, 50 concise statements were finalized and structured as short phrases for subsequent rating and grouping. Participants rated the importance of these statements on a 5-point Likert scale and grouped similar statements into categories, creating a similarity matrix essential for the concept mapping process. During the representation step, this task was facilitated through manual sorting and rating forms.

2.7 Data analysis

As continued representation step, the researcher (JL) created a group similarity matrix table by combining the similarity matrix tables evaluated by the medical students. A multidimensional scaling analysis was performed on the group similarity matrix. In the multidimensional scaling analysis, the number of dimensions was determined by considering three criteria: agreement, interpretability, and efficiency. Agreement represents the difference between the similar data evaluated by each interview participant and the finally derived spatial drawing, the degree of which is expressed as a stress value (18). Interpretability identifies whether the expressed dimensions are interpretable based on the attributes and contents of the statements (18). Efficiency determines the number of simple and of few dimensions as possible in consideration of agreement and interpretability (18). Kane and Trochim recommended that the concept map be expressed in two dimensions for efficient interpretation (18); therefore, this study also set it to two dimensions considering these results comprehensively. A distribution map based on the two-dimensional Euclidean distance model was derived. In concept mapping, statements located close to each other in two dimensions are recognized as having similar meanings, whereas statements far from each other are recognized as having different meanings. Hierarchical cluster analysis was conducted using the two-dimensional coordinate values obtained from the multidimensional scaling analysis. For cluster analysis, the Ward method was employed; as it makes distance-based data meaningful, hierarchical cluster analysis for conceptual mapping analysis is known to be particularly suitable (18). The number of clusters was then determined using a dendrogram, and concept mapping was completed by connecting the points corresponding to the statements within the clusters marked to the points from the multidimensional scaling analysis with lines.

Fifth, the concept mapping results were interpreted. As a result of the multidimensional scaling analysis, cluster names and dimensions were determined based on the relative positions of the statements displayed on the X- and Y-axes and the contents of the statements connected to the categories. Cluster names were determined based on the dendrogram results. The average importance and stress of the statements were calculated for each category. Finally, in the utilization phase, the overall results of the study were expressed as a concept map. Based on the results of the concept mapping, groups were identified and their names determined.

To analyze the qualitative content of the medical students' ideas about happiness and create the statements, Microsoft Excel ver. 2018 (Microsoft Corp., Redmond, WA, United States) was used. IBM SPSS ver. 24.0 (IBM Corp., Armonk, NY, United States) was used for the statistical analyses.

3 Results

3.1 Study participants

A total of 23 medical students responded to the focus questions on the concept of happiness. Sixteen medical students participated in statement rating and constructing the similarity matrix table (Table 1).

3.2 Concept mapping analysis for the perception of happiness

The 2D stress value was 0.279, which was within the average range (0.205–0.365) for multidimensional scaling analysis of concept

TABLE 1 Study participants.

Demographics		Generation of ideas	Sorting and rating
Sex	Male: Female	10:13	10:6
Grade	Premedical 1st year	8	6
	Premedical 2nd year	2	3
	Medical 1st year	1	2
	Medical 2nd year	3	3
	Medical 3rd year	4	1
	Medical 4th year	5	1
Total		23	16

mapping (22). The stress and squared correlation (RSQ) showed a relatively high explanatory power of 0.71.

The number of clusters was 2–5 based on the hierarchical cluster analysis dendrogram of the individual statements located at the coordinates derived through the multidimensional scaling analysis. As a result of the multidimensional scaling analysis, the statements were analyzed and classified into three categories and five subcategories, as reflected in the dendrogram (Figure 1).

The clusters derived from the hierarchical cluster analysis were determined by considering the relative positions of the statements displayed on the coordinates and the content of the statement bound to the category. The X-axis was named "Study–Life," and the Y-axis was named "Self–Relationship." The X-axis was divided into happiness related to academic achievement and personal life, and the Y-axis was divided into happiness with oneself and one's relationships with others (Figure 2, Table 2).

Based on the results of the Euclidean distance model and the dendrogram of the cluster analysis, the categories were named "Personal development," "Professional fulfillment," and "Social support." "Personal development" was classified into two sub-categories, "Self-management" and "Quality of life." "Social support" was its own category. "Professional fulfillment" was classified into two sub-categories, "Guaranteed future" and "Academic achievement" (Table 3). "Self-management" included 12 statements about one's attitude, emotions, life control, and self-awareness, while "Quality of life" included nine statements about one's health, sleep, economic power, rest, exercise, and work-life balance. "Social support" included 10 statements about friends, quality of people around oneself, family, and social activities. "Guaranteed future" included four statements about one's career as a doctor and their future goals, and "Academic achievement" included 15 statements about grades, studies, and examinations.

3.3 Importance of clusters and statements

Regarding the average importance score for each sub-category, "Social support" (3.84 ± 0.49) was rated as the most important, followed by "Self-management" (3.83 ± 0.35), "Quality of life" (3.82 ± 0.48), "Guaranteed future" (3.42 ± 0.57), and "Academic achievement" (3.30 ± 0.43). "When I have a healthy body and stamina" was considered the most important statement regarding happiness (4.56 ± 0.73), while "When I discuss academic content with colleagues" was rated as the least important (2.56 ± 1.21) (Table 3).

4 Discussion

In this study, concept mapping analysis was used to examine medical students' perception of happiness. The analysis was structured using multidimensional scaling and hierarchical cluster analyses. As a result, the 50 statements related to students' perception of happiness were divided into two axes (Study–Life and Self–Relationship) three categories (Personal development, Social support, and Professional fulfillment), and five sub-categories (Self-management and Quality of life; Social support; and Guaranteed future and Academic achievement).

The first cluster, "Self-management," included medical students' positive attitudes toward life, self-compassion, emotional control, mindfulness, and control over life, which was similar to previous studies showing that mindfulness training reduced medical students' anxiety, stress, and depression and improved their coping styles, empathy, and happiness (23, 24). Self-compassion has also been associated with authentic and durable happiness among Chinese college students (25). Stress and burnout are common among medical students due to excessive learning and frequent exams. Similar to Zhang et al.'s study, where positive psychology education enhanced the psychological well-being of Chinese medical students (14), medical schools should provide courses or programs that can improve students' emotional control, encourage mindfulness, and enhance their feelings of happiness.

Medical students said that they felt happy with their "Quality of life," which includes rest, hobbies, sleep, exercise, health, and economic power. Among the 50 statements, "When I have a healthy body and stamina," which had the highest importance score, belonged to this cluster. The importance students place on their physical health in this study can be found in previous research as well. Existing studies found similar factors influencing medical students' happiness, including well-being, quality of life, and health (1, 7, 8, 11). In addition, good physical, mental, and social health, strong social ties, and sufficient sleep were also associated with life satisfaction among medical students (26). Several studies conducted among medical students in Cyprus, India, and China have demonstrated a positive correlation between high levels of physical activity and happiness (27–29). This suggests that medical schools should make medical students aware of the importance of physical activity for their happiness, and support the creation of a physical environment and time to promote physical activity.

"Social support" includes friends, parents, social activities, and self-evaluations. Social support had the highest importance score of the five clusters, and the inclusion of family members seemed to reflect the cultural characteristics of South Korea. Psychological, health, life satisfaction, and positive emotional scores were correlated with happiness and quality of life of New Zealand college students, but there was little correlation between social and environmental factors, and happiness and quality of life (1). However, in this study, social aspects were important. In an exploratory factor analysis of survey responses on happiness among American college students, emotional, psychological, and social factors were classified, but Korean college students had other factors such as family relations, financial means, religion, appearance, health, and leisure (4). Koreans value social belonging, and Korean adults considered belonging to be more important for happiness than social recognition (30). In a study examining Hofstede's cultural dimensions across medical students and

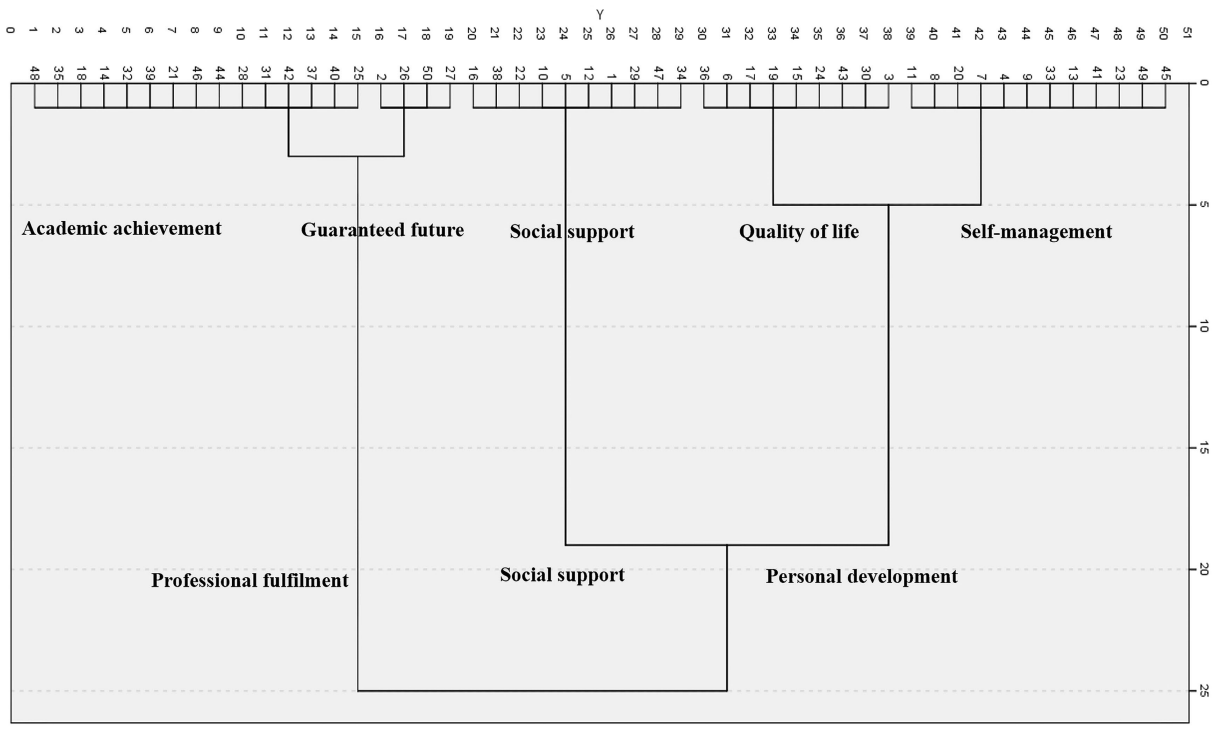


FIGURE 1
Dendrogram based on cluster analysis (Ward).

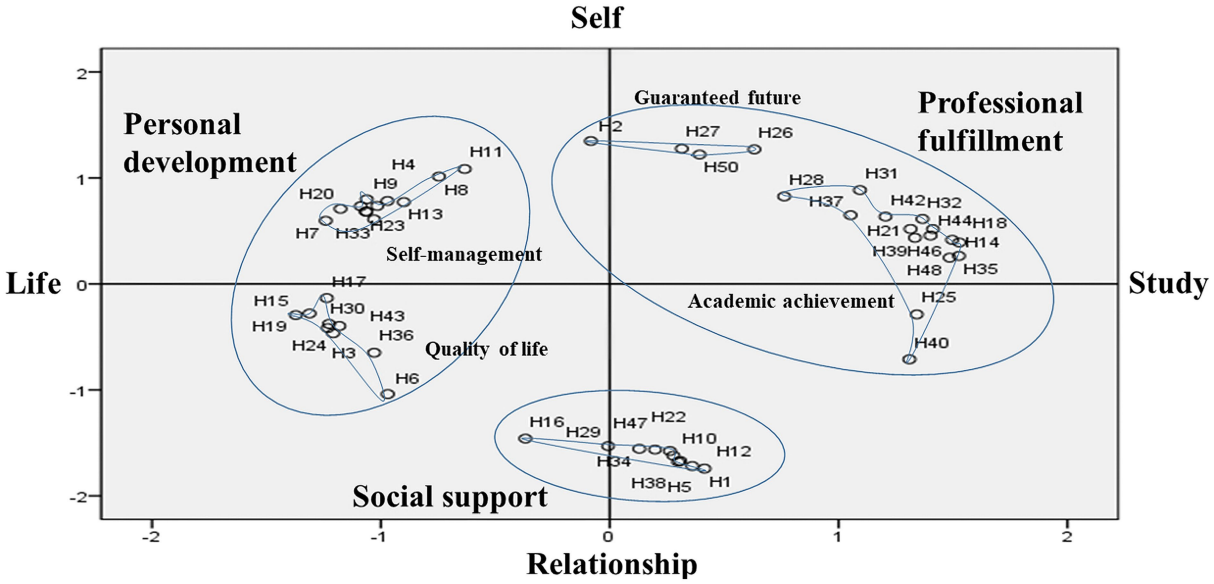


FIGURE 2
Concept map of when medical students feel happy.

trainees from 16 countries, most Asian countries showed lower individualism scores compared with English-speaking countries, South American countries, and Israel. Korean medical students and trainees, like the general Korean adult population, demonstrated low individualism scores and emphasized collectivism, suggesting they place high value on group belonging (31). Studies conducted on Korean nursing students also highlighted the importance of social relationships, demonstrating that activating group dynamics enhanced subjective happiness, leading to improved self-efficacy and resilience (32).

Another interpretation is that medical students value relationships in closed social environments because they spend most of their time

TABLE 2 Statements located at the extreme end of the X-Y axis.

X-axis: study–life	
(+) Study	(–) Life
14. When I enjoy studying medicine (1.5274)	15. When I exercise (−1.3718)
35. When I have safely passed difficult subjects without being flunked (1.5259)	19. When I have a healthy body and stamina (−1.3116)
18. When I feel that I am studying what I want to do (1.4966)	7. When I have my own way to overcome stress (−1.2408)
48. When I get a good grade compared to my work (1.4854)	17. When I maintain a good work–life balance (−1.2362)
44. When I feel proud and rewarded for my studies (1.4120)	3. When I am free to enjoy my hobbies (−1.2317)
46. When I feel that studying medicine is right for me (1.4017)	30. When I get enough sleep every day (−1.2266)

Y-axis: self–relationship	
(+) Self	(–) Relationship
2. When I work hard and do not obsess over the results (1.3487)	1. When I have good friendship (−1.7428)
27. When I have clearly defined my life goals (1.2764)	12. When I have friends I can share my feelings with (−1.7189)
26. When I have a desired direction of life after graduation, including a career as a doctor (1.2701)	10. When I get support from my family (−1.6792)
50. When I do not feel stressed about finding a job because a job (as a doctor) is guaranteed (1.2208)	5. When I have friends to overcome studying difficulties with (−1.6706)
11. When I am in control of my own life (1.0838)	38. When I adapt to school in the process of meeting and getting to know new people (−1.6203)

in medical schools or hospitals. In an Iranian study, medical students with secure attachment styles scored higher on the Oxford happiness inventory (33). In a Korean study using the Dundee Ready Educational Environment Measure (DREEM), students' social self-perception (SSSP) was the only predictor of subjective happiness both before and after the COVID-19 pandemic (34). Medical school life is tough, but programs, counseling, and mentoring can help medical students maintain positive relationships and feel a sense of belonging. Medical students should attempt to build positive relationships with their families and friends to increase their happiness.

"Guaranteed future" refers to one's stable career as a doctor and their life goals after graduation. A regression analysis showed that Iranian medical students' level of happiness is related to their attitudes toward their studies, especially their field of study, and future careers (35). Similar to our study, postgraduate and master's degree students were happy when their career optimism was higher (36). Students in health-related disciplines in Vietnam tend to report higher levels of subjective well-being, which may be attributed to their guaranteed employment prospects after graduation (37). Therefore, support is needed so that medical students can develop a positive attitude toward their studies, careers, and general future life direction.

"Academic achievement" involved grades and examinations. This cluster had the largest number of statements, indicating that students felt happiness related to academic achievement in various ways. However, this cluster also had the lowest importance score and it contained the statement "When I discuss academic content with colleagues," which was also rated the least important. Academic motivation was significantly associated with subjective well-being among Vietnamese university students, regardless of their major (37). Although academic motivation is associated with happiness, in our study as in others, medical students' grades did not seem to have a significant effect on their happiness. Yoo et al. reported that grade point average had no effect on Korean medical students' subjective happiness (15). Medical students with low academic performance have higher happiness scores than those with high academic performance (38). This suggests that students' grades have a low correlation with happiness and that whether they pass the course in general is more important.

The results of our study are consistent with those of a recent study that found that medical students were happier during the clinical practice period than during the pre-medical period (15). In addition, the medical students in this study felt happy about studying medicine and proud that their intended profession helped people. Enhancing medical students' pride and reminding them of the importance of the medical study process without over-emphasizing the importance of their grades can also improve their happiness. Although high or low grades do not have a significant impact on happiness, they cannot be ignored. It is also worth considering the introduction of an assessment system that prioritizes course completion on a pass/non-pass basis rather than an assessment system that assigns grades. For example, Korean medical students with criterion-referenced assessments in the medical curriculum had lower scores for stress, burnout, and depression and higher scores for quality of life than those with norm-referenced assessments (39).

4.1 Limitations and strengths of the study

This study has a few limitations. As it was conducted at a single medical college in Korea, generalization of the results may be difficult. Small sample size and relatively subjective interpretation, due to research design, could also cause difficult generalization. Future research should generalize the results with the increased sample size, expansion to a multi-center study, or supplement the interpretation method such as quantitative survey. Additionally, the results may have been influenced by the cultural background, medical education curriculum, and environment of the medical college in which the study was conducted. There is a need to replicate this study on other cultures, curricula, or educational environments.

TABLE 3 Clusters and statements about "when medical students feel happy."

Category	Subcategory (importance score)	Statement	Importance score
Personal development	Self-management (3.83 ± 0.35)	8. When I do my best in what I want to do	4.31 ± 0.79
		41. When I feel I am taking good care of myself	4.31 ± 0.70
		7. When I have my own way to overcome stress	4.25 ± 0.77
		45. When I feel good about myself and believe in myself	4.13 ± 0.96
		4. When I strive for self-realization even when I am busy	3.94 ± 1.12
		11. When I am in control of my own life	3.94 ± 1.12
		49. When I have an optimistic and positive personality	3.63 ± 1.45
		33. When I know what I like and what I do not like	3.56 ± 1.26
		20. When I am in control of my mood	3.56 ± 1.09
		23. When I have a non-comparison attitude	3.50 ± 1.21
		9. When I do not regret the past	3.44 ± 1.46
		13. When I know how to use my time effectively	3.44 ± 1.41
	Quality of life (3.82 ± 0.48)	19. When I have a healthy body and stamina	4.56 ± 0.73
		3. When I am free to enjoy my hobbies	4.31 ± 0.95
		30. When I get enough sleep every day	4.13 ± 1.26
		6. When I have more than enough money to live on	3.94 ± 1.29
		43. When I get enough rest on the weekend	3.94 ± 1.12
		15. When I exercise	3.50 ± 1.26
		17. When I maintain a good work–life balance	3.44 ± 1.26
		36. When I feel comfortable in my living space and study space	3.30 ± 1.26
		24. When I go on an overseas trip and experience a difference from my daily life	3.19 ± 1.38
	Social support (3.84 ± 0.49)	12. When I have friends I can share my feelings with	4.38 ± 0.89
		34. When I am evaluated as a trustworthy person for one reason or another by my peers	4.31 ± 0.79
		1. When I have a good friendship	4.31 ± 0.60
		5. When I have friends to overcome studying difficulties with	4.25 ± 0.86
		29. When I am in a happy relationship with a girlfriend/boyfriend	4.00 ± 1.10
		10. When I get support from my family	3.69 ± 1.08
		16. When I enjoy doing what I like while doing club activities	3.62 ± 1.02
		22. When I share my thought with like-minded people	3.44 ± 1.26
		38. When I adapt to school in the process of meeting and getting to know new people	3.44 ± 1.03
		47. When I participated in extracurricular activities (clubs, student council, etc.) at school	2.94 ± 1.00

(Continued)

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TABLE 3 (Continued)

Category	Subcategory (importance score)	Statement	Importance score
Professional fulfilment	Guaranteed future (3.42 ± 0.57)	27. When I have clearly defined my life goals	4.00 ± 0.82
		26. When I have a desired direction in life after graduation, including a career as a doctor	3.69 ± 1.08
		2. When I work hard and do not obsess over the results	3.31 ± 1.35
		50. When I do not feel stressed about finding a job because a job (as a doctor) is guaranteed	2.69 ± 1.35
	Academic achievement (3.30 ± 0.43)	39. When I feel a sense of accomplishment with good exam results	3.94 ± 1.00
		44. When I feel proud and rewarded for my studies	3.89 ± 0.89
		18. When I feel that I am studying what I want to do	3.81 ± 1.33
		37. When I feel that medical knowledge is mine	3.69 ± 1.08
		42. When I can continue learning with interest in my current study	3.56 ± 0.81
		25. When I finish the examination	3.25 ± 1.44
		28. When I think that I can use what I have studied to serve many people	3.31 ± 1.25
		21. When I have an appropriate desire for grades	3.31 ± 1.01
		31. When I have decided on the field I want to major in as a resident	3.31 ± 1.01
		46. When I feel that studying medicine is right for me	3.13 ± 1.36
		14. When I enjoy studying medicine	3.13 ± 1.15
		32. When I have a clinical clerkship in the department I am interested in	3.00 ± 0.97
		35. When I have safely passed the difficult subjects without being flunked	2.94 ± 1.06
		48. When I get good grades compared to my work	2.60 ± 1.40
		40. When I discuss academic content with colleagues	2.56 ± 1.21

Importance scores are presented as mean ± standard deviation.

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This study offers significant insights. First, it utilizes concept mapping analysis, allowing for a multidimensional understanding of happiness as medical students perceive it. This approach goes beyond traditional survey methods, capturing nuanced insights into students' perceptions. Second, it categorizes happiness into distinct dimensions, such as personal development, social support, and professional fulfillment, providing actionable recommendations for improving students' well-being.

4.2 Implications in medical education

Based on these research findings, we propose several interventions focusing on cultural and systemic factors that may influence the happiness of medical students. Medical schools should provide opportunities for mindfulness and emotional regulation training to enhance medical students' positive psychological states. While physical activity and health showed similar correlations with happiness across different cultural contexts among medical students, it may be challenging to incorporate physical activity into the formal curriculum. However, it is necessary to create an educational environment and hidden curriculum that enables physical activity. Korean medical students appear to be characterized by collectivistic culture, Confucian values, and a social rather than individual self-concept. Therefore, medical schools should provide opportunities for students to develop a sense of belonging to their medical school and the community, while supporting the formation of social support networks. Although medical students face greater burden regarding examinations and academic workload compared with other majors, their future career security and stability influence how academic achievement affects their happiness. Notably, academic grades have a relatively minor impact on their experience of happiness, indicating a need for career guidance that can instill professional pride in their future careers, along with curriculum management that emphasizes the learning process rather than grades.

5 Conclusion

In this study, medical students recognized happiness based on two criteria: study and life, and self and relationships. The concept of happiness was categorized into "Personal development," which was divided into "Self-management" and "Quality of life," "Social support," and "Professional fulfillment," which comprised "Guaranteed future" and "Academic achievement." Among these, "Social support," "Self-management," and "Quality of life" were considered to be the most important for medical students' happiness.

Based on the results of this study, medical educational institutions and educators should support medical students' happiness through emotional regulation and mindfulness programs, environments that support physical activities, programs that support positive social relationships, career and future coaching, and programs that support attitudes that emphasize the learning process over grades. Additionally, expanding on this research with a multicenter study with a larger sample size could enhance the results' generalizability and applicability.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study was approved by the Institutional Review Board of the Yonsei University Wonju Christian Severance Hospital (CR322034). 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, Formal analysis, Methodology, Software, Visualization, Writing – original draft. KP: Conceptualization, Data curation, Investigation, Supervision, Validation, Writing – original draft, Writing – review & editing. SL: Data curation, Project administration, Supervision, Writing – review & editing.

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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.

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Integrating jigsaw teaching into self-regulated learning instruction: an instructional design to improve nursing students' self-regulated learning

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Objective: This study aimed to investigate the impact of integrating Jigsaw teaching into Self-regulated learning instruction on nursing students' self-regulated learning ability and engagement.

Methods: This quasi-experimental study was conducted with 94 nursing students from Hubei University of Traditional Chinese Medicine (Hubei, China) in two classes during the fourth education semester. One classroom was assigned to the control group (43) and the other to the intervention group (50). In the course of Basic Nursing, the two classes adopted the traditional lecture teaching method and jigsaw teaching method to teach independent learning, respectively. The entire teaching scheme consisted of 12 class hours. The data collection tools were the self-regulated learning ability scale, the learning engagement scale, Self-assessment and mutual assessment forms. Data was collected before and after the interventions. Finally, data was analyzed by paired *t*-test, independent *t*-test and repeated measurement analysis of variance via SPSS 25.0 software.

Results: The total scores of self-regulated learning ability and learning engagement of nursing students in the Intervention group were better than that of the control group ($p < 0.05$) before and after the educational intervention. The Self-assessment ($F = 6.778$, $p < 0.001$).and group mutual assessment of nursing students ($F = 11.037$, $p < 0.001$) in the Intervention group at three time points would show an increasing trend with prolonging the intervention time.

Conclusion: Jigsaw teaching integrated with self-regulated learning can effectively enhance nursing students' self-regulated learning ability and commitment, which is worth using in other nursing courses.

KEYWORDS

jigsaw, self-regulated learning, nursing students, learning engagement, teaching

1 Introduction

Self-regulated learning is the ability of an individual to organize and manage learning activities spontaneously and independently in order to achieve learning objectives and maximize learning effects (1). Individuals with good self-regulate learning abilities can take the initiative to find learning resources, set learning goals, plan time and methods, self-assess and make adjustments timely to their learning strategies (2–4). This competency is particularly critical for nursing professionals, who operate in dynamic healthcare environments requiring continuous knowledge updates and skill refinement to meet evolving patient care standards and clinical demands. For nursing students—future frontline healthcare providers—cultivating robust SRL skills is essential not only for academic success but also for long-term professional competence and adaptability in clinical practice (5, 6).

Self-regulated learning theory believes that learners manage the learning process effectively by actively regulating their thoughts, feelings and behaviors so as to achieve satisfactory learning outcomes and a sense of achievement (7, 8). Based on Self-regulated Learning theory, Zimmerman et al. (9) Proposed a three-stage cyclic model of forethought, performance and self-reflection from the perspective of mutual support of Personality, Behavior and environment factors of social cognitive theory. The model is widely used in education (10–12). Several clinical or classroom teaching studies showed that the self-regulated learning cycle model positively enhanced learners' self-regulated learning skills (13–16). But now, in traditional classroom teaching, few teaching instructions take full account of environmental factors and are systematically designed using the cyclical effects of personality, behavior and the environment. Although Lan et al. and Baars et al. used the model to support learners' cognitive (i.e., learning strategies) and metacognitive processes by applying it to informational and networked teaching and learning, using applications to set up learning prompts and learning guidelines that provide a good physical environment and mobilize individual, behavioral factors. However, Lan et al. and Baars et al. applied the model to informational and online teaching. They used apps to set up learning prompts and guidelines to support learners' cognitive (i.e., learning strategies) and metacognitive processes, providing a good physical environment for learners and mobilizing individual behavioral factors (17–19). However, their cross-disciplinary applicability and scalability remain limited. This gap is especially pronounced in nursing education, where hands-on, group-based learning environments are prevalent, yet underutilized in fostering SRL (20, 21).

Among the environmental factors, apart from physical factors, social factors play an equally important role in the adjustment process of learners' self-regulated learning. By scientifically designing teaching programs, educators improve social factors' role in mobilizing students' individual and behavioral factors. Such teaching programs may be able to use individual, behavioral and environmental factors better to enhance the effectiveness of teaching and learning further. Another study indicated that social factors such as role modeling, peer learning and the support of others help learners to learn by imitation through observing the information, knowledge and experience of others. This facilitates the internalization and translation of learners' perceptions and behaviors into their own, thus contributing to the development of self-regulated learning. The Jigsaw teaching method, which incorporates role modeling, group work and balanced participation in learning activities, can make full use of social-environmental factors and mobilize the three factors to help each other (22, 23). Meanwhile, the Self-Regulated Learning cycle model can guide learners to set goals, make learning plans, and choose learning strategies in the self-learning process. This model can compensate for the Jigsaw teaching method's shortcomings in students' independent learning and self-monitoring.

Despite the recognized importance of SRL in nursing education, few studies have explicitly targeted nursing students or designed interventions tailored to their unique learning needs—such as balancing theoretical knowledge with clinical application and teamwork (24). Therefore, this study integrated jigsaw teaching into the Self-Regulated learning cycle model to form an instructional design for developing Self-regulated learning ability. The research addresses the urgent need for pedagogical strategies that prepare nursing students to thrive in both academic and clinical settings through improved self-regulation and collaborative competence.

2 Methods

2.1 Research design and setting

This quasi-experimental design was conducted on nursing students from February to March 2023, during the fourth academic semester at Hubei University of Traditional Chinese Medicine (Hubei, China).

2.2 Participants

To calculate the sample size for comparing two sample means, the formula is: $n1 = n2 = 2[(Z_\alpha + Z_\beta)s/\delta]^2$where the two sample sizes are equal, s represents the estimated standard deviation of the two populations, δ is the difference between the two population means, and Z_α and Z_β are the Z-values corresponding to the significance level α (α = 0.05) and Type II error probability β (β = 0.1), respectively. From the table, $Z_\alpha = 1.96$ and $Z_\beta = 1.282$. Referring to similar research (25), s was estimated as 6 and δ was set at 5.1. Substituting these values into the formula yields $n_1 = n_2 \approx 29$ for each group. Considering a 20% incidence of dropouts, each group should be recruited to ensure a minimum of 35 participants per group, resulting in a total sample size of at least 70 participants. Participants were recruited from two classrooms of nursing students in the fourth academic semester attending the Basic Nursing course. One classroom was assigned to the control group (43) and the other to the intervention group (50). During the study, three students failed to participate for some reason, and six students were unable to complete the questionnaire. Finally, 84 nursing students entered the control group and the intervention group (Figure 1).

Inclusion criteria: ① Nursing students in the fourth academic semester attended the Basic Nursing course at Hubei University of Traditional Chinese Medicine; ② voluntary participation in this study.

Exclusion criteria: ① Nursing students with a history of mental illness diagnosis before or during the intervention; ② those absent from the course more than once. ③ Those who filled out the questionnaire incompletely or did the answers regularly.

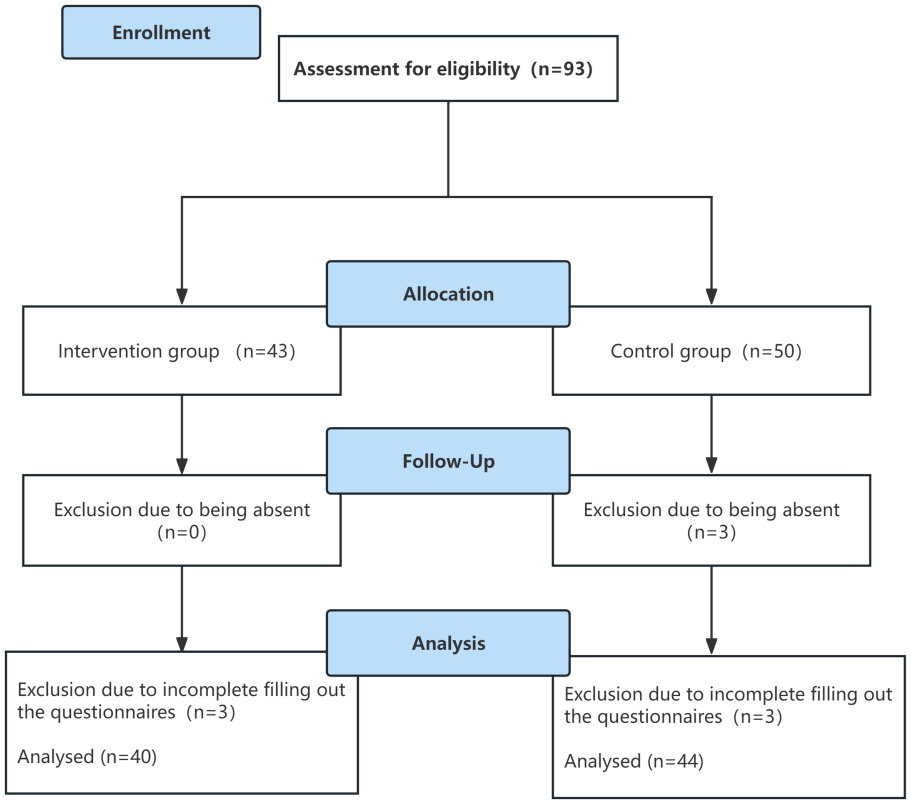


FIGURE 1
The process of the study.

2.3 Process

2.3.1 Teaching and learning arrangements

This study selected three teaching components (care of urination, common blood transfusion reactions and care, penicillin allergy test and management of allergic reactions) suitable for breaking down into multiple sub-tasks from the Basic Nursing course offered in the fourth semester. A total of 12 class hours (6 h online and 6 h offline) were devoted to this study. In this study, teachers in the intervention and control groups were randomly assigned, and the same teaching materials and syllabi were used in both groups. The teachers in both groups were consistent regarding teaching age, educational experience, and the results of the previous teaching evaluation. The teaching activities of the two groups were carried out concurrently. While the control group used traditional teaching methods, the intervention group implemented an instructional design to improve nursing students' Self-regulated Learning.

2.3.2 Control group

Traditional lecture strategies with interspersed questions and informational interactions were taught to the control group.

2.3.3 Intervention group

The intervention group implemented an instructional design to improve nursing students' Self-regulated Learning. Three content areas were selected for three cycles of instruction. Each cycle consisted of three implementation phases: forethought, performance, and self-reflection. The detailed implementation process is shown in Figure 2.

Pre-thinking (beforehand) stage: The purpose of this stage was to help nursing students **analyze the learning task** and **motivate their beliefs**. Self-study stage: Teachers set learning tasks for students and ask them to study the teaching content themselves. At the same time, teachers provided students with learning resources (teaching videos, teaching PPTs) and learning guidance. The learning guide had two parts, including the learning task explanation and learning guidance. The learning task explanation part explained the learning task, teaching process and role setting to students. In the study guide section, teachers guided students on study skills and strategies from the five dimensions of Engage, Explore, Explain, Expand, Elaborate, and Evaluate. These guides helped nursing students clarify learning objectives, develop learning plans, and provide directions and methods for finding teaching resources and resources.

Behavioral performance (in-progress) stage: The purpose of this stage was to guide nursing students to self-control and self-observation. In the self-regulated stage, students chose appropriate learning methods and techniques according to their learning objectives and study plans to gain an in-depth understanding and mastery of what they had learned. The Jigsaw method divided students into 'expert groups' and 'jigsaw groups'. 'In the "expert group" discussion stage, members of the group exchanged and shared what they had learned, understood their learning effect, filled in the gaps in knowledge, identified problems and corrected them in time to ensure the effectiveness of the teaching and learning process.

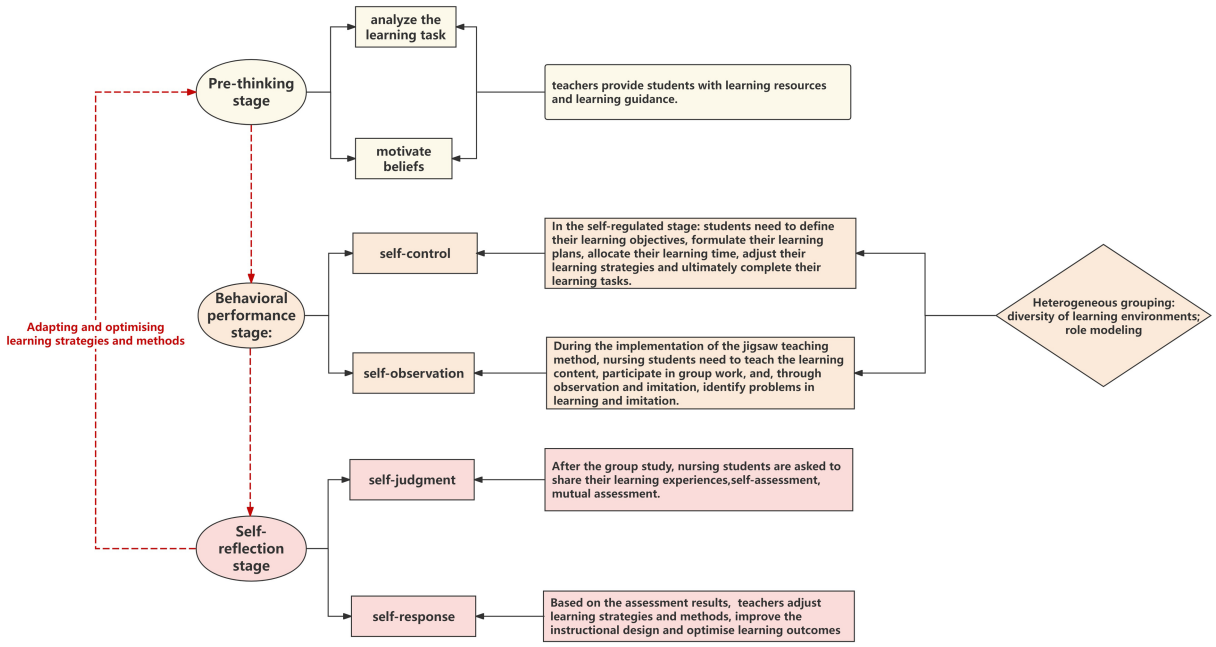


FIGURE 2
The instructional design for the integration of jigsaw teaching into independent learning.

In the 'jigsaw group' teaching stage, nursing students took turns teaching other members of the 'jigsaw group' the content boards they had learned and tested the learning effect. At the end of the 'jigsaw group' teaching, the teacher asked the nursing students who achieved good results to share their learning experiences and strategies.

Self-reflection (afterward) stage: The purpose of this stage was to create conditions for self-response and self-judgment for the nursing students. The jigsaw teaching method was completed by organizing the nursing students to share their learning experiences, self-assessment, and mutual assessment. Students make an objective and comprehensive assessment of their learning process, learning strategies and learning outcomes. This assessment could identify their learning strengths and weaknesses and provide guidance and direction for adjustment for the next round of independent learning.

In addition, the teacher progressively increased the task's difficulty over the 3 cycles of this teaching. Teachers changed from guiding the nursing students to providing counseling and ultimately achieving independent learning, thus promoting the development of nursing students' independent learning. In addition, the jigsaw method was implemented with the heterogeneous grouping strategy of 'jigsaw groups'. The heterogeneous grouping of nursing students was based on their third-semester grade point average (divided into four levels: 90–100 points, 80–89 points, 70–79 points, and 69 points and below), gender, and place of origin (in or out of the province).

2.4 Instruments

General demographic information included academic performance, place of origin, gender and arts and science division of the study population.

Zhang Xi Yan et al. developed the Self-regulated Learning Ability Scale in 2009 (47). It was mainly used to measure the self-regulated learning ability of nursing students. The scale covered four domains: learning motivation (8 items), self-management ability (11 items), cooperative ability (5 items), and information quality (6 items), with a total of 28 items. The scale was scored with a 5-point Likert scale ranging from total disagreement (score 1) to total agreement (score 5). The total score is 30 to 150. The higher the score of the nursing students, the better their independent learning skills. Cronbach's α coefficient of the scale was 0.82. The Cronbach's α coefficient for this study was 0.908.

The Learning Engagement Scale was developed by Schaufeli et al. in 2002 (26). This scale assessed students' psychological states of enduring, positive, and fulfilling emotions and perceptions of learning and research. The scale contains 17 items in three domains: vitality, dedication and concentration. The scoring was done on a Likert 7-point scale ranging from 1 (totally disagree) to 7 (totally agree). The minimum and maximum scores of the scale were reported as 17 to 85, respectively. Cronbach's α coefficient of the Learning Engagement Scale was 0.937. The Cronbach's α coefficient was 0.955 in this study.

Within the theoretical frameworks of self-regulated learning (SRL) and sociocultural constructivism, the researcher designed the self-assessment form and the mutual assessment form based on a review of the literature (27). The self-assessment form was used to help students find their strengths and room for improvement by reflecting on their performance in group learning. It mainly examines 4 aspects of nursing students' learning awareness, learning ability, effectiveness, and group cooperation. The mutual assessment form was designed to enhance the effectiveness and quality of whole group learning through evaluation and analysis by enabling students to look at problems from different perspectives and dimensions and to improve teamwork spirit. The mutual assessment form evaluates the rest of the group members

in 4 aspects: learning motivation, task completion, teamwork, and expression, and the form calculated the average score of each student. Both were scored on a 100-point scale. Higher scores represent better individual performance or better performance in team learning.

2.5 Data collection and analysis

This study employed descriptive and inferential statistical analyses. Pre-study data normality was assessed using the Kolmogorov–Smirnov test, with a significance level set at $p < 0.05$. The mean±standard deviation was used to describe self-regulated learning ability, learning engagement, self-appraisal, and peer evaluation. For between-subjects comparisons, an independent-samples *t*-test was conducted to analyze differences in self-regulated learning ability and learning engagement between the intervention and control groups. Within-subjects changes were evaluated using paired-samples *t*-tests. The self-appraisal and peer evaluation results were analyzed using repeated-measures ANOVA to examine trends in scoring across time points. To control for the family-wise error rate (FWER) resulting from multiple comparisons, the Bonferroni correction was applied. For pairwise comparisons across three time points, the adjusted significance level was set at $\alpha = 0.0167$ (0.05/3). If the assumption of sphericity in repeated measures ANOVA was violated, the Greenhouse–Geisser correction was utilized.

2.6 Ethical principles

Participants had the right not to participate or to withdraw from this study at any time and were informed of the study's purpose, content, scope, and confidentiality. In this study, if a student chooses to withdraw, that student may participate in the traditional teaching method with the control group and will not have their data included in this study. No students in this study refused to participate in the jigsaw method of instruction.

3 Results

3.1 General information

In the intervention group, there were 40 students, 2 boys (5%) and 38 girls (95%); 16 (40%) in science and 24 (60%) in arts; 25 (62.5%) in the province and 15 (37.5%) outside the province; the average grade in the third semester was (77.98 ± 5.73). In the control group, there were 44 students, 8 (18.2%) males and 36 (81.8%) females; 11 (25%) in science and 33 (75%) in arts; 28 (63.6%) in the province and 16 (36.4%) outside the province; and the average grade in the third semester was (80.16 ± 5.46). The differences between the two groups regarding gender, arts and sciences, place of origin and average grade in the 3rd semester were not statistically significant ($P>0.05$).

3.2 Self-regulated learning ability

As shown in Table 1. The independent samples t-test results showed that the difference between the self-regulated ability of nursing students in the intervention and control groups before the intervention was not statistically significant ($p > 0.05$). After the intervention, the difference between the two groups in nursing students' self-regulated ability was statistically significant ($p < 0.05$). Learning cooperative ability and information literacy were significantly higher than the control group's ($p < 0.05$). In addition, the paired t-test showed that the scores of nursing students' self-regulated ability in the intervention group were significantly higher after the intervention than before the intervention ($p < 0.05$), especially in the dimensions of motivation and cooperative ability ($p < 0.05$).

3.3 Learning engagement

According to the independent t-test results, the difference between the intervention and control groups of nursing students' learning engagement and their scores in each dimension before teaching was insignificant ($p > 0.05$). However, after the intervention, the total learning engagement and dedication dimension scores of nursing students in the intervention group were significantly higher than those of the traditional teaching method ($p < 0.05$). Meanwhile, the paired t-test results showed that the intervention of nursing students was better in vitality, dedication and total score after teaching than before teaching, and the differences were statistically significant (all $p < 0.05$; Table 2).

3.4 Self-assessment and mutual assessment of nursing students in the intervention group

Nursing students' self-assessment and mutual assessment forms were analyzed using repeated measures ANOVA with time as a within-group factor. Post-hoc paired t-tests were conducted to compare scores between specific time points. The results showed a statistically significant difference ($p < 0.05$) between the total self-assessment scale scores and the nursing students' learning ability and group cooperation dimensions at the three time points. It indicated that the nursing students' self-assessment would tend to increase with prolonging the intervention time ($p < 0.05$). The differences between the total scores of the mutual assessment scale and the dimensions of learning motivation and task completion of the nursing students at the three time points were also statistically significant ($p < 0.05$; Table 3). This suggested a gradual increase in the total scores of the mutual assessment form and the scores of the dimensions of motivation to learn and task completion of the nursing students with time.

4 Discussion

4.1 The instructional design of jigsaw teaching to develop self-regulated learning ability helped to strengthen nursing students' self-regulated learning ability

Self-regulated learning ability plays an important role in effectively promoting personal growth and professional development of nursing professionals and is an important support

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TABLE 1 Comparison of the differences between the intervention and control groups before and after the instructional design of self-regulated learning ability.

Sports event	Control group	Intervention group	*t*	*p*	Cohen's d
Motivation					
Before intervention	35.43 ± 6.42	34.45 ± 4.85	0.785	0.438	0.171
After intervention	34.20 ± 6.51	36.38 ± 3.66	−1.905	0.061	0.406
t	0.853	−3.071			
p	0.399	0.004*			
Cohen's d	0.128	0.486			
Self-management					
Before intervention	31.98 ± 5.47	31.40 ± 4.64	0.519	0.605	0.111
After intervention	30.84 ± 3.92	31.80 ± 3.52	−1.176	0.243	0.257
t	1.422	−0.934			
p	0.162	0.356			
Cohen's d	0.119	0.147			
Cooperative ability					
Before intervention	17.14 ± 2.58	17.03 ± 2.44	0.202	0.840	0.043
After intervention	16.70 ± 2.43	17.90 ± 1.65	−2.616	0.011*	0.506
t	0.782	−2.617			
p	0.438	0.012*			
Cohen's d	0.118	0.413			
Information quality					
Before intervention	20.75 ± 3.40	20.83 ± 3.06	−0.106	0.916	0.027
After intervention	20.32 ± 3.04	21.80 ± 2.30	−2.532	0.013*	0.546
t	0.587	−1.576			
p	0.560	0.123			
Cohen's d	0.088	0.249			
Self-regulated learning ability					
Before intervention	105.30 ± 16.73	103.70 ± 13.58	0.477	0.635	0.104
After intervention	102.07 ± 13.45	107.88 ± 7.67	−2.457	0.017*	0.524
t	1.014	−2.712			
p	0.316	0.010*			
Cohen's d	0.153	0.428			

*$p < 0.05$.

for realizing lifelong learning (28). The comparative results of this study found that the intervention group of nursing students' motivation, ability to cooperate in learning and total scores were significantly higher than those before teaching. After the intervention, the dimensions of learning cooperative ability and total scores of nursing students in the intervention group were significantly higher than those of the control group. The results indicated that incorporating the jigsaw method into the SRL (Self-regulated Learning) cycle model significantly affected nursing students' self-directed learning skills. Compared with SANAIE et al. (29), who used 14 h to implement Jigsaw teaching methods only, the implementation of Jigsaw teaching methods under the guidance of the SRL cycle model was able to enhance the nursing student's self-directed learning ability rapidly in a short period. This is closely related to the ability of the SRL cycle model to combine SRL theory and social cognitive theory to provide a structured learning path for nursing students (14, 30).

The SRL cycle model emphasizes the importance of the interplay of personal, behavioral and environmental factors in enhancing learners' self-regulated learning (7, 8, 23). The instructional design based on the SRL cyclic model provided nursing students with learning guidance in the pre-reflection phase. It enabled them to clarify learning objectives, formulate learning plans, develop learning strategies, and motivate learning in the individual dimension. At the behavioral performance stage, nursing students retrieve learning materials on the online platform according to the learning objectives, analyze and evaluate the information obtained, and organize and summarize what they have learned. Nursing students built their knowledge framework to enhance their information literacy level further. The jigsaw teaching method is a unique group-supportive

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TABLE 2 Comparison of differences between the intervention and control groups before and after the learning engagement intervention.

Sports event	Control group	Intervention group	*t*	*p*	Cohen's d
Vitality					
Before intervention	25.45 ± 4.17	26.48 ± 5.53	−0.960	0.340	0.209
After intervention	26.89 ± 4.20	28.28 ± 3.58	−1.623	0.109	0.354
t	−1.551	−3.257			
p	0.128	0.002*			
Cohen's d	0.233	0.515			
Dedication					
Before intervention	22.48 ± 3.42	23.78 ± 4.53	−1.490	0.140	0.324
After intervention	23.30 ± 3.55	25.20 ± 3.16	0.820	0.011*	0.565
t	−1.098	−2.794			
p	0.278	0.008*			
Cohen's d	0.165	0.442			
Concentration					
Before intervention	26.34 ± 4.25	27.60 ± 5.06	−1.239	0.219	0.271
After intervention	26.89 ± 4.44	28.05 ± 2.73	−1.428	0.157	0.312
t	−0.578	−0.589			
p	0.567	0.560			
Cohen's d	0.087	0.093			
Learning engagement					
Before intervention	74.27 ± 11.39	77.85 ± 14.38	0.218	0.208	0.277
After intervention	77.07 ± 10.83	81.53 ± 7.35	−2.185	0.032*	0.477
t	−1.149	−2.368			
p	0.257	0.023*			
Cohen's d	0.173	0.374			

*$p < 0.05$.

TABLE 3 Comparison of scores on self-assessment form and mutual assessment form of nursing students on 3 occasions of jigsaw methods.

Sports event	1st-Excretion	2nd-Blood transfusion	3rd-Penicillin	F	*p*
Self-assessment					
Awareness of learning	14.95 ± 1.80	15.65 ± 2.18	15.78 ± 2.34	2.150	0.123
Learning ability	14.13 ± 2.09	15.25 ± 2.15①	15.75 ± 3.13①	5.709	0.005
Learning effect	14.70 ± 2.70	15.35 ± 2.87	15.70 ± 2.41	1.780	0.175
Group work*	30.87 ± 4.30	31.68 ± 4.62	32.37 ± 4.25①	3.969	0.027
Total score*	74.65 ± 7.73	77.93 ± 9.35①	79.60 ± 8.27①②	6.778	0.000
Mutual assessment					
Learning motivation*	17.40 ± 0.75	18.34 ± 0.87①	18.54 ± 0.99①	15.809	0.000
Completion of the mandate	17.31 ± 0.81	17.84 ± 1.09①	18.02 ± 0.95①	7.721	0.001
Teamwork*	35.61 ± 3.35	35.72 ± 2.21	36.05 ± 3.29	1.523	0.231
Power of expression	17.43 ± 1.18	17.48 ± 0.81	17.81 ± 0.84①②	2.847	0.064
Totals	87.75 ± 4.04	89.38 ± 2.92①	90.42 ± 4.26①	11.037	0.000

① $p < 0.05$ compared with the 1st lecture; ② $p < 0.05$ compared with the 2nd lecture; *represents that the spherical hypothesis was not satisfied.

learning method. The jigsaw teaching method can provide nursing students with a social environment with role modeling, teaching support and feedback. This enables nursing students to continuously optimize their learning performance through observation, evaluation, and imitation (31, 32). This instructional design set up a self-reflection stage, where the teacher organized self-assessment, mutual assessment,

and learning experience sharing for the nursing students after each implementation of the jigsaw teaching method. In this process, nursing students could receive positive feedback to enhance their motivation and self-efficacy. Nursing students could also evaluate and learn the results, continuously adjust and improve their learning strategies, optimize the learning process, and further enhance their independent learning ability (33, 34). Although the difference in the dimensions of self-management ability was insignificant in this study, it could be seen from the data that the post-intervention data was higher than the pre-intervention data. As self-management was an ongoing process, extending the intervention time to a later stage was recommended to check the intervention's effect.

In summary, integrating the jigsaw teaching method into the SRL cycle model could not only fill the gap of the jigsaw teaching method in the pre-teaching stage of the inability to provide learning guidance for nursing students. It could also use the unique teaching advantages of the jigsaw teaching method, give full play to the role of social and environmental factors, mobilize the role of the three factors of mutual assistance, and rapidly improve the independent learning ability of nursing students.

4.2 The instructional design of jigsaw teaching to develop self-regulated learning ability helped to increase nursing students' learning engagement

The results of this study showed that the intervention group of nursing students scored significantly higher in dedication, vigor dimension, and total learning engagement after teaching than before teaching. The dedication dimension and total learning engagement scores were better than the control groups. In the jigsaw teaching method, each nursing student was required to undertake the assigned task alone. This form of division of labor and cooperation easily stimulated the nursing students' sense of responsibility, so they would participate in learning more actively and positively, complete their own tasks and contribute to the group. It was consistent with the findings of Toyokawa et al. (35) and Qin et al. (36). Cooperative learning and mutual support in the jigsaw teaching method could promote cooperation and emotional communication among students, establish a good learning atmosphere, develop a sense of responsibility and participation, and mobilize a reasonable balance between collaboration and competition. It could have a positive impact on students' learning engagement (29, 37). Guided by the SRL cycle model, this instructional design added heterogeneous grouping and instructional strategies such as experience sharing, self-assessment, and mutual assessment. This could give students exemplary role models and diverse learning experiences to enhance social influence (38). At the same time, it could also provide nursing students with timely explanation, guidance and feedback, stimulate healthy competition among peers, improve the accuracy of imitation behaviors, and then obtain positive feedback, which positively affected learning vitality and dedication (23, 39, 40). In this instructional design, the teacher provided learning guidance for students, which could help the nursing students generate learning path deviation in self-regulated learning to reach the learning objectives quickly and effectively (41, 42). It could be seen that combining the jigsaw teaching method with the SRL cycle model so that the advantages of both complement each other positively enhanced the learning engagement of nursing students. However, due to the short duration of the intervention and the absence of relevant intervention content, there was no obvious advantage in improving the concentration of nursing students. In later studies, appropriate interventions can be developed to enhance the concentration of nursing students.

4.3 The instructional design of jigsaw teaching to develop self-regulated learning ability helped to improve the general learning skills of nursing students

The results of this study showed that the experimental group's total self-assessment and mutual-assessment scores at the three time points tended to increase continuously, especially in the areas of learning ability and group cooperation in the self-assessment and learning motivation and task completion in the mutual assessment. This indicated that the instructional design of jigsaw teaching integrated with self-regulated learning teaching could effectively enhance nursing students' learning motivation and task completion. The instructional design of this study not only provided nursing students with a structured learning path and a framework for self-regulated learning but also provided them with a diverse form of metacognitive supervision. Such a self-learning structure could help nursing students recognize and monitor their learning process, improve their ability to use learning strategies and facilitate the integration and construction of knowledge, thus enhancing learning outcomes (43, 44). However, the teamwork and presentation skills differences were not statistically significant in the group mutual assessment. However, the presentation of the data showed that the trend was still increasing. This indicated that the group learning approach of verbally expressing one's opinions and thoughts was beneficial in improving nursing students' expressive and communication skills (45, 46). In addition, the heterogeneous grouping strategy was useful for nursing students to develop a cooperative spirit and a sense of teamwork that supports and promotes each other at different stages of learning.

5 Limitations

There were some limitations to this study. One, this study was implemented for only three rounds (a total of 12 class hours), which limited the improvement of the self-management skills of the nursing students, and it was recommended that the intervention be extended at a later stage. Secondly, as this study was conducted based on the normal teaching program of the school, the study participants were also involved in other courses and activities during the same period. Therefore, the influence of confounding factors on the findings could not be completely ruled out in this study. Thus, an independent instructional intervention program could be explored later by increasing the time and hours of instructional delivery for a more in-depth study.

6 Conclusion

The instructional design of jigsaw teaching integrated with self-regulated learning instruction could fully exploit social factors so that the three personal, behavioral, and environmental factors can interact

in the physical classroom. Furthermore, nursing students' self-regulated learning ability, learning engagement, and comprehensive learning ability could be rapidly improved. Therefore, the results of this study provide a useful reference for nursing professional education and can provide educators with effective teaching methods and strategies.

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 approval was not required for the studies involving humans because conducting teaching research in China is not required and cannot be applied for Ethics number. 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

YC: Conceptualization, Methodology, Project administration, Writing – original draft, Writing – review & editing. JS: Conceptualization, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. ML: Project administration, Software, Writing – review & editing, Writing – original draft. HH: Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing. XW: Formal analysis, Validation, Writing – review & editing. SZ: Data curation, Investigation, Writing – original draft. LW: Data curation, Investigation, Writing – original draft.

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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.

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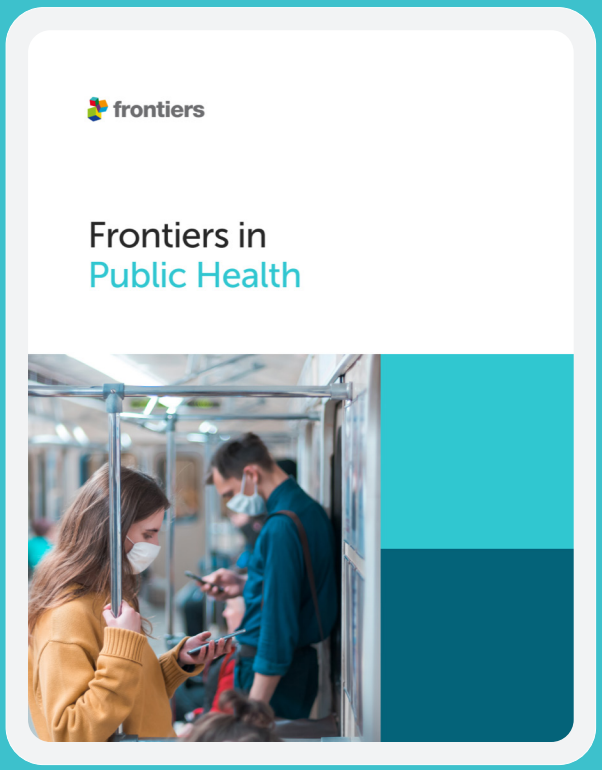
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