frontiers | Research Topics

Health literacy and disease prevention, volume II

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Published in
Frontiers in Public Health

ISSN 1664-8714
ISBN 978-2-8325-4564-5
DOI 10.3389/978-2-8325-4564-5

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Health literacy and disease prevention, volume II

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Citation

Bhattacharya, S., Gokdemir, O., Shikha, D., Petrazzuoli, F., Kushwaha, P., eds. (2024). *Health literacy and disease prevention, volume II*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-4564-5

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frontiers | Frontiers in Public Health

TYPE Editorial
PUBLISHED 27 February 2024
DOI 10.3389/fpubh.2024.1369146

OPEN ACCESS

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RECEIVED 11 January 2024
ACCEPTED 09 February 2024
PUBLISHED 27 February 2024

CITATION
Gokdemir O, Kushwaha P, Shikha D, Petrazzuoli F and Bhattacharya S (2024) Editorial: Health literacy and disease prevention, volume II.
Front. Public Health 12:1369146.
doi: 10.3389/fpubh.2024.1369146

Editorial: Health literacy and disease prevention, volume II

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KEYWORDS

editorial, health literacy, disease prevention and control, health promotion, public health

Editorial on the Research Topic
Health literacy and disease prevention, volume II

Introduction

In the twenty-first century, societies driven by knowledge face a dilemma in making health-related decisions. Individuals are ill-prepared and lack support in addressing the increasing challenges of navigating complex healthcare systems and making choices for personal and family wellbeing (1). Even those with higher education find it challenging to navigate healthcare systems in so-called "modern" societies, and education systems often fall short of providing people with the necessary skills to access, comprehend, evaluate, and apply information for improving their health. The quality and quantity of available evidence are influenced by factors such as the field, environment, healthcare system, or methodologies employed. Low health literacy levels have a significant negative impact on health placing a significant burden on the financial and personnel resources of the health system of any country (2). Policy initiatives to increase the health literacy epidemic are challenging due to multiple reasons. This editorial aims to contribute to reversing this situation by advocating health literacy by addressing micro, meso, and macro-level factors (3).

The Health Literacy and Disease Prevention series was launched 3 years ago. Its second volume included 22 research articles contributed by 138 authors and many reviewers around the globe. The series was launched with the goals of compiling the best available data on the subject, derived from complex scientific research and reviews and identifying policy implications and specific actions to translate these concepts into tangible results.

Examples from Europe

The World Health Organization (WHO) has released the survey titled "Conceptual Model of Health Literacy of the European Health Literacy Survey," where eight European countries contributed sample sizes 1,000 for validating this questionnaire. This dataset is the determinant of four levels of HL: which are "inadequate, problematic, sufficient, and outstanding." Limited HL

was operationalized as either poor or problematic HL, aiming to identify populations facing vulnerabilities. These statistics highlighted significant disparities and facilitated comparisons within and across these nations (4).

Higher levels of health literacy were associated with improved educational attainment, better self-reported overall health, and elevated indices of empowerment. Healthcare providers must acknowledge that people have varying degrees of HL, particularly those who have less education and self-reported health issues. Customizing health information to a person's HL level is essential to encouraging proactive disease management and giving people the confidence to take charge of their health (5).

Being health literate is essential to be able to get enough health information, navigate the healthcare system, receive the correct care, and be able to take charge of your health. As such, it is a significant predictor of health. According to Masquillier et al., innovative methods are needed to improve HL among socioeconomically disadvantaged people. Published research indicates that this innovation needs to offer dependable and understandable health information that is specific to the target population, facilitate "low-threshold access" to health resources through outreach in the community, and help people feel confident enough to act on that information. To meet this requirement, this article describes how the Integrated Community Care (ICC) framework was developed and put into use.

Examples from Asia

Abu-Humaidan et al., demonstrated satisfactory knowledge, attitudes, and practices (KAP) toward TB among Jordanian university students. The study emphasized the importance of raising awareness of TB transmission routes, treatment options, and availability, particularly among students pursuing careers unrelated to healthcare. It also revealed positive health-seeking behavior about tuberculosis, but it also revealed a concerning tendency of university students to question the value of mask wear. It makes sense to investigate the KAP toward tuberculosis among Jordanian refugee populations and risk groups to reduce the burden of disease going forward.

A study was conducted by Al-Gburi et al., on sexually transmitted infections among Baghdad University students. They reported that most participants had moderate to high knowledge, but there were gaps in knowledge regarding systemic symptoms of STIs and HIV. Respondents agreed on the need for sex education, but traditional and religious barriers were cited as major obstacles. There are specific knowledge gaps for certain high-risk groups, and negative attitudes and stigma should be addressed by increasing focused STI knowledge.

Li et al., conducted a study to analyze health literacy trends in China from 2008 to 2020 and found an improvement from 6.48 to 23.15%. However, significant disparities were noted between urban and rural areas, and the Eastern region had higher health literacy than the Central and Western regions. Age, education level, and social development index were found to be correlated with health literacy.

Marzo, ElSherif et al., examined the factors affecting burnout, resilience, and quality of life (QoL) among healthcare workers (HCWs) during the COVID-19 pandemic in Malaysia. Nurses were more susceptible to burnout and had lower resilience than doctors but reported higher QoL. Older HCWs had higher resilience, while younger and less experienced HCWs were overburdened. Higher-income was associated with better resilience, while longer work hours led to lower QoL. Policymakers and healthcare practitioners must prioritize interventions that promote a healthy workplace environment, address ethical concerns, and prevent burnout among HCWs. Managing long working hours could improve resilience, burnout, and QoL among HCWs.

In Malaysia, Marzo, Khaled et al., explored factors influencing parents' hesitancy to vaccinate their children. Based on their findings, they found that parents with higher levels of education tend to be more doubtful and believe that the vaccine is harmful and inefficient for their kids. It is critical to disseminate the required information about vaccine safety to the educated group.

Tao et al., examined the relationship between Ningbo citizens' knowledge of COVID-19 and HL. The knowledge of COVID-19 is associated with the following factors: age, gender, marital status, education, occupation, annual household income, and chronic conditions. To improve individuals' health literacy and stop the development of COVID-19, different demographic groups should undertake targeted health education and promotion programs.

To create a robust health literacy assessment in Hong Kong, Tian et al., conducted a study to develop the Hong Kong Health Literacy Scale (HLS-HK) and assess its "psychometric properties" among the Chinese adult population. The study concludes that the HLS-HK serves as a valid and dependable tool, and offers valuable insights into the challenges individuals might encounter when utilizing health-related information and services.

Wilandika et al., conducted a systematic review to describe the roles of nurses in promoting patient HL and identify its determinants. By facilitating patients' access to, comprehension, evaluation, and use of health information linked to their conditions, nurses can help patients become more health literate. They also need to be aware of the several elements that affect health literacy and take advantage of these elements to maximize the advancement of health literacy. Nurses can tackle health issues and enhance patient care by using a health literacy approach.

A study by Yang et al. found that the average rate of knowledge of cancer prevention and control measures among adults in Fujian Province was below the 70% target set by the Chinese Department of Health. Those living in urban areas, with white-collar jobs, married, having a bachelor's degree, family history of cancer, and good health, had higher knowledge. These findings can help policymakers design interventions to improve the general population's understanding of cancer prevention and control.

Correct medicine dosing is a crucial component of the safe and effective delivery of oral liquid medicines, particularly for the pediatric population. Younas et al., conducted a pre- and post-intervention survey to assess the knowledge and practice of university students for the same. The use of a tablespoon was significantly reduced, low-volume spoons were preferred, and a wide range of home spoons were rejected. The post-intervention survey also revealed a significant improvement in the proper

naming of spoons, the definition of the acronym "tsp," and the accurate amount of a standard teaspoon. They promoted the use of straightforward instruments, such as awareness seminars and brief video presentations, to enhance the appropriate administration and selection of dosing aids for oral liquid dose forms. This would reduce medication safety concerns and treatment failures.

Examples from Africa

Authors have created HL resources for Africa, but there is still a shortage of research. Research in 14 African nations showed low HL rates in rural, hard-to-reach areas and difficulties in understanding questionnaire responses. HL assessment tools specific to Africa are necessary (6).

Sah et al., opined that stigma about monkeypox in healthcare is a significant issue. Healthcare workers may conceal their condition due to stigma, posing a threat to transmit the infection. Educational campaigns to reduce stigma and urge infected cases to report their infection are necessary. Culturally acceptable health-promoting messages that provide accurate and timely information on monkeypox are essential. This helps create an environment where the disease and its effects can be discussed openly, honestly, and effectively, helping to prevent and control the disease and the outbreak.

Examples from America

Improving health literacy in Latin America requires a robust approach. International organizations recommend concerted efforts across sectors to enhance health literacy, improve outcomes, and reduce costs. Despite awareness among government officials, the issue remains inadequately addressed. There is a lack of understanding about how to achieve the goal of increasing health literacy (7).

Examples from Australia

Australia and other countries have policies for public health. Health literacy is poor in 60% of adult Australians, which affects their ability to make informed healthcare decisions. People with poor health literacy use more healthcare services and have worse health outcomes (8).

To ensure authentic engagement of all stakeholders and generate contextually appropriate, culturally sensitive, and implementable multisectoral solutions to identify the HL strengths, needs, and preferences of the former refugee community in Melbourne, Australia, Jawahar et al., presented a protocol that is a detailed adaptation of the Ophelia (Optimizing Health Literacy and Access) process. This protocol will develop and test new and improved approaches that are likely to be useful for community-based organizations and health services to thoroughly investigate and improve communication, services, and outcomes among disadvantaged groups, particularly migrants and refugees.

Conclusion

This Research Topic emphasized that HL is determined by various factors as mentioned above. To improve KAP, certain culturally acceptable, target-specific, health-promoting messages as well as required information about the epidemiology of the disease, its prevention, and treatment as well as other health-related practices should be disseminated through the Integrated Community Care approach. It also advocates the provision of a healthy workplace environment, addressing ethical concerns of HCWs, to improve resilience, burnout, and QoL so that they can tackle health-related issues and enhance patient care. This can be done by only developing and adapting a valid and dependable HL tool. Utilizing straightforward digital instruments, such as awareness seminars and brief video presentations can enhance HL, by enabling individuals to make informed choices.

Author contributions

OG: Writing—original draft, Writing—review & editing. PK: Writing—original draft, Writing—review & editing. DS: Writing—original draft, Writing—review & editing. FP: Writing—original draft, Writing—review & editing. SB: Writing—original draft, Writing—review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

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

Publisher's note

References

1. Kwame A, Petrucka PM. A literature-based study of patient-centered care and communication in nurse-patient interactions: barriers, facilitators, and the way forward. *BMC Nurs.* (2021) 20:158. doi: 10.1186/s12912-021-00684-2

2. Shahid R, Shoker M, Chu LM, Frehlick R, Ward H, Pahwa P. Impact of low health literacy on patients' health outcomes: a multicenter cohort study. *BMC Health Serv Res.* (2022) 22:1148. doi: 10.1186/s12913-022-08527-9

3. Sørensen K, Levin-Zamir D, Duong TV, Okan O, Brasil VV, Nutbeam D. Building health literacy system capacity: a framework for health literate systems. *Health Promot Int*. (2021) 36(Suppl.1):i13–23. doi: 10.1093/heapro/daab153

4. Kickbusch I, Pelikan JM, Apfel F, Tsouros AD. *Health Literacy: the Solid Facts [Internet]*. World Health Organization; Regional Office for Europe (2013). Available online at: https://iris.who.int/handle/10665/326432

5. Finbråten HS, Guttersrud Ø, Nordström G, Pettersen KS, Trollvik A, Wilde-Larsson B. Explaining variance in health literacy among people with type 2 diabetes: the association between health literacy and health behaviour and empowerment. *BMC Public Health.* (2020) 20:161. doi: 10.1186/s12889-020-8274-z

6. Ramos NNV, Kielmann K, Martins MDRO, Fronteira I. Health literacy in African countries: a scoping review. *Syst. Rev*. (2023) 3:156619. doi: 10.21203/rs.3.rs-3156619/v1

7. Arrighi E, Ruiz De Castilla EM, Peres F, Mejía R, Sørensen K, Gunther C, et al. Scoping health literacy in Latin America. *Glob Health Promot.* (2022) 29:78–87. doi: 10.1177/17579759211016802

8. *Health Literacy | Australian Commission on Safety and Quality in Health Care [Internet]*. Available online at: https://www.safetyandquality.gov.au/publications-and-resources/resource-library/health-literacy-taking-action-improve-safety-and-quality

frontiers | Frontiers in Public Health

TYPE Opinion
PUBLISHED 20 September 2022
DOI 10.3389/fpubh.2022.1023519

OPEN ACCESS

EDITED BY
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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 19 August 2022
ACCEPTED 29 August 2022
PUBLISHED 20 September 2022

CITATION
Sah R, Mohanty A, Reda A, Padhi BK and Rodriguez-Morales AJ (2022) Stigma during monkeypox outbreak. *Front. Public Health* 10:1023519. doi: 10.3389/fpubh.2022.1023519

Stigma during monkeypox outbreak

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KEYWORDS

stigma, monkeypox, outbreak, COVID-19, discrimination, healthcare worker

Monkeypox is an emerging viral zoonotic disease that is endemic in Central and West Africa. The first cases outside the African continent were detected in the United States of America (USA) in 2003 following the importation of infected animals. On July 23, 2022, the World Health Organization (WHO) declared monkeypox a Public Health Emergency of International Concern (PHIEC), following the rapid spreading into multiple continents in short time (1). Since July 6, 2022, 12,989 confirmed monkeypox cases have been detected, showing a more than 200% increase. The total number of cases has gone beyond 21,000 cases and has spread to 75 countries involving all six WHO regions (www.who.int) up to July 30, 2022. We need to increase the awareness about disease transmission, signs and symptoms, and how to prevent ourselves from this emerging infection. Lessons from research on past infectious disease outbreaks have taught us that stigma will pose a significant hurdle to health and wellness during any pandemic.

This problem of stigma needs to be identified in the current monkeypox pandemic. A stigma is a negative attitude about a person's mental, physical or social features or group of people. It is considered a type of social disapproval when the affected person thinks that society will not accept him/her due to this condition. Such social stigma in case of an outbreak can lead to many adverse effects, especially in low- and middle-income countries. That may mean people are being labeled, stereotyped, discriminated against, treated separately or are experiencing a loss of status given a perceived link with diseases (2). Stigma makes the people to hide the disease which boost the untrace spreading of the virus and making the outbreak worse. It has been seen in many infectious diseases, including HIV/AIDS, H1N1 and more recently in COVID-19, mainly due to false news published about a new condition and the fear of death when that new disease is associated with significant morbidity and fatality rates. In general, a new disease is always associated with many unknowns, and we are afraid of those unknowns, and thus, fear can be easily associated with them. New diseases transmitted *via* air and droplet are invariably associated with high social stigma, and COVID-19 is a perfect example of that. Healthcare workers and patients who survived COVID-19 faced substantial social stigma and discrimination worldwide. It created unprecedented panic in people's minds, with several socially stigmatized. Such discrimination resulted in affected people hiding their illness, prevented them from visiting hospitals and

ultimately led to certain psychological problems such as anxiety and depression and grave complications from the diseases due to lack of proper health care (3).

Such social stigma has now started appearing in monkeypox patients as the first confirmed case in Thailand could not be traced for nearly 5 days. He was a 27 years old Nigerian male who tested positive on July 18, 2022, in Phuket, Thailand, after which he went on the run, turned off his phone and failed to respond to messages from police and healthcare workers. After a countrywide chase across Thailand, his phone signal was detected in a northeastern province bordering Cambodia. Then Cambodian police captured him at Phnom Penh guest house and sent him to the Khmer–Soviet Friendship Hospital for medical care. The story of this Nigerian guy was like a movie where two country police were together trying to tract a single monkeypox-infected patient just like they were searching for some international mafia/terrorist. During the whole episode, he infected many others, all of whom are being screened. He had visited two entertainment venues and had unprotected sex with women. As a result, 142 people are now being screened for the monkeypox virus. Due to stigma, people avoid admitting infection or signs/symptoms and unknowingly spread the disease to others. This episode demonstrates the rising stigma associated with monkeypox and the difficulty in fighting the spread of the disease (4). The question is, then, how to combat this stigma associated with monkeypox?

Addressing stigma is fundamental in healthcare sector. Numerous studies during the COVID-19 pandemic have highlighted stigma and discrimination among healthcare workers. Lessons from COVID-19, which showed healthcare workers are vulnerable to such kind of emerging infections (5–7). Healthcare workers specifically belonging to LGBTQ+ community who get exposed to monkeypox virus can also hide their diseases status due to the stigma in the initial phase of the diseases and poses a threat to transmit the infection in the hospital setting during the working hours. Therefore, healthcare authorities should adopt educational campaigns to relieve this stigma and urge infected/suspected cases to report the infection and properly isolate themselves until proper care is provided. To reduce the social stigma associated with monkeypox, the Center for Disease Control and Prevention (CDC) has framed specific recommendations, including educating the general public about the disease as a legitimate public health concern (www.cdc.gov). It must be clear to people that everyone can acquire monkeypox, regardless of gender identity or sexual orientation, or age. Proper emphasis regarding the different modes of transmission, including direct contact with the infectious rash, respiratory secretions during face-to-face contact and touching infected objects, is also being given. We also should not stigmatize the gay and bisexual community (or in general LGBTIQ+ one) by holding them responsible for spreading the disease. They should be reached using targeted channels like specific websites, dating apps, or media programs, with a holistic approach. Reliable sources such as the CDC and WHO should be sought to obtain correct information about the disease. Any sign or symptom of the disease should be reported at the earliest, knowing that it is associated with a good prognosis in most cases. Besides all of the above, effective and impactful communication about monkeypox is critical to combat the disease and avoid fueling fear and stigma. It includes using friendly words with the patients, promoting the general population to participate in the spread of accurate scientific news and especially the social influencers whose voices have an impact (5–7). It is critically important to develop culturally acceptable health promoting messages that provide accurate and timely information on monkeypox its symptoms and prevention strategies. This certainly enable communities to fight against the disease. That ultimately helps create an environment where the disease and its effects can be discussed openly, honestly and effectively, finally helping in the prevention and control of the disease and the outbreak. Studies should explore how the Monkeypox stigma leads to differential diagnosis of the disease and its health outcomes including mental hygiene.

Author contributions

RS: draw and draft the manuscript. BP, AM, AR, and AR-M: review the literature, finalize, and edit the manuscript. All authors have read and approve for the final manuscript.

Conflict of interest

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

The handling editor SB declared a shared affiliation with the author AM at the time of review.

Publisher's note

References

1. *WHO Director-General's Statement at the Press Conference Following IHR Emergency Committee Regarding the Multi-Country Outbreak of Monkeypox - Jul 23 2022*. Available online at: https://www.who.int/director-general/speeches/detail/who-director-general-s-statement-on-the-press-conference-following-IHR-emergency-committee-regarding-the-multi--country-outbreak-of-monkeypox$-$23-july-2022 (accessed July 26, 2022).

2. *Stigma: Definition, Signs, Impact, and Coping*. Available online at: https://www.verywellhealth.com/stigma-5215412 (accessed July 26, 2022).

3. Saeed F, Mihan R, Mousavi SZ, Reniers RLEP, Bateni FS, Alikhani R, et al. A narrative review of stigma related to infectious disease outbreaks: what can be learned in the face of the Covid-19 pandemic? *Front Psychiatry*. (2020) 11:1369. doi: 10.3389/fpsyt.2020.565919

4. *Thailand's FiRst Monkeypox Patient Found After Fleeing to Cambodia*. Available online at: https://www.channelnewsasia.com/asia/thailands-first-monkeypox-patient-found-after-fleeing-cambodia-2831361 (acessed July 26, 2022).

5. *Reducing Stigma in Monkeypox Communication and Community Engagement | Monkeypox | Poxvirus | CDC*. Available online at: https://www.cdc.gov/poxvirus/monkeypox/reducing-stigma.html (acessed July 26, 2022).

6. *COVID-19 & Stigma: How to Prevent and Address Social Stigma in Your Community | UNICEF Sudan*. Available online at: https://www.unicef.org/sudan/covid-19-stigma-how-prevent-and-address-social-stigma-your-community (acessed July 26, 2022).

7. *Social Stigma Associated with COVID-19*. Available online at: https://www.who.int/docs/default-source/coronaviruse/covid19-stigma-guide.pdf (acessed July 26, 2022).

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 02 November 2022
DOI 10.3389/fpubh.2022.1038576

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 07 September 2022
ACCEPTED 18 October 2022
PUBLISHED 02 November 2022

CITATION
Gu C, Ma M, Xu J, Yuan W, Li R, Guo H, Gao H, Feng W, Guo H, Zheng L and Zhang Y (2022) Association between pulmonary ventilatory function and mild cognitive impairment: A population-based study in rural China. *Front. Public Health* 10:1038576. doi: 10.3389/fpubh.2022.1038576

Association between pulmonary ventilatory function and mild cognitive impairment: A population-based study in rural China

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Background: Mild cognitive impairment (MCI), a reversible intermediate state, plays an important role in the development and prevention of dementia. The relationship between pulmonary function and MCI risk has not yet been well-elucidated.

Methods: We included 2,947 rural Chinese residents aged ≥35 years who were free from a history of stroke, dementia, or other brain diseases and measured pulmonary ventilatory function using calibrated spirometry according to the recommended method. MCI was assessed with the Montreal Cognitive Assessment-Basic for Chinese scale. Logistic regression models and restricted cubic splines with covariate adjustment were performed to explore the association between pulmonary function and MCI risk.

Results: The prevalence of MCI increased with decreasing pulmonary function, from the lowest quartile to the highest quartile of pulmonary function: 63.9, 50.5, 43.8, and 43.6%, respectively. After adjustment for confounding factors, participants in the first quartile had a significantly increased risk of MCI (ORs, 1.691, 95% CI, 1.267–2.258), with the highest quartile as the reference. In the subgroup analysis, a significant association of pulmonary function and MCI was found in females and those with low physical activity. Meanwhile, we observed an L-shaped relationship between pulmonary function and MCI ($P_{non-linear} = 0.032$).

Conclusions: Poor pulmonary function was associated with an increased risk of MCI among rural Chinese adults, and presented a non-linear relationship. These findings remind us of the need for early cognitive assessment in local populations with lower pulmonary function.

KEYWORDS

pulmonary function, mild cognitive impairment, cognition, cross-sectional study, rural

Introduction

Dementia is one of the major public health problems and the leading cause of disability in elderly individuals worldwide (1). People with dementia in China account for ∼25% of the global dementia population, imposing immense challenges on patients, families and public health care systems (2). Mild cognitive impairment (MCI), a prodromal stage of dementia, is defined as subjective cognitive decline in combination with objective memory impairment beyond normal age-related changes without apparent impact on daily living (3). In China, large percentages of the population, particularly those living in rural areas, suffer from cognitive dysfunction. Recent studies have reported that the prevalence of MCI was 26.5% among elderly adults in rural areas, compared with 12.2% in urban areas and an overall prevalence of 15.5% (4–6). Additionally, adults with MCI are generally considered to have a higher risk of progression to dementia than the normal population, with an annual conversion rate ranging from 10 to 20% and a rate of 60–100% over 5–10 years in the elderly (7, 8). Encouragingly, MCI is a potentially reversible state, and the rate of progression from MCI to dementia is similar to that of reversion from MCI to normal (9). Thus, in the absence of any curative treatment for dementia, early identification of individuals at risk for MCI is a key interventional target for dementia, and adopting effective preventive strategies may delay or reverse disease progression to postpone the onset of dementia, which has prompted researchers to pay more attention in recent decades.

In addition to well-recognized risk factors, impaired pulmonary function is becoming increasingly recognized as a predictor of cognitive performance (10). A recent meta-analysis of cohort studies demonstrated that people with poorer pulmonary function and those with respiratory disease may be a risk factor for dementia (11). Data retrieved from the AGES-Reykjavik Study revealed that lower pulmonary function measured in midlife predicted poor memory, processing speed, executive function, MCI and dementia 23 years later (12). Accumulating epidemiological studies have also illustrated that the global cognitive decline and a greater risk of dementia have a significant relationship to indicators with pulmonary function expressed as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and peak expiratory flow (PEF) (12–17). However, previous studies have either focused on the association of COPD with dementia or MCI, or have targeted community-dwelling participants with relatively higher education and socioeconomic backgrounds, whereas information about the relationship between pulmonary function and MCI in rural populations is scarce (14–17). Furthermore, most studies have used only single a measure of ventilatory capacity to evaluate the respiratory condition and have not considered the resistance encountered during breathing and the contribution of respiratory muscles. Our aim, taken together, was to examine the association between pulmonary function and MCI among rural adults in China and whether the association may be modified by vital covariates.

Abbreviations: MCI, mild cognitive impairment; COPD, chronic obstructive pulmonary disease; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; PEF, peak expiratory flow; PF, composite pulmonary function; MoCA, montreal cognitive assessment; MoCA-BC, montreal cognitive assessment-basic for Chinese; ORs, odds ratios; CIs, confidence interval; BMI, body mass index; CHD, coronary heart disease; RCS, restricted cubic splines.

Materials and methods

Study population

All data were collected from a baseline survey in rural areas of Fuxin County, North China, from June to August 2019. Based on the demographic characteristics, participants were recruited from the eastern, southern, and northern townships to take part in our survey. The inclusion criteria were residents aged 35 and above who resided locally for at least 5 years and could sign a consent form during the investigation. Subjects were excluded if one of the following criteria were met: (1) were pregnant; (2) developed severe liver and renal failure; or (3) were unwilling to participate in this study. Finally, 4,689 participants were recruited. All participants gave their informed consent at the time of the examination and the Committee of China Medical University authorized the study protocol. The procedures followed were performed under the ethical standards of the responsible committee on human experimentation of China Medical University ([2018]083).

Of all 4,689 eligible participants, 1,600 dropped out due to missing information about spirometric indicators (n = 1,289), MoCA scores (n = 227) and confounding factors (n = 84). In addition, 142 participants with a self-reported history of stroke, depression, brain disease or dementia were excluded. In the end, Ultimately, 2,947 participants were enrolled in the analysis. A flowchart of the specific inclusion and exclusion criteria for participants in the current analysis is shown in Figure 1.

Assessment of pulmonary function

Spirometry was performed by trained medical physicians with a calibrated Chest HI-101 (CHESTGRAPH Tokyo, Japan) according to the recommended method. Participants were asked to take a sitting position and put the disposable mouthpiece into the mouth, with lips sealed tightly around the mouthpiece, while pinching the nose, breathe calmly, then took the deepest breath possible to fill the lungs with air and blow as hard and as fast as possible (18). For each participant, at least three

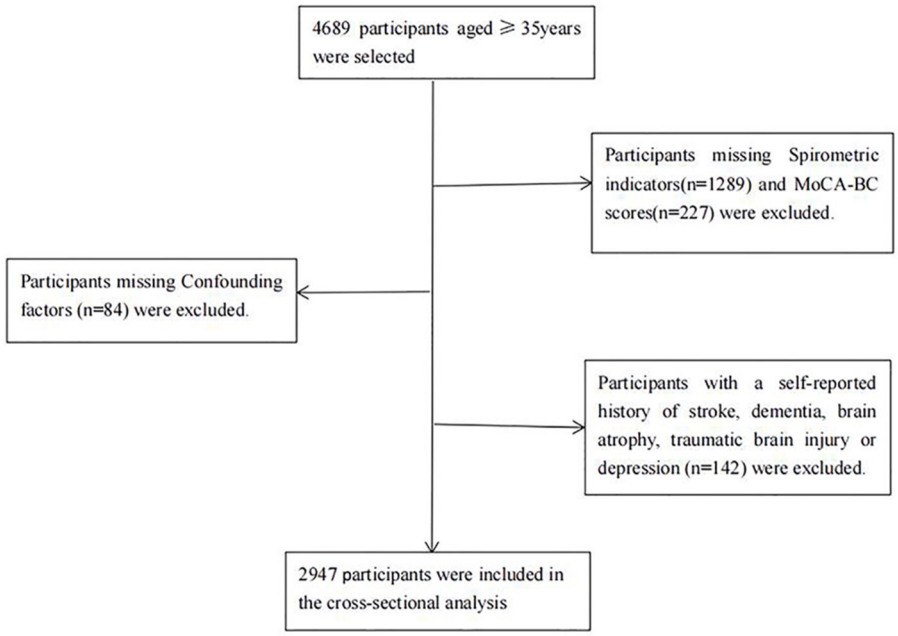

FIGURE 1
Flowchart of the participants included in the analysis. MoCA-BC, Chinese version of the Montreal Cognitive Assessment-Basic; MCI, mild cognitive impairment.

maneuvers were conducted to obtain repeatable results in which the corresponding best values were automatically recorded and confirmed by a technician. The best values of FVC, FEV1 and PEF were standardized into z scores by using the means and standard deviations computed from the entire study. According to previous studies (15, 16), we created a composite pulmonary function score by averaging the z-scores for FVC, FEV1, and PEF and then categorized them into four categories for the study.

Assessment of MCI

The Montreal Cognitive Assessment (MoCA), published in 2005, has been proven more sensitive and reliable in MCI screening than other scales (19). For the present study, we used the Chinese version of the Montreal Cognitive Assessment-Basic (MoCA-BC) to detect MCI in rural Chinese adults with different education levels, which is a 30-point test covering nine cognitive domains: executive function, episodic memory, orientation, calculation, abstraction, delayed recall, visuospatial skill, naming and attention, with higher scores reflecting a higher level of global cognition (20). The optimal cutoff scores for MCI assessment by the MoCA-BC were 19 for individuals with 6 or fewer years of education, 22 for those with 7–12 years of education, and 24 for those with more than 12 years of education (21, 22). The MOCA scale was conducted by specially trained investigators.

Assessment and definition of other variables

Relevant data on demographic variables (age, gender, ethnicity, education level), lifestyle factors (smoking, alcohol consumption), and history of disease were collected by face-to-face interview with a standardized questionnaire. Histories of disease were defined as self-reported and confirmed by medical records. Current smokers were defined as people who smoked at least one cigarette per day and continued for half a year. Alcohol ingestion was defined as at least three drinks every week for 6 months. Physical activity was rated three levels, low, moderate and high, based on the occupation engaged in.

Height and weight were measured using standardized procedures. BMI was calculated as weight (kg)/height $(m)^2$. Hypertension was taken as an antihypertensive medication in the last 2 weeks, DBP $\geq$90 mmHg or SBP $\geq$140 mmHg (23). Diabetes mellitus was defined as fasting serum glucose concentration $\geq$7.0 mmol/L, using hypoglycemic drugs or insulin, or self-reported diabetes diagnosis by a physician or other health professionals (24).

Statistical analysis

Continuous variables are represented as the mean $\pm$ standard deviation (SD) or medians (interquartile ranges),

and categorical variables are reported as frequencies (percentages). Analysis of variance or the Kruskal–Wallis rank-sum test for continuous variables, respectively, while the chi-square test for categorical variables was used to compare differences in basic characteristics of different pulmonary function quartile groups. In addition, baseline characteristics comparisons between MCI and non-MCI were also made using Student's *t*-test for continuous variables or the chi-square test for categorical variables.

We examined associations of each pulmonary function parameter (FVC, FEV1, PEF) and MCI. Binary logistic regression models were used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for composite pulmonary function and MCI. The composite pulmonary function score was assessed as quartiles 1–4 and quartile 1 vs quartiles 2–4. Three models were assessed, each building upon the prior model. Model 1 was unadjusted, model 2 was further adjusted for age and sex, and model 3 controlled for the variables in Model 2 plus body mass index (BMI), marital status, ethnicity, education level, smoke exposure, alcohol consumption, physical activity, hypertension, diabetes, histories of coronary heart disease (CHD), and chronic obstructive pulmonary disease (COPD). Tests for trends across quartiles were examined using ordinal values in separate models.

Moreover, we used restricted cubic splines (RCS) based on logistic regression models to visualize the relationship between pulmonary function and MCI on a continuous scale by adjusting the same confounders, with knots placed at the 10th, 50th, and 90th percentiles of the *z*-score of composite pulmonary function distribution. The threshold level for each section was determined using likelihood-ratio tests and bootstrap resampling methods. We further applied a piecewise regression model to examine the specific relationship between composite pulmonary function and MCI.

To assess relevant factors that had a modifying effect on the relationship between pulmonary function and MCI, we further conducted subgroup analyzes with study subjects stratified by sex, age (<65 or ≥65 years), smoking status (yes or no) and low physical activity (yes or no), respectively. We performed sensitivity analyzes to test the robustness of the results by repeating the analysis after excluding participants with respiratory symptoms ($n = 176$), histories of respiratory diseases, including COPD ($n = 61$), asthma ($n = 4$), pneumonia ($n = 5$), and other chronic lung diseases ($n = 2$). Subjects with occupational exposure ($n = 176$) or current smokers ($n = 980$) were also excluded.

The RCS analysis and threshold effect analyzes were conducted in R software, version 4.2.0 (http://www.R-project.org/) and other statistical analyzes were performed using IBM SPSS statistical software version 25.0 (SPSS Inc, USA). A 2-sided *P* value of <0.05 was considered statistically significant.

Results

Out of 2,947 subjects with available data, 1,487 (50.5%) were observed to have MCI. The average age of the participants was 57.5 ± 9.8 years, and 1,939 (65.8%) were females. The characteristics of the study participants are described by different quartiles of pulmonary function in Table 1. Participants in the lowest quartile of pulmonary function tended to be slightly older, female, lower BMI, less educational attainment, lower physical activity, poorer MoCA scores and more likely to have hypertension, diabetes mellitus, and a more extensive history of CHD and COPD. At the same time, Supplementary Table S1 summarizes the differences in baseline characteristics among people with and without MCI. Compared to the participants without MCI, a higher proportion of those with MCI were generally older and significantly related to lower education levels, less physical activity, a higher prevalence of hypertension and diabetes mellitus, and self-reported CHD and COPD, and were more prone to be current smokers and drinkers. There were significant differences between the included and excluded groups in baseline characteristics except BMI ($P = 0.359$).

There were inverse associations between FVC, FEV1 and PEF and the risk of MCI (Supplementary Table S2). Consistently, the prevalence of MCI in the participants decreased with increasing pulmonary function, being 63.9% (471/737), 50.5% (372/736), 43.8% (323/738), and 43.6% (321/736) in the lowest to highest quartiles of pulmonary function, respectively (Table 1). The association between composite pulmonary function and the risk of MCI is presented in Table 2. Compared to the highest quartile of pulmonary function, the risk of MCI was 1.691 (95% CI, 1.267–2.258) in quartile 1, 1.280 (95% CI, 0.979–1.674) in quartile 2 and 1.127 (95% CI, 0.881–1.441) in quartile 3, with a significant trend test ($P < 0.001$) in the fully adjusted model. When quartiles 2–4 were further combined, the participants in the lowest quartile had a 42.4% higher risk of MCI than those in the upper quartiles (ORs, 1.424; 95% CI, 1.164–1.741). Additionally, we observed a non-linear relationship between pulmonary function and the risk of MCI ($P_{\text{non-linear}} = 0.032$, Figure 2). A cutoff point of *z*-score for composite pulmonary function = 0.214 yielded the best fitting model in a piecewise regression after multivariable adjustment. The risk of MCI declined rapidly with increasing pulmonary function until to the turning point and then started relatively flat. As shown in Table 3, an increase of 1 SD in pulmonary function was associated with an OR of 0.715 (95% CI, 0.604–0.845) for MCI, while there was no significant difference between pulmonary function and the risk of MCI when the *z* score of composite pulmonary function was ≥0.214 (ORs, 0.967; 95% CI, 0.821–1.131).

We further performed subgroup analyzes to explore potential modifier and interaction effects on the PF-MCI

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TABLE 1 Baseline characteristics of participants by quartiles of composite pulmonary function.

	Quartile of PF [a]				*P*-value
	Q1 ($n = 737$)	Q2 ($n = 736$)	Q3 ($n = 738$)	Q4 ($n = 736$)	
Age, mean (SD)	63.2 (9.1)	58.5 (8.8)	54.9 (9.3)	53.5 (8.8)	<0.001
BMI, mean (SD)	24.2 (3.7)	25.0 (3.8)	24.9 (3.5)	24.8 (3.6)	<0.001
Female, *n* (%)	621 (84.3)	620 (84.2)	526 (71.3)	172 (23.4)	<0.001
Ethnicity, *n* (%)					
Han	472 (64.0)	439 (59.6)	486 (65.9)	485 (65.9)	0.055
Mongolian	240 (32.6)	255 (34.6)	227 (30.8)	223 (30.3)	
Others	25 (3.4)	42 (5.7)	25 (3.4)	28 (3.8)	
Education level, *n* (%)					
Primary school or below	417 (56.6)	327 (44.4)	230 (31.2)	145 (19.7)	<0.001
Junior high school	236 (32.0)	302 (41.0)	393 (53.3)	431 (58.6)	
Senior high school or above	84 (11.4)	107 (14.5)	115 (15.6)	160 (21.7)	
Marital status, *n* (%)					
Married	605 (82.1)	663 (90.1)	694 (94.0)	692 (94.0)	<0.001
Others	132 (17.9)	73 (9.9)	44 (6.0)	44 (6.0)	
Physical activity, *n* (%)					
Lower	296 (40.2)	207 (28.1)	176 (23.8)	142 (19.3)	<0.001
Moderate	429 (58.2)	509 (69.2)	531 (72.0)	532 (72.3)	
Higher	12 (1.6)	20 (2.7)	31 (4.2)	62 (8.4)	
Smoking, *n* (%)					
Non-smoker	521 (70.7)	555 (75.4)	539 (73.0)	317 (43.1)	<0.001
Current smoker	168 (22.8)	140 (19.0)	164 (22.2)	338 (45.9)	
Ex-smoker	48 (6.5)	41 (5.6)	35 (4.7)	81 (11.0)	
Drinking, *n* (%)					
Non-drinker	598 (81.1)	600 (81.5)	538 (72.9)	350 (47.6)	<0.001
Current drinker	91 (12.3)	103 (14.0)	161 (21.8)	320 (43.5)	
Ex-drinker	48 (6.5)	33 (4.5)	39 (5.3)	66 (9.0)	
Hypertension, *n* (%)	309 (41.9)	287 (39.0)	237 (32.1)	267 (36.3)	0.001
Diabetes, *n* (%)	100 (13.6)	100 (13.6)	78 (10.6)	65 (8.8)	0.008
CHD, *n* (%)	100 (13.6)	66 (9.0)	57 (7.7)	32 (4.3)	<0.001
COPD, *n* (%)	40 (5.4)	8 (1.1)	3 (0.4)	10 (1.4)	<0.001
Occupational exposure, *n* (%)	76 (10.3)	67 (9.1)	56 (7.6)	97 (13.2)	0.003
MoCA-BC, median (IQR)	19.0 (14.0, 23.0)	21.0 (16.0, 24.0)	22.0 (18.0, 26.0)	23.0 (19.0, 26.0)	<0.001
MCI, *n* (%)	471 (63.9)	372 (50.5)	323 (43.8)	321 (43.6)	<0.001

FVC, forced vital capacity; FEV1, forced expiratory volume in 1 s; PEF, peak expiratory flow; PF, composite pulmonary function; BMI, body mass index; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; MCI, mild cognitive impairment; MoCA-BC, the Chinese version of the Montreal Cognitive Assessment-Basic.

[a] Q1: PF < -0.6386; Q2: $-0.6386 \leq$ PF < -0.0687; Q3: $-0.0687 \leq$ PF < 0.5913; Q4: ≥ 0.5913.

association in participants with *z*-score for composite pulmonary function <0.214. As shown in Figure 3, no significant evidence of the effects of the interactions between pulmonary function and important covariables on the risk of MCI was found (all $P \geq 0.05$). Notably, we only found a relationship between lower pulmonary function and a higher risk of MCI in the female group and those with low physical activity, and the multivariate-adjusted ORs for MCI were 1.465 (95% CI, 1.165–1.071) and 2.000 (95% CI, 1.362–2.936), respectively. The risk of MCI for individuals with lower pulmonary function in non-smoker was higher (ORs, 1.301; 95% CI, 1.021–1.675), and even higher in smokers (ORs, 1.928; 95% CI, 1.224–3.035).

After exclusion of participants with respiratory symptoms, histories of respiratory diseases, occupational exposure and those who were current smokers, sensitivity analyzes yielded no any substantial differences from the main results (Supplementary Table S3).

TABLE 2 Odds ratios (ORs) and 95% confidence intervals (CIs) for the relationship between composite pulmonary function and MCI[a].

	Model 1		Model 2		Model 3	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Quartiles						
Q1 (<-0.6386)	2.289 (1.857–2.822)	<0.001	1.759 (1.328–2.330)	<0.001	1.691 (1.267–2.258)	<0.001
Q2 (−0.6386 to −0.0687)	1.321 (1.076–1.622)	0.008	1.294 (0.994–1.683)	0.055	1.280 (0.979–1.674)	0.071
Q3 (−0.0687 to −0.5913)	1.006 (0.819–1.236)	0.953	1.135 (0.892–1.446)	0.303	1.127 (0.881–1.441)	0.342
Q4 (≥0.5913)	1.000 (Ref.)		1.000 (Ref.)		1.000 (Ref.)	
P for trend [b]		<0.001		<0.001		<0.001
Categories						
Q1 (<-0.6386)	2.081 (1.752–2.472)	<0.001	1.471 (1.210–1.789)	<0.001	1.424 (1.164–1.741)	0.001
Q2–Q4 (≥-0.6386)	1.000 (Ref.)		1.000 (Ref.)		1.000 (Ref.)	

OR, odds ratio; CI, confidence interval; MCI, mild cognitive impairment; BMI, body mass index; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; SD, standard deviation; Ref, reference.
Model 1: unadjusted; Model 2: Adjusted for age, sex; Model 3: Adjusted for age, sex, BMI, marital status, ethnicity, education level, smoke exposure, alcohol consumption, physical activity, hypertension, diabetes, histories of CHD and COPD.
[a]ORs and CIs were calculated using binary logistic regression models.
[b]Test for trend based on variable containing median value for each quartile.

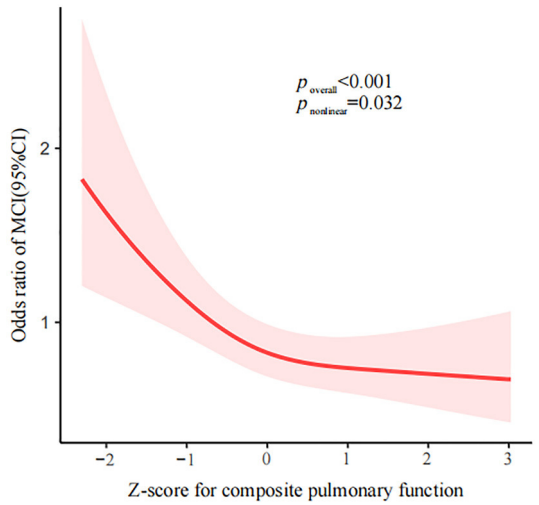

FIGURE 2
Association between *z*-score for composite pulmonary function and MCI using a restricted cubic spline regression. Multivariable adjusted odds ratios (ORs) and 95% CIs were derived from restricted cubic spline regression, with knots placed at the 10th, 50th, and 90th percentiles of *z*-score for composite pulmonary function. Solid red line represents multivariable adjusted odds ratios, with shaded part showing 95% confidence interval. Model adjusted for the same variables as model 3 in Table 2. MCI, mild cognitive impairment; ORs, odds ratio; CIs, confidence interval.

TABLE 3 Threshold effect analyzes of association between composite pulmonary function and MCI using two piecewise regression models.

	Adjust OR (95% CI)[a]	*P*-value
Logistic regression models	0.832 (0.745–0.926)	0.001
Piecewise regression models		
PF<0.214	0.715 (0.604–0.845)	<0.001
PF≥0.214	0.967 (0.821–1.131)	0.678
Likelihood ratio test		0.020

PF, composite pulmonary function; MCI, forced vital capacity.
[a]Adjusted for age, sex, BMI, marital status, ethnicity, education level, smoke exposure, alcohol consumption, physical activity, hypertension, diabetes, histories of CHD and COPD.

Discussion

In this population-based study of rural adults in Northeast China, we highlighted that poor pulmonary function was associated with a significantly increased risk of MCI and presented a non-linear relationship. Moreover, poor pulmonary function was associated with an elevated risk of MCI in females and those with low physical activity.

In normal human lungs, airflow depends on the expiratory driving pressure including the magnitude of expiratory muscle and elastic recoil as well as the size and viscoelastic properties of the lung and airway (25). FVC and FEV1/FVC have good sensitivity for diagnosing airflow limitation and are widely used relevant parameters for pulmonary function interpretation (26). PEF mainly reflects the caliber of the central airway and the pressure exerted by the expiratory muscles (27). These indicators of ventilator capacity are usually evaluated jointly in clinical diagnosis. Therefore, we used a composite pulmonary function indicator, including FVC, FEV1 and PEF, which took the thoracic volume, the resistance encountered during respiration and muscle strength into consideration, evaluating pulmonary function from different dimensions.

Evidence is converging as compromised lung health may be closely linked to cognitive performance. Burgraff et al. (28) found that a sustained decrease in cognitive function during

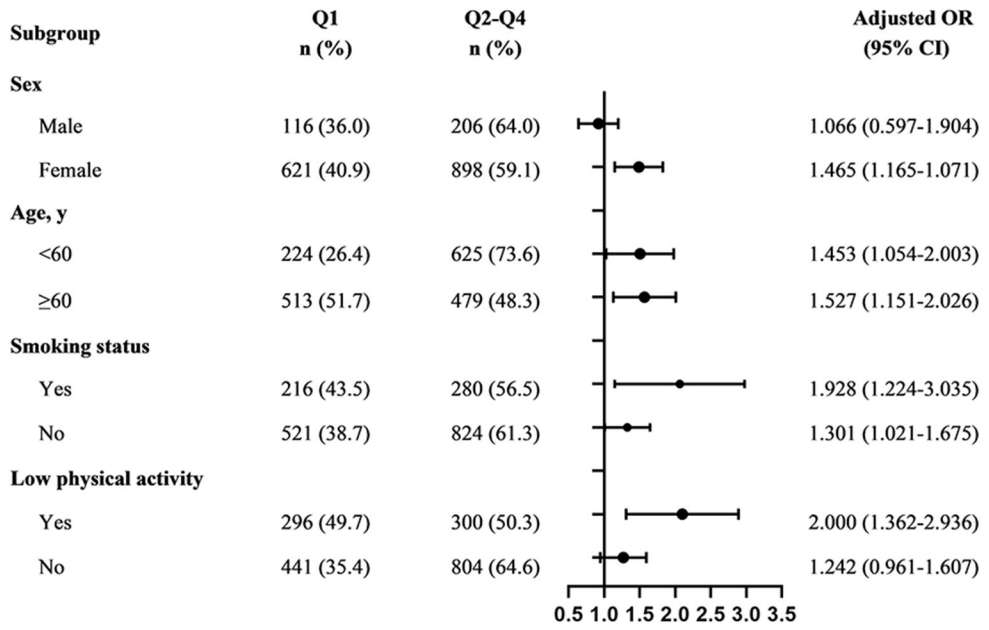

FIGURE 3
Subgroup analyzes of the association between composite pulmonary function and MCI among participants with *z*-score for composite pulmonary function <0.214. Q1: PF < −0.6386; Q2–Q4: ≥ −0.6386. Adjusted, if not stratified, for age, sex, BMI, marital status, ethnicity, education level, smoke exposure, alcohol consumption, physical activity, hypertension, diabetes, histories of CHD and COPD; MCI, mild cognitive impairment; ORs, odds ratio; CIs, confidence interval.

30 days of chronic hypercapnia in adult goats. Liang et al. (29) identified that children with hand, foot and mouth disease may have abnormalities in cognition, and respiratory function. A community-based cohort study involving 4,735 older Chinese adults showed that baseline COPD was independently associated with a 48.6% increased risk of MCI incidence (30). Another a prospective study including 1,425 cognitively normal participants aged 70–89 years, a diagnosis of COPD at baseline was associated with an increased risk of MCI, particularly na-MCI and presented a dose–response relationship between COPD duration of over 5 years at baseline and risk of MCI (31). Nevertheless, minimal data were available on the association between pulmonary function and MCI. In a previous population-based study, pulmonary function measured by FEV1/height^2 exhibited that lower pulmonary function during midlife was associated with an increased likelihood of MCI in later life (12). Also, data from the Atherosclerosis Risk in Communities (ARIC), poor FEV1 and FVC were indicated to be associated with a higher risk of MCI (14). Recently, Wang et al. (15) reported that poor pulmonary function was linked to a nearly two-fold elevated risk of MCI. Our study, in line with the results mentioned above, held up the conclusion that lower pulmonary function was associated with a higher MCI risk. To note, we found that, adjusting for confounding factors, every increase of per SD in pulmonary function was associated with a 28.5% lower risk of MCI, whereas it was 22.0% in Reykjavik (OR, 0.78; 95% CI, 0.68, 0.89) (12). The ARIC study, which included 15,792 American adults, demonstrated that participants in the lowest quartile of FEV1% predicted (OR 1.34, 95% CI, 1.10–1.64) and FVC% predicted (OR 1.32, 95% CI 1.08–1.60) had significantly higher risks of MCI, after adjustment for potential confounders, with the highest quartile as the reference (14). Our finding, when pulmonary function was expressed in quartiles, that those in the lowest quartile were associated with an OR of 1.691 (95% CI, 1.267–2.258) for MCI compared with the highest quartile. Additionally, the prevalence of MCI for participants in the lowest quartile and in the highest quartile groups was 63.9 and 43.6%, respectively, which was much higher than the prevalence in Reykjavik (10.5% vs 4.8% for FEV1/height^2) (12). Indeed, China has an unbalanced distribution of medical resources and a wide variation in medical standards between urban and rural areas (32). Residents in rural areas tend to experience disadvantages due to low income, poor living conditions, and reduced access to health services and low job satisfaction of primary health-care doctors (33, 34). In this regard, our findings may have important public health implications, as spirometry, which is easily measured, inexpensive, and highly reproducible in clinical practice, may be a potentially quick and easy-to-administer screening method for cognitive impairment to early identify people with poor pulmonary function who are at high risk of MCI and who might benefit from further neurodegenerative

health assessments. However, further research to assess the feasibility and predictive ability of using pulmonary function tests as a screening tool for MCI is warranted.

In addition, we observed an L-shaped association between pulmonary function and MCI. There existed a threshold at which the risk of MCI decreased significantly with the increase in pulmonary function, and an additional increase in pulmonary function will have no substantial effects on the risk of MCI. These findings remind us of the need for early cognitive assessment in local populations with lower pulmonary function. We should be aware of potential cognitive deficits in individuals with poor pulmonary function that will likely further worsen their general health and quality of life. Village doctors, known as "gatekeepers" of the rural primary health-care system, play an indispensable role in ensuring and improving the health level of rural residents (34, 35). Therefore, they are advised to become acquainted with how to conduct brief cognitive assessment tests. In terms of underlying mechanisms, researchers have proposed that the lung and brain operate under common regulatory processes (36). The detrimental influence on brain is mediated *via* an intricate web of signaling involving hypoxia, oxidative stress, systemic inflammation, neurotransmitter function, or a combination of these processes (37–41). On the one hand, poor pulmonary function may reduce oxygen supply to the brain, affecting brain energy metabolism, thereby promoting the occurrence and development of ischemic brain injury, and exacerbating white matter lesions or lacunar infarction. On the other hand, brain ischemia induces oxidative stress and synaptic dysfunction that may result in oxidative stress–mediated damage, accelerating vascular damage and degenerative lesions. These pathophysiological processes may interact with each other, ultimately resulting in cognitive impairment.

A longitudinal study of older Chinese adults demonstrated that the positive association between pulmonary function and cognition was stronger in females (17). Similar to our results, participants with poor pulmonary function had higher odds of MCI in the female group and in the physically inactive group. The discrepancy in different sex was attributed to a reduction of estrogen after menopause (42). Moreover, females might have a higher risk of MCI than males because of differences in sensitivity to hypoxia or other physiological changes associated with pulmonary function decline (43). Another possible explanation was that the sample size in the male subgroup was much smaller than that in the female subgroup, which may have resulted in insufficient power to detect the significance of the difference. In this population-based study, we could not corroborate this speculation; thus, it is imperative to this hypothesis in the future. The evidence from population-based studies indicates that remaining an appropriate level of physical activity is not only associated with a lower risk of depression but may also may be an important protective factor of pulmonary function and cognitive health (44–46). Apart from the benefits of physical activity on respiratory muscle endurance and strength, it is increasingly accepted that regular physical activity has long-term systemic anti-inflammatory effects (44, 47). This may be closely related to the reduction of airway inflammation, the release and expression of neurotransmitters, brain-derived neurotrophic factor and other chemical factors in the brain, and the changes of cerebral hemodynamics (45, 48).

Strengths and limitations

The major strength of our study is not only supported and extended existing evidence but also further found the non-linear relationship between pulmonary function and MCI, thereby further highlighting the need for early detection of cognitive performance in the lung-compromised population. Furthermore, integrated approach assessing pulmonary function, whereas previous studies have mainly focused on a single pulmonary function parameter.

However, inevitable limitations need to be borne in mind when interpreting the results. First, the associations of pulmonary function and MCI should be interpreted in the context of the cross-sectional design of the current study, in which the observed relationships are subject to potential confounding caused by unknown or unmeasured factors as well as the possibility of reverse causality, and thus cannot be interpreted as causal effects. Second, we only used a brief MoCA scale to define MCI, rather than a combination with comprehensive neuropsychological test assessments. Third, we must acknowledge that there might be selection bias due to a low response rate in spirometry. However, the pattern of age and sex distribution in subjects undergoing spirometry was similar to that in the entire subject group. Finally, all participants in this study were recruited from rural regions in Northeast China, which may limit the generalizability of our results.

In conclusion, poor pulmonary function was associated with an increased risk of MCI among rural Chinese adults, and presented a non-linear relationship. Further large prospective studies are needed to validate our findings. Overall, spirometry may be a simple and useful measure in primary health care practice, and individuals, especially those with poor lung function, should receive cognitive screening as early as possible to identify individuals at risk for early manifestations of dementia, which has important public implications for primary prevention targeted to rural adults.

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

The studies involving human participants were reviewed and approved by the procedures followed were performed under the ethical standards of the responsible committee on human experimentation of China Medical University ([2018]083). The patients/participants provided their written informed consent to participate in this study.

Author contributions

YZ and LZ foresaw this work and designed the overall research. JX, WY, RL, HuG, HG, and WF collected primary data and screened the data. CG performed the statistical analysis and drafted the manuscript. MM participated in data interpretation and critically revised the manuscript. HaG supervised the analysis. All authors contributed substantially to discussions of the content of this paper and agreed to the submitted version of the manuscript.

Funding

This research was supported by funds from the National Nature Science Foundation of China [No. 82073645].

Acknowledgments

We thank all the investigators and staffs who participated in this study for their important contributions. Thanks to all the enthusiastic participants.

Conflict of interest

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

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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.2022.1038576/full#supplementary-material

References

1. GBD 2016 Dementia Collaborators. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol.* (2019) 18:88–106. doi: 10.1016/S1474-4422(18)30403-4

2. Jia L, Quan M, Fu Y, Zhao T, Li Y, Wei C, et al. Dementia in China: epidemiology, clinical management, and research advances. *Lancet Neurol.* (2020) 19:81–92. doi: 10.1016/S1474-4422(19)30290-X

3. Petersen RC, Caracciolo B, Brayne C, Gauthier S, Jelic V, Fratiglioni L. Mild cognitive impairment: a concept in evolution. *J Intern Med.* (2014) 275:214–28. doi: 10.1111/joim.12190

4. Jia L, Du Y, Chu L, Zhang Z, Li F, Lyu D, et al. Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: a cross-sectional study. *Lancet Public Health.* (2020) 5:e661–71. doi: 10.1016/S2468-2667(20)30185-7

5. Cong L, Ren Y, Wang Y, Hou T, Dong Y, Han X, et al. Mild cognitive impairment among rural-dwelling older adults in China: a community-based study. *Alzheimer's Dement.* (2022) 8:1335–44. doi: 10.1002/alz.12629

6. Lu Y, Liu C, Yu D, Fawkes S, Ma J, Zhang M, et al. Prevalence of mild cognitive impairment in community-dwelling Chinese populations aged over 55 years: a meta-analysis and systematic review. *BMC Geriatr.* (2021) 21:10. doi: 10.1186/s12877-020-01948-3

7. Etgen T, Sander D, Bickel H, Förstl H. Mild cognitive impairment and dementia: the importance of modifiable risk factors. *Dtsch Arztebl Int.* (2011) 108:743–50. doi: 10.3238/arztebl.2011.0743

8. Petersen RC. Clinical practice. Mild cognitive impairment. *N Engl J Med.* (2011) 364:2227–34. doi: 10.1056/NEJMcp0910237

9. Sanz-Blasco R, Ruiz-Sánchez de León JM, Ávila-Villanueva M, Valentí-Soler M, Gómez-Ramírez J, Fernández-Blázquez MA. Transition from mild cognitive impairment to normal cognition: determining the predictors of reversion with multi-state Markov models. *Alzheimer's Dement.* (2022) 18:1177–85. doi: 10.1002/alz.12448

10. Dodd JW. Lung disease as a determinant of cognitive decline and dementia. *Alzheimer's Res Ther.* (2015) 7:32. doi: 10.1186/s13195-015-0116-3

11. Russ TC, Kivimäki M, Batty GD. Respiratory disease and lower pulmonary function as risk factors for dementia: a systematic review with meta-analysis. *Chest.* (2020) 157:1538–58. doi: 10.1016/j.chest.2019.12.012

12. Vidal JS, Aspelund T, Jonsdottir MK, Jonsson PV, Harris TB, Lopez OL, et al. Pulmonary function impairment may be an early risk factor for late-life cognitive impairment. *J Am Geriatr Soc.* (2013) 61:79–83. doi: 10.1111/jgs.12069

13. Weuve J, Glymour MM, Hu H, Sparrow D, Spiro A 3rd, Vokonas PS, et al. Forced expiratory volume in 1 second and cognitive aging in men. *J Am Geriatr Soc.* (2011) 59:1283–92. doi: 10.1111/j.1532-5415.2011.03487.x

14. Lutsey PL, Chen N, Mirabelli MC, Lakshminarayan K, Knopman DS, Vossel KA, et al. Impaired lung function, lung disease, and risk of incident dementia. *Am J Respir Crit Care Med.* (2019) 199:1385–96. doi: 10.1164/rccm.201807-1220OC

15. Wang J, Dove A, Song R, Qi X, Ma J, Bennett DA, et al. Poor pulmonary function is associated with mild cognitive impairment, its progression to dementia, and brain pathologies: a community-based cohort study. *Alzheimer's Dement.* (2022). doi: 10.1002/alz.12625. [Epub ahead of print].

16. Wang J, Song R, Dove A, Qi X, Ma J, Laukka EJ, et al. Pulmonary function is associated with cognitive decline and structural brain differences. *Alzheimer's Dement.* (2021). doi: 10.1002/alz.12479. [Epub ahead of print].

17. Shang X, Scott D, Chan RK, Zhang L, He M. Association of pulmonary function with cognitive decline in older adults: a nationwide longitudinal study in China. *J Gerontol A Biol Sci Med Sci.* (2021) 76:1423–30. doi: 10.1093/gerona/glab096

18. Landi F, Salini S, Zazzara MB, Martone AM, Fabrizi S, Bianchi M, et al. Relationship between pulmonary function and physical performance among community-living people: results from Look-up 7+ study. *J Cachexia Sarcopenia Muscle.* (2020) 11:38–45. doi: 10.1002/jcsm.12485

19. Hoops S, Nazem S, Siderowf AD, Duda JE, Xie SX, Stern MB, et al. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology.* (2009) 73:1738–45. doi: 10.1212/WNL.0b013e3181c34b47

20. Tang Y. The MoCA as a cognitive screening tool for mild cognitive impairment (MCI) in elderly adults in China. *Psychiatry Res.* (2020) 291:113210. doi: 10.1016/j.psychres.2020.113210

21. Chen KL, Xu Y, Chu AQ, Ding D, Liang XN, Nasreddine ZS, et al. Validation of the Chinese version of montreal cognitive assessment basic for screening mild cognitive impairment. *J Am Geriatr Soc.* (2016) 64:e285–90. doi: 10.1111/jgs.14530

22. Huang L, Chen KL, Lin BY, Tang L, Zhao QH, Lv YR, et al. Chinese version of montreal cognitive assessment basic for discrimination among different severities of Alzheimer's disease. *Neuropsychiatr Dis Treat.* (2018) 14:2133–40. doi: 10.2147/NDT.S174293

23. Joint Committee for Guideline Revision. Chinese guidelines for prevention and treatment of hypertension-a report of the revision committee of Chinese guidelines for prevention and treatment of hypertension. *J Geriatr Cardiol.* (2019) 16:182–241. doi: 10.11909/j.issn.1671-5411.2019.03.014

24. Wang L, Li X, Wang Z, Bancks MP, Carnethon MR, Greenland P, et al. Trends in prevalence of diabetes and control of risk factors in diabetes among US adults, 1999–2018. *JAMA.* (2021) 326:1–13. doi: 10.1001/jama.2021.9883

25. Stanojevic S, Kaminsky DA, Miller MR, Thompson B, Aliverti A, Barjaktarevic I, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. *Eur Respir J.* (2022) 60, 2101499. doi: 10.1183/13993003.01499-2021

26. Tseng HJ, Henry TS, Veeraraghavan S, Mittal PK, Little BP. Pulmonary function tests for the radiologist. *Radiographics.* (2017) 37:1037–58. doi: 10.1148/rg.2017160174

27. Ma H, Liu F, Yang X, Liu Q, Wang X, Xing X, et al. Association of short-term fine particulate matter exposure with pulmonary function in populations at intermediate to high-risk of cardiovascular disease: a panel study in three Chinese cities. *Ecotoxicol Environ Saf.* (2021) 220:112397. doi: 10.1016/j.ecoenv.2021.112397

28. Burgraff NJ, Neumueller SE, Buchholz K, Langer TM 3rd, Hodges MR, Pan L, et al. Ventilatory and integrated physiological responses to chronic hypercapnia in goats. *J Physiol.* (2018) 596:5343–63. doi: 10.1113/JP276666

29. Liang L, Cheng Y, Li Y, Shang Q, Huang J, Ma C, et al. Long-term neurodevelopment outcomes of hand, foot and mouth disease inpatients infected with EV-A71 or CV-A16, a retrospective cohort study. *Emerg Microbes Infect.* (2021) 10:545–54. doi: 10.1080/22221751.2021.1901612

30. Xie F, Xie L. COPD and the risk of mild cognitive impairment and dementia: a cohort study based on the Chinese longitudinal health longevity survey. *Int J Chron Obstruct Pulmon Dis.* (2019) 14:403–8. doi: 10.2147/COPD.S194277

31. Singh B, Mielke MM, Parsaik AK, Cha RH, Roberts RO, Scanlon PD, et al. A prospective study of chronic obstructive pulmonary disease and the risk for mild cognitive impairment. *JAMA Neurol.* (2014) 71:581–8. doi: 10.1001/jamaneurol.2014.94

32. Yi M, Peng J, Zhang L, Zhang Y. Is the allocation of medical and health resources effective? Characteristic facts from regional heterogeneity in China. *Int J Equity Health.* (2020) 19:89. doi: 10.1186/s12939-020-01201-8

33. Zhang X, Ning N, Zhou H, Shan L, Hao Y, Jiao M, et al. Inequity in health services utilization in economically underdeveloped regions of northeast China. *Front Public Health.* (2022) 10:850157. doi: 10.3389/fpubh.2022.850157

34. Chen Y, You Y, Wang Y, Wang Y, Dai T. Global insights into rural health workers' job satisfaction: a scientometric perspective. *Front Public Health.* (2022) 10:895659. doi: 10.3389/fpubh.2022.895659

35. Chen Y, You Y, Wang Y, Wang Y, Dai T. Systematic and meta-based evaluation on job satisfaction of village doctors: an urgent need for solution issue. *Front Med.* (2022) 9:856379. doi: 10.3389/fmed.2022.856379

36. Stevens RD, Puybasset L. The brain-lung-brain axis. *Intensive Care Med.* (2011) 37:1054–6. doi: 10.1007/s00134-011-2233-1

37. Terraneo L, Samaja M. Comparative response of brain to chronic hypoxia and hyperoxia. *Int J Mol Sci.* (2017) 18, 1914. doi: 10.3390/ijms18091914

38. Newton DF, Naiberg MR, Goldstein BI. Oxidative stress and cognition amongst adults without dementia or stroke: implications for mechanistic and therapeutic research in psychiatric disorders. *Psychiatry Res.* (2015) 227:127–34. doi: 10.1016/j.psychres.2015.03.038

39. Hancox RJ, Gray AR, Sears MR, Poulton R. Systemic inflammation and lung function: a longitudinal analysis. *Respir Med.* (2016) 111:54–9. doi: 10.1016/j.rmed.2015.12.007

40. Kumar GK. Hypoxia. 3 hypoxia and neurotransmitter synthesis. *Am J Physiol Cell Physiol.* (2011) 300:C743–51. doi: 10.1152/ajpcell.00019.2011

41. Love S. Oxidative stress in brain ischemia. *Brain Pathol.* (1999) 9:119–31. doi: 10.1111/j.1750-3639.1999.tb00214.x

42. Snyder HM, Asthana S, Bain L, Brinton R, Craft S, Dubal DB, et al. Sex biology contributions to vulnerability to Alzheimer's disease: a think tank convened by the women's Alzheimer's research initiative. *Alzheimer's Dement.* (2016) 12:1186–96. doi: 10.1016/j.jalz.2016.08.004

43. McMorris T, Hale BJ, Barwood M, Costello J, Corbett J. Effect of acute hypoxia on cognition: a systematic review and meta-regression analysis. *Neurosci Biobehav Rev.* (2017) 74(Pt A):225–32. doi: 10.1016/j.neubiorev.2017.01.019

44. Fuertes E, Carsin AE, Antó JM, Bono R, Corsico AG, Demoly P, et al. Leisure-time vigorous physical activity is associated with better lung function: the prospective ECRHS study. *Thorax.* (2018) 73:376–84. doi: 10.1136/thoraxjnl-2017-210947

45. Zheng G, Xia R, Zhou W, Tao J, Chen L. Aerobic exercise ameliorates cognitive function in older adults with mild cognitive impairment: a systematic review and meta-analysis of randomized controlled trials. *Br J Sports Med.* (2016) 50:1443–50. doi: 10.1136/bjsports-2015-095699

46. You Y, Chen Y, Yin J, Zhang Z, Zhang K, Zhou J, et al. Relationship between leisure-time physical activity and depressive symptoms under different levels of dietary inflammatory index. *Front Nutr.* (2022) 9:983511. doi: 10.3389/fnut.2022.983511

47. O'Donovan G, Hamer M. The association between leisure-time physical activity and lung function in older adults: the English longitudinal study of aging. *Prev Med.* (2018) 106:145–9. doi: 10.1016/j.ypmed.2017.10.030

48. Kim YJ, Han KD, Baek MS, Cho H, Lee EJ, Lyoo CH. Association between physical activity and conversion from mild cognitive impairment to dementia. *Alzheimer's Res Ther.* (2020) 12:136. doi: 10.1186/s13195-020-00707-1

frontiers | Frontiers in Public Health

TYPE Review
PUBLISHED 07 November 2022
DOI 10.3389/fpubh.2022.1034907

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 02 September 2022
ACCEPTED 19 October 2022
PUBLISHED 07 November 2022

CITATION
Li Y, Lv X, Liang J, Dong H and Chen C (2022) The development and progress of health literacy in China. *Front. Public Health* 10:1034907. doi: 10.3389/fpubh.2022.1034907

The development and progress of health literacy in China

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Limited health literacy is a serious public health problem. It is strongly associated with increased hospital admissions and readmission, poorer self-management, and health outcomes. It can lead to poor management of chronic disease, lower health care quality, increased mortality, and higher healthcare expenditures. Understanding China's current situation and the progress of health literacy levels are critical to achieving practical solutions for improving population health. This paper intended to provide a concise overview of the key milestones and specific practices in health literacy in China. We summarized the characteristics and changing profile of health literacy from 2008 to 2020 in China. We developed an intervention framework based on social ecosystem theory for improving health literacy in China. Meanwhile, some multi-level actionable recommendations were proposed. The study revealed that China has made progress in improving health literacy in the last decades. Health literacy levels increased from 6.48% of the population in 2008 to 23.15% in 2020. Geographic disparities were substantial. The East performed better health literacy than the Central and West, and cities had higher adequate health literacy than rural areas. Social development index, age, and education level were highly associated with health literacy. A global joint effort to improve health literacy will be required. And we advocate a whole-of-society approach that involves the participation of the entire ecosystem around the targeted population.

KEYWORDS

health literacy, health promotion, health education, health progress, China

Introduction

Health literacy was first introduced in the 1970s and had considerable attention worldwide in recent years in public health (1). The World Health Organization (WHO) defined it as the personal knowledge and competencies that enable people to access, understand, appraise and use information and services to promote and maintain good health for themselves and those around them (2). Health literacy is a comprehensive reflection of economic and social development and is influenced by various factors,

including politics, economics, education, society, culture, and the health development level (3). The level of health literacy is a strong predictor of a person's health outcomes. Low health literacy has been associated with riskier health choices, risker behaviors, higher readmissions, and poorer health status. It can lead to poor management of chronic disease, increased morbidity, and premature death. Additionally, it can significantly drain the financial resources of the health system (4). Effective responses to health literacy issues can improve health outcomes and reduce health inequities. Improving the level of health literacy could produce potential economic savings of ∼8% of total costs (5). WHO advocates that all countries should make an effort to promote health literacy to ensure the realization of the Millennium Development Goals. Policies and practices should identify health literacy issues and implement the targeted responses.

In China, we use the Chinese Health Literacy Scale to measure health literacy (6). It was developed by experts from public health, health education and promotion, and clinical medicine. And it was designed based on the "Chinese Resident Health Literacy—Basic Knowledge and Skills (Trial)" issued by the National Health Commission of the People's Republic of China in 2008. It contains three domains: basic knowledge and attitudes (BKA), healthy behavior and lifestyle (HBL), and health-related skills (HRS). The three domains covered 80 items and six aspects, including safety and first aid (SFA), scientific views of health (SVH), health information (HI), infectious diseases (ID), chronic diseases (CD), and primary medical care (PMC). The health literacy level refers to the proportion of people with basic health literacy in the total population. Criteria for determining basic health literacy: the health literacy measure questionnaire scored 80% or more of the total score. The health literacy level was 25.4% in 2021 in China, which means that an estimated 75% of adult Chinese (ages 16–69) lack the capacity to obtain, understand and act on health information and services, and also the ability to make appropriate health decisions on their own (7). Furthermore, China still faces daunting challenges in non-communicable diseases, which are driven by unhealthy dietary behaviors, environmental exposure risk factors, industrialization, urbanization, and a rapidly aging population (8). Taking a thorough understanding of the current situation and the characteristics of the health literacy level is critical for identifying priorities to organize them into a comprehensive framework for improving health literacy in China.

This study aimed to provide a concise overview of the promotion of health literacy in China from 2008 to 2020 in China, including the current situation, characteristics, changing profile, and key milestones and practices in improving health literacy. In addition, we proposed a social ecosystem-based intervention framework and offered some actionable recommendations for addressing the health literacy issue in China. We hope this study could offer some practical ideas for disseminating health inequities, improving population health, and contributing to making universal health coverage and Millennium Development Goals achievable.

Methods

To understand the progress of health literacy in China, we conducted a scoping review. We collected and analyzed the policy files and data relevant to health literacy. We searched for these files and data on government departments' websites, including the State Council of the People's Republic of China, the National Health Commission of the People's Republic of China, the National Bureau of Statistics of the People's Republic of China, and the provincial Health Commission of China. In addition, to better develop the intervention framework, we searched Pubmed, China Academic Journals full-text database (CNKI), and Wangfang Database, and reviewed articles relevant to the broad scope of this review. "Health literacy," "eHealth literacy," "internet literacy," "health intervention," "health education," "health promotion," "health progress," and "China" were used as search terms. A narrative synthesis summarized the results of included files and data. Additionally, we conducted spearman's rank correlation analysis to examine the association between the regional health literacy level and the social development index (SDI).

The development and progress of health literacy in China

Since the concept of health literacy was introduced in 2005 in China, there has been a comprehensive effort to enhance the study and promotion of health literacy. We reviewed the policy documents and health literacy reports issued by the national and provincial Health Commission. Based on this, in this section, we summarized the key milestones in the promotion of health literacy in China, the characteristics, and the changing profile of the Health Literacy level in China from 2008 to 2020.

Key milestones in the promotion of health literacy in China

Table 1 summarized the key information on the development of health literacy issued by the Chinese government. In 2008, China launched the nationwide health literacy promotion action, and released the first government document "Chinese Resident Health Literacy—Basic Knowledge and Skills (Trial)." It covered 66 aspects of health literacy including basic knowledge and beliefs, healthy lifestyles and behaviors, and basic skills (9). Based on this document, we issued the "Chinese Resident Health Literacy Promotion

TABLE 1 Key milestones of the development of health literacy, in China.

Year	Key milestones
2008	Released "Chinese Resident Health Literacy Promotion National Action Plan (2008–2010)", released Chinese Resident Health Literacy—Basic Knowledge and Skills (Trial), and initiated the first-ever national assessment of the health literacy of Chinese residents. Implemented the National Tobacco Control Mass Media Campaign in China.
2009	Released "National Basic Public Services of the Peoples Republic of China", health education is one of the independent services.
2010	Conducted health literacy index system research.
2012	Issued "Twelfth Five-Year Plan for National System of Basic Public Services of the People's Republic of China"; Issued the "Twelfth Five-Year Plan for Health Sector Development". Improving the health monitoring system, initiating a central subsidy program for health promotion action; carrying out comprehensive health education, conducted continuous health literacy monitoring.
2014	Released "National Health Literacy Promotion Action Plan (2014–2020)", planning the rate of national health literacy is aimed to increase to 20% by 2020.
2016	Issued "Health China 2030", planning the rate of national health literacy is aimed to increase to 30% by 2030.
2019	Released "Health China Programme (2019–2030)", and initiated health China action.
2020	Issued "Chinese Resident Ecological Environment and Health Literacy" by the Ministry of Ecology and Environment, emphasize the importance of the ecological environment and its impact on health literacy.

National Action Plan (2008–2010)," developed the health literacy scale, and conducted the first national survey of health literacy (10). Subsequently, the State Council of the People's Republic of China released the "National Basic Public Health Services (NBPHS)." It provided 22 in nine categories of free basic public health services, and health education was one of the independent services as the key rule for improving citizens' health literacy (11, 12).

In 2012, the State Council of the People's Republic of China initiated a central subsidy program for health promotion action, advocating establishing a gradual and stable health literacy monitoring system (13, 14). In 2014, China released the "National Health Literacy Promotion Action Plan (2014–2020)." And this was a programmatic document for the in-depth development of health promotion and health education. It clarified the goals and tasks of health literacy promotion in the future, intended to increase adequate health literacy to 20% by 2020 (15). In 2016, "Health China 2030" was launched, and intended to increase the national health literacy level to 30% by 2030 (16). Meanwhile, the ecological environment and its impact on health literacy became increasingly important, and the Ministry of Ecology and Environment released the "Chinese Resident Ecological Environment and Health Literacy" in 2018 (17).

The characteristics and the changing profile of health literacy level in China

We summarized the characteristics and changing profile of the health literacy level in China from 2008 to 2012 (Figures 1–3). Additionally, we presented the association between the regional health literacy level and the SDI (Figure 4).

Figure 1 showed the overall health literacy level from 2008 to 2020 by year and region. The national overall health literacy level increased from 6.48 to 23.15%, with a 1.13% of average annual growth rate. The city had a higher level than rural areas, with it increasing from 9.94 to 28.08% and from 3.43 to 20.02% in the urban and rural areas, respectively. East had higher health literacy levels (ranging from 7.67 to 21.01%) than the Central (ranging from 7.67 to 21.01%) and West areas (ranging from 5.23 to 16.72%).

Figures 2, 3 displayed the three aspects and six dimensions of health literacy level. Significantly, they all increased over time. Regarding the three aspects, the health literacy level of BKA was comparatively higher than HBL and HRS. From 2008 to 2020, the BKA literacy increased from 14.97 to 37.15%, while HBL and HRS literacy increased from 6.93–26.44 to 20.39–23.12%, respectively. Regarding the six dimensions, SFA literacy had the highest level (ranging from 18.70 to 55.23%), closely followed by SVH (ranging from 29.97 to 50.48%). PMC and CD literacy had the lowest level among the six dimensions, ranging from 7.43–23.44 to 4.66–26.73%, respectively. The HI and ID literacy increased from 18.16–35.93 to 15.86–26.77%, respectively.

Figure 4 addressed the geographical distribution of the overall health literacy level in 2019 in China. We used the spearman rank correlation analysis to examine the association between health literacy and SDI. It presented a statistical significance that health literacy was highly associated with SDI (Supplementary Figure 1). The Spearman's correlation coefficient was 0.76. Areas with higher SDI have higher levels of health literacy. Beijing and Shanghai had the highest health literacy level (34.30 and 32.31%), followed by Zhejiang (29.49%), Tianjin (26.29%), and Jiangsu (25.33%). Xinjiang had the lowest health literacy level (9.72%).

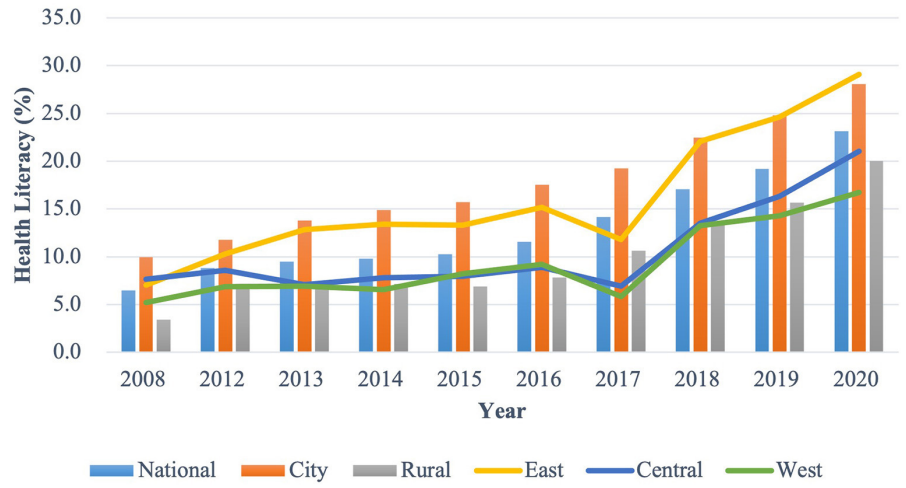

FIGURE 1
The distribution of the overall health literacy level by year and region, in China.

FIGURE 2
The distribution of the three aspects of health literacy, in China.

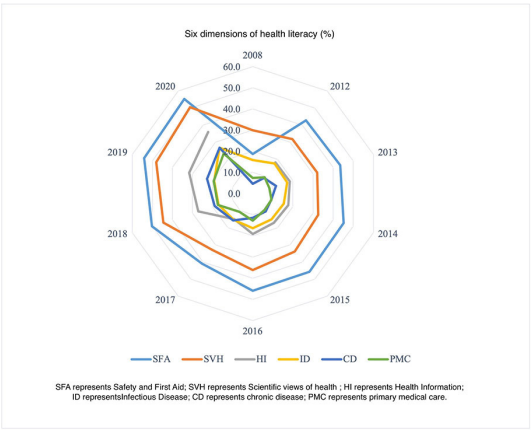

FIGURE 3
The distribution of the six dimensions of health literacy, in China.

Key practices in the promotion of health literacy in China

In the last decades, China adopted comprehensive intervention to improve health literacy. In this section, we reviewed policy documents, China Health Statistics Yearbook (2012–2020), and some published papers, and presented the key practices in the promotion of health literacy, including developing national basic public health services, health education and promotion, tobacco control, continuous health literacy monitoring, and holding special revenue fund.

National Basic Public Health Services

The Chinese State Council has released comprehensive actions to improve health literacy. The NBPHS was first issued in 2009. It was an essential public health service provided freely by the Chinese Government to address the main health problems of all the Chinese residents, especially focusing on children, pregnant women, the elderly, and patients with chronic diseases (11). In 2022, its coverage categories increased from 22 public services in nine categories in 2009 to 54 services in 14 categories, defining health education and health literacy promotion action as the two independent services. Health education provides five public

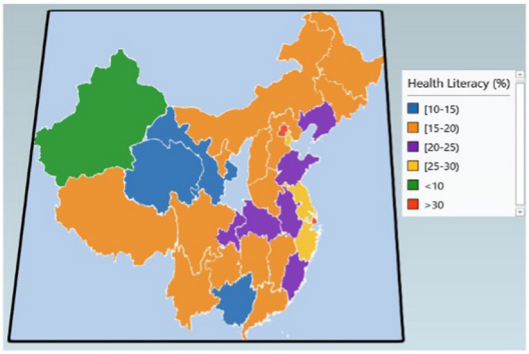

FIGURE 4
Geographical distribution of health literacy in 2019, in China.

health services, including providing health education materials, setting up a health education bulletin board, carrying out public health consultations, holding health knowledge lectures, and providing individualized health education. Health literacy promotion action provides six public services, including building a health promotion county, carrying out science popularization, building a health promotion hospital and smoking cessation clinic, monitoring the health literacy and tobacco epidemic, setting up a health hotline (12,320), and promoting health education for key disease, fields, and key populations.

Health education and promotion services

The key initiative for improving citizens' health literacy is health education. China established professional health organizations (PHO). These organizations provided comprehensive health education and promotion services. Table 2 addressed the detailed national health education and promotion services that were collected from China Health Statistics Yearbook (18). From 2012 to 2020, PHO provided a large number and useful health technical and policy advice and public health education activities. They worked with the media together to build digital health communication and health science popularization platform. They disseminated the basic knowledge and skills of citizens' health literacy through a large number of brochures, short messages, and health promotion supplies. Meanwhile, they established a team of health science experts to organize a series of health China activities and opened national hotlines to provide professional advice for health promotion.

Furthermore, the role of health literacy across cultures became more important, mainly from the perspectives of individuals, families, and communities. In 2014, National Health Literacy Promotion Action Plan (2014–2020) proposed the goal to build health promotion counties including health promotion schools, health promotion hospitals, health promotion enterprises, health promotion communities, and healthy promotion families (15). Population in these groups have common cultures, values, and needs, and share a commitment to meeting them. Cultural norms and family interpersonal relations, and values influence health literacy and help deepen the understanding and promotion of health literacy. Until 2020, health activities have covered about 40 million people every year and intend to reach 320 million people.

Tobacco control

Tobacco use is a leading risk factor for major non-communicable diseases, and 1.4 million deaths were attributed to tobacco use in 2010 in China (19). Tobacco control is a top priority in health promotion worldwide. Serious tobacco control policies and comprehensive control actions have been actively promoted in China since the late 1970s, including adjustment of China's consumption tax on the wholesale price of cigarettes, providing a completely smoke-free environment, protecting from second-hand smoke, enforcing and revising the advertising law, carrying out smoking cessation hotline consultation, smoking cessation clinic and other services (19–21). In 2003, China signed the WHO Framework Convention on tobacco control to implement effective tobacco control policies, which provides a roadmap for effective tobacco control strategies and gives signatory countries a timetable to achieve specified milestones (22). In 2007, China issued the "Chinese Smoking Cessation Guidelines", while in 2014 provincial government started to establish smoking cessation clinics (23, 24). In 2008, China implemented the National Tobacco Control Mass Media Campaign, including strengthening the publicity and education of tobacco and innovating the forms and content of mass-reached communications on tobacco control. The campaign advocated reinforcing people's knowledge about the health effects of smoking and second-hand tobacco smoke exposure and shaping attitudes and behaviors toward smoking bans in public places (25). In 2012, China released the "China Tobacco Control Action Plan (2012–2015)" (26). Subsequently, new national laws banned smoking in public and workplaces and cigarette advertising on TV (19). Health China Action Plan (2019–2030) proposed the goal of 80% of the population will be protected by 100% smoking bans by 2030 (17). In 2018, the smoking prevalence was 25.6% of adults aged $\geq$ 18, with an estimated 282 million smokers in China (27). Even though the smoking prevalence has decreased steadily in the last decades, more targeted intervention efforts should be needed to fulfill the goal of a 20% smoking rate by 2030.

TABLE 2 National services of health education and promotion by the professional health organizations from 2012 to 2020 in China.

Year	Health education services				Production of health promotion materials				Web hosting (columns)	Total health education trainees (million visits)
	Technical and policy advice (times)	Media cooperative programs (times)	Public health education activities (times)	Media cooperative broadcasting health promotion information (times)	Brochures (million copies)	Video products (million copies)	Short message service (million copies)	Health promotion supplies (million copies)		
2012	57,955	206,959	77,599	666,283	373.9	2.4	210.3	25.5	787	1.1
2013	6,856	4,759	47,245	183,539	367.0	1.0	144.5	33.7	884	1.2
2014	9,305	6,827	74,034	407,400	396.4	0.9	155.0	33.0	987	1.3
2015	10,700	5,589	79,283	356,369	395.7	1.3	121.1	42.8	1,050	1.3
2016	10,461	4,764	66,780	256,107	421.4	2.0	141.0	47.9	1,198	1.6
2017	10,439	4,176	61,507	213,469	380.4	1.3	98.8	42.5	1,088	1.4
2018	9,090	4,509	70,515	298,679	404.4	1.6	131.1	53.5	787	1.8
2019	10,217	4,124	72,728	312,280	394.1	1.3	116.1	48.8	884	1.5
Total	125,023	241,707	549,691	2,694,126	3,527.4	13.1	1,234.0	376.5	9,045	12.7

*Data was collected from China Health Statistics Yearbook (2012–2020).

10.3389/fpubh.2022.1034907

Continuous health literacy monitoring

The first nationwide survey on health literacy in China was conducted in 2008. In 2012, China has established a national continuous health literacy monitoring system. Since then, we carried out a national health literacy survey every year between July to September. Until 2021, we have already conducted 11 times national health literacy surveys. Now, the monitoring system is increasing gradually and stable which carries out health work in a scientific, standardized, and effective manner. Meanwhile, China has worked on promoting infodemic strategies and establishing a health literacy monitoring network and direct reporting system.

To better understand Chinese residents' health literacy levels and factors influencing them and prioritize intervention areas, health literacy monitoring for key groups such as the elderly and occupational groups has been included since 2022 (28). The health literacy survey was conducted using a multistage stratified sampling method. Participants of the Chinese residents' health literacy and Chinese elderly health literacy survey are aged 15–69 and 60 years and older, while participants of the Chinese key population occupational health literacy survey are workers engaged in manufacturing production and related activities. The surveys were organized and coordinated by the Health Commission, Health Education Center, and the Chinese Center for Disease Control and Prevention through household face-to-face interviews. The survey covered 1,008 communities of 336 monitoring sites in 31 provinces (excluding Hong Kong, Macao, and Taiwan).

Fund guarantee

In 2012, China initiated a central subsidy program for health promotion activities. It was the first government special fund for health literacy promotion. The central subsidy was 238 million yuan in 2012, while it was 2.44 and 2.59 million yuan in 2013 and 2014, respectively. And it is used for carrying out public service advertisements, health tours, and other activities, popularizing health knowledge, and promoting the development of healthy behaviors. Additionally, China spends tens of billions of Yuan on NBPHS every year. From 2009 to 2021, the total government subsidy for NBPHS increased from 200.2 billion yuan to 1,117.2 billion yuan, with of 16.21% compound annual growth rate, while the personal subsidy increased from 15 yuan to 79 yuan, with of 15.61% compound annual growth rate (Supplementary Table 2, Figure 5).

Discussion

This paper aimed to provide a concise overview of the characteristics and changing profile of the health literacy level from 2008 to 2020 in China. We identified the key milestones and specific practices for the promotion of health literacy advocated in China. Health literacy levels increased from 6.48 to 23.15%. Though China has made considerable progress in improving health literacy in the last decade, there was only about one-quarter of the population mastered basic health knowledge and skills in 2020. Additionally, it is positively related to the social development index. And geographic disparities were substantial, with eastern coastal provinces performing better than central and western provinces, and cities performing better than rural areas. The three aspects and six dimensions of health literacy level increased over years. However, clear disparities among them were found. Among the three aspects, the BKA literacy lever was the highest, followed by HRS, while the HBL literacy level was the lowest. Concerning the six dimensions, CD and PMC literacy was relatively low.

An effective response to health literacy issues could be more helpful for improving health outcomes and reducing health inequities. Social ecosystem theory (SET) has been increasingly used to address health issues and prevention programs (29). In this section, we proposed a SET-based framework for improving health literacy that focuses on both individual and social environment factors (Figure 6). We also presented some multi-level actionable recommendations. This framework is visualized as four concentric circles, which inform corresponding intervention strategies. From micro to macro levels, the four circles are individuals, interpersonal, community, and social culture.

The innermost circle is the individual level. It represents the individual's demography, cognition and emotion, and behavior changes. These characteristics are positively related to health literacy. Studies revealed that adults aged 25–34 had higher health literacy levels than older-aged 65–69, individuals with lower education levels and economic status, and higher risk behavior had lower health literacy levels (30–32). Currently, health literacy interventions mostly focused on 15–69 years people with higher levels of education, especially city citizens. Interventions for patients with high health needs, special groups, and their families have just started (33). All of these suggested developing more targeted and stratified literacy improvement goals and paying more attention to the age difference, geographic and education disparities, high health needs, special groups, and individuals' preferences (34, 35). Our study revealed that HBL literacy was the lowest among the three aspects, while CD and PMC literacy were relatively low among the six dimensions. And this indicated the importance of strengthening the understanding of healthy lifestyles and behaviors, chronic disease prevention, and basic medical care and treatment. Health education is always the most important and directed toward improving health literacy. Therefore, we highlighted promoting healthy lifestyles and behaviors linked to

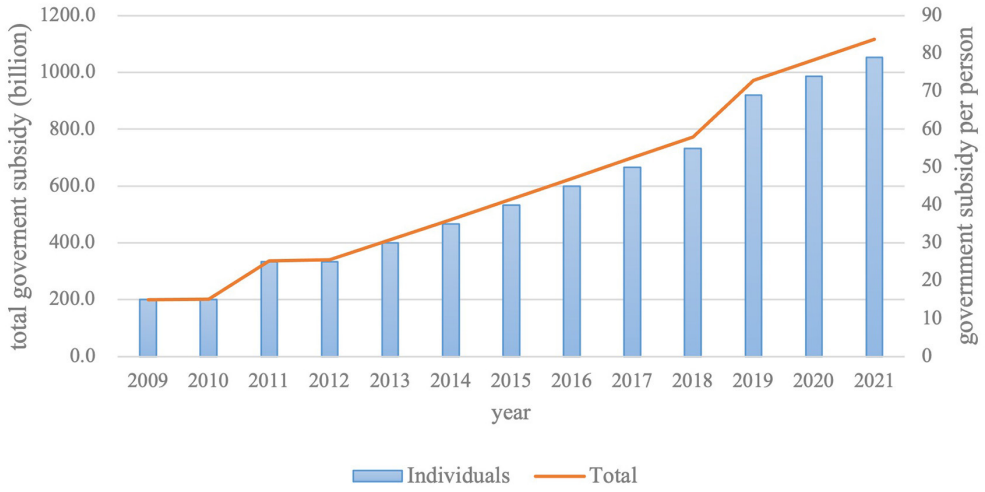

FIGURE 5
The government subsidy for National Basic Public Health Services from 2009 to 2020.

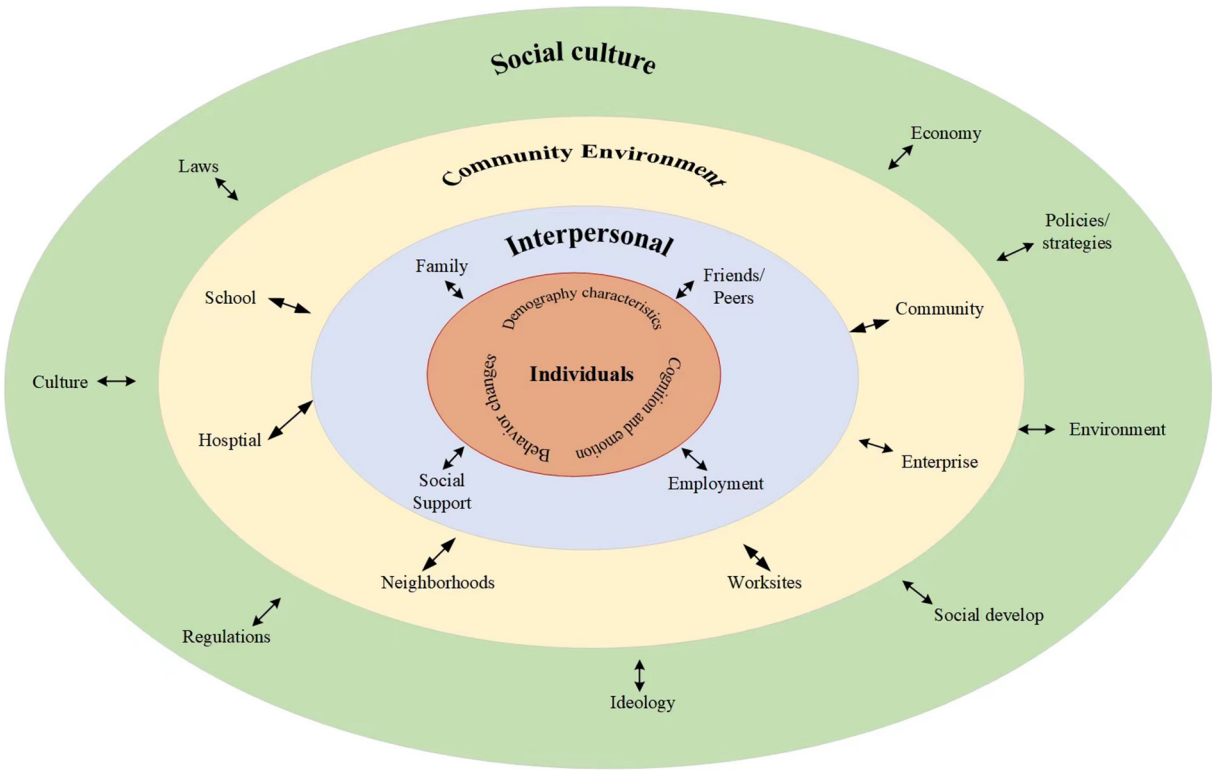

FIGURE 6
Social ecosystem theory-based framework for improving health literacy.

the risk of contracting the chronic disease in good ecological and social environments through strengthening the health education system and early intervention and popularizing health knowledge.

The second circle is the interpersonal level, which represents the direct person-to-person interaction, such as social support, family, friends and peers, and employment. Health decisions are often not made by individuals. They need a supportive

environment that enables them to make informed health decisions and lifestyle choices. Often, families, peer groups, and employment are the primary sources of health information. These sources can be useful in developing functional health literacy skills to the selection of products and services. Additionally, families shape personality traits, and people with different personalities will adopt different lifestyles, resulting in variations in health outcomes (36). Family engagement is critical to fostering positive health outcomes (37). We recommended building effective principles of family engagement and capitalizing on their intrinsic motivation for improving the whole family's health.

The third circle is the community level, which involved formal or informal social structures, such as communities, schools, hospitals, enterprises, neighborhoods, and worksites. Communities are key settings for health literacy. People make daily health-related decisions in their homes and communities. It is essential that interventions are embedded within the environment where people live, work, and play to improve population health and reduce health disparities (38). We highly recommend community health education since the importance of concrete and efficient community action in setting priorities for health, making decisions, planning strategies, and implementing them to achieve better health. Further, popularizing health knowledge through face-to-face community health education activities and focusing on health literacy-friendliness of the various settings in which people live, play, and work are effective ways of improving health literacy (4, 31).

The outermost circle is the society level, which represents the economy, policies strategies, environment, ideology, culture, laws, and regulations. Our study showed that, in China, there were considerable differences in performance between eastern coastal provinces, central and western provinces, as well as cities and rural areas. However, these conclusions were made without considering the sociodemographic factors. Rurality may not be the only factor contributing to health literacy differences, as socioeconomic status and access to healthcare resources may also be important. Some published studies demonstrated that after controlling for confounders, rural and urban groups were not significantly different (39). Consequently, evidence-based studies are needed to investigate the true association between health literacy and geographic distribution. Evidence-based interventions should be developed, with rural populations in particular in need of improvement. Importantly, we highly advocate implementing comprehensive, whole-of-government, multisectoral policies and strategies for improving health literacy, This included promoting economic growth, increasing public investment in public goods and services, developing health-related laws and regulations, establishing state-supported health insurance schemes to increase population coverage, promoting public participation, advocating multisectoral coordination and collaboration, creating community health-supporting environments, and promoting a green lifestyle (40–43).

Additionally, the internet has already affected Chinese residents. Online information sources are increasingly used by citizens caring for their own and their Families' needs. It was estimated by the end of 2020 that 989 million Chinese people had internet access, with internet penetration has reached 70.4%. And wide internet coverage has been achieved in rural areas, and the proportion of national poverty-stricken villages with access to fiber optics increased to 98% (44). Internet literacy was positively associated with self-efficacy in utilizing eHealth. However, it is no longer the primary determinant of eHealth literacy competencies for adults who are tech-savvy users (45). We strongly recommended "Internet+" intervention on health literacy, since Internet Plus health care in China became an emerging health service model aimed at increasing access and improving the quality of health care delivery (46). Until 2020, a total of 268 internet hospitals in China have been granted official licenses (47). They primarily provided medical care to patients with common diseases or chronic diseases and to remote and rural patients who do not have access to medical care (47).

General literacy is defined as "the ability to read and write". It is more basic and justifies your skills of reading and writing and not necessarily understanding it. Health literacy is more in-depth and is centered on the health field. Health literacy affects a person's ability to accurately search for and use health information and adopt healthier behaviors. There are nearly three-quarters of Chinese, about half of all Europeans, at least 88% of US adults, and 55.3% of Southeast Asians have poor health literacy skills (4, 7, 48, 49). Although we had made considerable efforts to promote health literacy worldwide, improving health literacy remains a critical component of achieving the Global Millennium Development Goals. A global effort to improve health literacy will be required. We strongly recommend adopting a whole-of-society approach that involves the participation of the entire ecosystem around the targeted population. First, establish a health management model and long-term working mechanism with personal responsibility, interpersonal assistance, social support, and government guidance. Second, improve health outcomes and provide access to health services for people with different health needs. Thirdly address the changing health literacy needs of individuals and communities using community wisdom, cultural systems, and local corresponding health literacy needs. Fourth, engage multiple stakeholders (individuals, government, education sector, workplaces and businesses, and community organizations) at all levels of society in the development and implementation of interventions. Moreover, pay more attention to the improvement at all levels of the health system and continuous improvement in health literacy through changes to the environment, practice, culture, and policy.

Author contributions

YL: conceptualization, design, funding acquisition, software, draft writing, review and editing, and data analysis. XL: data collection, review, and analysis. JL: acquisition, analysis, or interpretation of data. HD: conceptualization, design, methodology, and project administration. CC: conceptualization, design, methodology, and writing—review and editing. All authors contributed to the article and approved the submitted version.

Funding

This research was supported by the National Natural Science Foundation of China (Grant No. 81871455), Zhejiang Provincial Natural Science Foundation of China (Grant No. LY21G030013 and LY22H180001), and the Medical and Health Science and Technology Program of Hangzhou, China (Grant No. A20210432).

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.2022.1034907/full#supplementary-material

References

1. Simonds SK. Health education as social policy. *Health Educ Monogr.* (1974) 2:1–25. doi: 10.1177/10901981740020S102

2. World Health Organization. *Health Promotion Glossary of Terms 2021*. Geneva: World Health Organization (2021). Available online at: https://www.who.int/publications/i/item/9789240038349 (accessed December 6, 2021).

3. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health.* (2012) 12:80. doi: 10.1186/1471-2458-12-80

4. World Health Organization. *Regional Office for Europe. Health Literacy- the Solid Facts*. Geneva: World Health Organization (2013).

5. Haun JN, Patel NR, French DD, Campbell RR, Bradham DD, Lapcevic WA. Association between health literacy and medical care costs in an integrated healthcare system: a regional population based study. *BMC Health Serv Res.* (2015) 15:249. doi: 10.1186/s12913-015-0887-z

6. National Health Commission. *National Bureau of Statistics. Chinese Residents' Health Literacy Monitoring Program*. Beijing: National Health Commission (2021). Available online at: http://www.zixi.gov.cn/module/download/downfile.jsp?classid=0&filename=cd4fe54c689440738f01334f70d2d0b7.pdf (accessed August 1, 2021).

7. National Health Commission of the People's Republic of China. *The National Level of Health Literacy Reached to 25.4%*. Beijing: National Health Commission (2021). Available online at: http://www.nhc.gov.cn/xcs/s3582/202206/5dc1de46b9a04e52951b21690d74cdb9.shtml (accessed June 7, 2022).

8. Chen S, Guo L, Wang Z, Mao W, Ge Y, Ying X, et al. Current situation and progress toward the 2030 health-related sustainable development goals in China: a systematic analysis. *PLoS Med.* (2019) 16:e1002975. doi: 10.1371/journal.pmed.1002975

9. National Health Commission of the People's Republic of China. *Chinese Resident Health Literacy- Basic Knowledge and Skills (Trial)*. Beijing: National Health Commission (2008). Available online at: http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=37661 (accessed September 2, 2008).

10. National Health Commission of the People's Republic of China. *Chinese Resident Health Literacy Promotion National Action Plan (2008–2010)*. Beijing: National Health Commission (2008). Available online at: http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=37665 (accessed August 11, 2008).

11. National Health Commission of the People's Republic of China. *The Office of the Leading Group for Medical Reform Held a Teleconference to Initiate and Deploy the National Basic Public Health Service Project*. Beijing: National Health Commission (2009). Available online at: http://www.nhc.gov.cn/tigs/s9661/200907/5386fa1ff8eb42c7885b76f8fffdfe29.shtml (accessed July 10, 2009).

12. National Health Commission of the People's Republic of China. *Opinions of the Ministry of Health, the Ministry of Finance, the National Population and Family Planning Commission on Promoting the Gradual Equalization of Basic Public Health Services*. Beijing: National Health Commission (2009). Available online at: http://www.nhc.gov.cn/jws/zcwj/201304/6cf4917e8af44fe28ac655f215f8e4ed.shtml (accessed July 14, 2009).

13. National Health Commission of the People's Republic of China. Twelfth *Five-Year Plan for Health Sector Development*. Beijing: National Health Commission (2012). Available online at: http://www.nhc.gov.cn/wsb/pwsyw/201210/56114.shtml (accessed October 8, 2012).

14. Chinese Health Education Center. *Report of the Health Literacy Monitoring of Chnisese Resident*. Beijing: National Health Commission (2018)

15. National Health Commission of the People's Republic of China. *National Health Literacy Promotion Action Plan (2014–2020)*. Beijing: National Health Commission (2014). Available online at: http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=218e14e7aee6493bbca74acfd9bad20d (accessed May 9, 2014).

16. The State Council of the People's Republic of China. *Health China 2030*. Beijing: The State Council of the People's Republic of China (2016). Available online at: http://www.gov.cn/xinwen/2016-10/25/content_5124174.htm (accessed October 25, 2016).

17. State Council of the People's Republic of China. *Health China Programme (2019–30)*. Beijing: The State Council of the People's Republic of China (2019). Available online at: http://www.gov.cn/xinwen/2019-07/15/content_5409694.htm (accessed July 15, 2019).

18. Statistical Information Center of the National Health Commission. *China Health Statistics Yearbook (2012–2020)*. Beijing: National Health Commission (2020). Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjzxtjsj/tjsj_list.shtml (accessed December 6, 2021).

19. Yang G, Wang Y, Wu Y, Yang J, Wan X. The road to effective tobacco control in China. *Lancet.* (2015) 385:1019–28. doi: 10.1016/S0140-6736(15)60174-X

20. Wan X. Protecting people from tobacco smoke in China: current status and challenges. *China CDC Wkly.* (2022) 4:460–4. doi: 10.46234/ccdcw2022.102

21. Goodchild M, Zheng R. Tobacco control and healthy China 2030. *Tob Control.* (2019) 28:409–13. doi: 10.1136/tobaccocontrol-2018-054372

22. Hu TW, Lee AH, Mao Z. Who framework convention on tobacco control in China: barriers, challenges and recommendations. *Glob Health Promot.* (2013) 20:13–22. doi: 10.1177/1757975913501910

23. Lin H, Xiao D, Liu Z, Shi Q, Hajek P, Wang C. National survey of smoking cessation provision in China. *Tob Induc Dis.* (2019) 17:25. doi: 10.18332/tid/104726

24. The China National Health and Family Planning Commission. Guideline on China clinical smoking cessation. *Chin J Publ Health Manag.* (2016) 10:88–95.

25. Jin X, Song J, Zhang Y. Evaluation of the national tobacco control mass media campaign in China. In: *Proceedings of the 17th World Conference on Tobacco or Health; 1/2018*. Paris: WCTOH: Tobacco Induced Diseases (2018). p. 479. doi: 10.18332/tid/84435

26. National Health Commission of the People's Republic of China. *China Tobacco Control Action Plan (2012–2015)*. Beijing: National Health Commission (2012). Available online at: http://www.nhc.gov.cn/zwgk/wtwj/201304/4f012dc811994a80ba121936b2640085.shtml (accessed December 24, 2012).

27. Zhang M, Yang L, Wang L, Jiang Y, Huang Z, Zhao Z, et al. Trends in smoking prevalence in urban and rural China, 2007–2018: findings from 5 consecutive nationally representative cross-sectional surveys. *PLoS Med.* (2022) 19:e1004064. doi: 10.1371/journal.pmed.1004064

28. National Health Commission, National Bureau of Statistics. *Health Literacy Monitoring Statistical Survey System of Chinese Residents and Key Populations*. Beijing: National Health Commission (2022). Available online at: http://www.stats.gov.cn/tjfw/bmdcxmsp/bmzd/202203/t20220303_1828305.html (accessed March 03, 2022).

29. McCormack L, Thomas V, Lewis MA, Rudd R. Improving low health literacy and patient engagement: a social ecological approach. *Patient Educ Couns.* (2017) 100:8–13. doi: 10.1016/j.pec.2016.07.007

30. Mei X, Zhong Q, Chen G, Huang Y, Li J. Exploring health literacy in Wuhan, China: a cross-sectional analysis. *BMC Public Health.* (2020) 20:1417. doi: 10.1186/s12889-020-09520-9

31. Li Z, Tian Y, Gong Z, Qian L. Health literacy and regional heterogeneities in China: a population-based study. *Front Public Health.* (2021) 9:603325. doi: 10.3389/fpubh.2021.603325

32. Liu L, Huang J, Li G, Chen Z, He T. The economic costs of limited health literacy in China: evidence from China's national health literacy surveillance data. *BMC Health Serv Res.* (2022) 22:521. doi: 10.1186/s12913-022-07795-9

33. Xue Z, Tong Y, Wu Y, Chen S, Zhang X, Cao M, et al. Construction of health literate health care organizations and its enlightenment to China. *Chin J Hosp Admin.* (2021) 2021:550–4. doi: 10.3760/cma.j.cn111325-20201208-02193

34. Yee LM, Silver R, Haas DM, Parry S, Mercer BM, Wing DA, et al. Association of health literacy among nulliparous individuals and maternal and neonatal outcomes. *JAMA Netw Open.* (2021) 4:e2122576. doi: 10.1001/jamanetworkopen.2021.22576

35. Pickles K, Scherer LD, Cvejic E, Hersch J, Barratt A, McCaffery KJ. Preferences for more or less health care and association with health literacy of men eligible for prostate-specific antigen screening in Australia. *JAMA Netw Open.* (2021) 4:e2128380. doi: 10.1001/jamanetworkopen.2021.28380

36. Mai J, Yibo W, Ling Z, Lina L, Xinying S. Health literacy and personality traits in two types of family structure-a cross-sectional study in China. *Front Psychol.* (2022) 13:835909. doi: 10.3389/fpsyg.2022.835909

37. Sivanand B, Herman A, Teutsch C, Teutsch S. Building health literacy and family engagement in head start communities: a case study. In: *NAM PerspectivesDiscussion Paper*. Washington, DC: National Academy of Medicine. (2017). doi: 10.31478/201704c

38. Green LW, Allegrante JP. Healthy people 1980–2020: raising the ante decennially or just the name from public health education to health promotion to social determinants? *Health Educ Behav.* (2011) 38:558–62. doi: 10.1177/1090198111429153

39. Aljassim N, Ostini R. Health literacy in rural and urban populations: a systematic review. *Patient Educ Couns.* (2020) 103:2142–54. doi: 10.1016/j.pec.2020.06.007

40. Martin LT, Parker RM. Insurance expansion and health literacy. *JAMA.* (2011) 306:874–5. doi: 10.1001/jama.2011.1212

41. Wayne M, Rootman I. *An Inter-Sectoral Approach for Improving Health Literacy for Canadians. A Discussion Paper*. Vancouver: Public Health Association of British Columbia (2012).

42. Sun B, Cheng Y, Wang X, Zhang W, Yao X, Xiaoming S. Suggestions on environmental and health work from health environment promotion campaigns. *Chin J Prev Med.* (2019) 2019:1193–7. doi: 10.3760/cma.j.issn.0253-9624.2019.12.001

43. He T, Liu L, Huang J, Li G, Guo X. The community health supporting environments and residents' health and well-being: the role of health literacy. *Int J Environ Res Public Health.* (2021) 18:18157769. doi: 10.3390/ijerph18157769

44. China Internet Network Information Center. *The 47th Statistical Report on China's Internet Devlopment*. Beijing: China Internet Network Information Center (2021). Available online at: https://www.cnnic.com.cn/IDR/ReportDownloads/202104/P020210420557302172744.pdf (accessed February, 2021).

45. Lwin MO, Panchapakesan C, Sheldenkar A, Calvert GA, Lim LKS, Lu J. Determinants of ehealth literacy among adults in China. *J Health Commun.* (2020) 25:385–93. doi: 10.1080/10810730.2020.1776422

46. Zhou XF, Chen L. Digital health care in China and access for older people. *Lancet Public Health.* (2021) 6:e873–e4. doi: 10.1016/S2468-2667(21)00051-7

47. Lai Y, Chen S, Li M, Ung COL, Hu H. Policy interventions, development trends, and service innovations of internet hospitals in China: documentary analysis and qualitative interview study. *J Med Internet Res.* (2021) 23:e22330. doi: 10.2196/22330

48. Lopez C, Kim B, Sacks K. *Health Literacy in the United States: Enhancing Assessments and Reducing Disparities*. Santa Monica: Milken Institute (2022). doi: 10.2139/ssrn.4182046

49. Rajah R, Hassali MAA, Murugiah MK. A systematic review of the prevalence of limited health literacy in southeast Asian Countries. *Public Health.* (2019) 167:8–15. doi: 10.1016/j.puhe.2018.09.028

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 21 November 2022
DOI 10.3389/fpubh.2022.1055037

OPEN ACCESS

EDITED BY
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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 27 September 2022
ACCEPTED 07 November 2022
PUBLISHED 21 November 2022

CITATION
Abu-Humaidan AHA, Tarazi A, Hamadneh Y, Al-leimon A, Al-leimon O, Aljahalin M, Ahmad F, Awajan D and Alaridah N (2022) Knowledge, attitudes, and practices toward tuberculosis among Jordanian university students.
Front. Public Health 10:1055037.
doi: 10.3389/fpubh.2022.1055037

Knowledge, attitudes, and practices toward tuberculosis among Jordanian university students

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Background: Tuberculosis (TB) is one of the leading causes of death from infectious diseases worldwide with numerous undiagnosed and untreated cases, emphasizing the need for TB awareness to minimize transmission and initiate early treatment. Data regarding the knowledge, attitudes, and practices (KAP) toward TB among Jordanians is lacking but requires attention given the massive migration spells to Jordan from neighboring countries in the past decade.

Methods: A descriptive cross-sectional study was conducted from May to June 2022. An online questionnaire was developed following World Health Organization (WHO) recommendations for TB KAP surveys and was distributed to Jordanian university students. The questionnaire documented sociodemographic data and measured participants' KAP toward TB. Descriptive and analytic statistics were used to report KAP levels and highlight relevant sociodemographic factors associated with better KAP.

Results: 602 participants completed the survey; most were females (60.8%), in their first 3 years of school (84.4%), and from a healthcare field of study (57.0%). The knowledge section median score was 27 out of 51. Knowledge gaps in TB treatment, and to a lesser extent, TB transmission routes were identified. The attitudes section median score was 6 out of 9, attitudes were generally positive toward TB patients with no indication of a social stigma. The practice section median score was 6 out of 8, most participants would take the correct measures if they suspected being infected, yet around 41.0% were not confident that masks are important in preventing airborne diseases. Students in healthcare specialties had significantly better KAP scores and identifying as a smoker was associated with a lower practice score.

Conclusion: Although university students displayed satisfactory KAP scores, the focus should be aimed at informing students from non-healthcare fields on

TB transmission routes, treatment options, and the role of masks in preventing disease transmission.

KEYWORDS

tuberculosis, KAP, infectious diseases, university students, Jordan, Mtb (Mycobacterium tuberculosis), stigma and awareness, mask wearing

Introduction

Tuberculosis (TB) is a communicable disease caused by the bacillus *Mycobacterium tuberculosis* (Mtb), which is spread by aerosols expelled from people with active TB disease. Right until the coronavirus (COVID-19) pandemic, TB was the leading cause of death from a single infectious agent, ranking above HIV/AIDS as indicated by the World Health Organization (WHO) Global tuberculosis report 2021 (1). Infection with Mtb occurs primarily by aerosolized particles when coughing or sneezing, ∼90% of those who develop the disease are adults, with more cases among men than women. Pulmonary TB causes symptoms such as persistent cough with sputum and blood at times, chest pain, weakness, weight loss, fever, and night sweats. Other less recognized extrapulmonary infection sites are the skeletal and central nervous systems (2).

Jordan is considered one of the low-burden countries with a total TB incidence below 10 cases per 100,000 in 2019 (3), however, its location near several war zones led to the country receiving around 760,000 refugees and asylum seekers registered with UNHCR over the past decade (4). Previous studies of such crisis-affected populations found higher TB incidence and delayed TB treatment compared with reference populations (5).

The arrival of Syrian refugees led to a considerable impact on Jordan's national TB program, where TB cases among Syrian refugees made up 24.4 and 13.8% of all TB cases in Jordan in 2013 and 2015, respectively (6). Since refugees are increasingly having access to higher education (7), it is likely that university students, who form a considerable percentage of Jordanian society, will be in contact with displaced and resettled populations through shared education, volunteer work, or proximity in residence, and in the case of healthcare specialties, when they join the workforce. Additionally, funding in low- and middle-income countries (LMIC), which account for 98% of reported TB cases, cannot cope with the increased TB burden (1).

Most of the studies regarding knowledge and attitude toward TB were done in high-burden TB countries such as India (8), Uganda (9), and South Africa (10). Previous KAP surveys were performed in neighboring countries but not in Jordan and did not include non-healthcare university students (11). University students, whether in the healthcare field or not, are an important subgroup of the population whose decisions could impact transmission trends in the future, hence several studies investigated KAP toward TB in this specific group (12–14).

Given the increased TB burden in Jordan associated with refugees' resettlement and the importance of university students in determining the future of TB burden in the country, this cross-sectional study aimed to measure KAP toward TB among university students in Jordan using an online questionnaire adopted from a WHO guide to developing TB KAP surveys (15).

Materials and methods

Study design and population

This was a descriptive cross-sectional study. The sample consisted of students from all schools enrolled at 6 Jordanian universities (Supplementary Figure 1). These Jordanian Universities have around 206,000 students enrolled in various programs and schools (16). Data were collected from healthcare schools (e.g., Medicine, Dentistry, Pharmacy, and Nursing), and non-healthcare schools (e.g., Physics, Mechanical engineering, Law, Business, and Arts).

The study was conducted using an online questionnaire created on Google Forms and delivered to students in the period between 22 May and 23 June 2022. The questionnaire was posted on online groups that the students use for school-specific communications, student communication channels are moderated by student committees who grant access only to students with verified university email addresses. In addition, representatives from each university were contacted to help in distributing the questionnaire.

Questionnaire design

This questionnaire was based on WHO recommendations for TB KAP surveys with a slight modification (15), which involved removing detailed questions regarding HIV/AIDS since it is not prevalent in Jordan. The first page of the questionnaire included an informed consent form, as well as a description of the contents of the questionnaire, what it aims to study, and the confidentiality of the data. It was written

in both Arabic and English. To assess the accuracy of the questionnaire, an internal pre-validation procedure was carried out at all 6 Jordanian universities involving 38 students and was re-evaluated with input from experts in the field.

The questionnaire consisted of 35 multiple-choice questions that covered four main themes: (1) Demographics and general information about the participant (sex, age, field of study, academic year, smoking, Nationality, and residence), (2) Knowledge of TB symptoms, transmission routes, at-risk groups, and treatment. (3) TB attitudes, practices, and care-seeking behavior, (4) TB awareness and sources of information.

Questions were scored as follows: for questions with a single correct answer, correct and incorrect answers were scored as 5 and 0, respectively. While for questions with multiple correct answers, correct and incorrect answers were scored as 1 and 0, respectively. This scoring system was done to equalize the weight given for each knowledge question, whether it had one, or more than one correct answer. The internal consistency of the questionnaire was measured using Cronbach's alpha. The questionnaire can be found in the Supplementary material.

Ethical approval

The study protocol was approved by the Institutional Review Board (IRB) at UJ (Ref. No. 19/2022/271). Decision No. (46-2022). In addition, the work was conducted according to the principles of Good Clinical Practice (GCP) that has its origin in the Declaration of Helsinki (64th World Medical Association General Assembly, Fortaleza, Brazil, October 2013). All collected data were treated with confidentiality. Participation in the study was voluntary. Informed consent was obtained from all participants at the start of the questionnaire following a full explanation of the study objectives, then they were asked to complete an anonymous questionnaire.

Data analysis

Data generated were organized in Microsoft Excel, and statistical analysis was carried out using IBM Statistical Package for the Social Sciences (SPSS) for Windows version 25.0 (Armonk, NY, USA) and GraphPad Prism 8 (San Diego, CA, USA).

Categorical variables were presented as count and percentages in the tables and as percentages in the text, while continuous variables were presented as (Mean ± SD). Independent sample *T*-tests, one-way ANOVA, and Chi-square test were used to compare KAPS between different school categories or demographic variables. A *p*-value of 0.05 was adopted as a threshold for significance.

Results

Demographics and characteristics of participants

Six hundred and two (602) students completed the survey. Students were from six Jordanian universities that are distributed among the major governorates of Jordan (Supplementary Figure 1). Males represented 39.2% of the sample, while females represented 60.8%. The median age of participants was 20 years with 402 participants (66.8%) between 18 and 21 years old and 200 participants (33.2%) between 22 and 26 years old. Most (36.5%) participants were in their second year of study. The majority (78.2%) were cities/central urban areas residents, whilst 21.8% resided in rural and countryside areas. The participants were grouped by their field of study as healthcare students (57%) from fields such as medicine, nursing, and pharmacy, or non-healthcare students (43%) from fields such as law, engineering, and arts. Also, most (79.1%) participants described themselves as non-smokers and only 10% knew someone who had TB (Table 1).

TABLE 1 Participants' demographics.

Demographic variable	Count (%)
Gender	
Male	236 (39.2%)
Female	366 (60.8%)
Age group	
18–21	402 (66.8%)
22–26	200 (33.2%)
Year of study	
First	163 (27.1%)
Second	220 (36.5%)
Third	125 (20.8%)
Fourth	73 (12.1%)
Fifth	17 (2.8%)
Sixth	4 (0.7%)
Field of study	
Healthcare field	343 (57%)
Non-healthcare field	259 (43%)
Smoking	
Yes	126 (20.9%)
No	476 (79.1%)
Residence	
Urban	471 (78.2%)
Rural	131 (21.8%)
Knew someone with TB	
Yes	60 (10%)
No	542 (90%)

Knowledge of TB among university students

Knowledge of TB was assessed through questions regarding symptoms, transmission routes, high-risk groups, and treatment. As for symptoms, most participants (75.4%) identified "coughing up blood" as a symptom of TB, this was followed by 62.8% of participants who chose "cough that lasts for more than 3 weeks" which is the most reported TB symptom, indicating that most participants have good knowledge about the symptoms of TB. Still, 16.1% of participants stated that they did not know any of the symptoms. When asked about spinal tuberculosis or a relationship between bone inflammation and tuberculosis, most participants (51.8%) were not sure if such a relation exists (Table 2).

Participants were also asked about the routes of transmission of the disease, and most participants (66.6%) selected the statement "Through the air when the person with TB coughs or sneezes," which is thought to be the most common way of TB transmission. A small proportion (6.3%) thought it was not a contagious disease. Notably, around one-quarter (23.8%) did not know transmission routes (Table 2).

When asked about populations at risk, only a minority of participants (10–15%) correctly chose the various risk groups, except for the group "people living with HIV or AIDS" which was chosen by 30.6% of participants. Additionally, most participants correctly identified that immunocompromised participants (87.4%) are more susceptible to TB (Table 2).

When asked about TB treatment, almost half (49.5%) of the participants agreed that TB can be cured, with almost the other half (44.4%) not sure if it can be cured or not. Concerning side effects, 37.2% of participants thought that it can have minor side effects, while the most chosen answer was "I do not know" (45.8%). Also, most participants (52.2%) did not know the duration of TB treatment, and only 27.4% correctly answered that it needs 6–12 months. As for TB vaccines, most (79.4%) participants agree that there is a vaccine that can protect against TB (Table 3).

The most chosen answers to knowledge questions were rather similar in healthcare and non-healthcare student groups, but the distribution of correct answers varied significantly in most questions (Table 2). Non-healthcare students tended to choose (maybe) and (I do not know) more often than healthcare students especially with regards to TB treatment. For example, 53.7% of non-healthcare students were not sure whether TB can be treated or not compared to 37.3% of healthcare students, similar results were also found with regards to TB treatment side effects (Table 3). The only question with similar answers in both groups was about the availability of vaccines that protect from TB, to which 80.5 and 78.0% of healthcare and non-healthcare students, respectively, answered in the affirmative (Table 3).

Attitudes and practices toward TB

In the attitude section, participants were first asked whether they believe they can get TB, to which (62.5%) of participants believed they could. Afterward, participants were asked how they view, and how they think society views, TB patients. Most participants felt compassion and a desire to help (41.7%) or compassion but would rather stay away (30.9%) from TB patients. Similarly, most (52.0%) thought their communities are friendly but would stay away from TB patients. As for the TB situation in Jordan, 45.3% of participants thought it was somewhat serious, and only 11.5% knew that TB treatment in Jordan was free of charge (Table 4).

Health-seeking behavior was assessed as well. Participants were asked about their actions if they had a persistent or bloody cough and most participants (87.9%) choose to go to the doctor over other options like drinking herbs, taking any medicine from the pharmacy, or just ignoring it. To expand on this point, participants were asked about when they might go to a health facility if they had TB symptoms, most (68.4%) would go as soon as they realize that their symptoms might be related to TB, indicating positive health-seeking behaviors in most participants (Table 5).

This behavior was further emphasized by most participants (81.9%) choosing their doctor or health provider to talk to about their symptoms. A good percent of participants also chose their parents, other family members, or close friends, (54.2, 29.5, and 26.6%, respectively) to tell them about their illness, signaling trust in medical institutes as well as family members, with little signs of stigma around the disease (Table 5).

As for hygiene practices, most participants indicated they sometimes use hygiene products in public (43.9%), other participants use them always (40.0%), and 16.1% don't use them at all. Notably, a large proportion of participants either were not sure (25.1%) or did not believe (15.9%) that masks can prevent the transmission of airborne infectious diseases. Most participants believed that their daily habits related to the transmission of respiratory diseases were affected by the COVID-19 pandemic (76.9%) (Table 5).

Unlike the significant differences in answers to knowledge questions, attitudes were rather similar in healthcare and non-healthcare student groups, which were generally positive toward TB patients (Table 4). On the other hand, practices in the two groups differed in important aspects, such as the person to talk to if the participant had TB, where around 91.5 and 69.1% of healthcare and non-healthcare students, respectively, chose a doctor or a healthcare provider, this indicated that almost one third of non-healthcare students would not choose to talk about their disease with a doctor (Table 5). Another significant difference was found with regards to wearing a mask to prevent infections transmitted by air, where more than half of non-healthcare students (52.5%) were not convinced that wearing a

10.3389/fpubh.2022.1055037

TABLE 2 Knowledge of TB symptoms, transmission routes, and risk groups[a].

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
What are the signs and symptoms of TB?[c]	Cough that lasts for more than 3 weeks	378 (62.8%)	249 (72.6%)	129 (49.8%)
	Coughing up blood	**454 (75.4%)**	**283 (82.5%)**	**171 (66.0%)**
	Severe headache	134 (22.3%)	79 (23.0%)	55 (21.2%)
	Weight loss	251 (41.7%)	183 (53.4%)	68 (26.3%)
	Fever	304 (50.5%)	213 (62.1%)	91 (35.1%)
	Chest pain	300 (49.8%)	211 (61.5%)	89 (34.4%)
	Shortness of breath	323 (53.7%)	227 (66.2%)	96 (37.1%)
	Ongoing fatigue	294 (48.8%)	210 (61.2%)	84 (32.4%)
	I do not know	97 (16.1%)	34 (9.9%)	63 (24.3%)
How can a person get TB?[c]	Through handshakes	135 (22.4%)	86 (25.1%)	49 (18.9%)
	Through the air when the person with TB coughs or sneezes	**401 (66.6%)**	**272 (79.3%)**	**129 (49.8%)**
	Through sharing dishes	185 (30.7%)	113 (32.9%)	72 (27.8%)
	Through eating from the same plate	9 (1.5%)	6 (1.7%)	3 (1.2%)
	Through touching items in public spaces (doorknobs, handles in transportation, etc)	184 (30.6%)	113 (32.9%)	71 (27.4%)
	It is not a contagious disease	38 (6.3%)	17 (5.0%)	21 (8.1%)
	I do not know	143 (23.8%)	44 (12.8%)	99 (38.2%)
In your opinion, who can be infected with TB?[c]	**Anybody**	**417 (69.3%)**	**246 (71.7%)**	**171 (66.0%)**
	Poor people	79 (13.1%)	64 (18.7%)	15 (5.8%)
	Homeless people	86 (14.3%)	68 (19.8%)	18 (6.9%)
	Alcoholics	77 (12.8%)	60 (17.5%)	17 (6.6%)
	Drug users	86 (14.3%)	65 (19.0%)	21 (8.1%)
	People living with HIV or AIDS	184 (30.6%)	140 (40.8%)	44 (17.0%)
	People who have been in prison	81 (13.5%)	63 (18.4%)	18 (6.9%)
	I do not know	94 (15.6%)	33 (9.6%)	61 (23.6%)
Do you think that there is a relationship between TB and bone inflammation or curvature of the spine?[c]	Yes	163 (27.1%)	116 (33.8%)	47 (18.1%)
	No	127 (21.1%)	66 (19.2%)	61 (23.6%)
	Maybe	**312 (51.8%)**	**161 (46.9%)**	**151 (58.3%)**
Do you think that immunocompromised people are more susceptible to TB?[c]	**Yes**	**526 (87.4%)**	**319 (93.0%)**	**207 (79.9%)**
	No	17 (2.8%)	7 (2.0%)	10 (3.9%)
	I do not know	59 (9.8%)	17 (5.0%)	42 (16.2%)

[a]Data is presented as count and percent.
[b]Most chosen answers are in bold.
[c]Answers to these questions differed significantly between healthcare and non-healthcare students.

TABLE 3 Knowledge of TB treatment and vaccines[a].

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
Can TB be cured?[c]	**Yes**	**298 (49.5%)**	**200 (58.3%)**	98 (37.8%)
	No	37 (6.1%)	15 (4.4%)	22 (8.5%)
	Maybe	267 (44.4%)	128 (37.3%)	**139 (53.7%)**
How can someone with TB be cured?[c]	Herbal remedies	54 (9%)	17 (5.0%)	37 (14.3%)
	Home rest without medicine	17 (2.8%)	8 (2.3%)	9 (3.5%)
	Specific drugs provided by a health center or a doctor	**470 (78.1%)**	**300 (87.5%)**	**170 (65.6%)**
	I do not know	128 (21.3%)	46 (13.4%)	82 (31.7%)
How long does it take to treat TB?[c]	<6 Months	66 (11%)	34 (9.9%)	32 (12.4%)
	6–12 months	165 (27.4%)	137 (39.9%)	28 (10.8%)
	13–18 months	13 (2.2%)	5 (1.5%)	8 (3.1%)
	19–24 months	18 (3%)	10 (2.9%)	8 (3.1%)
	More than 24 months	26 (4.3%)	16 (4.7%)	10 (3.9%)
	I do not know	**314 (52.2%)**	**141 (41.1%)**	**173 (66.8%)**
Does TB treatment have side effects?[c]	It does not have side effects	12 (2%)	6 (1.7%)	6 (2.3%)
	It can have minor side effects (e.g., nausea, anorexia, joint pain, orange red urine)	224 (37.2%)	**146 (42.6)**	78 (30.1%)
	It can have severe side effects (e.g., deafness, vomiting, jaundice, visual impairment)	90 (15%)	60 (17.5%)	30 (11.6%)
	I do not know	**276 (45.8%)**	131 (38.2%)	**145 (56.0%)**
Do we have vaccines that can protect us against TB?	**Yes**	**478 (79.4%)**	**276 (80.5%)**	**202 (78.0%)**
	No	124 (20.6%)	67 (19.5%)	57 (22.0%)

[a]Data is presented as count and percent.
[b]Most chosen answers are in bold.
[c]Answers to these questions differed significantly between healthcare and non-healthcare students.

mask might be useful, in contrast to only (32.4%) of healthcare students (Table 5).

Characteristics associated with better KAP

Participants were grouped according to the characteristics mentioned in Table 1, and the average KAP score was compared among those groups using appropriate statistical tests. There was a significant difference in the knowledge score, but not attitude and practice scores according to the year of study, but there was no incremental knowledge score with more years of study (Table 6). Expectedly, students in the healthcare field had significantly better knowledge scores compared to non-healthcare students (30.8 ± 10.1 vs. 21.6 ± 9.8, respectively, $p < 0.001$), which was also reproduced in attitude scores (6.2 ± 1.7 vs. 5.9 ± 1.7, respectively, $p = 0.027$) and practice scores (6.4 ± 1.3 vs. 5.6 ± 1.6, respectively, $p < 0.001$) (Table 6).

Participants who knew someone with TB did not show a significant difference in knowledge and attitude scores compared to those who did not know someone with TB, but there was a significant difference in the practice score, which was surprisingly better in those who did not know a person with TB (5.6 ± 1.7 vs. 6.1 ± 1.5, $p = 0.026$) (Table 6). There was a better practice score among non-smokers compared to smokers (6.2 ± 1.5 vs. 5.6 ± 1.6, respectively, $p < 0.001$), but no differences were found in attitude or knowledge scores. Finally, there was

TABLE 4 Attitudes toward TB[a].

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
Do you think you can get TB?	**Yes**	**376 (62.5%)**	**214 (62.4%)**	**162 (62.5%)**
	No	226 (37.5%)	129 (37.6%)	97 (37.5%)
Which statement is closest to your feeling about people with TB disease?	**I feel compassion and a desire to help**	**251 (41.7%)**	**147 (42.9%)**	**104 (40.2%)**
	I feel compassion but I tend to stay away from these people.	186 (30.9%)	109 (31.8%)	77 (29.7%)
	It is their problem and I cannot get TB	4 (0.7%)	3 (0.9%)	1 (0.4%)
	I fear them because they may infect me	29 (4.8%)	12 (3.5%)	17 (6.6%)
	I have no particular feeling	132 (21.9%)	72 (21.0%)	60 (23.2%)
In your community, how is a person who has TB usually regarded/treated?	Most people reject him or her	165 (27.4%)	88 (25.7%)	77 (29.7%)
	Most people are friendly, but they generally try to avoid him or her	**313 (52.0%)**	**199 (58.0%)**	**114 (44.0%)**
	The community mostly supports and helps him or her	124 (20.6%)	56 (16.3%)	68 (26.3%)
How serious a problem do you think TB is in Jordan?[c]	Very serious	121 (20.1%)	60 (17.5%)	61 (23.6%)
	Somewhat Serious	**273 (45.3%)**	**168 (49.0%)**	**105 (40.5%)**
	Not serious at all	50 (8.3%)	36 (10.5%)	14 (5.4%)
	I don't know	158 (26.2%)	79 (23.0%)	79 (30.5%)
How expensive do you think TB diagnosis and treatment is in Jordan?	It is free of charge	68 (11.5%)	35 (10.2%)	33 (12.7%)
	It is reasonably priced	76 (12.8%)	46 (13.4%)	30 (11.6%)
	It is somewhat/moderately expensive	141 (23.8%)	87 (25.4%)	54 (20.8%)
	It is very expensive	41 (6.9%)	28 (8.2%)	13 (5.0%)
	I don't know	**267 (45%)**	**145 (42.3%)**	**122 (47.1%)**

[a]Data is presented as count and percent.
[b]Most chosen answers are in bold.
[c]Answers to these questions differed significantly between healthcare and non-healthcare students.

no significant difference in KAP scores when comparing males to females, or urban to rural residents.

The correlations between knowledge and attitude scores, as well as knowledge and practice scores, were described using Spearman's correlation coefficient (r_s). There was a weak positive but significant correlation between Knowledge and attitude scores ($r_s = 0.243$, 95% CI 0.164–0.319, $p < 0.001$) as well as between knowledge and practice scores ($r_s = 0.314$, 95% CI 0.237–0.386, $p < 0.001$) (Supplementary Figure 2).

TB awareness and sources of information

Participants were asked about the first time they learned about TB. Most learned about TB for the first time from TV (38.4%), with school or college and social media coming in second and third places respectively. Two other close choices were family or friends and teachers (22.4 and 21.6%, respectively). Only 7.3% of participants didn't hear about TB before. Most participants (73.6%) did not feel that they were well

TABLE 5 Practices related to TB and respiratory diseases among university students[a].

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
If you had a cough for more than three weeks or if you were coughing up blood in your sputum, what would you do?[c]	**Go to a doctor**	**529 (87.9%)**	**317 (92.4%)**	**212 (81.9%)**
	Drink herbs	20 (3.3%)	4 (1.2%)	16 (6.2%)
	Take any medicine from the pharmacy	27 (4.5%)	9 (2.6%)	18 (6.9%)
	Just Ignore it	26 (4.3%)	13 (3.8%)	13 (5.0%)
Who would you talk to about your illness if you had TB?[c]	**A doctor or any healthcare provider**	**493 (81.9%)**	**314 (91.5%)**	**179 (69.1%)**
	Spouse	83 (13.8%)	58 (16.9%)	25 (9.7%)
	Parent	326 (54.2%)	193 (56.3%)	133 (51.4%)
	Children	36 (6%)	22 (6.4%)	14 (5.4%)
	Other family members	178 (29.5%)	98 (28.6%)	80 (30.9%)
	Close friends	160 (26.6%)	100 (29.2%)	60 (23.2%)
	Others	42 (7%)	23 (6.7%)	19 (7.3%)
	No one	39 (6.5%)	14 (4.1%)	25 (9.7%)
If you had symptoms of TB, at what point would you go to the health facility?[c]	When treatment on my own does not work	47 (7.8%)	14 (4.1%)	33 (12.7%)
	When symptoms that look like TB signs last for 3–4 weeks	134 (22.3%)	79 (23.0%)	55 (21.2%)
	As soon as I realize that my symptoms might be related to TB	**412 (68.4%)**	**248 (72.3%)**	**164 (63.3%)**
	I would not go to the doctor	9 (1.5%)	2 (0.6)	7 (2.7%)
If you would not go to the health facility, what is the reason?	**Not sure where to go**	**4 (44.4%)**	**1 (0.3%)**	**3 (1.2%)**
	Cost and difficulties with transportation/distance to clinic	2 (22.2%)	**1 (0.3%)**	1 (0.4%)
	Do not trust medical workers	0 (0%)	0 (0.0%)	0 (0.0%)
	Do not like attitude of medical workers	1 (11.1%)	0 (0.0%)	1 (0.4%)
	Cannot leave work (overlapping work hours with medical facility working hours)	0 (0%)	0 (0.0%)	0 (0.0%)
	Do not want to find out that something is really wrong.	2 (22.2%)	0 (0.0%)	2 (0.8%)
Do you use hygiene products in public places?	Yes	241 (40%)	141 (41.1%)	100 (38.6%)
	No	97 (16.1%)	53 (15.5%)	45 (17.4%)
	Sometimes	**264 (43.9%)**	**149 (43.4%)**	**114 (44.0%)**

(Continued)

TABLE 5 (Continued)

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
Are you convinced that the mask is an appropriate way to prevent infectious diseases that can be transmitted in air?[c]	**Yes**	**355 (59%)**	**232 (67.6%)**	**123 (47.5%)**
	No	96 (15.9%)	39 (11.4%)	57 (22.0%)
	Maybe	151 (25.1%)	72 (21.0%)	79 (30.5%)
Were your daily habits related to the transmission of chest diseases affected by the COVID-19 pandemic?	**Yes**	**463 (76.9%)**	**268 (78.1%)**	**195 (75.3%)**
	No	139 (23.1%)	75 (21.9%)	64 (24.7%)

[a]Data is presented as count and percent.
[b]Most chosen answers are in bold.
[c]Answers to these questions differed significantly between healthcare and non-healthcare students.

TABLE 6 Demographic variables associated with better TB KAPS[a].

Demographic variable	Mean knowledge score (±SD)	*P*-value	Mean attitude score (±SD)	*P*-value	Mean practice score (±SD)	*P*-value
Year of study						
First	23.4 (±8.8)	**<0.001**	6.2 (±1.6)	0.511	5.8 (±1.4)	0.402
Second	29.2 (±10.9)		6.1 (±1.8)		6.1 (±1.5)	
Third	27.9 (±11.1)		6.1 (±1.8)		6.1 (±1.7)	
Fourth	25.6 (±12.4)		5.8 (±1.4)		6.1 (±1.4)	
Fifth	26.9 (±14.4)		5.8 (±2.1)		6.4 (±1.2)	
Sixth	28.3 (±13.2)		5.0 (±1.6)		5.8 (±1.5)	
Gender						
Male	27.6 (±11.4)	0.157	6.2 (±1.7)	0.065	5.9 (±1.5)	0.115
Female	26.3 (±10.7)		6.0 (±1.7)		6.1 (±1.5)	
Field of study						
Healthcare field	30.8 (±10.1)	**<0.001**	6.2 (±1.7)	**0.027**	6.4 (±1.3)	**<0.001**
Non-healthcare field	21.6 (±9.8)		5.9 (±1.7)		5.6 (±1.6)	
Smoking						
Yes	25.2 (±11.9)	0.065	5.8 (±1.8)	0.099	5.6 (±1.6)	**<0.001**
No	27.3 (±10.7)		6.1 (±1.7)		6.2 (±1.5)	
Residence						
Urban	27.3 (±11.2)	0.088	6.1 (±1.7)	0.623	6.0 (±1.5)	0.930
Rural	25.4 (±10.0)		6.1 (±1.8)		6.0 (±1.5)	
Knew someone with TB						
Yes	27.5 (±10.6)	0.617	6.2 (±1.7)	0.468	5.6 (±1.7)	**0.026**
No	26.8 (±11.0)		6.1 (±1.7)		6.1 (±1.5)	

[a]Statistically significant differences are in bold.

TABLE 7 Sources of information used to learn about TB[a].

Question	Answer[b]	All students ($n = 602$)	Healthcare students ($n = 343$)	Non-healthcare students ($n = 259$)
Where did you first learn about TB?[c]	Newspapers and magazines	52 (8.6%)	26 (7.6%)	26 (10.0%)
	Social media	180 (29.9%)	85 (24.8%)	95 (36.7%)
	Teachers	130 (21.6%)	69 (20.1%)	61 (23.6%)
	Television	**231 (38.4%)**	128 (37.3%)	**103 (39.8%)**
	Brochures, posters, and other printed materials	68 (11.3%)	34 (9.9%)	34 (13.1%)
	Healthcare workers	59 (9.8%)	36 (10.5%)	23 (8.9%)
	Family and friends	135 (22.4%)	65 (19.0%)	70 (27.0%)
	School or college	188 (31.2%)	**178 (51.9%)**	10 (3.9%)
	Never heard about it	44 (7.3%)	14 (4.1%)	30 (11.6%)
Do you feel well informed about TB?[c]	Yes	159 (26.4%)	122 (35.6%)	37 (14.3%)
	No	**443 (73.6%)**	**221 (64.4%)**	**222 (85.7%)**
Do you wish you could get more information about TB?	**Yes**	**517 (85.9%)**	**301 (87.8%)**	**216 (83.4%)**
	No	85 (14.1%)	42 (12.2%)	43 (16.6%)
What are the sources of information that you think can most effectively reach people like you with information on TB?	Newspapers and magazines	78 (13%)	46 (13.4%)	32 (12.4%)
	Social media	**477 (79.2%)**	**269 (78.4%)**	**208 (80.3%)**
	Radio	54 (9%)	20 (5.8%)	34 (13.1%)
	Television	195 (32.4%)	102 (29.7%)	93 (35.9%)
	Billboards	147 (24.4%)	76 (22.2%)	71 (27.4%)
	Brochures, posters, and other printed materials	125 (20.8%)	66 (19.2%)	59 (22.8%)
	Healthcare workers	315 (52.3%)	221 (64.4%)	94 (36.3%)
	Family and friends	205 (34.1%)	112 (32.7%)	93 (35.9%)
	Teachers	231 (38.4%)	137 (39.9%)	94 (36.3%)

[a]Data is presented as count and percent.
[b]Most chosen answers are in bold.
[c]Answers to these questions differed significantly between healthcare and non-healthcare students.

informed about TB, and this was reflected in the wish of most participants (85.9%) to learn more about TB (Table 7).

At the end of the questionnaire, participants were asked about the source they thought was most effective for TB education with 9 possible choices: newspapers and magazines, social media, radio, TV, billboards, brochures or posters, and other printed materials, healthcare workers, family and friends, and teachers. The top two sources chosen were social media (79.2%) and healthcare workers (52.3%) (Table 7).

It should be noted that healthcare and non-healthcare student groups varied significantly in terms of where they first learned about TB, since most healthcare students (51.9%) chose school or college compared to only 3.9% of non-healthcare students. Additionally, 85.7% of non-healthcare students felt they were not well informed about TB, compared to 64.4% of healthcare students. But both groups wanted to be more informed about TB and chose social media as the preferred source of information with no significant differences between the two (Table 7).

Discussion

While similar KAP surveys have been carried out in neighboring countries (17, 18), this descriptive cross-sectional study was the first to measure KAP toward TB among university

students in Jordan. Although KAP scores were satisfactory, this study revealed knowledge gaps related to TB transmission and treatment especially in non-healthcare students, additionally, it showed no social stigma around TB, good health seeking behavior, and doubt regarding the use of masks in preventing respiratory disease.

Awareness of infectious respiratory diseases such as TB is considered the first step in reducing their burden on the community. KAP surveys should draw attention to knowledge gaps, disease stigma, or practices that increase the chance of disease transmission. Since KAP surveys usually yield distinct results amongst various communities around the world (19–21), it is essential to conduct them in different settings to form targeted awareness campaigns and specific regional policies.

The sample that was studied was representative of Jordanian university students to a certain extent, firstly, females represent the larger proportion of university students in Jordan, which explains their representation in this study (16), secondly, the universities that were included in this study are the largest and most diverse in Jordan since they host students from different parts of the country (16). On the other hand, healthcare students were overrepresented in this study, probably since they are more interested in health-related topics and are more willing to complete such surveys, which denotes a selection bias. Nevertheless, the almost equal number of students from healthcare and non-healthcare-related fields in this study allowed for a more accurate comparison between the two groups.

Total knowledge scores in this study were satisfactory, and when compared to a national survey performed among the general public in Nigeria, which is a high-burden TB country, better knowledge scores were found in this study, but the authors of the study noted that respondents with tertiary education had the highest TB knowledge scores, comparable to scores in this study (22), which highlights the need for TB educational programs for those who do not attend higher education.

Specific knowledge weaknesses were identified in this study, especially in knowledge about TB treatment, where almost half of the respondents were not sure if TB can be cured and one-fifth did not know of the presence of vaccines, although the Bacille Calmette Guerin (BCG) vaccine is part of the mandatory vaccination program in Jordan. Moreover, about a quarter of the participants did not know about TB routes of transmission and about 16% did not know any of the symptoms, which is a considerable percentage given the educational level of the population being studied. This issue was further highlighted when examining answers from non-healthcare students separately, where over one third of students (38.2%) did not know TB routes of transmission and around a quarter did not know any TB symptoms or the people at risk of TB. This should be addressed by incorporating TB knowledge in health curricula given to non-healthcare specialties in Jordanian universities. The benefit of introducing general TB knowledge to non-healthcare students at university is supported by the fact that only 3.9% of non-healthcare students learned about TB from school or college, compared to 51.9% of healthcare students.

Students in healthcare fields showed significantly better KAP scores than students from non-healthcare fields, which is unsurprising given their training and has been demonstrated in other related TB knowledge surveys (23). But unlike studies that found KAP levels to be associated with gender or age (24, 25), this study found a better KAP score only in healthcare students and a worse practice score in smokers.

KAP surveys completed by students from healthcare fields in Jordan usually reveal satisfactory scores, as demonstrated by a recent study that measured KAP toward COVID-19 (26). Similarly, a cross-sectional study on Italian healthcare students showed satisfactory TB knowledge, but concluded that there could be places for improvement in healthcare curricula, especially for nursing students (27). Another study on Iranian medical students showed good KAP scores but found gaps in TB transmission and diagnosis knowledge (28). In contrast, healthcare students in this study displayed good knowledge in transmission routes with around 80% correctly identifying the most common route of transmission. It should be noted that the questionnaire used in this study was different from the two studies mentioned earlier as it was not directed solely to healthcare students, thus the questions did not require in-depth knowledge with regards to treatment and diagnosis. Rather, this survey was based on WHO recommendations for TB KAP surveys with some modifications made to fit the population being tested (15).

Before the recent migration spells from Syria, a community-based study investigated the prevalence of TB suspects (defined as persons with a persistent cough for more than 3 weeks) in Jordan in 2008 and reported a relatively low prevalence of 2.51% (29). Interestingly, the study also investigated attitudes of TB suspects and showed a high level of stigma, in contrast to what we found in this study, since >70% of participants indicated they feel compassion for TB patients, and >70% thought that the community is usually friendly to TB patients. The difference could be attributed to the populations tested, in this survey all participants were university students and the majority resided in cities, contrary to the population in the 2008 study where most participants had a high school education only, many were illiterate, and all resided in rural areas.

Good health-seeking behavior among university students was demonstrated in this study as well, since over 80% of participants would go to a doctor if they had TB symptoms and most would do it as soon as they suspect the symptoms were due to TB. Most participants also thought healthcare workers are a preferred source of information on TB, which further emphasizes good health-seeking behavior and indicates trust in the medical system. Most of the studies investigating

health-seeking behavior were done in TB patients and indicated a significant association with TB knowledge (30, 31). This study also demonstrated a weak positive yet significant correlation between TB knowledge scores and both, attitude, and practice scores, similar to a study that was conducted on healthcare workers in Saudi Arabia (11).

Although the practice score was satisfactory in this study, it was found that around 41.0% of participants were not sure or did not agree that a mask is effective in preventing airborne diseases, which reached 52.5% in non-healthcare students. This could be addressed through education on the role of masks and when to use them. Several guidelines including those adopted by the WHO (32) and Center for Disease Control (CDC) (33) advocate for the use of respiratory protection when dealing with TB patients and especially when there is a risk of inhaling Mtb containing aerosols by a healthcare worker, although definitive practices such as the type of mask and when to wear it differs between guidelines and would require further evidence (34). A similar study conducted in Iran showed that around 86% agreed that wearing face masks is necessary for the examination of all patients, in contrast to 67.6% of healthcare students in this study, the higher percentage could be attributed to the settings of the study, which involved medical students in their last year of studies (28).

Only 11.5% of participants were aware that TB diagnosis and treatment are free in Jordan. This is very similar to another study conducted among a mainly uneducated population in the urban slums in Nigeria (35), which implies that treatment centers in Jordan should advertise treatment options more, especially since (85.9%) of participants wanted to learn more about TB, and a large percentage (73.6%) felt they were not well informed on TB. The distribution of TB knowledge could be done using new media outlets such as social media, which most participants (79.2%) believed was the most effective in reaching their peers, in agreement with a recent study from Oman that emphasized the role of digital platforms in TB knowledge dissemination (36).

This study has some limitations, for example, it was not possible to determine the actual response rate given the way the questionnaire was distributed, which took place through student communication channels online. Secondly, since this study involved several universities, we had to use an open platform for online forms and did our best to ensure that the survey reached only the population that was targeted, this was done by using locked communication channels accessible only to students with verified email addresses, nevertheless, the possibility of sending a link to a non-student outside those channels to complete the survey cannot be disregarded. But we believe that the detailed instructions at the start of the questionnaire (which emphasize that the questionnaire is meant only for students) and having to complete all answers across several pages to submit the form, make it unlikely that a substantial number of non-students, if any, have completed this form. Another limitation was that students who were informed about the topic of TB and pulmonary infections in general, were more likely to respond to the questionnaire, which could have introduced a sampling bias as alluded to earlier.

In conclusion, this study was the first to measure and demonstrate satisfactory KAP toward TB among Jordanian university students. The study underlined the need to promote knowledge on TB treatment and its availability, as well as TB transmission routes, especially among students from non-healthcare related fields. It also showed good health-seeking behavior in relation to TB but indicated a worrying trend of doubting the benefit of mask wearing among university students. Investigating the KAP toward TB among risk groups and refugee populations in Jordan is a logical next step in curtailing disease burden in the future.

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 Institutional Review Board (IRB) at The University of Jordan (Ref. No. 19/2022/271). Decision No. (46-2022). The patients/participants provided their written informed consent to participate in this study.

Author contributions

AA-H contributed to study conception, study design, data analysis, data interpretation, manuscript writing, and revision. AT contributed to study conception, acquisition and analysis of data, manuscript writing, and revision. YH contributed to study design, analysis of data, manuscript writing, and revision. AA-l, OA-l, and MA contributed to study design, acquisition of data, manuscript writing, and revision. FA, DA, and NA contributed to interpretation of data, manuscript writing, and revision. All authors contributed to the article and approved the submitted version.

Acknowledgments

We are grateful for the help provided by students in distributing the questionnaire through student communication channels.

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.2022.1055037/full#supplementary-material

References

1. WHO. *Global Tuberculosis Report 2021*. Geneva: WHO (2021).

2. Bussi C, Gutierrez MG. Mycobacterium tuberculosis infection of host cells in space and time. *FEMS Microbiol Rev.* (2019) 43:341–61. doi: 10.1093/femsre/fuz006

3. WHO. *WHO Global Lists of High Burden Countries for TB, Multidrug/Rifampicin-Resistant TB (MDR/RR-TB) and TB/HIV, 2021–2025*. Geneva: WHO (2021).

4. UNHCR. *External Statistical Report on UNHCR Registered People of Concern Jordan as of 31 August 2022*. Geneva: UNHCR (2022).

5. Kimbrough W, Saliba V, Dahab M, Haskew C, Checchi F. The burden of tuberculosis in crisis-affected populations: a systematic review. *Lancet Infect Dis.* (2012) 12:950–65. doi: 10.1016/S1473-3099(12)70225-6

6. Boyd AT, Cookson ST, Almashayek I, Yaacoub H, Qayyum MS, Galev A. An evaluation of a tuberculosis case-finding and treatment program among Syrian refugees—Jordan and Lebanon, 2013–2015. *Conflict Health.* (2019) 13:32. doi: 10.1186/s13031-019-0213-1

7. Krafft C, Sieverding M, Salemi C, Keo C. *141Syrian Refugees in Jordan: Demographics, Livelihoods, Education, and Health, in The Jordanian Labor Market: Between Fragility and Resilience*. Oxford: Oxford University Press (2019). doi: 10.1093/oso/9780198846079.003.0006

8. Sreeramareddy CT, Harsha Kumar HN, Arokiasamy JT. Prevalence of self-reported tuberculosis, knowledge about tuberculosis transmission and its determinants among adults in India: results from a nation-wide cross-sectional household survey. *BMC Infect Dis.* (2013) 13:16. doi: 10.1186/1471-2334-13-16

9. Buregyeya E, Kulane A, Colebunders R, Wajja A, Kiguli J, Mayanja H, et al. Tuberculosis knowledge, attitudes and health-seeking behaviour in rural Uganda. *Int J Tuberc Lung Dis.* (2011) 15:938–42. doi: 10.5588/ijtld.10.0211

10. Kigozi NG, Heunis JC, Engelbrecht MC, Janse van Rensburg AP, van Rensburg HC. Tuberculosis knowledge, attitudes and practices of patients at primary health care facilities in a South African metropolitan: research towards improved health education. *BMC Public Health.* (2017) 17:795. doi: 10.1186/s12889-017-4825-3

11. Alotaibi B, Yassin Y, Mushi A, Maashi F, Thomas A, Mohamed G, et al. Tuberculosis knowledge, attitude and practice among healthcare workers during the 2016 Hajj. *PLoS ONE.* (2019) 14:e0210913. doi: 10.1371/journal.pone.0210913

12. Puspitasari IM, Sinuraya RK, Aminudin AN, Kamilah RR. Knowledge, attitudes, and preventative behavior toward tuberculosis in university students in Indonesia. *Infect Drug Resist.* (2022) 15:4721–33. doi: 10.2147/IDR.S365852

13. Jairoun A, Hassan N, Ali A, Jairoun O, Shahwan M. Knowledge, attitude and practice of antibiotic use among university students: a cross sectional study in UAE. *BMC Public Health.* (2019) 19:518. doi: 10.1186/s12889-019-6878-y

14. AlSalem SB, AlEisa AM, Raslan IA, BinJawhar AS, Khouqeer AF, Gad A. Tuberculosis: awareness among students in a Saudi university. *Health.* (2015) 7:175. doi: 10.4236/health.2015.72020

15. World Health Organization. *Advocacy, Communication and Social Mobilization for TB Control: A Guide to Developing Knowledge, Attitude and Practice Surveys*. Geneva: World Health Organization (2008).

16. MOE. *The Annual Statistical Report on Higher Education in Jordan for the Year 2019–2020 Ministry of Higher Education and Scientific Research*. Woodland Park: MOE (2021).

17. Aseeri AA, Turkestani RA, Alamri MA, Algabr GA, Alobaysi SA, Alghazal Z, et al. Assessment of knowledge, attitudes and practices regarding pulmonary tuberculosis among Saudi Arabia community in 2017. *Egy J Hosp Med.* (2017) 69:2421–5. doi: 10.12816/0041687

18. Hashim DS, Al Kubaisy W, Al Dulayme A. Knowledge, attitudes and practices survey among health care workers and tuberculosis patients in Iraq. *EMHJ-Eastern Mediter Health J.* (2003) 9:718–31. doi: 10.26719/2003.9.4.718

19. Dorji T, Tshering T, Wangdi K. Assessment of knowledge, attitude and practice on tuberculosis among teacher trainees of Samtse College of Education, Bhutan. *PLoS ONE.* (2020) 15:e0241923. doi: 10.1371/journal.pone.0241923

20. Datiko DG, Habte D, Jerene D, Suarez P. Knowledge, attitudes, and practices related to TB among the general population of Ethiopia: findings from a national cross-sectional survey. *PLoS ONE.* (2019) 14:e0224196. doi: 10.1371/journal.pone.0224196

21. Kasa AS, Minibel A, Bantie GM. Knowledge, attitude and preventive practice towards tuberculosis among clients visiting public health facilities. *BMC Res Notes.* (2019) 12:1–6. doi: 10.1186/s13104-019-4292-2

22. Hassan AO, Olukolade R, Ogbuji QC, Afolabi S, Okwuonye LC, Kusimo OC, et al. Knowledge about tuberculosis: a precursor to effective TB control—findings from a follow-up national KAP study on tuberculosis among Nigerians. *Tubercul Res Treatment.* (2017) 2017:6309092. doi: 10.1155/2017/6309092

23. Abu-Humaidan AH, Alrawabdeh JA, Theeb LS, Hamadneh YI, Omari MB. Evaluating knowledge of human microbiota among University students in Jordan, an online cross-sectional survey. *Int J Environ Res Public Health.* (2021) 18:13324. doi: 10.3390/ijerph182413324

24. Tolossa D, Medhin G, Legesse M. Community knowledge, attitude, and practices towards tuberculosis in Shinile town, Somali regional state, eastern Ethiopia: a cross-sectional study. *BMC Public Health.* (2014) 14:804. doi: 10.1186/1471-2458-14-804

25. Wang J, Fei Y, Shen H, Xu B. Gender difference in knowledge of tuberculosis and associated health-care seeking behaviors: a cross-sectional study in a rural area of China. *BMC Public Health.* (2008) 8:354. doi: 10.1186/1471-2458-8-354

26. Khasawneh AI, Humeidan AA, Alsulaiman JW, Bloukh S, Ramadan M, Al-Shatanawi TN, et al. Medical students and COVID-19: knowledge, attitudes, and precautionary measures. A descriptive study from Jordan. *Front Public Health.* (2020) 8:253–253. doi: 10.3389/fpubh.2020.00253

27. Montagna MT, Napoli C, Tafuri S, Agodi A, Auxilia F, Casini B, et al. Knowledge about tuberculosis among undergraduate health care students in 15 Italian universities: a cross-sectional study. *BMC Public Health.* (2014) 14:1–6. doi: 10.1186/1471-2458-14-970

28. Behnaz F, Mohammadzade G, Mohammadzadeh M. Assessment of knowledge, attitudes and practices regarding tuberculosis among final year students in Yazd, central Iran. *J Epidemiol Global Health.* (2014) 4:81–5. doi: 10.1016/j.jegh.2013.09.003

29. Rumman KA, Sabra NA, Bakri F, Seita A, Bassili A. Prevalence of tuberculosis suspects and their healthcare-seeking behavior in urban and rural Jordan. *Am J Trop Med Hyg.* (2008) 79:545–51. doi: 10.4269/ajtmh.2008.79.545

30. Chimbanrai B, Fungladda W, Kaewkungwal J, Silachamroon U. Treatment-seeking behaviors and improvement in adherence to treatment regimen of

tuberculosis patients using intensive triad-model program, Thailand. *Southeast Asian J Trop Med Public Health*. (2008) 39:526–41.

31. Badane AA, Dedefo MG, Genamo ES, Bekele NA. Knowledge and healthcare seeking behavior of tuberculosis patients attending Gimbi general hospital, West Ethiopia. *Ethiop J Health Sci.* (2018) 28:529–38. doi: 10.4314/ejhs.v28i5.3

32. Organization WH. *WHO Guidelines on Tuberculosis Infection Prevention and Control: 2019 Update*. Geneva: World Health Organization (2019)

33. Jensen PA, Lambert LA, Iademarco MF, Ridzon R. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care settings, 2005. *MMWR Recomm Rep.* (2005) 54:1–141.

34. Diel R, Nienhaus A, Witte P, Ziegler R. Protection of healthcare workers against transmission of *Mycobacterium tuberculosis* in hospitals: a review of the evidence. *ERJ Open Res.* (2020) 6:00317–2019. doi: 10.1183/23120541.00317-2019

35. Balogun MR, Sekoni AO, Meloni ST, Odukoya OO, Onajole AT, Longe-Peters OA, et al. Predictors of tuberculosis knowledge, attitudes and practices in urban slums in Nigeria: a cross-sectional study. *Pan Afr Med J.* (2019) 32:60. doi: 10.11604/pamj.2019.32.60.14622

36. Al Khalili S, Al Yaquobi F, Al Abri B, Al Thuhli K, Al Marshoudi S, Al Rawahi B, et al. Assessing Oman's knowledge, attitude and practice regarding tuberculosis: a cross-sectional study that calls for action. *Int J Infect Dis.* (2022). doi: 10.1016/j.ijid.2022.06.002. Available online at: https://www.ijidonline.com/article/S1201-9712(22)00334-4/fulltext

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 25 November 2022
DOI 10.3389/fpubh.2022.1042236

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 12 September 2022
ACCEPTED 08 November 2022
PUBLISHED 25 November 2022

CITATION
Lee X, Gao Y, Zhang Y, Feng Y, Gao L, Wang A, Jiang Y and Huang H (2022) Comparison of 10 obesity-related indices for predicting hypertension based on ROC analysis in Chinese adults.
Front. Public Health 10:1042236.
doi: 10.3389/fpubh.2022.1042236

Comparison of 10 obesity-related indices for predicting hypertension based on ROC analysis in Chinese adults

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Objective: To compare the predictive performance of the percentage body fat (PBF), body mass index (BMI), waist circumference (WC), hip circumference (HC), waist–hip ratio (WHR), waist–height ratio (WHtR), a body shape index (ABSI), body roundness index (BRI), abdominal volume index (AVI), and conicity index (CI) for identifying hypertension.

Methods: A cross-sectional study was conducted among 2,801 adults (1,499 men and 1,302 women) aged 18 to 81 in Ningbo, China. The receiver operator characteristic (ROC) analysis and multiple non-parametric Z tests were used to compare the areas under the curve (AUC). The maximum Youden's indices were used to determine the optimal cut-off points of 10 obesity-related indices (ORI) for hypertension risk.

Results: The AUC of all the indices were statistically significant ($P < 0.05$). The AUC of all the indices in men and women were 0.67–0.73 and 0.72–0.79, respectively. Further non-parametric Z tests showed that WHR had the highest AUC values in both men [0.73 (95% CI: 0.70, 0.76)] and women (0.79 (95% CI: 0.75, 0.83)], and several central ORI (men: WHR, WC, BRI, AVI, and CI, 0.71–0.73; women: WC, WHR, and AVI, 0.77–0.79) were higher than general ORI (PBF and BMI, 0.68 in men; 0.72–0.75 in women), with adjusted $P < 0.05$. The optimal cut-off points for identifying hypertension in men and women were as follows: PBF (23.55%, 32.55%), BMI (25.72 kg/m^2, 23.46 kg/m^2), HC (97.59 cm, 94.82 cm), WC (90.26 cm, 82.78 cm), WHR (0.91, 0.88), WHtR (0.51, 0.55), ABSI (0.08 m$^{7/6}$/kg$^{2/3}$, 0.08 m$^{7/6}$/kg$^{2/3}$), BRI (4.05, 4.32), AVI (16.31 cm^2, 13.83 cm^2), and CI (1.23 m$^{2/3}$/kg$^{1/2}$, 1.27 m$^{2/3}$/kg$^{1/2}$). Multivariate logistic regression models showed that all indices were statistically significant ($P < 0.05$) with the adjusted ORs (per 1-SD increase) at 1.39–2.06 and ORs (over the optimal cut-off points) at 1.80–2.64.

Conclusions: All 10 ORI (PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, and CI) can effectively predict hypertension, among which WHR should be recommended as the best predictor. Central ORI (WHR, WC, and AVI) had

a better predictive performance than general ORIs (PBF and BMI) when predicting the risk of hypertension.

KEYWORDS

hypertension, general obesity-related indices, central obesity-related indices, predictive performance, ROC analysis

Introduction

Hypertension is a risk factor for cardiovascular diseases (CVD) and death; thus, it is an essential global health threat (1, 2). A nationwide epidemiological study involving 451,755 residents from 31 provinces in China showed that the prevalence of hypertension among adults in China was 23.2% (3). By 2025, the number of adults with hypertension is expected to reach 1.56 billion (4). Therefore, preventing and reducing the incidence of hypertension has become an urgent problem. Some research have revealed that obesity is a significant, independent, and modifiable risk factor for hypertension and other CVD (5, 6). Obesity-related indices (ORI) have become the primary choice for health risk screening because of their convenience and economy (7).

Speculation has grown in recent years about which measure of obesity is a better predictor of hypertension. However, there are some contradictions in some studies. Body mass index (BMI) is commonly used in many obesity studies. However, it was reported in many studies that it failed to distinguish between body fat and lean body mass (8, 9). Several central obesity indices, such as waist–hip ratio (WHR), waist circumference (WC), and waist–height ratio (WHtR), were considered better indices of CVD risk because they reflect body fat distribution and upper body adiposity. Some studies indicated that WC is the best indicator for reflecting the associations between obesity and hypertension risk (10, 11). However, WC does not account for differences in height, so risk assessments for tall and short people may be too high and too low, respectively. Jensen et al.'s and Calderón-García et al.'s views were that measuring WHR is not advantageous over measuring WC alone and is not recommended as part of routine obesity assessment (12, 13). Several studies proposed the WHtR as an alternative to WC (5, 8). A meta-analysis concluded that WHtR was the best predictor of hypertension in both sexes (14). Moreover, several studies indicated that women's hip circumference (HC) is a more robust independent predictor of death and CVD development than BMI or WC (15, 16).

Researchers have explored several new ORI to improve the above limitations, such as a body shape index (ABSI), body roundness index (BRI), visceral adiposity index (VAI), Chinese visceral adiposity index (CVAI), lipid accumulation product (LAP), abdominal volume index (AVI), and conicity index (CI). The ABSI was developed in 2012 by Krakauer et al., combining BMI, WC, and height (17). A high ABSI relates to a greater fraction of abdominal adipose tissue and appears to be a significant risk factor for premature death (17). In 2013, Thomas et al. developed the BRI, which is a new geometrical index that combines height and WC to predict the percentage body fat (PBF) and evaluate health status (18). Amato et al. set up a VAI in 2010 that integrated WC, triglyceride (TG), high-density lipoprotein cholesterol (HDL–C), and BMI (19). Visceral obesity in Chinese can be assessed with CVAI, which is developed by combining BMI, age, WC, TG, and HDL–C (20). The LAP is based on combining two measurements (WC and TG) (21). Although many studies have verified that VAI, CVAI, and LAP were reliable visceral adiposity measures (19–22), their calculation requires biochemical blood indices (HDL–C and TG), which are not easy to measure. The AVI is another anthropometric tool for assessing the whole volume. In addition, CI is often used in epidemiological studies. However, it is not known whether the new ORI is a better predictor of hypertension presence or risk than the traditional ORI for Chinese.

PBF reflects body composition more accurately than traditional ORI. Recent studies demonstrated that PBF is a risk factor for CVD, including hypertension (23). The fifth physical monitoring of the General Administration of Sport first adopted the bioelectrical impedance method to measure PBF on a large scale in China in 2020 (24). However, the measurement of PBF is more complex than traditional ORI, and

Abbreviations: ABSI, a body shape index; AUC, areas under the curve; AVI, abdominal volume index; baPWV, brachial–ankle pulse wave velocity; BMI, body mass index; BRI, body roundness index; CI, conicity index; CRF, cardiorespiratory fitness; CVAI, Chinese visceral adiposity index; CVD, cardiovascular disease; DBP, diastolic blood pressure; FDR, False Discovery Rate; HC, hip circumference; HDL–C, high density lipoprotein–cholesterol; HR, rest heart rate; LAP, lipid accumulation product; METs, metabolic equivalent values; ORI, obesity–related indices; ORs, odds ratios; PBF, percentage body fat; ROC, receiver operator characteristic; SBP, systolic blood pressure; SD, standard deviation; STROBE, strengthening the reporting of observational studies in ipidemiology; TG, triglyceride; WC, waist circumference; WGOC, Working Group on Obesity in China; WHO, World Health Organization; WHR, waist–hip ratio; WHtR, waist–height ratio.

many studies have not included PBF (8, 25, 26). Therefore, the predictive performance of PBF compared with traditional ORI for identifying hypertension among the same large population still remained unclear.

Previous studies showed that the hypertension prevalence and the ORI values indicate significant differences with sex (4, 5, 27–30). Therefore, we conducted a cross-sectional study in both sexes to (1) compare the predictive performance of 10 easy-to-measure ORI (PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, and CI) for identifying hypertension except the indices that needed biochemical blood indices (such as VAI, CVAI, and LAP); and (2) determine the optimal cut-off points for 10 types of ORI to predict hypertension.

Materials and methods

Study design

This study was designed as a cross-sectional study. The study methods complied with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement.

Participants

We recruited participants who received a routine physical fitness examination at the Affiliated Hospital of Ningbo University from 2018 to 2019 in Ningbo City. Participants were recruited by inclusion and exclusion criteria. Inclusion criteria: (1) age from 18 to 81 years old; (2) volunteered for this study; and (3) independent completion of the body composition test, medical examination, and physical fitness test). Exclusion criteria (1) pregnant, using a pacemaker, wheelchair-bound, unable to stand, an amputee, unable to grip the handles of the analyzer, or unwilling to take off their shoes for body composition test; (2) severe CVD and infectious disease; and (3) inability to complete the physical fitness examination. Initially 2,813 participants were recruited. A total of 12 participants were excluded because the body composition test data were missing. The final sample size was 2801 participants, comprising 1,499 men and 1,302 women. Informed consent in a signed form was obtained from involved participants. The design and protocol of this study were approved by the Institutional Review Board of the Faculty of Sports Science, Ningbo University (NO. 2018RAGH1025).

Measurements and definitions

Dependent variables

The dependent variable in this study was blood pressure. The participants were advised to avoid caffeinated beverages and exercise for at least 30 min before the measurement (31). Each participant's seated brachial blood pressure was measured after at least 5 min of rest by a standardized automatic electronic sphygmomanometer (HEM-907; Omron, Kyoto, Japan). During the measurement, each participant was seated with their tested arm supported at the level of the heart. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured three times with 2-min intervals, and SBP and DBP were estimated by the average of these three successive reading values (32). Hypertension was defined as elevated blood pressure (SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg) or the patient having undergone antihypertensive medication therapy (32).

Independent variables

The ten types of easy-to-measure ORI (PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, and CI) were collected by trained technicians following standard procedures in the study as independent variables. All measurements were performed with the participants standing upright, with light clothing and without shoes. Weight and PBF were measured by a bioimpedance body composition analyzer (Inbody720, Inbody Co. Ltd., Seoul, Korea). Each participant's height was measured using a stadiometer. An anthropometric tape was used to measure HC and WC. HC was measured around the thighs at the height of the greater trochanter (33). The WC measurements were obtained at the end of normal expiration at the midpoint level between the lower end of the 12th rib and the upper end of the iliac crest (33). Weight, height, HC, and WC were measured to the nearest 0.1 kg and 0.1 cm. The formula of ORI is shown in Table 1.

Covariates

Previous studies indicated that several variables, such as age, rest heart rate (HR), cardiorespiratory fitness (CRF), and brachial-ankle pulse wave velocity (baPWV), arteriosclerosis, and lifestyle (smoking and exercise status), which may be associated with both obesity and hypertension, were considered as potential confounders (5, 38, 39). These covariates were classified as continuous and categorical variables. In this study, the continuous variables comprised age, HR, cardiorespiratory fitness (CRF), and brachial–ankle pulse wave velocity (baPWV). Questionnaires collected participants' ages. CRF was determined using a submaximal VO_2 max test conducted on a stationary bicycle in accordance with the Ekblom-Bak cycle ergometer test (40), presented as relative values in ml/kg/min and analyzed by metabolic equivalent values (METs). CRF was not tested in participants over 60 years of age. The HR and baPWV were measured by a VP-1000 automated arteriosclerosis analyzer (Colin Medical Technology Corp., Komaki, Japan). Participants rested in a supine position for at least 5 min, wrapping four cuffs around their upper arms and ankles. Then, the upper and

TABLE 1 ORI (formula and reference).

Indices	Formula	Reference
PBF (%)	Fat mass (kg) / Weight (kg) × 100%	(34)
BMI (kg/m^2)	Weight (kg) / (Height)^2 (m)	(35)
HC (cm)	-	-
WC (cm)	-	-
WHR	WC (cm) / HC (cm)	(35)
WHtR	WC (cm) / Height (cm)	(35)
ABSI (m$^{7/6}$/kg$^{2/3}$)	$WC\ (m)\ /\ [BMI^{2/3}(kg/m^2) \times Height^{1/2}(m)]$	(17)
BRI	$364.2 - 365.5 \times \sqrt{1 - (\frac{\text{WC (m)} / 2\pi}{0.5 \times \text{Height (m)}})^2}$	(18)
AVI (cm^2)	$[2 \times \text{WC}^2\ \text{(cm)} + 0.7 \times (\text{WC} - \text{HC})^2\ \text{(cm)}] / 1000$	(36)
CI (m$^{2/3}$/kg$^{1/2}$)	$0.109^{-1} \times \text{WC (m)} \times [\text{Weight (kg)} / \text{Height (m)}]^{-1/2}$	(37)

ORI, obesity–related indices; PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index.

lower extremity arteries were measured simultaneously by a non-invasive shock pressure wave graph (38).

Categorical variables comprised age grade, arteriosclerosis, and lifestyle (smoking and exercise status). In this study, participants' ages ranged from 18 to 81 years. They were divided into two groups according to age: 18–49 and 50–81. In regular clinical and epidemiological settings, baPWV is the most widely used measure of arteriosclerosis. Arteriosclerosis was defined by a baPWV ≥1400 cm/s (41). The smoking status was defined as smoking at least one cigarette per day continuously or cumulatively for 6 months (42). The exercise status was defined as at least 30 minutes of moderate-intensity exercise thrice per week (43).

Statistical analysis

Statistical analysis was performed with the SPSS software (version 26.0). Continuous variables (age, height, weight, PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, CI, HR, CRF, baPWV, SBP, and DBP) are presented as the mean ± standard deviation (SD). Data are presented as numbers (%) for categorical variables (age grade, arteriosclerosis, smoking, and exercise status). The predictive performance of 10 types of ORI for identifying hypertension was evaluated by receiver operating characteristic (ROC) analysis. A multiple nonparametric Z-test was used to compare differences between different areas under the curve (AUC) of the ROC curves. When the Z value is >1.96, the *P*-value of the AUC difference between the two ORI is < 0.05 (44, 45). Furthermore, we adjusted the *P*-value in multiple hypothesis testing to minimize type I errors by False Discovery Rate (FDR) (adjusted P = original P × n/rank, n is the multiple test times, and rank is the original *P*-value' rank) (46). The optimal cut-off points of ORI were determined by the maximum Youden's index (sensitivity + specificity –1).

A multivariable logistic regression model was used to analyze the association between ORI and hypertension in two conditions: per 1-SD increase and over the optimal cut-off points. The odds ratios (ORs) were standardized by transformed observations [(observation – mean)/SD] in the models. Potential confounding factors included age, HR, arteriosclerosis, lifestyle (smoking and exercise status), and CRF. When there were covariables with missing data, the continuous variables were ignored, and the categorical variables used dummy variables.

The sensitivity analysis was performed by re-running the ROC analysis by the alternative cut-off point of hypertension (SBP ≥ 135 mmHg and/or DBP ≥ 85 mmHg) (47, 48).

Results

Participants characteristics at baseline

Table 2 showed the characteristics of the participants. The study enrolled 2,801 participants (526 with hypertension and 2,275 without hypertension), comprising 1,499 men (374 with hypertension and 1,125 without hypertension) and 1,302 women (152 with hypertension and 1,150 without hypertension). The SBP and DBP of hypertensive participants were 143.06 (11.84) and 87.31 (7.76), respectively. The missing data for the covariates were as follows: CRF, 552 (participants over 60 years of age were not tested); smoking status, 180; exercise status, 165.

TABLE 2 Participants characteristics at baseline.

Characteristic	Overall ($n = 2801$)		Men ($n = 1499$)		Women ($n = 1302$)	
	Hypertension ($n = 526$)	No hypertension ($n = 2275$)	Hypertension ($n = 374$)	No hypertension ($n = 1125$)	Hypertension ($n = 152$)	No hypertension ($n = 1150$)
Age (years)	50.58 (9.82)	42.26 (10.83)	49.40 (10.00)	43.13 (10.85)	53.49 (8.73)	41.41 (10.74)
Height (cm)	165.63 (7.80)	164.59 (7.89)	169.01 (5.70)	170.29 (5.82)	157.32 (5.76)	159.03 (5.24)
Weight (kg)	73.11 (11.19)	64.67 (11.11)	76.49 (9.81)	71.50 (9.40)	64.77 (9.94)	57.98 (8.21)
PBF (%)	27.53 (5.96)	25.37 (6.29)	25.08 (4.28)	21.65 (4.98)	33.56 (5.19)	29.02 (5.20)
BMI (kg/m^2)	26.57 (3.10)	23.76 (3.00)	26.73 (2.81)	24.63 (2.78)	26.16 (3.71)	22.91 (2.96)
HC (cm)	99.28 (5.55)	94.78 (5.26)	99.58 (5.23)	95.76 (5.31)	98.56 (6.24)	93.81 (5.03)
WC (cm)	92.56 (9.35)	83.24 (9.21)	92.93 (8.59)	85.43 (9.06)	91.67 (10.99)	81.10 (8.86)
WHR	0.93 (0.04)	0.87 (0.05)	0.93 (0.04)	0.88 (0.04)	0.92 (0.58)	0.86 (0.05)
WHtR	0.54 (0.05)	0.50 (0.05)	0.53 (0.05)	0.48 (0.05)	0.57 (0.06)	0.51 (0.05)
ABSI ($m^{7/6}/kg^{2/3}$)	0.08 (0.003)	0.07 (0.003)	0.08 (0.003)	0.07 (0.004)	0.08 (0.004)	0.08 (0.003)
BRI	4.62 (1.34)	3.54 (1.12)	4.40 (1.09)	3.46 (1.07)	5.17 (1.70)	3.62 (1.17)
AVI (cm^2)	17.35 (3.52)	14.13 (3.07)	17.46 (3.19)	14.84 (3.06)	17.10 (4.21)	13.44 (2.93)
CI ($m^{2/3}/kg^{1/2}$)	1.28 (0.07)	1.22 (0.07)	1.26 (0.06)	1.20 (0.07)	1.31 (0.07)	1.23 (0.06)
HR (beats/min)	73.24 (10.60)	71.69 (9.43)	73.78 (10.53)	71.91 (9.90)	71.98 (10.72)	71.49 (8.95)
CRF (Mets)	9.59 (2.60)	9.58 (2.17)	10.03 (2.51)	10.70 (2.04)	7.35 (1.86)	8.72 (1.84)
baPWV (cm/s)	1547.36 (233.43)	1234.08 (221.4)	1540.25 (230.92)	1292.34 (161.88)	1564.84 (239.35)	1177.10 (160.92)
SBP (mmHg)	143.06 (11.84)	114.26 (10.14)	141.67 (11.51)	118.04 (8.46)	146.48 (11.97)	110.56 (10.29)
DBP (mmHg)	87.31 (7.76)	68.53 (8.17)	87.87 (7.95)	71.89 (7.09)	85.92 (7.08)	65.25 (7.82)
Age grade, *n (%)*						
18–49, *n (%)*	229 (43.54)	1671 (73.45)	175 (46.8)	803 (71.37)	54 (35.53)	868 (75.48)
50–81, *n (%)*	297 (56.46)	604 (36.55)	199 (53.2)	322 (28.62)	98 (64.47)	282 (24.52)
Arteriosclerosis, *n (%)*						
No, *n (%)*	143 (27.19)	1917 (84.26)	106 (28.3)	871 (77.42)	37 (24.32)	1046 (90.96)
Yes, *n (%)*	383 (72.81)	358 (15.74)	268 (71.7)	254 (22.58)	115 (75.66)	104 (9.04)
Smoking status, *n (%)*						
No, *n (%)*	311 (61.22)	1722 (81.50)	177 (49.0)	705 (67.85)	134 (91.16)	1017 (94.69)
Yes, *n (%)*	197 (38.78)	391 (18.50)	184 (51.0)	334 (32.15)	13 (8.84)	57 (5.31)
Exercise status, *n (%)*						
No, *n (%)*	430 (83.33)	1683 (79.39)	308 (84.2)	855 (81.58)	122 (81.33)	828 (77.24)
Yes, *n (%)*	86 (16.67)	437 (20.61)	58 (15.8)	193 (18.42)	28 (18.67)	244 (22.76)

Values are expressed as mean (SD) or n (%). The missing values are as follows: CRF, 552 (not tested in those more than 60 years old); smoking status, 180; exercise status, 165. PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index; HR, rest heart rate; CRF, cardiorespiratory fitness; Mets, metabolic equivalent; baPWV, brachial-ankle pulse wave velocity; SBP, systolic blood pressure; DBP, diastolic blood pressure; 10 types of ORI for predicting hypertension.

10.3389/fpubh.2022.1042236

TABLE 3 The AUC of 10 types of ORI for predicting hypertension.

Indices	Men ($n = 1,499$)		Women ($n = 1,302$)	
	AUC (95% CI)	*P*	AUC (95% CI)	*P*
PBF (%)	0.68 (0.65, 0.72)	< 0.01	0.72 (0.67, 0.77)	< 0.01
BMI (kg/m^2)	0.68 (0.64, 0.71)	< 0.01	0.75 (0.71, 0.80)	< 0.01
HC (cm)	0.67 (0.63, 0.71)	< 0.01	0.72 (0.68, 0.77)	< 0.01
WC (cm)	0.71 (0.67, 0.74)	< 0.01	0.77 (0.73, 0.82)	< 0.01
WHR	0.73 (0.70, 0.76)	< 0.01	0.79 (0.75, 0.83)	< 0.01
WHtR	0.70 (0.66, 0.73)	< 0.01	0.76 (0.71, 0.80)	< 0.01
ABSI (m$^{7/6}$/kg$^{2/3}$)	0.70 (0.67, 0.74)	< 0.01	0.75 (0.70, 0.80)	< 0.01
BRI	0.72 (0.68, 0.75)	< 0.01	0.78 (0.73, 0.82)	< 0.01
AVI (cm^2)	0.71 (0.67, 0.74)	< 0.01	0.77 (0.73, 0.81)	< 0.01
CI (m$^{2/3}$/kg$^{1/2}$)	0.72 (0.69, 0.76)	< 0.01	0.78 (0.73, 0.82)	< 0.01

ORI, obesity–related indices; PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index.

Comparisons of ROC analyses of 10 ORI for predicting hypertension

ROC analysis showed that the AUC of all the indices were statistically significant ($P < 0.05$). The AUC of all the indices in men and women were 0.67–0.73 and 0.72–0.79, respectively (Table 3). The ROC curve and overall model quality plot of 10 ORI for predicting hypertension by sex are shown in Figure 1. The ROC curves of all indices were above the reference line, indicating that the 10 types of ORI can be used to predict hypertension. The left side of a vertical red reference line in the overall model quality plot indicates that the lower limit of the 95% CI of AUC is <0.5. As shown in Figure 1, the overall model quality plots show that the lower limit of the 95% CI of AUC of the 10 types of ORI is >0.5. The lower limit of the 95% CI of AUC (men, 0.70; women, 0.75) and AUC (men, 0.73, 95% CI: 0.70, 0.76; women, 0.79, 95% CI: 0.75, 0.83) of WHR was the largest. In men, the lower limit of the 95% CI of AUC (0.63) and AUC (0.67, 95% CI: 0.63, 0.71) of HC was the smallest. For women, the lower limit of the 95% CI of AUC (0.67) and AUC (0.72, 95% CI: 0.67, 0.77) of PBF was the smallest.

Table 4 showed the comparisons of AUC for predicting hypertension among 10 types of ORI by the multiple non-parametric Z test. Moreover, we used the FDR to adjust the *P*-value in multiple hypothesis testing to minimize type I errors. In men, the AUC of WHR was highest, and the AUC of PBF, BMI, and HC was lower (adjusted $P < 0.05$). The AUC of five central ORI (WHR, WC, BRI, AVI, and CI) were higher than general ORI (PBF and BMI), all with adjusted $P < 0.05$. Women showed a similar trend: the AUC of three central ORI (WHR, WC, and AVI) were higher than general ORI (PBF and BMI), all with adjusted $P < 0.05$. The AUC of WHR was the largest except for WC, AVI, and CI (adjusted $P < 0.05$). Moreover, the AUC of PBF and HC was <5 central ORI (WC, WHR, BRI, AVI, and CI) in women (adjusted $P < 0.05$).

Overall, the results of ROC analyses (Figure 1, Table 3) and multiple non-parametric Z-tests (Table 4) showed that the AUC of WHR was the largest, and the AUC of PBF, BMI, and HC showed lower predictive performance in both men and women.

The optimal cut-off points of 10 types of ORI for predicting hypertension

According to the ROC curves, we determined the optimal cut-off points of 10 types of ORI for predicting hypertension using the maximum Youden's index (Table 5). The Youden's indices of 10 types of ORI were 0.20–0.40 among men and 0.35–0.45 among women. The optimal cut-off points for identifying hypertension in men and women were as follows: PBF (23.55%, 32.55%), BMI (25.72 kg/m^2, 23.46 kg/m^2), HC (97.59 cm, 94.82 cm), WC (90.26 cm, 82.78 cm), WHR (0.91, 0.88), WHtR (0.51, 0.55), ABSI (0.08 m$^{7/6}$/kg$^{2/3}$, 0.08 m$^{7/6}$/kg$^{2/3}$), BRI (4.05, 4.32), AVI (16.31 cm^2, 13.83 cm^2), and CI (1.23 m$^{2/3}$/kg$^{1/2}$, 1.27 m$^{2/3}$/kg$^{1/2}$).

The association of 10 types of ORI and hypertension in multivariate logistic regression models

The associations between 10 types of ORI and hypertension in two conditions (per 1-SD increase and over the optimal cut-off points) were listed in Table 6. In the multivariate logistic regression models, potential confounding factors were age, HR, arteriosclerosis, lifestyle (smoking and exercise status), and CRF. All indices were statistically significant ($P < 0.05$) in the crude models. The OR (per 1-SD increase) values

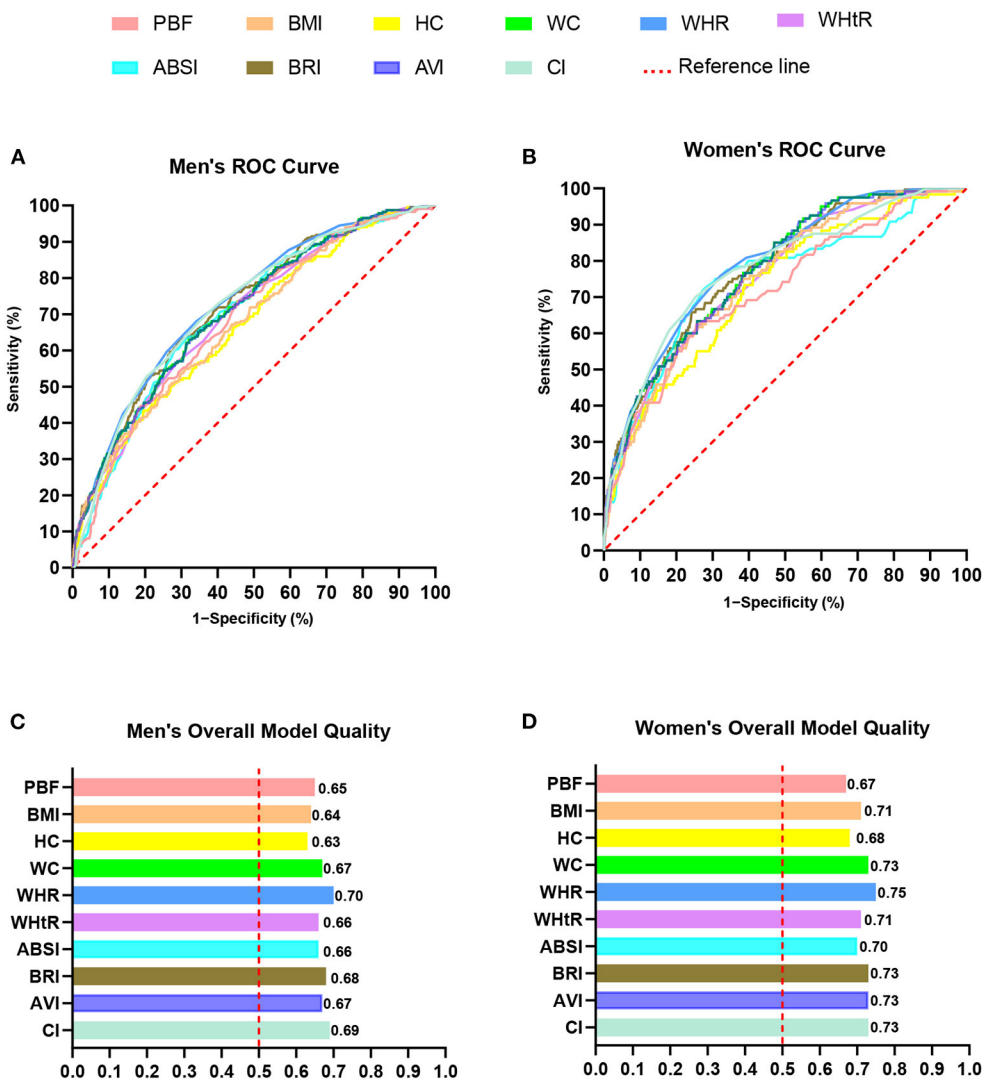

FIGURE 1
ROC analysis of ten types of ORI for predicting hypertension. **(A)** Men's ROC curve. **(B)** Women's ROC curve. **(C)** Men's overall model quality. **(D)** Women's overall model quality. ORI, obesity-related indices; PBF, percent body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index.

of 10 ORI in men and women were 1.96–2.79 and 2.28–2.94, respectively. In the adjusted model, the OR values of women (1.39–1.93) decreased more than men's (1.51–2.06), indicating that women are more affected by potential confounding factors.

According to the optimal cut-off points of the 10 types of ORI in Table 5, we divided participants into two groups (under and over the optimal cut-off points). Similarly, we analyzed the associations between ORI and hypertension using multivariate logistic regression models. The OR values of 10 ORIs in men and women were 2.25–4.06 and 3.70–6.75, respectively. Women's (1.80–2.50) decreased more than men's (1.80–2.64) after adjusting for the potential confounding factors.

Sensitivity analysis

When using the hypertension alternative cut-off point (SBP $\geq$ 135 mmHg and/or DBP $\geq$ 85 mmHg) to re-run the ROC analysis of the 10 types of ORI, the results showed that the ROC curve, overall model quality plots, and AUC of the 10 types of ORI were roughly similar to the above results (Supplementary material).

TABLE 4 Comparisons of AUC for predicting hypertension among 10 types of ORI by the multiple non-parametric Z tests.

Comparator	Men ($n = 1,499$)				Women ($n = 1,302$)			
	AUC difference (95%CI)	Z	*P*	P[a]	AUC difference (95%CI)	Z	*P*	P[a]
PBF—BMI	0.01 (−0.02, 0.03)	0.54	0.59	0.64	−0.03 (−0.06, −0.00)	−2.05	0.04	0.09
PBF—HC	0.02 (−0.01, −0.04)	1.17	0.24	0.29	−0.00 (−0.04, 0.03)	−0.23	0.82	0.88
PBF—WC	−0.02 (−0.04, −0.01)	−2.60	0.01	0.02	−0.05 (−0.08, −0.03)	−5.01	< 0.01	< 0.01
PBF—WHR	−0.05 (−0.06, −0.03)	−6.01	< 0.01	< 0.01	−0.07 (0.10, −0.05)	−5.67	< 0.01	< 0.01
PBF—WHtR	−0.01 (−0.03, −0.01)	−1.40	0.16	0.21	−0.04 (−0.06, −0.01)	−2.85	0.00	0.01
PBF—ABSI	−0.02 (−0.04, 0.01)	−1.50	0.13	0.18	−0.03 (−0.06, 0.01)	−1.38	0.17	0.24
PBF—BRI	−0.04 (−0.05, −0.02)	−4.64	< 0.01	< 0.01	−0.06 (−0.08, −0.03)	−4.78	< 0.01	< 0.01
PBF—AVI	−0.02 (−0.04, −0.01)	−2.49	0.01	0.02	−0.05 (−0.07, −0.03)	−4.91	< 0.01	< 0.01
PBF—CI	−0.04 (−0.06, −0.02)	−4.91	< 0.01	< 0.01	−0.06 (−0.08, −0.03)	−4.15	< 0.01	< 0.01
BMI—HC	0.01 (−0.01, 0.02)	1.17	0.24	0.28	0.03 (0.01, 0.05)	2.66	0.01	0.02
BMI—WC	−0.03 (−0.05, −0.02)	−4.00	< 0.01	< 0.01	−0.02 (−0.04, −0.00)	−2.40	0.02	0.04
BMI—WHR	−0.05 (−0.08, −0.03)	−4.61	< 0.01	< 0.01	−0.04 (−0.07, −0.01)	−2.59	0.01	0.03
BMI—WHtR	−0.02 (−0.04, −0.01)	−2.53	0.01	0.02	−0.01 (−0.03, 0.01)	−0.60	0.55	0.67
BMI—ABSI	−0.02 (−0.06, 0.02)	−1.20	0.23	0.28	0.01 (−0.05, 0.06)	0.21	0.83	0.87
BMI—BRI	−0.04 (−0.06, −0.02)	−4.07	< 0.01	< 0.01	−0.02 (−0.05, 0.00)	−1.94	0.05	0.10
BMI—AVI	−0.03 (−0.04, −0.02)	−3.92	< 0.01	< 0.01	−0.02 (−0.04, −0.00)	−2.36	0.02	0.04
BMI—CI	−0.05 (−0.08, −0.02)	−2.96	0.00	0.01	−0.02 (−0.07, 0.02)	−1.18	0.24	0.31
HC—WC	−0.04 (−0.05, −0.03)	−6.49	< 0.01	< 0.01	−0.05 (−0.07, −0.03)	−4.58	< 0.01	< 0.01
HC—WHR	−0.06 (−0.08, −0.04)	−5.33	< 0.01	< 0.01	−0.07 (−0.11, −0.03)	−3.43	0.01	0.00
HC—WHtR	−0.03 (−0.05, −0.007)	−2.62	0.01	0.02	−0.03 (−0.07, 0.00)	−1.98	0.05	0.09
HC—ABSI	−0.03 (−0.07, −0.01)	−1.67	0.10	0.14	−0.02 (−0.079, 0.03)	−0.78	0.44	0.55
HC—BRI	−0.05 (−0.07, −0.03)	−4.31	< 0.01	< 0.01	−0.05 (−0.09, −0.02)	−2.89	0.00	0.01
HC—AVI	−0.04 (−0.05, −0.03)	−6.47	< 0.01	< 0.01	−0.05 (−0.07, −0.03)	−4.63	< 0.01	< 0.01
HC—CI	−0.05 (−0.08, −0.03)	−3.65	< 0.01	< 0.01	−0.05 (−0.10, −0.01)	−2.30	0.02	0.05
WC—WHR	−0.02 (−0.04, −0.01)	−3.92	< 0.01	< 0.001	−0.017 (−0.035, 0.001)	−1.875	0.061	0.101
WC—WHtR	0.01 (−0.01, 0.02)	1.22	0.22	0.279	0.016 (−0.002, 0.034)	1.703	0.089	0.137
WC—ABSI	0.01 (−0.02, 0.03)	0.45	0.66	0.69	0.03 (−0.01, 0.07)	1.36	0.17	0.24
WC—BRI	−0.01 (−0.03, 0.00)	−1.76	0.08	0.13	−0.00 (−0.02, 0.01)	−0.28	0.78	0.88
WC—AVI	0.00 (0.000, 0.00)	5.06	< 0.01	< 0.01	0.00 (0.000, 0.00)	2.05	0.04	0.08
WC—CI	−0.02 (−0.04, 0.00)	−1.63	0.10	0.15	−0.00 (−0.03, 0.02)	−0.20	0.84	0.86
WHR—WHtR	0.03 (0.02, 0.05)	4.31	< 0.01	< 0.01	0.03 (0.02, 0.05)	3.72	< 0.01	0.00
WHR—ABSI	0.03 (0.01, 0.05)	3.02	0.00	0.01	0.05 (0.02, 0.07)	3.21	0.00	0.00
WHR—BRI	0.01 (0.00, 0.02)	2.94	0.00	0.01	0.02 (0.01, 0.02)	3.42	0.00	0.00
WHR—AVI	0.02 (0.01, 0.04)	3.98	< 0.01	< 0.01	0.02 (−0.00, 0.04)	1.89	0.06	0.10
WHR—CI	0.01 (−0.00, 0.02)	1.47	0.14	0.19	0.01 (0.00, 0.03)	2.01	0.04	0.09
WHtR—ABSI	−0.00 (−0.03, 0.03)	−0.19	0.85	0.85	0.01 (−0.03, 0.05)	0.55	0.58	0.69
WHtR—BRI	−0.02 (−0.03, −0.01)	−4.28	< 0.01	< 0.01	−0.02 (−0.03, −0.01)	−3.45	0.00	0.00
WHtR—AVI	−0.01 (−0.02, 0.01)	−1.11	0.27	0.30	−0.02 (−0.03, 0.00)	−1.60	0.11	0.17
WHtR—CI	−0.03 (−0.05, −0.00)	−2.36	0.02	0.03	−0.02 (−0.05, 0.01)	−1.28	0.20	0.27
ABSI—BRI	−0.02 (−0.04, 0.01)	−1.57	0.12	0.16	−0.03 (−0.06, 0.00)	−1.76	0.08	0.13
ABSI—AVI	−0.01 (−0.03, 0.02)	−0.39	0.70	0.71	−0.03 (−0.07, 0.01)	−1.31	0.19	0.26
ABSI—CI	−0.02 (−0.03, −0.01)	−4.13	< 0.01	< 0.01	−0.03 (−0.05, −0.02)	−3.91	< 0.01	< 0.01
BRI—AVI	0.01 (−0.00, 0.03)	1.86	0.06	0.11	0.00 (−0.01, 0.02)	0.35	0.72	0.84
BRI—CI	−0.00 (−0.02, 0.01)	−0.62	0.53	0.59	0.00 (−0.02, 0.02)	−0.05	0.96	0.96
AVI— CI	−0.02 (−0.04, 0.00)	−1.70	0.09	0.14	−0.00 (−0.03, 0.02)	−0.25	0.80	0.88

P[a], False Discovery Rate (FDR) were used to adjust p-value in multiple hypothesis testing. ORI, obesity–related indices; AUC, area under curve; CI, confidence interval; PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index.

TABLE 5 The optimal cut points of 10 types of ORI for predicting hypertension.

Indices	Cut–off point	Sensitivity (%)	Specificity (%)	Youden's index
Men (n = 1,499)				
PBF (%)	23.55	63.40	61.80	0.25
BMI (kg/m^2)	25.72	60.90	61.50	0.22
HC (cm)	97.59	61.30	58.80	0.20
WC (cm)	90.26	63.00	68.00	0.31
WHR	0.91	68.10	65.80	0.40
WHtR	0.51	66.80	60.70	0.28
ABSI (m$^{7/6}$/kg$^{2/3}$)	0.08	63.00	69.20	0.32
BRI	4.05	63.40	70.20	0.34
AVI (cm^2)	16.31	63.00	67.70	0.31
CI (m$^{2/3}$/kg$^{1/2}$)	1.23	71.50	62.80	0.34
Women (n = 1,302)				
PBF (%)	32.55	62.50	74.50	0.37
BMI (kg/m^2)	23.46	75.00	61.60	0.37
HC (cm)	94.82	73.30	61.20	0.35
WC (cm)	82.78	76.70	61.60	0.38
WHR	0.88	75.80	67.90	0.44
WHtR	0.55	60.80	75.80	0.37
ABSI (m$^{7/6}$/kg$^{2/3}$)	0.08	72.50	72.30	0.45
BRI	4.32	65.80	75.80	0.42
AVI (cm^2)	13.83	75.80	61.90	0.38
CI (m$^{2/3}$/kg$^{1/2}$)	1.27	70.80	74.50	0.45

Youden's Index = (sensitivity + specificity – 1). ORI, obesity–related indices; PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index.

Discussion

Obesity and hypertension, two major risk factors for CVD, contribute to global health and economic burdens (1, 2, 5, 6, 41). Given the dramatic increase in hypertension with the significant rise in obesity, early detection of hypertension using ORI screening could effectively prevent future hypertension and CVD risk. This study adopted ROC analysis to compare the predictive performance of 10 types of ORI for hypertension risk. Generally, the predictive performance is determined by the AUC of the ROC analysis. Some previous studies only used the rank of AUC values to determine predictive performance (4, 5, 8, 25). However, this method was unreliable. The AUC value is an expression of point estimation in statistics, which cannot be considered as a strength or weakness, only referring to the ranked value. Further statistical procedures should be used to compare statistical differences among different AUC values. Therefore, we used the multiple non-parametric Z test to compare differences in AUC among 10 types of ORI for predicting hypertension. Meanwhile, we adjusted the P-values in multiple hypothesis testing by FDR. Based on a cross-sectional study of 2,801 participants, the results showed that the 10 types of ORI (PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, and CI) could predict hypertension, among which WHR should be recommended as the best predictor. We believe those results may help the Chinese population to select the appropriate ORI to estimate the risk of hypertension.

The multiple non-parametric Z test results showed that central ORI (WC, WHR, and AVI) had a better predictive performance for identifying hypertension compared to general ORI (PBF and BMI). Some studies showed that CVD risk factors were more strongly associated with central obesity than with general obesity in Chinese (30), Japanese (49), Thai (50), and Indian (51, 52), which was in agreement with our findings for hypertension. A Brazilian survey showed that women with abdominal obesity were 30% more likely to develop hypertension than those with general obesity (53). One reason for the strong association between central obesity and hypertension may be that excess abdominal fat would lead to increased insulin resistance (54). Regarding obesity-related hypertension, insulin resistance may synergistically affect the obesity–hypertension association by increasing adipokine secretion and sympathetic nervous system activity (55, 56). Insulin resistance may induce renal sodium retention, activate the renin–angiotensin system and enhance the sympathetic nervous system activity, and promote endothelial dysfunction,

TABLE 6 Crude and adjusted ORs (per 1–SD increase and over the optimal cut–off points) of 10 types of ORI in multivariate logistic regression models.

Indices	Model 1 [a]		Model 2 [b]	
	Men ($n = 1,499$)	Women ($n = 1,302$)	Men ($n = 1,499$)	Women ($n = 1,302$)
	ORs (95% CI)[a]	ORs (95% CI)[a]	ORs (95% CI)[b]	ORs (95% CI)[b]
Per 1–SD increase				
PBF (%)	2.33 (1.92, 2.84)	2.85 (2.23, 3.66)	1.92 (1.50, 2.45)	1.75 (1.25, 2.45)
BMI (kg/m^2)	2.18 (1.8, 2.58)	2.43 (2.03, 2.91)	2.06 (1.67, 2.53)	1.90 (1.48, 2.45)
HC (cm)	1.96 (1.69, 2.28)	2.28 (1.89, 2.74)	1.85 (1.53, 2.24)	1.91 (1.48, 2.47)
WC (cm)	2.31 (1.96, 2.72)	2.67 (2.21, 3.22)	1.95 (1.60, 2.39)	1.93 (1.47, 2.51)
WHR	2.79 (2.30, 3.37)	2.94 (2.41, 3.59)	2.06 (1.63, 2.62)	1.85 (1.38, 2.52)
WHtR	2.24 (1.90, 2.63)	2.63 (2.17, 3.18)	1.98 (1.62, 2.43)	1.90 (1.45, 2.49)
ABSI ($m^{7/6}/kg^{2/3}$)	2.09 (1.79, 2.46)	2.71 (2.19, 3.37)	1.51 (1.21, 1.88)	1.39 (1.00, 1.94)
BRI	2.36 (2.01, 2.77)	2.39 (2.03, 2.81)	1.92 (1.57, 2.35)	1.70 (1.35, 2.15)
AVI (cm^2)	2.13 (1.84, 2.47)	2.44 (2.05, 2.90)	1.84 (1.54, 2.21)	1.85 (1.46, 2.34)
CI ($m^{2/3}/kg^{1/2}$)	2.34 (1.99, 2.77)	2.81 (2.31, 3.43)	1.79 (1.45, 2.23)	1.70 (1.26, 2.31)
Over the optimal cut–off points				
PBF (%)	2.77 (2.07, 3.69)	3.70 (2.50, 5.49)	1.97 (1.43, 2.70)	1.80 (1.05, 3.06)
BMI (kg/m^2)	2.46 (1.85, 3.27)	4.58 (2.98, 7.03)	2.04 (1.49, 2.79)	2.19 (1.24, 3.84)
HC (cm)	2.25 (1.69, 2.99)	4.29 (2.81, 6.53)	1.80 (1.27, 2.54)	2.18 (1.44, 3.30)
WC (cm)	3.56 (2.66, 4.75)	6.75 (4.50, 10.12)	2.36 (1.72, 3.25)	2.24 (1.41, 3.95)
WHR	3.89 (2.84, 5.32)	6.53 (4.09, 10.43)	2.48 (1.67, 3.67)	2.50 (1.44, 4.36)
WHtR	3.09 (2.30, 4.14)	4.71 (3.20, 6.95)	2.24 (1.63, 3.08)	2.48 (1.55, 3.97)
ABSI ($m^{7/6}/kg^{2/3}$)	3.58 (2.67, 4.80)	6.79 (4.35, 10.59)	2.28 (1.55, 3.37)	2.25 (1.24, 3.93)
BRI	4.06 (3.03, 5.44)	5.98 (4.01, 8.92)	2.64 (1.95, 3.56)	2.14 (1.25, 3.67)
AVI (cm^2)	3.54 (2.65, 4.73)	5.07 (3.28, 7.82)	2.49 (1.91, 3.24)	2.05 (1.25, 3.65)
CI ($m^{2/3}/kg^{1/2}$)	4.01 (2.93, 5.50)	6.09 (4.03, 9.21)	2.49 (1.66, 3.74)	2.41 (1.45, 3.97)

[a], crude model; [b], adjusted for age; HR, arteriosclerosis, lifestyle (smoking and exercise status), and CRF; ORI, obesity–related indices; ORs, odds ratios; CI, confidence interval; PBF, percentage body fat; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist–hip ratio; WHtR, waist–height ratio; ABSI, a body shape index; BRI, body roundness index; AVI, abdominal volume index; CI, conicity index; HR, rest heart rate; CRF, cardiorespiratory fitness. The participants under the optimal cut–off points were taken as the reference, and standardized OR values of above the optimal cut–off points were calculated for each index.

and increase peripheral and renal vascular resistance (57, 58). However, the precise pathophysiological mechanisms contributing to the development of obesity-related hypertension have not been elucidated (59). Therefore, further studies are needed to investigate the causal relationship between hypertension and obesity.

The prevention of hypertension cannot be limited only to obese people. Recently, CRF has been advocated as a risk factor for CVD, given its strong inverse association with adverse outcomes, particularly all-cause mortality, and cardiovascular events (39). Ge et al. showed that the optimal ORI for predicting hypertension differed among women in different age groups (5). Previous studies have shown that factors such as sex, arteriosclerosis, and lifestyle may influence obesity and hypertension (5, 38). Therefore, when analyzing the association between ORI and hypertension, potential confounding factors were age, HR, arteriosclerosis, lifestyle (smoking and exercise status), and CRF in this study. When there are multiple potential confounders, multivariate logistic regression model has the advantage of controlling the mixed relationship among the multiple factors, which is a better statistical method (38). Therefore, we used a multivariate logistic regression model to control the confounding factors for analyzing the association between ORI and hypertension in two conditions (per 1-SD increase and over the optimal cut-off points). The units of each index in this study were inconsistent, so standardized indices were used in the models. In the crude models, multivariate logistic regression model results demonstrated that the OR values of all ORI of women were higher than those of men in the two conditions. However, women's OR values decreased more than those of men after adjusting for potential confounding factors, and even the ORs of some indices were smaller than those of men. This could be partially explained by women being perhaps more affected by potential confounding factors. Further study needs to be explored concerning the effects of those potential confounding factors on hypertension.

This study has determined the optimal cut-off points of 10 types of ORI to predict hypertension by the maximum Youden's index. According to the literature (60, 61), the Working Group on Obesity in China (WGOC) also established BMI and WC cut-off points for Chinese adult obesity criteria. The optimal cut-off points for BMI identified in this study (25.72 among men and 23.46 kg/m^2 among women) were lower than obesity (28 kg/m^2) as defined by the WGOC but close to the WGOC cut-off point of 24 kg/m^2 for overweight (60, 61). In addition, WGOC indicated that being overweight had better sensitivity and specificity for identifying risk factors. Accordingly, the overweight criteria by BMI can also be used to predict hypertension appropriately. The WC optimal cut-off points for predicting hypertension were 90.26 (men) and 82.78 cm (women), respectively. Since the WC cut-off point for obesity in Chinese adults established by WGOC (85 cm among men and 80 cm among women) is mainly determined based on the comprehensive CVD risk, it may not be suitable when predicting hypertension alone. However, the cut-off points of PBF for Chinese adult obesity criteria have yet to be developed due to a lack of national data on PBF and CVD. In this study, the PBF optimal cut-off points were 23.55% among men and 32.55% among women for predicting hypertension, which is close to the World Health Organization's (WHO) definition of obesity by PBF ($\geq$ 25% for men and $\geq$ 35% for women) (62). Although PBF reflected body composition more accurately than traditional ORI, in this study, PBF had merely no advantage in predicting hypertension compared with central ORI (WC, WHR, and AVI). Therefore, our findings indicated that the optimal cut-off points of central ORI may be more significant in identifying hypertension risk for adults in China.

These 10 types of ORI and the optimal cut-off points of these indices were suitable for predicting hypertension in the Chinese population. However, it does not mean that they can be effectively applied to predict other CVDs or hypertension in other regions. For example, a study exploring the association between ORI and diabetes showed that BMI and WC are better indices for diabetes screening (63). A Singapore study indicated that integrating BMI and WHtR has better clinical utility in evaluating CVD risk factors (8). In addition, a study of Iranian adults suggested that ABSI is a weak predictor of CVD risks (64). Hence, the predictive performance of the 10 types of ORI for identifying other CVDs or hypertension in other regions need to be studied further.

Limitations

Regarding limitations, this study did not provide a causal relationship between ORI and hypertension because it was a cross-sectional study. Further studies are needed to validate the optimal cut-off point. Next, covariates such as smoking and exercise are based on self-reports. Other variables that might influence hypertension were not collected, such as drinking alcohol; the results may therefore be less reliable. Finally, the participants were predominately from Ningbo city and could not represent the whole Chinese population.

Conclusions

All 10 types of ORI (PBF, BMI, HC, WC, WHR, WHtR, ABSI, BRI, AVI, and CI) can effectively predict hypertension, among which WHR should be recommended as the best predictor. The optimal cut-off points for the 10 ORI for predicting hypertension were determined. Moreover, central ORI (WC, WHR, and AVI) have better prediction performance than general ORI (PBF and BMI) when predicting the risk of hypertension. Therefore, greater emphasis should be placed on the measurement of central ORI in future studies surveying the relationship between risk factors for hypertension in the Chinese population.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by Design and protocol of this study were approved by the Institutional Review Board of the Faculty of Sports Science, Ningbo University (NO. 2018RAGH1025). The patients/participants provided their written informed consent to participate in this study.

Author contributions

XL and HH conceived the presented idea, developed the framework, and wrote the manuscript. YG, YF, YZ, and LG were involved in the data collection. YJ, AW, and HH provided critical feedback and contributed to the final version. All authors have read and agreed to the published version of the manuscript.

Funding

This research was funded by the National Social Science Foundation of China (Grant number 18BTY100).

Acknowledgments

We thank all the participants for participating in this study.

Conflict of interest

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

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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.2022.1042236/full#supplementary-material

References

1. Ferdinand KC, Reddy TK, Vo TN. Global interventions in hypertension: new and emerging concepts. *Curr Opin Cardiol.* (2021) 36:436–43. doi: 10.1097/HCO.0000000000000866

2. Jiang J, Deng S, Chen Y, Liang S, Ma N, Xu Y, et al. Comparison of visceral and body fat indices and anthropometric measures in relation to untreated hypertension by age and gender among Chinese. *Int J Cardiol.* (2016) 219:204–11. doi: 10.1016/j.ijcard.2016.06.032

3. Wang Z, Chen Z, Zhang L, Wang X, Hao G, Zhang Z, et al. Status of hypertension in China: results from the China hypertension survey, 2012–2015. *Circulation.* (2018) 137:2344–56. doi: 10.1161/CIRCULATIONAHA.117.032380

4. Islam MR, Moinuddin M, Saqib SM, Rahman SM. Relationship of anthropometric indicators of general and abdominal obesity with hypertension and their predictive performance among Albanians: a nationwide cross-sectional study. *Nutrients.* (2021) 13:3373. doi: 10.3390/nu13103373

5. Ge Q, Qi Z, Xu Z, Li M, Zheng H, Duan X, et al. Comparison of different obesity indices related with hypertension among different sex and age groups in China. *Nutr Metab Cardiovasc Dis.* (2021) 31:793–801. doi: 10.1016/j.numecd.2020.11.022

6. Kotsis V, Nilsson P, Grassi G, Mancia G, Redon J, Luft F, et al. New developments in the pathogenesis of obesity-induced hypertension. *J Hypertens.* (2015) 33:1499–508. doi: 10.1097/HJH.0000000000000645

7. Van Dijk S, Takken T, Prinsen E, Wittink H. Different anthropometric adiposity measures and their association with cardiovascular disease risk factors: a meta-analysis. *Netherlands Heart J.* (2012) 20:208–18. doi: 10.1007/s12471-011-0237-7

8. Lam BCC, Koh GCH, Chen C, Wong MTK, Fallows SJ. Comparison of body mass index (BMI), body adiposity index (BAI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) as predictors of cardiovascular disease risk factors in an adult population in Singapore. *PLOS ONE.* (2015) 10:e0122985. doi: 10.1371/journal.pone.0122985

9. Fan Y, He D, Liu S, Qiao Y, Gao H, Xin L. Association between visceral adipose index and risk of hypertension in a middle-aged and elderly Chinese population. *Nutr Metab Cardiovasc Dis.* (2021) 31:2358–65. doi: 10.1016/j.numecd.2021.04.024

10. Zhong Y, Tian C-W, Liu B-R. Association between adiposity indicators and hypertension over 35 years old. *Chinese Gen Pract.* (2012) 15:4064–7.

11. Yasien N, Jarrah S, Petro-Nustas W, Ahmad M, Jaber R, Terzi N, et al. Obesity indices and their relationship to cardiovascular risk factors in young adult group. *J Bahrain Med Soc.* (2010) 22:133–7.

12. Jensen M, Ryan D, Apovian C, Ard J, Comuzzie A, Donato K, Hu F, Hubbard V, Jakicic J, Kushner R. Obesity Society 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Circulation.* (2014) 129(Suppl. 25):S102–38. doi: 10.1161/01.cir.0000437739.71477.ee

13. Calderón-García JF, Roncero-Martín R, Rico-Martín S, Nicolás-Jiménez D, Jorge M, López-Espuela F, et al. Effectiveness of Body Roundness Index (BRI) and a Body Shape Index (ABSI) in predicting hypertension: a systematic review and meta-analysis of observational studies. *Int J Environ Res Public Health.* (2021) 18:11607. doi: 10.3390/ijerph182111607

14. Lee CMY, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. *J Clin Epidemiol.* (2008) 61:646–53. doi: 10.1016/j.jclinepi.2007.08.012

15. Heitmann BL, Frederiksen P, Lissner L. Hip circumference and cardiovascular morbidity and mortality in men and women. *Obes Res.* (2004) 12:482–7. doi: 10.1038/oby.2004.54

16. Lanfer A, Mehlig K, Heitmann BL, Lissner L. Does change in hip circumference predict cardiovascular disease and overall mortality in Danish and Swedish women? *Obesity.* (2014) 22:957–63. doi: 10.1002/oby.20604

17. Krakauer NY, Krakauer JC, A. new body shape index predicts mortality hazard independently of body mass index. *PLoS ONE.* (2012) 7:e39504. doi: 10.1371/journal.pone.0039504

18. Thomas DM, Bredlau C, Bosy-Westphal A, Mueller M, Shen W, Gallagher D, et al. Relationships between body roundness with body fat and visceral adipose tissue emerging from a new geometrical model. *Obesity.* (2013) 21:2264–71. doi: 10.1002/oby.20408

19. Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M, et al. Visceral Adiposity Index: a reliable indicator of visceral fat function associated with cardiometabolic risk. *Diabetes Care.* (2010) 33:920–2. doi: 10.2337/dc09-1825

20. Cai X, Li N, Hu J, Wen W, Yao X, Zhu Q, et al. Nonlinear relationship between Chinese visceral adiposity index and new-onset myocardial infarction in patients with hypertension and obstructive sleep apnoea: insights from a Cohort Study. *J Inflamm Res.* (2022) 15:687. doi: 10.2147/JIR.S351238

21. Kahn HS. The" lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. *BMC Cardiovasc Disord.* (2005) 5:1–10. doi: 10.1186/1471-2261-5-26

22. Han M, Qie R, Li Q, Liu L, Huang S, Wu X, et al. Chinese visceral adiposity index, a novel indicator of visceral obesity for assessing the risk of incident hypertension in a prospective cohort study. *Br J Nutr.* (2021) 126:612–20. doi: 10.1017/S0007114520004298

23. Yamashita K, Kondo T, Osugi S, Shimokata K, Maeda K, Okumura N, et al. The significance of measuring body fat percentage determined by bioelectrical impedance analysis for detecting subjects with cardiovascular disease risk factors. *Circulation J.* (2012) 76:2435–42. doi: 10.1253/circj.CJ-12-0337

24. China GAoSo. The Fifth National Health Monitoring Bulletin. Available online at: https://www.sport.gov.cn/n315/n329/c24335066/content.html

25. Liu J, Tse LA, Liu Z, Rangarajan S, Hu B, Yin L, et al. Predictive values of anthropometric measurements for cardiometabolic risk factors and cardiovascular diseases among 44 048 Chinese. *J Am Heart Assoc.* (2019) 8:e010870. doi: 10.1161/JAHA.118.010870

26. Olinto M, Nacul L, Gigante D, Costa J, Menezes A, Macedo S. Waist circumference as a determinant of hypertension and diabetes in Brazilian women: a population-based study. *Public Health Nutr.* (2004) 7:629–35. doi: 10.1079/PHN2003582

27. Everett B, Zajacova A. Gender differences in hypertension and hypertension awareness among young adults. *Biodemography Soc Biol.* (2015) 61:1–17. doi: 10.1080/19485565.2014.929488

28. Song J-J, Ma Z, Wang J, Chen L-X, Zhong J-C. Gender differences in hypertension. *J Cardiovasc Transl Res.* (2020) 13:47–54. doi: 10.1007/s12265-019-09888-z

29. Deng G, Yin L, Liu W, Liu X, Xiang Q, Qian Z, Ma J, Chen H, Wang Y, Hu B. Associations of anthropometric adiposity indexes with hypertension risk: a systematic review and meta-analysis including PURE-China. *Medicine.* (2018) 97:13262. doi: 10.1097/MD.0000000000013262

30. Chen Y, Zhang Z, Wang J, Sun H, Zhao X, Cheng X, et al. Sex differences in the association of abdominal adipose tissue and anthropometric data with untreated hypertension in a Chinese population. *Biol Sex Differ.* (2020) 11:1–9. doi: 10.1186/s13293-020-00317-4

31. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Hypertension.* (2005) 45:142–61. doi: 10.1161/01.HYP.0000150859.47929.8e

32. for Control CC, Society CSS, Society CN, Committee CMDAH, Association CS, Cardiology EBoCJo. National guideline for hypertension management in China (2019). Zhonghua xin xue guan bing za zhi. (2020) 48:10–46. doi: 10.3760/cma.j.issn.0253-3758.2020.01.004

33. Paniagua L, Lohsoonthorn V, Lertmaharit S, Jiamjarasrangsi W, Williams MA. Comparison of waist circumference, body mass index, percent body fat and other measure of adiposity in identifying cardiovascular disease risks among Thai adults. *Obes Res Clin Pract.* (2008) 2:215–23. doi: 10.1016/j.orcp.2008.05.003

34. Status WP. The use and interpretation of anthropometry. *World Health Organ Tech Rep Ser*. (1995) 854. 1–452

35. Ou Y-L, Lee M-Y, Lin I-T, Wen W-L, Hsu W-H, Chen S-C. Obesity-related indices are associated with albuminuria and advanced kidney disease in type 2 diabetes mellitus. *Ren Fail.* (2021) 43:1250–8. doi: 10.1080/0886022X.2021.1969247

36. Guerrero-Romero F, Rodriguez-Morán M. Abdominal volume index. An anthropometry-based index for estimation of obesity is strongly related to impaired glucose tolerance and type 2 diabetes mellitus. *Arch Med Res.* (2003) 34:428–32. doi: 10.1016/S0188-4409(03)00073-0

37. Valdez R. A simple model-based index of abdominal adiposity. *J Clin Epidemiol.* (1991) 44:955–6. doi: 10.1016/0895-4356(91)90059-I

38. Yu L, Yan J, Yang C, Gao Y, Wang A, Huang H. Predictive performance and optimal cut-off points of blood pressure for identifying arteriosclerosis among adults in Eastern China. *Int J Environ Res Public Health.* (2021) 18:8927. doi: 10.3390/ijerph18178927

39. Kamil-Rosenberg S, Kokkinos P, e Silva CGdS, Yee WLS, Abella J, Chan K, Myers J. Association between cardiorespiratory fitness, obesity, and incidence of atrial fibrillation. *IJC Heart Vasculature.* (2020) 31:100663. doi: 10.1016/j.ijcha.2020.100663

40. Björkman F, Ekblom-Bak E, Ekblom Ö, Ekblom B. Validity of the revised Ekblom Bak cycle ergometer test in adults. *Eur J Appl Physiol.* (2016) 116:1627–38. doi: 10.1007/s00421-016-3412-0

41. Li X, Yu J, Bai J, Huang H, Ying S, Wang A, Wang P. Interaction between obesity and hypertension on arteriosclerosis in chinese urban adults: a population-based cross-sectional study. *Clin Nurs Res.* (2022) 28:10547738221120733. doi: 10.1177/10547738221120733

42. Yuan L-Z, Yi P, Wang G-S, Tan S-Y, Huang G-M, Qi L-Z, et al. Lifestyle intervention for gastroesophageal reflux disease: a national multicenter survey of lifestyle factor effects on gastroesophageal reflux disease in China. *Therap Adv Gastroenterol.* (2019) 12:1756284819877788. doi: 10.1177/1756284819877788

43. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee I-M, et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc.* (2011) 43. doi: 10.7916/D8CR5T2R

44. Mishra P, Pandey CM, Singh U, Gupta A, Sahu C, Keshri A. Descriptive statistics and normality tests for statistical data. *Ann Card Anaesth.* (2019) 22:67. doi: 10.4103/aca.ACA_157_18

45. Kaur A, Kumar R. Comparative analysis of parametric and non-parametric tests. *J Comput Math Sci.* (2015) 6:336–42.

46. Noble WS. How does multiple testing correction work? *Nat Biotechnol.* (2009) 27:1135–7. doi: 10.1038/nbt1209-1135

47. Verdecchia P, Reboldi G, Angeli F. The 2020 International Society of Hypertension global hypertension practice guidelines-key messages and clinical considerations. *Eur J Intern Med.* (2020) 82:1–6. doi: 10.1016/j.ejim.2020.09.001

48. Thabane L, Mbuagbaw L, Zhang S, Samaan Z, Marcucci M, Ye C, et al. tutorial on sensitivity analyses in clinical trials: the what, why, when and how. *BMC Med Res Methodol.* (2013) 13:1–12. doi: 10.1186/1471-2288-13-92

49. Hsieh SD, Muto T. Metabolic syndrome in Japanese men and women with special reference to the anthropometric criteria for the assessment of obesity: proposal to use the waist-to-height ratio. *Prevent Med.* (2006) 42:135–9. doi: 10.1016/j.ypmed.2005.08.007

50. Aekplakorn W, Kosulwat V, Suriyawongpaisal P. Obesity indices and cardiovascular risk factors in Thai adults. *Int J Obes.* (2006) 30:1782–90. doi: 10.1038/sj.ijo.0803346

51. Taing KY, Farkouh ME, Moineddin R, Tu JV, Jha P. Age and sex-specific associations of anthropometric measures of adiposity with blood pressure and hypertension in India: a cross-sectional study. *BMC Cardiovasc Disord.* (2016) 16:1–14. doi: 10.1186/s12872-016-0424-y

52. Kshatriya GK, Kumari A, Acharya SK. Comparing the ability of anthropometric indicators in determining the prevalence of hypertension among Indian tribes. *Diabetes Metab Syndr.* (2019) 13:696–706. doi: 10.1016/j.dsx.2018.11.038

53. de Orçamentos Familiares P. Pesquisa de Orçamentos Familiares 2008-2009. *Antropometria e Estado Nutricional de Crianças, Adolescentes e Adultos no Brasil Rio de Janeiro*. Brasília: IBGE, Ministério da Saúde. (2010).

54. Ostchega Y, Hughes JP, Terry A, Fakhouri TH, Miller I. Abdominal obesity, body mass index, and hypertension in US adults: NHANES 2007–2010. *Am J Hypertens.* (2012) 25:1271–8. doi: 10.1038/ajh.2012.120

55. Zhang T, Zhang H, Li S, Li Y, Liu Y, Fernandez C, et al. Impact of adiposity on incident hypertension is modified by insulin resistance in adults: longitudinal observation from the Bogalusa Heart Study. *Hypertension.* (2016) 67:56–62. doi: 10.1161/HYPERTENSIONAHA.115.06509

56. Hall JE. do Carmo JM, da Silva AA, Wang Z, Hall ME. Obesity-induced hypertension: interaction of neurohumoral and renal mechanisms. *Circulation Res.* (2015) 116:991–1006. doi: 10.1161/CIRCRESAHA.116.305697

57. Wang F, Han L, Hu D. Fasting insulin, insulin resistance and risk of hypertension in the general population: a meta-analysis. *Clinica Chimica Acta.* (2017) 464:57–63. doi: 10.1016/j.cca.2016.11.009

58. Fonseca VA. Insulin resistance, diabetes, hypertension, and renin—angiotensin system inhibition: reducing risk for cardiovascular disease. *J Clin Hyper.* (2006) 8:713–22. doi: 10.1111/j.1524-6175.2006.05583.x

59. Vlasova M, Purhonen A, Jarvelin M, Rodilla E, Pascual J, Herzig K. Role of adipokines in obesity-associated hypertension. *Acta Physiologica.* (2010) 200:107–27. doi: 10.1111/j.1748-1716.2010.02171.x

60. Zhou B-F. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults–study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *BES.* (2002) 15:83–96.

61. Zhou B. Predictive value of body mass index and waist circumference for abnormal risk factors of related diseases in Chinese adults: a study of appropriate bmi and waist circumference cut-off points. *Chin J Epidemiol.* (2002) 23:5–10.

62. WHO Physical status: the use of and interpretation of anthropometry, report of a WHO expert committee. *World Health Organ Tech Rep Ser.* (1995) 854:1–452. doi: 10.1002/(SICI)1520-6300(1996)8:6<786::AID-AJHB11>3.0.CO;2-I

63. Wei J, Liu X, Xue H, Wang Y, Shi Z. Comparisons of visceral adiposity index, body shape index, body mass index and waist circumference and their associations with diabetes mellitus in adults. *Nutrients.* (2019) 11:1580. doi: 10.3390/nu11071580

64. Haghighatdoost F, Sarrafzadegan N, Mohammadifard N, Asgary S, Boshtam M, Azadbakht L. Assessing body shape index as a risk predictor for cardiovascular diseases and metabolic syndrome among Iranian adults. *Nutrition.* (2014) 30:636–44. doi: 10.1016/j.nut.2013.10.021

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 30 November 2022
DOI 10.3389/fpubh.2022.1021497

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 17 August 2022
ACCEPTED 27 October 2022
PUBLISHED 30 November 2022

CITATION
Marzo RR, Khaled Y, ElSherif M, Abdullah MSAMB, Zhu Thew H, Chong C, Soh SY, Siau CS, Chauhan S and Lin Y (2022) Burnout, resilience and the quality of life among Malaysian healthcare workers during the COVID-19 pandemic. *Front. Public Health* 10:1021497. doi: 10.3389/fpubh.2022.1021497

Burnout, resilience and the quality of life among Malaysian healthcare workers during the COVID-19 pandemic

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Background: Healthcare workers have to deal with highly demanding work situations, making healthcare as one of the most challenging professions. Up to now, far too little attention has been paid to burnout, resilience and the quality of life among Malaysian healthcare workers. Therefore, this paper explores the correlation between burnout, resilience and quality of life among Malaysian healthcare workers during the COVID-19 pandemic.

Method: A total of 394 healthcare workers reported their responses on Maslach Burnout Inventory questionnaire, World Health Organization Quality of Life (WHOQOL)-BREF, and Brief Resilience Scale. Respondents were contacted through convenience sampling method and targeted population constituted Malaysian healthcare workers aged 18 years and above.

Results: For occupational exhaustion, about 50.5% of participants have moderate degree, 40.6% have high degree, and 8.9% have low degree of burnout. Health workers from age 25 to 35 years have lower physical health compared to health workers aged <25 years (coefficient = −0.77, $p = 0.021$). Similarly, healthcare workers who were working more than 10 h every day were more likely to report poor psychological health (coefficient = −2.49, $p = 0.06$). Positive correlation between physical and psychological health was observed. Further, a negative correlation was found between occupational exhaustion and the quality of life.

10.3389/fpubh.2022.1021497

Conclusion: It is important to target physical as well as psychological wellbeing of the healthcare workers. Also, it is important to understand the contribution of long working hours in declining the quality of life of the healthcare workers. Thus, allocating fixed working hours for healthcare workers would bring a much-required change.

KEYWORDS

burnout, resilience, quality of life, health-workers, COVID-19

Introduction

Healthcare workers have to deal with highly demanding work situations, making healthcare as one of the most challenging professions. As a result of the highly stressful nature of the healthcare profession, it requires the healthcare workers to possess a high level of physical and emotional resilience to deal with work-related issues to perform better at work (1). Therefore, the quality of one's mental health determines the capacity of an individual to perform their roles, including their ability to work. The state of good mental health is defined by feeling well and coping well with pressure, adapting to changing conditions, enjoying rewarding relationships and performing duties effectively (2).

It is well-known that stress is a physiological response to pressure in a wide range of situations and events in our lives (3). It is often triggered when we are faced with something unexpected or new in our lives or feel that we have little control over the situation. Our responses to stress differ from one another. Depending on our genetics, our early life experiences, our personalities, and our economic and social circumstances, we all cope with different situations to varying degrees. Our body reacts to stress by producing stress hormones that are responsible for triggering a fight or flight response when faced with stress. This helps us respond quickly to dangerous situations. Getting through fear or pain is sometimes essential for us to succeed in an endeavor and is unlikely that our stress hormones will remain elevated for long after a stressful event has passed. There can, however, be negative effects if too much stress is experienced. Eventually we can end up in a permanent state of fight or flight, overburdened or unable to cope. In the long run, this can have a negative effect on our physical and mental health and lead to disorder.

According to the DSM-5, acute stress disorder is characterized by specific fear behaviors that last from 3 days up to 1 month following a traumatic event (4). The symptoms are always triggered by death, serious injury, or sexual assault. The DSM-5 lists physical attack, physical abuse, mugging, active combat, sexual violence, natural disasters, and serious accidents as traumatic events. Traumatic events or hearing about the violent death of a loved one can also trigger acute stress disorder. It affects every aspect of a patient's life. Depressive symptoms are associated with acute stress disorder, and causes problems with feelings of joy, happiness, satisfaction, and sexual arousal in patients. The negative impact also may lead to being late for work and appointments or missing them altogether. In turn, this will cause sleep problems, which can further lead to mood issues as well as a lack of energy and focus. As these conditions persist on a long-term basis, there are dangers that impulsive behavior, such as gambling, substance abuse, or reckless driving, could occur because of these behaviors. It is extremely common for people to turn to drugs and alcohol after experiencing trauma. It is possible that alcohol or drug abuse may persist after the designated time for acute stress disorder has expired in some cases (5).

However, long-term exposure to work-related stress can cause burnout (2). The term burnout was first introduced in 1974 by Freudenberger due to a professional's physical and mental exhaustion (6). The World Health Organization (WHO) has recently updated the definition of burnout as a chronic stress condition associated with prolonged periods of high-stress levels and is, therefore, an occupational phenomenon (7). WHO defines quality of life as the perception of an individual's life position in relation to the culture, emphasizing that quality of life is subjective that includes both positive and negative facets of life and is multidimensional in nature.

According to the International Classification of Diseases, 11th edition, burnout is an occupational phenomenon associated with employment or unemployment that causes the person to feel tired or drained of energy. Cynicism or negativism about one's job, or an increase in mental distance from it. A reduction in professional effectiveness. The syndrome is specific to work environments and should not be applied elsewhere (8).

Worldwide, there has been an increase in burnout following the outbreak of coronavirus disease 2019 (COVID-19) that resulted in increasing the number of competing demands on the healthcare systems (9–11). In Malaysia, healthcare workers are reported to be more likely to suffer from burnout due to long working hours, lack of social support from their families, and stressful work conditions that leads to high rates of job dissatisfaction and worker migration to other countries (12). Since the spread of COVID-19, burnout has escalated

and worsened in many areas of healthcare. Consequently, it negatively impacts the quality of life in a wide range of individuals, as well as quality of care for patients leading to higher levels of emotional exhaustion and turnover for those delivering care to patients (10).

Resilience was reported to be a significant predictor of compassion satisfaction, secondary traumatic stress and burnout as possible protective factors against burnout (13, 14). Recent studies have also described resilience as a critical quality that allows healthcare workers to face challenges amid the COVID-19 pandemic (15). The concept of resilience refers to a dynamic process of positive adaptation in the face of stress or adversity. Experience, learning and training can all contribute to developing this skill. The ability to recover or bounce back from adverse circumstances distinguishes resilient individuals (13, 16, 17).

Healthcare workers or healthcare professionals are provider of healthcare treatment and these can include nurse, physician, internist, surgeon, radiologist, obstetrician, psychiatrist optometrist, medical assistant, midwife, dentist and so on based on their qualification and expertise. Each one of the healthcare professional has different role with varying work burden and therefore it is possible that one type of healthcare professional may feel burnout while other may not and similarly, one may have higher resilience than other healthcare professionals because of different training they have undergone to become one of the healthcare professionals. Doctors and nurses were put under extreme work burden during COVID-19 pandemic and that is why they had poor emotional experience including depression, burnout, and anxiety (18). Tabur et al. (18) in their study noted that around two-fifths (38.6%) of the nurses/midwives and one-sixth (17.3%) of the doctors experienced severe burnout (18). Adequate preparedness for response to COVID-19 was found to be associated with lower burnout among healthcare workers (19). Further, appreciation from management and family support helped healthcare workers in managing their burnout and a study found that these factors were associated with lower burnout risk among healthcare professionals (19). Resilience and burnout go hand in hand as these are interdependent, Di Trani et al. (20), in their study conducted among Italian healthcare workers, noted that high-risk burnout group had lower resilience and greater difficulties in tolerating the uncertainties than the low-risk burnout group (20).

Since the coronavirus pandemic erupted in late 2019, several studies have explored the knowledge, attitude and practices and ill-effects of COVID-19 on population health (21–28). After the advent of COVID-19 vaccines, studies also examined the vaccine hesitancy and effectiveness among various population (29–33). Also, quality of life during COVID-19 pandemic has been reported in abundance (34, 35). In addition, some studies have also explored mental health, risk perception, and coping strategies adopted by healthc are workers during COVID-19 pandemic (36–38). Moreover, Psychological support is largely underutilized due to a lack of awareness, equipment, staff time, or skill for intervention, according to systematic reviews. On the other hand, effective communication, safe and supportive environments for frontline workers, and careful attention to local needs can promote mental health (39).

However, studies examining burnout, resilience, and quality of life altogether are missing in the Malaysian context. Research on early burnout has focused on maintaining the integrity of healthcare workers' mental health. This has emerged as a crucial topic throughout the COVID-19 pandemic and has been receiving attention as a key to preventing the progression of mental disorders (40, 41). A high level of burnout has a negative impact on the healthcare industry, healthcare services, as well as healthcare workers. Little is known about burnout, resilience and the quality of life among healthcare workers in Malaysia, and it is unclear what factors are associated with it (42). This paper explores the correlation between burnout, resilience and quality of life among Malaysian healthcare workers during the COVID-19 pandemic.

Materials and methods

Study population and sampling

This cross-sectional study was conducted between February 15, 2022 and March 15, 2022 to evaluate the level of burnout, quality of life and resilience among healthcare workers from Putrajaya and Selangor hospitals. The study was conducted during the fifth wave fuelled by the Omicron variant that led to maximum daily cases in February and March 2022 (43, 44), but is marked by lower numbers of hospitalizations and deaths than during the spread of the Delta variant (44). In March 2022, the BA.2 Omicron sub-variant is projected to be the dominant strain in the country (45). The country's vaccination programme, which commenced in late February 2021 (46), has fully inoculated over 80% of the population and 97% of adults as of 24 April 2022 (47). On February 13, 2022, the total number of cases in Malaysia exceeded the 3 million mark, reaching 3,040,235 (47). By February 24, 2022, the total number of recoveries had reached the 3 million mark, reaching 3,018,172 (47).

The study used a convenience sampling method for recruitment. The online survey was disseminated *via* various social media platforms such as Instagram, Twitter, LinkedIn, Facebook, WhatsApp, and Telegram. The target population was adult Malaysian healthcare workers aged 18 years and above. We invited Malaysian assistant medical officers, doctors, health inspectors, hospital food preparation personnel, medical laboratory technologists, nurses, paramedics, pharmacists, physicians, physiotherapists, dieticians, therapists, psychologists, counselors, radiographers, and social workers

from public and private healthcare services to enroll in this study. All respondents were informed that their participation was anonymous and voluntary at the beginning of the survey. Consent was implied if the participants started answering the questionnaire. This research complied with the tenets of the Declaration of Helsinki.

Cochran's formula was used to calculate the minimum recommended sampling size (48). The minimal sample size required for this study, with a confidence level of 95%, ± 5% precision and 0.5 estimated proportion, was 385 study participants. A total of 394 completed responses were collected.

The Institutional Review Board granted approval (Above already mention). Participation was voluntary and anonymity was assured. All personal information was kept confidential. Furthermore, researchers analyzed only de-identified data.

Study instruments

Sociodemographic and work-related characteristics

The data collection instrument comprised of five parts. The first part of the tool asked questions pertaining sociodemographic and work-related characteristics. The choice of variables was informed by the available literature and inputs from the investigators. Participants were requested to indicate their age, gender, marital status, speciality, educational level, income, number of family members, job title, place of work, years of experience, hours of working, and socialization time per week. This section also asked whether the respondent had been attending COVID-19 patients directly, had been infected with COVID-19, their willingness to having COVID-19 vaccine's booster doses in the future.

Maslach burnout inventory questionnaire

The second part of the study tool was a translated version of Maslach Burnout Inventory (MBI) (49). To limit the study to burnout related to COVID-19, the phrase "due to COVID-19" was added to each item. MBI is an internationally recognized, validated, self-report questionnaire for measuring the severity of workplace burnout, using the three dimensions of emotional exhaustion, depersonalization and personal accomplishment. The questionnaire has 22 items and each item is answered on a seven-point Likert scale. This tool has been extensively used in many studies in different parts of the world and the Malay translation has also been validated previously (50, 51).

Burnout is expressed by scores of each of the three MBI subscales, with a high score meaning a high level of burnout. Each subscale score is calculated by adding up all scores of all items in that subscale, with the notion that the items on personal accomplishment domain are reversely scored (49). Scores range from 0 to 54 for emotional exhaustion (EE), from 0 to 30 for depersonalization (DP) and from 0 to 48 for personal accomplishment (PA) subscale. Scales are scored such that higher scores indicate more of each construct. Higher scores on the EE and DP subscales indicate a higher burnout symptom burden; lower scores on the PA subscale indicate a higher burnout symptom burden. The standard cut-off values were used to define low, moderate, and high levels in each dimension (49).

WHO quality of life-BREF 26

The WHO quality of life (WHOQOL)-BREF is a 26-item instrument consisting of four domains: physical health (7 items), psychological health (6 items), social relationships (3 items) and environmental health (8 items); it also contains QOL and general health items. Each individual item of the WHOQOL-BREF is scored from 1 to 5 on a response scale, which is stipulated as a five-point ordinal scale.

The physical health domain questions are based on daily activities, medical aid, energy, mobility, the extent of pain, sleeping pattern and working capacity. The psychological domain focuses on participants' personal beliefs, positive and negative feelings, self-esteem, body image, thoughts and learning capabilities. The social relationships domain explores the respondent's overall satisfaction with their personal and social life. Lastly, the environmental domain comprises questions about safety and security, contentment with one's property and physical surroundings, finances (does one have enough money to satisfy one's requirements), access to the necessary care, information and transport. Moreover, the questionnaire has two specific questions regarding participants' opinions regarding their overall quality of life and health. We used the Malay validated version of the original WHOQOL-BREF questionnaire (52, 53).

Brief resilience scale

The last section is the Brief Resilience Scale (BRS) questionnaire to assess the perceived ability to bounce back or recover from stress. The scale was developed to assess a unitary construct of resilience, including both positively and negatively worded items.

The Brief Resilience Scale has six items presented in Table 1. Items 1, 3, and 5 are positively worded, and items 2, 4, and 6 are negatively worded. The BRS is scored by reverse coding items 2, 4, and 6 and finding the mean of the six items. The following instructions are used to administer the scale: "Please indicate the extent to which you agree with each of the following statements by using the following scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree." The possible score range on the BRS is from 1 (low resilience) to 5 (high resilience). It composes of 6 questions with a score on

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interpretation 1.00–2.99 as low resilience, 3.00–4.30 as normal resilience and 4.31–5.00 as high resilience.

Data analysis

Descriptive statistics are presented in the form of frequencies and percentages for the categorical variables. Mean and standard deviation (SD) are reported for numerical variables. Multiple linear regression was used to study the association of different variables with the outcomes of interest. Correlation between quality of life, burnout, and resilience levels was studied using Pearson's correlation and a heatmap for the correlation coefficients was developed. IBM SPSS 28 for windows software was used for the analysis while Stata 17 software was used for the multiple linear regression. $P < 0.05$ is considered statistically significant.

Ethic statement

The study was designed and conducted in line with the declaration of Helsinki and was approved by the Ethics Committee of Management and Science University (Ethics Code: MSU-RMC-02/FR01/09/L1/085). Respondents were informed that their participation was voluntary, and written consent was implied on the completion of the questionnaire. All participants were aged 18 years or older.

Results

A total of 394 participants were enrolled in this study. About 87.1% of them were females, while the rest were males (Table 1). 43.1% of the participants belonged to the age group of 25–35 years old, 31.2% were 36 to 55 years old, 20.6% were <25 years, and 5.1% were more than 55 years old. About 62.9% of participants were nurses, 14% were doctors and the rest were from other specialties in the medical field. About 71.6% of participants' income was less than RM 4,850, 25.4% of participants' income was from RM 4,850 to RM 10,959, while the rest took more than RM 10,959 per month. About 47.2% of participants had tertiary education, 45.2% of them had secondary education, while the rest had primary education. About 37.8% of the participants had work experience of more than 10 years, 31.7% had work experience of <5 years, 23.4% had work experience from 5 to 10 years and 7.1% did not have any experience. About 54.8% of participants worked from 8 to 10 hours daily, 29.7% worked 7 h daily, 14.5% worked more than 10 h daily and 1% worked <7 h daily. About 40.1% of participants were socializing more than 10 h weekly, 32.7% were socializing from 5 to 10 h and 24.1% were socializing

TABLE 1 Socio-demographics of participants ($N = 394$).

	N	%
Gender		
Male	51	12.9
Female	343	87.1
Age		
< 25 years	81	20.6
From 25 to 35 years	170	43.1
From 35 to 55 years	123	31.2
More than 55years	20	5.1
Specialty		
Doctor	55	14.0
Nurse	248	62.9
Others	91	23.1
Income level		
≤Less than RM 4,850	282	71.6
RM 4,850–10,959	100	25.4
≥ RM 10,959	12	3.0
Education background		
Primary	30	7.6
Secondary	178	45.2
Tertiary	186	47.2
Working experiences		
No experience	28	7.1
<5 years	125	31.7
From 5 to 10 years	92	23.4
More than 10 years	149	37.8
Working duration		
<7 h	4	1.0
7 h daily	117	29.7
From 8 to 10 h daily	216	54.8
More than 10 h	57	14.5
Family members		
<5	152	38.6
5–10	220	55.8
More than 10	22	5.6
Socializing duration		
No time	12	3.0
<5 h	95	24.1
From 5 to 10 h	129	32.7
More than 10 h	158	40.1
Dealing with COVID-19		
No	205	52.0
Yes	189	48.0
Infected with COVID-19		
No	213	54.1
Yes	181	45.9
COVID-19 vaccine booster		
Very unlikely	32	8.1
Unlikely	63	16.0

(Continued)

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TABLE 1 (Continued)

	N	%
Somewhat unlikely	58	14.7
Somewhat likely	79	20.1
Likely	101	25.6
Very likely	61	15.5

<5 h weekly, while the rest did not socialize at all. Of all the participants, 45.9% had been infected with COVID-19.

For occupational exhaustion, about 50.5, 40.6, and 8.9% of the participants had moderate, high and low degree of burnout, respectively (Table 2). For degree of depersonalization, high, moderate and low degree of burnout was found in 89.1, 9.6, and 1.3% of participants, respectively. For D]degree of personal accomplishment, about 76.4% of participants have low degree, 15% have moderate degree, and 8.6% have high degree of burnout.

The means and SD for each question and domain are reported in Table 3.

Table 4 depicts the mean and SD for BRS questionnaire, about 23.9% of participants have low resilience, 74.6% have normal resilience, and 1.5% has high resilience.

Multiple linear regressions were done to study the factors associated with physical health (Table 5). The only significant factor was age. Healthcare workers from age 25 to 35 years have lower physical health compared to healthcare workers < 25 years (coefficient = −0.77, $P = 0.021$).

Multiple linear regressions were done to study the factors associated with psychological health (Table 6). The only significant factors were educational level and working duration. Health workers who have secondary education level had higher psychological health compared to health workers have primary education level (coefficient = 1.0, $P = 0.049$). Similarly, participants who were working more than 10 h every day were more likely to report poor psychological health.

Table 7 depicts result for multiple linear regressions for social relationships. None of the background variables were significant predictor for social relationships.

Multiple linear regressions were done to study the factors associated with environment level (Table 8). The only significant factor was income level. Health workers who had Rm 4,850–10,959 have higher environmental level compared to health workers who had < Rm 4,850 (coefficient = 0.81), $P = 0.028$. Health workers who have > Rm 10,959 have higher environment level compared to health workers have < Rm 4,850 (coefficient =1.92), $P = 0.034$.

Multiple linear regressions were done to study the factors associated with level of resilience (Table 9). The only significant factor was gender. Participants aged more than 55 years have higher resilience compared to those aged <25 (coefficient = 0.391, $P < 0.001$). Participants who took more than Rm 10,959 have higher resilience compared to those taking <Rm 4,850 (coefficient = 0.458, $P = 0.001$).

Table 10 depicts the correlation between quality of life, burnout and resilience levels. A negative correlation was found between occupational exhaustion and the four domains of quality of life; higher score in occupational exhaustion is

TABLE 2 Maslach burnout inventory questionnaire.

	Mean	SD
Occupational exhaustion	27.84	7.05
I feel emotionally exhausted because of my work.	3.55	1.60
I feel worn out at the end of a working day.	3.52	1.63
I feel tired as soon as I get up in the morning and see a new working day stretched out in front of me.	3.36	1.67
Working with people the whole day is stressful for me.	2.55	1.74
I feel burned out because of my work.	3.23	1.75
I feel frustrated by my work.	2.47	1.72
I get the feeling that I work too hard.	3.49	1.65
Being in direct contact with people at work is too stressful.	2.58	1.74
I feel as if I'm at my wits end.	2.65	1.66
Degree of depersonalization	17.10	4.72
I get the feeling that I treat some clients/colleagues impersonally, as if they were objects.	2.42	1.78
I have become more callous to people since I have started doing this job.	2.62	1.73
I'm afraid that my work makes me emotionally harder.	2.93	1.74
I'm not really interested in what is going on with many of my colleagues.	2.59	1.79
I have the feeling that my colleagues blame me for some of their problems.	2.31	1.75
Degree of personal accomplishment	26.49	9.55
I can easily understand the actions of my colleagues/supervisors.	4.07	1.48
I deal with other people's problems successfully.	3.60	1.49
I feel that I influence other people positively through my work.	3.69	1.49
I feel full of energy.	3.58	1.55
I find it easy to build a relaxed atmosphere in my working environment.	3.32	1.52
I feel stimulated when I had been working closely with my colleagues.	3.57	1.57
I have achieved many rewarding objectives in my work.	3.26	1.62
In my work, I am very relaxed when dealing with emotional problems.	3.23	1.47

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TABLE 3 (WHOQOL-BREF) questionnaire.

	Mean	SD
Physical health	12.78	2.33
To what extent do you feel that physical pain prevents you from doing what you need to do? (in the last 2 weeks)	2.92	1.06
How much do you need any medical treatment to function in your daily life? (in the last 2 weeks)	2.53	1.17
Do you have enough energy for everyday life?	3.36	0.97
How well are you able to get around physically?	3.40	0.90
How satisfied are you with your sleep?	3.19	1.11
How satisfied are you with your ability to perform your daily living activities?	3.49	0.91
How satisfied are you with your capacity for work?	3.47	0.94
Psychological health	13.5	2.5
How much do you enjoy life? (in the last 2 weeks)	3.40	1.03
To what extent do you feel your life to be meaningful? (in the last 2 weeks)	3.54	0.95
How well are you able to concentrate?	3.46	0.86
Are you able to accept your bodily appearance?	3.41	1.01
How satisfied are you with yourself?	3.55	1.05
How often do you have negative feelings such as blue mood, despair, anxiety or depression?	2.91	1.15
Environment	14.1	3.35
How safe do you feel in your daily life?	3.56	0.86
How healthy is your physical environment?	3.40	0.96
Do you have enough money to meet your needs?	3.29	1.11
How available to you is the information you need in your daily life?	3.57	0.84
To what extent do you have the opportunity for leisure activities?	3.19	0.92
How satisfied are you with the conditions of your living place?	3.76	0.91
How satisfied are you with your access to health services?	3.77	0.91
How satisfied are you with your transport?	3.91	0.94
Social relationships	14.2	2.6
How satisfied are you with your personal relationships?	3.65	1.01
How satisfied are you with your sex life?	3.35	1.10
How satisfied are you with the support you get from your friends?	3.64	0.94

TABLE 4 The brief resilience scale questionnaire.

	Mean	SD
I tend to bounce back quickly after hard times	3.46	0.86
I have a hard time making it through stressful events.	2.88	0.94
It does not take me long to recover from a stressful event.	3.28	0.97
It is hard for me to snap back when something bad happens.	2.92	0.97
I usually come through difficult times with little trouble.	3.07	0.94
I tend to take a long time to get over setbacks in my life.	2.97	0.97

associated with lower score in quality of life. Positive correlation was found between occupational exhaustion and resilience; higher score in occupational exhaustion is associated with high resilience level. Positive correlation was found between degree of depersonalization and resilience; higher score in degree of depersonalization was associated with high resilience level. A negative correlation was found between personal accomplishment degree and the four domains of quality of life; higher score in personal accomplishment degree is associated with lower score in quality of life. Negative correlation was found between personal accomplishment degree and resilience; higher score in personal accomplishment degree is associated with high resilience level. A positive correlation was found between resilience level and the four domains of quality of life; higher score in resilience level is associated with higher score in quality of life.

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TABLE 5 Multiple linear regression for the factors associated with physical health.

	Coefficient	P-value	95% C.I. of the coefficient	
Age				
< 25 years				
From 25 to 35 years	−0.77	0.021	−1.43	−0.12
From 35 to 55 years	−0.17	0.646	−0.90	0.56
More than 55 years	−0.37	0.561	−1.64	0.89
Gender				
Male				
Female	0.07	0.850	−0.63	0.77
Specialty				
Doctor				
Nurse	0.60	0.181	−0.28	1.48
Others	0.10	0.825	−0.78	0.98
Education level				
Primary				
Secondary	0.30	0.524	−0.62	1.21
Tertiary	0.03	0.956	−0.94	1.00
Income level				
≤ RM 4,850				
RM 4,850–10,959	0.07	0.83	−0.58	0.72
≥ RM 10,959	0.53	0.52	−1.08	2.13
Working duration				
< 7 h				
7 h daily	−0.52	0.663	−2.86	1.82
From 8 to 10 h daily	−0.45	0.707	−2.77	1.88
More than 10 h	−1.70	0.163	−4.08	0.69
Socializing duration				
No time				
< 5 h	0.03	0.964	−1.41	1.48
From 5 to 10 h	0.14	0.845	−1.29	1.57
More than 10 h	0.28	0.700	−1.14	1.70

TABLE 6 Multiple linear regression for the factors associated with psychological health.

	Coefficient	P-value	95% C.I. of the coefficient	
Age				
< 25				
From 25 to 35 years	−0.49	0.178	−1.20	0.22
From 35 to 55	0.00	0.994	−0.80	0.79
More than 55	0.03	0.97	−1.35	1.41
Gender				
Male				
Female	0.27	0.491	−0.49	1.03
Specialty				
Doctor				
Nurse	0.61	0.214	−0.35	1.56
Others	0.38	0.43	−0.57	1.34
Education level				
Primary				
Secondary	1.00	0.049	0.00	1.99
Tertiary	0.54	0.315	−0.52	1.60
Income level				
≤RM 4,850				
RM 4850–10,959	0.28	0.432	−0.42	0.99
≥ RM 10,959	1.29	0.148	−0.46	3.04
Working duration				
< 7 h				
7 h daily	−1.60	0.218	−4.15	0.95
From 8 to 10 h daily	−1.51	0.241	−4.05	1.02
More than 10 h	−2.49	0.06	−5.09	0.11
Socializing duration				
No time				
< 5 h	0.50	0.529	−1.07	2.08
From 5 to 10 h	0.69	0.384	−0.87	2.24
More than 10 h	0.74	0.345	−0.80	2.29

Table 11 shows a heat map for the Correlation between quality of life, burnout, and resilience levels. The darker the color, the stronger is the correlation.

Discussion

This study aimed to determine the factors that correlated with burnout, resilience, and quality of life among Malaysian healthcare workers during the COVID-19 pandemic. Approximately half of the healthcare workers in our study had a moderate to a high degree of burnout in occupational exhaustion and depersonalization with a low degree of personal accomplishment. According to the findings regarding quality of life, all four domains (physical health, psychological, social, and environmental) fell below the international standard (54). Of all the analyzed factors, age, education and income level correlated with physical health, psychological and environmental domains. The results of the study did not show any significant differences in the social domain. According to our study, all healthcare workers have an average level of resilience, and females demonstrated a lower level of resilience as compared to males. Systemic reviews have found that COVID-19 patients, psychiatric patients, health care workers, and the public all have mental health consequences during COVID-19 pandemic (55).

Many people across the globe are experiencing unexpected stress and trouble due to COVID-19. As a result, burnout is common among healthcare personnel who work in the COVID-19-affected healthcare system. Many variables, such as

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TABLE 7 Multiple linear regressions for the factors associated with social relationships.

	Coefficient	P-value	95% C.I. of the coefficient	
Age				
< 25 years				
From 25 to 35 years	0.48	0.328	−0.48	1.43
From 35 to 55 years	0.60	0.27	−0.47	1.67
More than 55 years	0.66	0.481	−1.19	2.52
Gender				
Male				
Female	−0.32	0.538	−1.34	0.70
Specialty				
Doctor				
Nurse	1.07	0.103	−0.22	2.35
Others	0.37	0.572	−0.91	1.65
Education level				
Primary				
Secondary	0.86	0.205	−0.47	2.19
Tertiary	0.14	0.847	−1.28	1.56
Income level				
≤ RM 4,850				
RM 4850–10,959	0.44	0.356	−0.50	1.39
≥ RM 10,959	1.54	0.198	−0.81	3.88
Working duration				
< 7 h				
7 h daily	−0.46	0.791	−3.88	2.96
From 8 to 10 h daily	−0.47	0.784	−3.88	2.93
More than 10 h	−1.65	0.353	−5.14	1.84
Socializing duration				
No time				
< 5 h	−0.32	0.763	−2.43	1.79
From 5 to 10 h	0.22	0.834	−1.86	2.31
More than 10 h	0.47	0.652	−1.60	2.55

TABLE 8 Multiple linear regressions for the factors associated with environment level.

	Coefficient	P-value	95% C.I. of the coefficient	
Age				
< 25 years				
From 25 to 35 years	−0.21	0.569	−0.94	0.52
From 35 to 55 years	0.42	0.308	−0.39	1.23
More than 55 years	0.88	0.219	−0.52	2.28
Gender				
Male				
Female	0.13	0.745	−0.65	0.90
Specialty				
Doctor				
Nurse	0.32	0.518	−0.65	1.29
Others	−0.11	0.824	−1.08	0.86
Education level				
Primary				
Secondary	0.63	0.224	−0.38	1.63
Tertiary	0.33	0.552	−0.75	1.40
Income level				
< Rm 4,850				
Rm 4,850–10,959	0.81	0.028	0.09	1.52
> Rm 10,959	1.92	0.034	0.15	3.70
Working duration				
< 7 h				
7 h daily	−1.81	0.172	−4.40	0.79
From 8 to 10 h daily	−1.60	0.222	−4.18	0.97
More than 10 h	−3.02	0.025	−5.66	−0.38
Socializing duration				
No time				
< 5 h	−0.47	0.56	−2.07	1.12
From 5 to 10 h	−0.12	0.882	−1.70	1.46
More than 10 h	0.14	0.864	−1.43	1.71

heavy workload, limited manpower and facilities to treat the rising number of patients and fear of contracting COVID-19 might be sources of burnout for the healthcare workers (56, 57). According to our study findings, over half of the Malaysian healthcare workers were burned out. These findings were similar to previous studies on healthcare workers in the neighboring countries (58, 59). Compared to the burnout rate before the pandemic, higher rates of burnout reported here indicate that the COVID-19 pandemic may have contributed to the increased staff burnout. During the pandemic crisis, we identified several characteristics positively connected to healthcare worker burnout. These characteristics included female gender, workplace, wage, workload, and finally, the COVID-19 status of a healthcare worker.

In our study, women appeared to be less resilient than men. They usually exhibit more significant emotional tiredness, posttraumatic stress, anxiety and depression than men, based on demographic and work-related characteristics. This result is comparable to the European countries (60, 61). Traditionally, females have been linked to a higher prevalence of these symptoms. This might be attributable to the fact that women have to spend more time in the family to take care of the family members instead of working outside. Most research conducted during the COVID-19 pandemic shows nurses worldwide have moderate resilience levels (62).

According to our study, our nurses have an average resilience score. Therefore, it is essential for healthcare professionals to prioritize assistance and other resources. Support and

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TABLE 9 Multiple linear regression for the factors associated with level of resilience.

	Coefficient	P-value	95% C.I. of the coefficient	
Age				
< 25 years				
From 25 to 35 years	0.020	0.723	−0.091	0.131
From 35 to 55 years	−0.018	0.777	−0.142	0.106
More than 55 years	0.391	<0.001	0.176	0.606
Gender				
Male				
Female	−0.050	0.407	−0.169	0.069
Specialty				
Doctor				
Nurse	0.130	0.086	−0.019	0.279
Others	0.114	0.134	−0.035	0.263
Education level				
Primary				
Secondary	−0.013	0.871	−0.168	0.142
Tertiary	−0.007	0.937	−0.172	0.158
Income level				
< Rm 4,850				
Rm 4,850–10,959	0.056	0.321	−0.054	0.165
> Rm 10,959	0.458	0.001	0.185	0.730
Working duration				
< 7 h				
7 h daily	0.021	0.916	−0.376	0.419
From 8 to 10 h daily	0.071	0.724	−0.324	0.466
More than 10 h	−0.018	0.930	−0.423	0.387
Socializing duration				
No time				
<5 h	−0.025	0.839	−0.271	0.220
From 5 to 10 h	−0.050	0.686	−0.292	0.192
More than 10 h	0.040	0.744	−0.201	0.281

other resources must be available to people in front-line positions, especially during a pandemic, which presents unique challenges. Intervention should focus on increasing resilience in the health care personnel. These include communicating, evaluating burnout and offering assistance to those at risk for or experiencing burnout. Those healthcare workers who had gone beyond their resilience barrier should be provided with support and therapy before they safely return to work. Nobody should be stigmatized for seeking help for mental health. Mentors and peer support can effectively build a sense of coherence among healthcare workers. They are allowed to express their feelings and concerns openly (63). Constant expression of gratitude is a valuable strategy to promote resilience among health care workers (64).

One of the objectives of this study is to assess the quality of life led by healthcare workers during the COVID-19 pandemic crisis. This finding was consistent with a previous study, which showed that healthcare workers are below the international standard quality of life (65). During this hard time, healthcare workers are the ones that stand on the front line in delivering care to patients. They are usually extremely devoted and dedicated to their work at critical times. However, according to the research, healthcare workers' quality of life is negatively impacted by various factors during pandemics. These include mental and physical health problems such as depression and anxiety, concerns about viral transmission while caring for hospitalized patients and burdens placed on families due to their uncertain health status. These issues, directly and indirectly, are affecting the quality of life for healthcare workers worldwide. Hence, all public and private health institution stakeholders must ensure that healthcare workers have an excellent quality of life.

In our study, multiple linear regression revealed a decline in physical health domain of quality of life between 25 and 35 years of age. We can attribute this to the pre-existing medical condition that begins to manifest in this proportion of responses. In the psychological health domain of quality of life, we observed a positive correlation between quality of life scores and education level among the respondents. These were consistent with the other studies done over the world (66, 67). This is probably because higher education levels can improve financial stability and overall quality of life. Therefore, healthcare workers who received higher education likely experience a better lifestyle due to their higher income, which ensures a higher environmental quality of life. We can prove this as we observed a favorable correlation between the financial solvency of respondents and their environmental domain of quality of life.

This study identified several limitations. Due to the cross-sectional nature of our study, we are unable to determine the temporal relationship between outcome exposure. We did not examine any co-morbid conditions other than psychological distress, religion, or family support that can affect burnout, resilience and quality of life in our study. The study of causality and effectiveness related to improving resilience and quality of life among healthcare workers are recommended for the future studies. Further, the study finding may not have enough confidence on the back of imbalance sample, such as sample had only 51 males as compared to 343 females and similarly, 55 doctors alongside to 248 nurses.

Conclusion

This study used three separate inventories namely MBI, WHOQOL -BREF questionnaire, and BRS to explore burnout,

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TABLE 10 Correlation between quality of life, burnout, and resilience levels.

		Physical health	Psychological health	Social relationships	Environment level	EE score	DP	Pa	
Physical health	Pearson correlation	–							
Psychological health	Pearson correlation	0.812	–						
	p-value	<0.001							
Social relationships	Pearson correlation	0.581	0.605	–					
	p-value	<0.001	<0.001						
Environment	Pearson correlation	0.751	0.739	0.651	–				
	p-value	<0.001	<0.001	<0.001					
EE score	Pearson correlation	−0.136	−0.099	−0.224	−0.188	–			
	p-value	0.007	0.050	<0.001	<0.001				
DP	Pearson correlation	0.005	0.066	−0.045	0.030	0.615	–		
	p-value	0.914	0.194	0.375	0.549	<0.001			
Pa	Pearson correlation	−0.252	−0.243	−0.277	−0.321	0.777	0.547	–	
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Resilience level	Pearson correlation	0.217	0.227	0.253	0.327	−0.150	0.052	−0.291	
	p-value	<0.001	<0.001	<0.001	<0.001	0.003	0.299	<0.001	

TABLE 11 Heatmap for correlation between quality of life, burnout, and resilience levels.

	Physical health	Psychological health	Social relationships	Environment	EE	DP	Pa	
Physical health	–							
Psychological health	0.746	–						
Social relationships	0.562	0.605	–					
Environment	0.722	0.739	0.651	–				
EE score	−0.112	−0.099	−0.224	−0.188	–			
DP	0.016	0.065	−0.044	0.030	0.615	–		
Pa	−0.216	−0.243	−0.277	−0.321	0.777	0.547	–	
Resilience level	0.22	0.23	0.25	0.33	−0.15	0.05	−0.29	

−1 0 +1

quality of life and resilience, respectively. Lower physical health was reported among healthcare workers aged 25–35 years, poor psychological health was reported by those who were working for more than 10 h every day and environmental level was affected by income level and working hours of the respondents. Findings from this study call for specific interventions. High correlation between physical and psychological health signifies that if a respondent is facing physical health issues, then it is likely that he/she might face some psychological health issues. Therefore, it is important to improve physical as well as psychological wellbeing of the healthcare workers. Further, negative correlation was found between occupational exhaustion and the four domains of quality of life. Higher score in occupational exhaustion is associated with lower score in quality of life. Therefore, it is important to understand the contribution of long working hours in declining the quality of life. Thus, allocating fixed working hours for healthcare workers would bring a much required change. In the future, we need to take swift action if we're going to respond to COVID-19. It's important to involve a variety of community stakeholders, like traditional and religious leaders, opinion leaders, and healthcare workers. Each country's national government should build its capacity while receiving support from other organizations to ensure the safe integration of COVID-19 outbreak response activities and improve healthcare workers' mental health.

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

Author contributions

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

Funding

This work was supported by the Special Projects of the Central Government Guiding Local Science and Technology Development, China [No.2021L3018]. The funder was not involved in study design, in the collection, analysis and interpretation of data; in the writing of the manuscript; nor in the decision to submit the manuscript for publication.

Conflict of interest

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

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References

1. Jennings BM. Work stress and burnout among nurses: role of the work environment and working conditions. In: Hughes RG, editor. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US) (2008). Available online at: http://www.ncbi.nlm.nih.gov/books/NBK2668/ (accessed July 31, 2022).

2. Funk M, WHO. *Mental Health Policies and Programmes in the Workplace*. Geneva: World Health Organization (2005).

3. Mental Health Foundation. *Stress Mental Health Foundation, United Kingdom*. (2021). Available online at: https://www.mentalhealth.org.uk/explore-mental-health/a-z-topics/stress (accessed October 13, 2022).

4. Substance Abuse and Mental Health Services Administration. *Table 3.30, DSM-IV to DSM-5 Acute Stress Disorder Comparison Substance Abuse and Mental Health Services Administration (US), United States*. (2016). Available online at: https://www.ncbi.nlm.nih.gov/books/NBK519704/table/ch3.t30/ (accessed October 13, 2022).

5. Sinha R. Chronic stress, drug use, and vulnerability to addiction. *Ann N Y Acad Sci*. (2008) 1141:105–30. doi: 10.1196/annals.1441.030

6. Freudenberger HJ. Staff burn-out. *J Soc Issues*. (1974) 30:159–65. doi: 10.1111/j.1540-4560.1974.tb00706.x

7. WHO. *Burn-Out an Occupational Phenomenon: International Classification of Diseases*. Geneva: WHO (2019).

8. Berg S. *WHO Adds Burnout to ICD-11. What it Means for Physicians. | American Medical Association United States*. (2019). Available online at: https://www.ama-assn.org/practice-management/physician-health/who-adds-burnout-icd-11-what-it-means-physicians (accessed October 13, 2022).

9. De Hert S. Burnout in healthcare workers: prevalence, impact and preventative strategies. *Local Reg Anesth*. (2020) 13:171. doi: 10.2147/LRA.S240564

10. National Academies of Sciences, Engineering, and Medicine; National Academy of Medicine; Committee on Systems Approaches to Improve Patient Care by Supporting Clinician Well-Being. *Taking Action against Clinician Burnout: A Systems Approach to Professional Well-Being*. Washington, DC: National Academies Press (US), 2019. Available online at: http://www.ncbi.nlm.nih.gov/books/NBK552618/ (accessed July 31, 2022).

11. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA*. (2002) 288:1987-93. doi: 10.1001/jama.288.16.1987

12. Long CS, Kowang TO, Ping TA, Muthuveloo R. Investigation on the impact of job stressors on nurses in Malaysia. *Asian Soc Sci*. (2014) 10:67–77. doi: 10.5539/ass.v10n4p67

13. Luceño-Moreno L, Talavera-Velasco B, García-Albuerne Y, Martín-García J. Symptoms of posttraumatic stress, anxiety, depression, levels of resilience and burnout in spanish health personnel during the COVID-19 pandemic. *Int J Environ Res Public Health*. (2020) 17:5514. doi: 10.3390/ijerph17155514

14. Jackson D, Firtko A, Edenborough M. Personal resilience as a strategy for surviving and thriving in the face of workplace adversity: a literature review. *J Adv Nurs*. (2007) 60:1–9. doi: 10.1111/j.1365-2648.2007.04412.x

15. Santarone K, McKenney M, Elkbuli A. Preserving mental health and resilience in frontline healthcare workers during COVID-19. *Am J Emerg Med*. (2020) 38:1530. doi: 10.1016/j.ajem.2020.04.030

16. Rutter M. Annual research review: resilience–clinical implications. *J Child Psychol Psychiatry*. (2013) 54:474–87. doi: 10.1111/j.1469-7610.2012.02615.x

17. Permarupan YY, Mamun AA, Samy NK, Saufi RA, Hayat N. Predicting nurses burnout through quality of work life and psychological empowerment: a study towards sustainable healthcare services in Malaysia. *Sustainability*. (2020) 12:1–18. doi: 10.3390/su12010388

18. Tabur A, Elkefi S, Emhan A, Mengenci C, Bez Y, Asan O. Anxiety burnout and depression, psychological well-being as predictor of healthcare professionals' turnover during the COVID-19 pandemic: study in a pandemic hospital. *Healthcare*. (2022) 10:1–11. doi: 10.3390/healthcare10030525

19. Afulani PA, Gyamerah AO, Nutor JJ, Laar A, Aborigo RA, Malechi H, et al. Inadequate preparedness for response to COVID-19 is associated with stress and burnout among healthcare workers in Ghana. *PLoS ONE*. (2021) 16:e0250294. doi: 10.1371/journal.pone.0250294

20. Di Trani M, Mariani R, Ferri R, De Berardinis D, Frigo MG. From resilience to burnout in healthcare workers during the COVID-19 emergency: the role of the ability to tolerate uncertainty. *Front Psychol*. (2022) 12:2021. doi: 10.3389/fpsyg.2021.646435

21. Rahman MM, Marzo RR, Chowdhury S, Qalati SA, Hasan MN, Paul GK, et al. Knowledge, attitude and practices toward Coronavirus disease (COVID-19) in Southeast and South Asia: a mixed study design approach. *Front Public Health*. (2022). doi: 10.3389/fpubh.2022.875727

22. Chen HWJ, Marzo RR, Anton H, Abdalqader MA, Rajasekharan V, Baobaid MF, et al. Dietary habits, shopping behavior and weight gain during COVID-19 pandemic lockdown among students in a private university in Selangor, Malaysia. *J. Public Health Res.* (2021) 10:1–12. doi: 10.4081/jphr.2021.2921

23. Marzo RR, Aye SS, Naing TW, Mon Kyaw T, Win MT, Kyaw Soe HH, et al. Factors associated with psychological distress among Myanmar residents during COVID-19 pandemic crises. *J Public Health Res*. (2021) 10:1–8. doi: 10.4081/jphr.2021.2279

24. Marzo RR, Vinay V, Bahari R, Chauhan S, Ming DAF, Nelson Fernandez SFA, et al. Depression and anxiety in Malaysian population during third wave of the COVID-19 pandemic. *Clin Epidemiol Glob Health*. (2021) 12:100868. doi: 10.1016/j.cegh.2021.100868

25. Marzo RR, Ismail Z, Nu Htay MN, Bahari R, Ismail R, Villanueva EQ 3rd, et al. Psychological distress during pandemic COVID-19 among adult general population: Result across 13 countries. *Clin Epidemiol Glob Health*. (2021) 10:100708. doi: 10.1016/j.cegh.2021.100708

26. Marzo RR, Singh A, Mukti RF. A survey of psychological distress among Bangladeshi people during the COVID-19 pandemic. *Clin Epidemiol Glob Health*. (2021) 10:100693. doi: 10.1016/j.cegh.2020.100693

27. Htay MNN, Marzo RR, AlRifai A, Kamberi F, El-Abasiri RA, Nyamache JM, et al. Immediate impact of COVID-19 on mental health and its associated factors among healthcare workers: A global perspective across 31 countries. *J Glob Health*. (2020) 10:020381. doi: 10.7189/jogh.10.020381

28. Respati T, Irasanti SN, Sartika D, Akbar IB, Marzo RR. A nationwide survey of psychological distress among Indonesian residents during the COVID-19 pandemic. *Int J Public Health Sci*. (2021) 10:119–26. doi: 10.11591/ijphs.v10i1.20609

29. Marzo RR, Ahmad A, Islam MS, Essar MY, Heidler P, King I, et al. Perceived COVID-19 vaccine effectiveness, acceptance, and drivers of vaccination decision-making among the general adult population: a global survey of 20 countries. *PLoS Negl Trop Dis.* (2022) 16:e0010103. doi: 10.1371/journal.pntd.0010103

30. Marzo RR, Sami W, Alam MZ, Acharya S, Jermsittiparsert K, Songwathana K, et al. Hesitancy in COVID-19 vaccine uptake and its associated factors among the general adult population: a cross-sectional study in six Southeast Asian countries. *Trop Med Health.* (2022) 50:4. doi: 10.1186/s41182-021-00393-1

31. Elsayed M, El-Abasiri RA, Dardeer KT, Kamal MA, Htay MNN, Abler B, et al. Factors influencing decision making regarding the acceptance of the COVID-19 vaccination in Egypt: a cross-sectional study in an urban, well-educated sample. *Vaccines*. (2022) 10:20. doi: 10.3390/vaccines10010020

32. Marzo RR, Ahmad A, Abid K, Khatiwada AP, Ahmed A, Kyaw TM, et al. Factors influencing the acceptability of COVID-19 vaccination: a cross-sectional study from Malaysia. *Vacunas.* (2022) 23:S33–40. doi: 10.1016/j.vacun.2021.07.007

33. King I, Heidler P, Marzo RR. The long and winding road: uptake, acceptability, and potential influencing factors of COVID-19 Vaccination in Austria. *Vaccines.* (2021) 9:790. doi: 10.3390/vaccines9070790

34. Marzo RR, Khanal P, Ahmad A, Rathore FA, Chauhan S, Singh A, et al. Quality of life of the elderly during the COVID-19 pandemic in Asian countries: a cross-sectional study across six countries. *Life*. (2022) 12:365. doi: 10.3390/life12030365

35. Marzo RR, Bhattacharya S, Aye SS, Tripathi S, Naing TW, Soe MM, et al. Study on the quality of life among cancer survivors attending a tertiary care cancer center in Malaysia. *J Public Health Res*. (2021) 10:1–8. doi: 10.4081/jphr.2021.2919

36. RilleraMarzo R, Villanueva EQ, Chandra U, Htay MNN, Shrestha R, Shrestha S. Risk perception, mental health impacts and coping strategies during COVID-19 pandemic among Filipino healthcare workers. *J Public Health Res*. (2021) 10:1–9. doi: 10.4081/jphr.2021.2604

37. Kamberi F, Sinaj E, Jaho J, Subashi B, Sinanaj G, Jaupaj K, et al. Impact of COVID-19 pandemic on mental health, risk perception and coping strategies among health care workers in Albania - evidence that needs attention. *Clin Epidemiol Glob Health*. (2021) 12:1–7. doi: 10.1016/j.cegh.2021.100824

38. Htay MNN, Marzo RR, Bahari R, AlRifai A, Kamberi F, El-Abasiri RA, et al. How healthcare workers are coping with mental health challenges during COVID-19 pandemic? - a cross-sectional multi-countries study. *Clin Epidemiol Glob Health*. (2021) 11:100759. doi: 10.1016/j.cegh.2021.100759

39. Magnavita N, Chirico F, Garbarino S, Bragazzi NL, Santacroce E, Zaffina S. SARS/MERS/SARS-CoV-2 outbreaks and burnout syndrome among healthcare workers. An umbrella systematic review. *Int J Environ Res Public Health.* (2021) 18:4361. doi: 10.3390/ijerph18084361

40. O'Brien N, Flott K, Bray O, Shaw A, Durkin M. Implementation of initiatives designed to improve healthcare worker health and wellbeing during the COVID-19 pandemic: comparative case studies from 13 healthcare provider organisations globally. *Global Health*. (2022) 18:24. doi: 10.1186/s12992-022-00818-4

41. Liljestrand R, Martin S. Stress and resilience among healthcare workers during the COVID-19 pandemic: consideration of case studies. *Rehabil Nurs*. (2021) 46:300–4. doi: 10.1097/RNJ.0000000000000344

42. Roslan NS, Yusoff MSB, Asrenee AR, Morgan K. Burnout prevalence and its associated factors among Malaysian healthcare workers during COVID-19 pandemic: an embedded mixed-method study. *Healthcare*. (2021) 9:90. doi: 10.3390/healthcare9010090

43. Noorshahrizam SA. *As Omicron Cases Spike, Health Coalition Calls for Reinforced Plan Against COVID-19," Malaysia.* (2022). Available online at: https://malaysia.news.yahoo.com/omicron-cases-spike-health-coalition-040155133.html (accessed July 31, 2022).

44. New Straits Times. "*KJ: Malaysia fully into Omicron Wave," NST Online, Malaysia.* (2022). Available online at: https://www.nst.com.my/news/nation/2022/02/769160/kj-malaysia-fully-omicron-wave (accessed July 31, 2022).

45. Ying TP. *"Omicron BA.2 to Become Dominant Coronavirus Variant in Malaysia," NST Online.* (2022). Available online at: https://www.nst.com.my/news/nation/2022/03/781780/omicron-ba2-become-dominant-coronavirus-variant-malaysia (accessed July 31, 2022).

46. Anand R. *"PM Muhyiddin Receives First COVID-19 Vaccine as Malaysia Kicks Off Mass Inoculation Campaign," The Straits Times, Singapore.* (2021). Available online at: https://www.straitstimes.com/asia/se-asia/pm-muhyiddin-receives-first-covid-19-vaccine-as-malaysia-kicks-off-mass-inoculation (accessed July 31, 2022).

47. Ministry of Health, Malaysia. *"COVIDNOW in Malaysia," COVIDNOW.* Available online at: https://covidnow.moh.gov.my/ (accessed July 31, 2022).

48. Cochran WG. Note on an approximate formula for the significance levels of *Z. Ann Math Stat*. (1940) 11:93–5. doi: 10.1214/aoms/1177731945

49. Maslach C, Jackson SE, Leiter MP. "Maslach burnout inventory: third edition," in *Evaluating Stress: A Book of Resources*, Lanham, MD, US: Scarecrow Education (1997), pp. 191–218.

50. Chen WS, Haniff J, Siau C, Seet W. Translation, cross-cultural adaptation and validation of the Malay version of the Maslach Burnout Inventory (MBI) in Malaysia. *Int J Soc Sci Stud.* (2014) 2:66. doi: 10.11114/ijsss.v2i2.309

51. Chen W-S, Haniff J, Siau C-S, Seet W, Loh S-F, Jamil MHA. Pilot study of the Malay maslach burnout inventory and Malay work-related quality of life scale in Malaysia. *Stud Asian Soc Sci.* (2014) 1:20–6. doi: 10.5430/sass.v1n1p20

52. Cheung YB, Yeo KK, Chong KJ, Khoo EY, Wee HL. Reliability and validity of the English-, Chinese-and Malay-language versions of the World Health Organization quality of life (WHOQOL-BREF) questionnaire in Singapore. *Ann Acad Med Singap.* (2017) 46:461–9. doi: 10.47102/annals-acadmedsg.V46N12p461

53. Hasanah CI, Naing L, Rahman ARA. World Health Organization quality of life assessment: brief version in Bahasa Malaysia. *Med J Malaysia.* (2003) 58:79–88. Available online at: http://e-mjm.org/2003/v58n1/WHO_Quality_of_Life_Assessment.pdf

54. Hawthorne G, Herrman H, Murphy B. Interpreting the WHOQOL-brèf: preliminary population norms and effect sizes. *Soc Ind Res.* (2006) 77:37–59. doi: 10.1007/s11205-005-5552-1

55. Vindegaard N, Benros ME. COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. *Brain Behav Immun.* (2020) 89:531–42. doi: 10.1016/j.bbi.2020.05.048

56. Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Net Open*. (2020) 3:e203976. doi: 10.1001/jamanetworkopen.2020.3976

57. Nemati M, Ebrahimi B, Nemati F. Assessment of Iranian nurses' knowledge and anxiety toward COVID-19 during the current outbreak in Iran. *Arch Clin Infect Dis*. (2020) 15:1–5. doi: 10.5812/archcid.102848

58. Khasne RW, Dhakulkar BS, Mahajan HC, Kulkarni AP. Burnout among healthcare workers during COVID-19 pandemic in India: results of a questionnaire-based survey. *Indian J Crit Care Med*. (2020) 24:664–71. doi: 10.5005/jp-journals-10071-23518

59. Chor WPD, Ng WM, Cheng L, Situ W, Chong JW, Ng LYA, et al. Burnout amongst emergency healthcare workers during the COVID-19 pandemic: a multi-center study. *Am J Emerg Med*. (2021) 46:700. doi: 10.1016/j.ajem.2020.10.040

60. Samaniego A, Urzúa A, Buenahora M, Vera-Villarroel P. Symptomatology associated with mental health disorders in health workers in paraguay: COVID-19 effect. *Int J Psychol*. (2020) 54:1–19. doi: 10.30849/ripijp.v54i1.1298

61. Ausín B, González-Sanguino C, Castellanos MÁ, Muñoz M. Gender-related differences in the psychological impact of confinement as a consequence of COVID-19 in Spain. *J Gend Stud*. (2021) 30:29–38. doi: 10.1080/09589236.2020.1799768

62. Yusefi AR, Daneshi S, Davarani ER, Nikmanesh P, Mehralian G, Bastani P. Resilience level and its relationship with hypochondriasis in nurses working in COVID-19 reference hospitals. *BMC Nurs*. (2021) 20:1–9. doi: 10.1186/s12912-021-00730-z

63. Tomlin J, Dalgleish-Warburton B, Lamph G. Psychosocial support for healthcare workers during the COVID-19 pandemic. *Front Psychol*. (2020) 11:1960. doi: 10.3389/fpsyg.2020.01960

64. Kim SR, Park OL, Kim HY, Kim JY. Factors influencing well-being in clinical nurses: a path analysis using a multi-mediation model. *J Clin Nurs*. (2019) 28:4549–59. doi: 10.1111/jocn.15045

65. Jones S, White S, Ormrod J, Sam B, Bull F, Pieh S, et al. Work-based risk factors and quality of life in health care workers providing maternal and newborn care during the sierra leone ebola epidemic: findings using the WHOQOL-BREF and HSE Management Standards Tool. *BMJ Open*. (2020) 10:e032929. doi: 10.1136/bmjopen-2019-032929

66. Skevington SM. Qualities of life, educational level and human development: an international investigation of health. *Soc Psychiatry Psychiatr Epidemiol*. (2010) 45:999–1009. doi: 10.1007/s00127-009-0138-x

67. Regidor E, Barrio G, Fuente LDL, Domingo A, Rodriguez C, Alonso J. Association between educational level and health related quality of life in Spanish adults. *J Epidemiol Community Health*. (1999) 53:75–82. doi: 10.1136/jech.53.2.75

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 08 December 2022
DOI 10.3389/fpubh.2022.1027514

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 25 August 2022
ACCEPTED 22 November 2022
PUBLISHED 08 December 2022

CITATION
Tu H, Lu X, Wang J, Sheng Z, Liu D, Li J, Sun C and Yin Z (2022) At-home disposal practices of used insulin needles among patients with diabetes in China: A single-center, cross-sectional study.
Front. Public Health 10:1027514.
doi: 10.3389/fpubh.2022.1027514

At-home disposal practices of used insulin needles among patients with diabetes in China: A single-center, cross-sectional study

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Background: Most insulin injections for people with diabetes are administered at home, thus generating many used needles. Unsafe disposal of these at-home needles can lead to needle stick injuries, blood-borne disease transmission, and environmental contamination. Previous studies have shown varying results on the prevalence of and factors associated with safe sharps disposal practices of people with diabetes.

Objective: To assess the prevalence of and the factors associated with the safe disposal of used insulin needles among patients with diabetes.

Methods: We collected data from 271 insulin-using patients at a tertiary care hospital in China. A self-designed instrument was used to assess sociodemographic data, disease- and treatment-related characteristics, sharps disposal practices, education on diabetes self-management and sharps disposal, and awareness of the potential risks associated with unsafe sharps disposal. Multivariate logistic regression analysis was used to explore factors associated with safe sharps disposal practices.

Results: Only 10.3% (28/271) of participants disposed of used at-home insulin needles in a safe manner, and 14.8% (45/271) of participants had received previous instruction on sharps disposal. Previous sharps disposal instruction (AOR = 4.143, 95% CI = 1.642–10.450) and awareness of the risk of blood-borne pathogen transmission (AOR = 3.064, 95% CI = 1.332–7.046) were associated with safe disposal of used insulin needles.

Conclusion: In our study, the prevalence of safe sharps disposal practices was low, and a minority of respondents had received previous instruction on sharps disposal. Participants who had previously received instruction and were aware of the risk of blood-borne pathogen transmission were more likely to handle sharps safely. Our study findings suggest that health care professionals should pay attention to sharps disposal practices of patients with diabetes and conduct diabetes education programs that include information on safe sharps disposal methods and potential hazards of unsafe sharps disposal.

KEYWORDS

diabetes, patients, sharps, needles, disposal

Introduction

In 2021, the number of people with diabetes worldwide was estimated to be 537 million (1). Diabetes can cause a variety of complications that lead to stroke, kidney failure, blindness, and lower limb amputation, resulting in reduced quality of life and increased healthcare costs for patients. Moreover, in 2021, an estimated 6.7 million adult deaths were due to diabetes or its complications (1). Therefore, the prevention and control of diabetes is a global public health priority.

In 2021, China had ∼141 million people with diabetes, the largest diabetic population in the world; furthermore, by 2045, China is expected to have 175 million patients with diabetes (1). China has made many efforts to manage diabetes (2, 3); however, the continued increase in the number of people with diabetes still poses a significant challenge.

Insulin injections are an important means to control blood glucose and reduce the risk of diabetic complications (4, 5). In a previous study, the number of patients with diabetes using insulin in China was ∼9 million (6). Most of these insulin injections are administered at home, thus generating many medical sharps, such as used needles, in the community.

Used needles are classified as infectious and injurious waste. Under no circumstances should these sharps be disposed of in public trash cans or through public waste disposal systems (7). However, China's current regulations for medical waste disposal apply only to medical institutions, not to households or communities (8). Previous studies reported that many patients with diabetes discarded used insulin needles in their household garbage (9–11). Such unsafe disposal can lead to needle stick injuries, blood-borne disease transmission, and environmental contamination. Therefore, there is an urgent need to correct the unsafe handling of medical sharps among people with diabetes in the home environment.

Several factors have been associated with at-home sharps disposal practices of people with diabetes. Previous studies have shown that patients with diabetes who had received education on safe sharps disposal were more likely to safely dispose of at-home sharps than those who had not (12–15). In addition, several studies showed that such education helps improve sharps disposal practices among community-based patients with diabetes (16–19). Additionally, two studies indicated that patients with higher levels of education were more aware of the dangers associated with sharps and the need for safe sharps disposal (20, 21). A study conducted in the United States showed that patients who had diabetes for more than 30 years had the lowest rates of proper sharps disposal (13). Another study indicated that patients who handled needles unsafely had diabetes longer than those who handled sharps safely (22). Moreover, a study in the Philippines revealed that patients with diabetes who had been on insulin for a longer period were less likely to dispose of sharps correctly than those who had been on insulin for a shorter period (23). Another study showed that sharps disposal practices were worse in patients with diabetes who had been receiving insulin for more than a year than those who had been receiving it for less than a year (12). In addition, participants who were aware of the risk of blood-borne pathogen transmission *via* used needles were less likely to dispose of sharps in their household trash (24).

Understanding the current disposal practices for at-home insulin needles among patients with diabetes and identifying the factors associated with safe sharps disposal are essential for tailoring interventions to improve such practices in China. Therefore, the objectives of this study were to (a) assess the prevalence of safe disposal of used insulin needles and (b) explore the factors associated with safe sharps disposal practices within our study group.

Methods and measurement

Study design

This was a cross-sectional study using convenience sampling to explore the prevalence of and factors associated with the safe disposal of used insulin needles among Chinese patients with diabetes.

Participants

We conducted our study from December 2021 to May 2022 in the endocrinology ward of the First Affiliated Hospital of Wenzhou Medical University, a tertiary care hospital in Wenzhou. During the investigation period, patients with diabetes admitted to the ward were invited to participate in our study. Our inclusion criteria were as follows: diabetes mellitus diagnosis, age ≥18 years, insulin use for at least 6 months prior to the survey, insulin injected by the patient himself, and ability to communicate with the investigator. Patients using insulin pumps or diagnosed with gestational diabetes were excluded. Informed consent was obtained, and participation was voluntary. The required sample size was determined based on the following single population proportion formula: $n = \frac{Z^2_{\alpha/2}P(1-P)}{\delta^2}$. Additionally, it was based on the following assumptions: an estimated 18.8% prevalence of safe disposal of used insulin needles (9), a critical value of 95% confidence interval, a 5% margin of error, and a response invalidity rate of 10%. The required sample size was calculated to be 261 and 271 participants ultimately provided valid responses to our survey.

Survey instrument

For our study, sharps was defined as used insulin needles. Furthermore, safe sharps disposal was defined as discarding used insulin needles in designated sharps or puncture-resistant containers; other sharps disposal methods were categorized as unsafe.

After reviewing the literature, we listed possible factors associated with safe sharps disposal and subsequently developed a five-part tool to collect data based on these factors. The first part collected the following sociodemographic data: age, gender, education, marital status, and presence of children under 14 years of age in the household. Second, we surveyed the following disease and treatment characteristics: duration of diabetes diagnosis, duration of insulin use, schedule of daily insulin injections, needle reuse, and needle stick injuries experienced by the patient or family members. The third part evaluated the participants' disposal method of used needles; in addition, participants with safe sharps disposal practices were required to report how they eventually disposed of containers filled with used needles. Fourth, we assessed whether or not participants had received education on diabetes self-management and sharps disposal. Those who had previously received instruction on sharps disposal were also asked about the source and their primary means of obtaining it; moreover, all participants were asked about their favorite means of obtaining information on sharps disposal. Finally, the fifth part of our survey asked three questions to assess participants' awareness of the potential hazards of unsafe sharps disposal, including needle stick injuries, blood-borne pathogen transmission, and environmental contamination.

We invited five diabetes experts, including two physicians, two advanced practice nurses, and a diabetes educator, to review our original survey instrument. Based on the experts' recommendations, statements that did not match the conventions of expression were modified. The survey instrument was pilot tested in 30 people with diabetes and was appropriate for our study.

Data collection

Our investigators obtained a list of patients with diabetes receiving insulin injections through the head nurse of the ward and subsequently interviewed these patients. Prior to the interview, investigators received training on the purpose and content of the study as well as the inclusion and exclusion criteria of the sample. Additionally, participants were informed of the purpose and content of the study, and verbal consent was obtained prior to the survey. The investigator first asked the patients whether they had been injecting insulin for 6 months and whether they self-injected; if either question received a "no," the interview ended. Next, the investigators asked the remaining questions one by one and recorded the participants' verbal responses.

Ethical considerations

This study was approved by the Ethics Committee in Clinical Research of the First Affiliated Hospital of Wenzhou Medical University (IRB No. KY2021-180).

Data analysis

Data analysis was performed using SPSS Statistics 22 (IBM, Armonk, NY, USA). The variable of age did not follow a normal distribution and was expressed as medians and quartiles (P25, P75). Categorical variables were represented as cases (n) and percentages (%). In our univariate and multivariate analyses, the dependent variable was defined as whether used insulin needles were disposed of safely, i.e., whether they were placed in a designated sharps or puncture-resistant container. Mann–Whitney U and chi-square tests were used for univariate analysis for skewed continuous and categorical variables, respectively. Variables with a significance of $p < 0.20$ were included in multivariate logistic regression models to identify factors influencing safe sharps disposal practices, with the significance level set at $p < 0.05$. Variance inflation factor (VIF) was used to check for multicollinearity, and variables with VIF of <5 were included in the multivariate model. In multivariate logistic regression analysis, variables with a significance of $p < 0.05$ were considered statistically significant. Unadjusted odds ratios (UORs) and adjusted odds ratios (AORs) were used to assess the association between independent and dependent variables.

Results

Characteristics of the sample

In this study, 420 patients with diabetes using insulin agreed to participate and were interviewed. Of the 149 excluded patients, 65 had been injecting insulin for <6 months, 79 did not inject the insulin themselves, three used an insulin pump, and two were under the age of 18. Altogether, a total of 271 participants provided valid responses. The age of the participants ranged from 20 to 87 years [63 (55, 70)]. Most participants were married, had diabetes for more than 10 years, and used insulin once or twice a day. Furthermore, we found that 69.0% (187/271) of the participants used needles repeatedly. The sociodemographic, disease and treatment characteristics of the participants are shown in Table 1.

TABLE 1 Univariate analysis of factors associated with safe disposal of insulin needles.

	Total ($N = 271$)	Safe disposal ($n = 28$)	Unsafe disposal ($n = 243$)	χ^2/Z	p-Value
N (%)/median (mode)					
Age (years)	63 (55, 70)	60.5 (47, 68)	63 (56, 70)	−1.667	0.095
Gender					
Male	161 (59.4)	17 (60.7)	144 (59.3)	0.022	0.882
Female	110 (40.6)	11 (39.3)	99 (40.7)		
Education					
None/primary level	151 (55.7)	12 (42.9)	139 (57.2)	2.094	0.148
Junior high level or above	120 (44.3)	16 (57.1)	104 (42.8)		
Marital status					
Married	252 (93.0)	24 (85.7)	228 (93.8)	1.443	0.230
Single/unmarried/divorced/widowed	19 (7.0)	4 (14.3)	15 (6.2)		
Presence of children under 14 year of age					
Yes	52 (19.2)	4 (14.3)	48 (19.8)	0.484	0.487
No	219 (80.8)	24 (85.7)	195 (80.2)		
Duration of diabetes diagnosis (years)					
≤10	78 (28.8)	9 (32.1)	69 (28.4)	0.172	0.678
>10	193 (71.2)	19 (67.9)	174 (71.6)		
Duration of insulin use (years)					
≤5	111 (41.0)	15 (53.6)	96 (39.5)	2.054	0.152
>5	160 (59.0)	13 (46.4)	147 (60.5)		
Schedule of daily insulin injections					
Once	67 (24.7)	9 (32.1)	58 (23.9)	1.724	0.422
Twice	96 (35.4)	7 (25.0)	89 (36.6)		
Three times or more	108 (39.9)	12 (42.9)	96 (39.5)		
Needle reuse					
Yes	187 (69.0)	14 (50.0)	173 (71.2)	5.272	0.022
No	84 (31.0)	14 (50.0)	70 (28.8)		
Needle stick injuries experienced by the patient or family members					
Yes	36 (13.3)	7 (25.0)	29 (11.9)	2.673	0.102
No	235 (86.7)	21 (75.0)	214 (88.1)		
Previous education on diabetes self-management					
Yes	137 (50.6)	17 (60.7)	120 (49.4)	1.290	0.256
No	134 (49.4)	11 (39.3)	123 (50.6)		
Previous instruction on sharps disposal					
Yes	32 (11.8)	9 (32.1)	23 (9.5)	10.317	0.001
No	239 (88.2)	19 (67.9)	220 (90.5)		
Awareness of the risk of needle stick injuries from unsafe sharps disposal					
Yes	118 (43.5)	19 (67.9)	99 (40.7)	7.510	0.006
No	153 (56.5)	9 (32.1)	144 (59.3)		
Awareness of the risk of blood-borne pathogen transmission from sharps disposal					
Yes	104 (38.4)	18 (64.3)	86 (35.4)	8.864	0.003
No	167 (61.6)	10 (35.7)	157 (64.6)		
Awareness of the risk of environmental contamination from unsafe sharps disposal					
Yes	132 (48.7)	19 (67.9)	113 (46.5)	4.583	0.032
No	139 (51.3)	9 (32.1)	130 (53.5)		

Age was tested to be skewed numeric data, expressed as medians and quartiles (P25, P75) and analyzed by Mann–Whitney U-test; categorical variables were described as cases (n) and percentages (%) and analyzed by Chi-square test; safe sharps disposal was defined as placing sharps into designated sharps or puncture-resistant containers.

10.3389/fpubh.2022.1027514

TABLE 2 Participants' disposal practices of insulin needles.

Variables	Frequency (%)
Disposal of insulin needles ($N = 271$)	
Designated sharps containers	5 (1.8)
Puncture-resistant containers	23 (8.5)
Directly into household garbage with recapping	191 (70.5)
Directly into household garbage without recapping	52 (19.2)
Disposal of designated or puncture-resistant containers ($n = 26$)	
Health care facility	4 (15.4)
Handed over to the cleaner	2 (7.7)
Household garbage	18 (69.2)
Placed in her toilet and had not been disposed of yet	1 (3.8)

Disposal practices of insulin needles

Table 2 presents the disposal methods of insulin needles used by our participants. Only 28 participants placed their insulin needles in designated sharps or puncture-resistant containers. Thus, the prevalence of safe sharps disposal practices was 10.3% (28/271). Most participants (89.7%, 243/271) disposed of insulin needles with or without caps directly in their household trash. Regarding the disposal of containers filled with used needles, two of the 28 respondents who safely disposed of used needles did not respond; of the remaining 26 participants, 18 discarded their sharps containers in their household trash.

Instruction on sharps disposal

Table 3 shows that 14.8% (45/271) of respondents had received previous instruction on how to handle sharps. The most frequently mentioned source of information was a nurse, followed by a doctor, a friend or relative, and others. The information was primarily obtained verbally. Additionally, the majority (69.7%, 189/271) of participants wanted to receive information regarding sharps disposal verbally.

Univariate analysis of safe sharps disposal practices

After univariate analysis of factors associated with the safe disposal of insulin needles, the following nine variables were entered into the multivariate logistic regression model: age, education, duration of insulin use, needle reuse, needle stick experience, previous instruction on sharps disposal, awareness of the risk of needle stick injuries, awareness of the risk of blood-borne pathogen transmission and awareness of the risk of environmental contamination ($p < 0.20$; Table 1).

TABLE 3 Instruction on sharps disposal.

Variables	Frequency (%)
Previous instruction on sharps disposal ($N = 271$)	
Yes	45 (14.8)
No	259 (85.2)
Source of sharps disposal instruction ($n = 45$)	
Nurse	24 (75.0)
Doctor	5 (15.6)
Pharmacist	0 (0.0)
Friend or relative	2 (6.3)
Others[a]	1 (3.1)
Primary means of obtaining information on sharps disposal ($n = 32$)	
Verbal	26 (81.3)
Booklets, magazines or books	0 (0.0)
Television or broadcast	0 (0.0)
Internet	6 (18.8)
Favorite means of obtaining information on sharps disposal ($n = 271$)	
Verbal	189 (69.7)
Booklets, magazines or books	26 (9.6)
Television or broadcast	14 (5.2)
Internet	42 (15.5)

[a]Others referred to a community worker.

TABLE 4 Multivariate analysis of factors associated with safe disposal of insulin needles ($N = 271$).

Variables	AOR	95% CI	*p*-Value
Previous instruction on sharps disposal			
Yes	4.143	1.642, 10.450	0.003
No	Reference		
Awareness of the risk of blood-borne pathogens transmission from sharps disposal			
Yes	3.064	1.332, 7.046	0.008
No	Reference		

AOR, adjusted odds ratio; CI, confidence interval.

Multivariate analysis of safe sharps disposal practices

The Box–Tidwell test indicated that the relationship between age and safe sharps disposal was linear. The VIF values of the nine independent variables that entered the multivariate logistic regression were < 2 and no collinearity was detected. Hosmer-Lemeshow test [chi-square = 0.014, degrees of freedom (df)

= 1, $p = 0.906$] and omnibus tests of model coefficients (chi-square = 16.680, df = 2, $p = 0.000$) suggested that forward stepwise (likelihood ratio) multivariate logistic regression was appropriate.

After adjusting for potential confounders, previous instruction on sharps disposal and awareness of the risk of blood-borne pathogen transmission remained two significant predictors of safe insulin needle disposal practices (Table 4). Patients with diabetes who had previously received sharps disposal instruction were 4.143 times (AOR = 4.143, 95% CI = 1.642–10.450) more likely to dispose of insulin needles safely than those who had not. Furthermore, participants who were aware of the risk of blood-borne pathogen transmission from unsafe sharps disposal were 3.064 times more likely to dispose of needles safely than those who were not (AOR = 3.064; 95% CI, 1.332–7.046).

Discussion

This was a cross-sectional study using a self-administered instrument to gain insight into insulin needle disposal practices among patients with diabetes and to explore factors associated with safe sharps disposal practices.

Disposal practices of insulin needles

In the present study, the prevalence of safe sharps disposal practices was low, with only 10.3% of participants safely disposing of their insulin needles. This finding is similar to previous studies conducted in China (9, 11) and other countries (14, 15, 20, 25). However, two studies from the United States showed much higher rates of safe sharps disposal, with Montoya and Huang reporting 67 and 59%, respectively (13, 22). This difference may be related to the specific policies and clear guidelines for at-home sharps disposal that exist in the United States (26, 27).

Of the participants who placed used needles in designated sharps or puncture-resistant containers, most ultimately discarded these containers in their household trash. This is in line with findings from Bangladesh (25), Sri Lanka (12), and India (28). This may be due to the lack of sharps collection terminals or community sharps disposal programs; patients with diabetes do not have access to sharps container disposal and instead place them in household waste (12).

Associated factors of safe sharps disposal

In our study, previous instruction on sharps disposal and awareness of the risk of blood-borne pathogen transmission were two factors significantly associated with safe sharps disposal practices. Our findings showed that patients with diabetes who had received previous sharps disposal instruction were more likely to have safe sharps disposal practices compared to those who had not. This is supported by the results of other cross-sectional studies (12–15). Furthermore, a study conducted in India found that a provider-initiated patient-centered insulin-use health education program with information on sharps disposal significantly improved the knowledge and practice of used insulin sharps disposal among people with diabetes (18). A quasi-experimental study conducted in northeast Peninsular Malaysia reported that a structured community sharps disposal education module that included content on the proper handling of sharps, was effective in improving sharps disposal knowledge and encouraging safe sharps disposal practices among Malaysian patients with diabetes (16). The positive relationship between previous instruction on sharps disposal and safe sharps disposal practices can be explained by the health belief model, where information on safe sharps disposal can serve as a cue for action, activating readiness and stimulating positive health-related behaviors among people with diabetes (29). In contrast, a study conducted in the Philippines showed that sharps disposal instruction from health care professionals was not a significant predictor of safe sharps disposal practices (23). They speculated that this might result from either patients having low adherence to sharps disposal advice from health care professionals or health care professionals providing incorrect information in the first place.

In our study, only a few respondents had previously received instruction on sharps disposal, which is similar to findings from Sri Lanka (12). The reason for this may be that health care professionals and patients are not fully aware that home sharps disposal is a serious public health issue. According to our results, nurses were the primary provider of sharps disposal information, which may result from the fact that education on insulin injection in China is mainly performed by nurses and diabetes educators (30). Notably, most diabetes educators in China are also nurses (31). Future research is needed to identify barriers that prevent other health care professionals from educating patients about safe sharps disposal. Most participants in this study preferred to receive verbal information on how to safely dispose of sharps. Therefore, nurses, diabetes educators, physicians, and pharmacists should provide early and sustainable verbal counseling to their patients to improve sharps disposal practices. Furthermore, online and offline materials, such as pamphlets and videos, should be available for patients to independently review safe sharps disposal practices at home.

Our study also showed that patients with diabetes who were aware of the risk of blood-borne pathogen transmission were more likely to have safe practices than patients who were not aware of this risk. This finding is consistent with a study conducted in Pakistan, which revealed that

people with diabetes who knew the risk of blood-borne disease transmission were less likely to dispose of sharps in their household trash (24). Understanding precautions that can reduce the spread of blood-borne pathogens, such as safe sharps disposal, is important (32). This can be explained by the health belief model, whereby patients who have diabetes understand the serious consequences of blood-borne disease transmission and develop fears about their current behavior, which can motivate them to change this behavior (29). In short, when discussing sharps disposal with patients who have diabetes, health care professionals should inform them of the potential harms associated with unsafe disposal.

Limitations

The present study has some limitations. First, some factors that may influence sharps disposal practices were not included, such as income, place of residence, and comorbid blood-borne diseases. Second, some participants may have had difficulty accurately recalling past events, such as needle stick injuries, duration of diabetes diagnosis, and duration of insulin use, so we cannot exclude the possibility of recall bias. Third, participants in this study were recruited from a single hospital through convenience sampling, which limits the generalizability of our study. A multi-center study with larger samples is needed. In addition, interventional studies could be considered.

Conclusion

In our hospital-based sample of patients with diabetes, the prevalence of safe sharps disposal was low, and only a minority of respondents had received previous sharps disposal instruction. Patients who had previously received sharps disposal instruction and were aware of the risk of blood-borne pathogen transmission were more likely to perform sharps disposal correctly. Our results may provide a basis for conducting sharps education programs for patients with diabetes and urging the government to issue regulations for the management of sharps disposal in the community. Our study findings suggest that safe sharps disposal methods and potential risks of unsafe sharps disposal should be incorporated into education programs for patients with diabetes and that health care professionals should receive training on the safe disposal of home-generated sharps.

Data availability statement

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee in Clinical Research of the First Affiliated Hospital of Wenzhou Medical University (IRB No. KY2021-180). The patients/participants provided their written informed consent to participate in this study.

Author contributions

HT performed the analysis, wrote the initial manuscript, and revised the manuscript. XL coordinated the data collection and interpreted the results. XL and CS reviewed the manuscript. JW, ZS, and DL contributed to data collection and data analysis. JL designed the study. CS supervised data collection. ZY and HT conceptualized and designed the study. ZY and JL reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

Funding

The research was supported by Wenzhou Science and Technology Bureau, Grant Number: Y20190033.

Conflict of interest

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

Publisher's note

References

1. International Diabetes Federation. *IDF Diabetes Atlas 10th Edition*. (2021). Available online at: https://diabetesatlas.org/atlas/tenth-edition/ (accessed August 18, 2022).

2. General Office of National Health and Family Planning Commission, National Administration of Traditional Chinese Medicine. *Notice on the Pilot Project of Graded Diagnosis and Treatment for Hypertension and Diabetes*. (2015). Available online at: http://www.nhc.gov.cn/yzygj/s3593g/201512/073b50bd7d2b4454872126f2bc830410.shtml (accessed August 18, 2022).

3. Ministry of Health, Ministry of Finance, National Population and Family Planning Commission. *Views on the Promotion of Progressive Equalisation of Basic Public Health Services*. (2009). Available online at: http://www.gov.cn/ztzl/ygzt/content_1661065.htm (accessed August 18, 2022).

4. Chinese Diabetes Society. Guideline for the prevention and treatment of type 2 diabetes mellitus in China (2020 Edition). *Chin J Diabetes*. (2021) 13:315–409. doi: 10.3760/cma.j.cn115791-20210221-00095

5. Yang T, Guo L, Weng J, Zhou Z. Guidelines for insulin therapy in type 1 diabetes in China. *Chin J Diabetes*. (2016) 8:591–7. doi: 10.3760/cma.j.issn.1674-5809.2016.10.005

6. Ji L, Sun Z, Li Q, Qin G, Wei Z, Liu J, et al. Lipohypertrophy in China: prevalence, risk factors, insulin consumption, and clinical impact. *Diabetes Technol Ther*. (2017) 19:61–7. doi: 10.1089/dia.2016.0334

7. National Health Commission of the People's Republic of China & Ministry of Ecology and Environment of the People's Republic of China. *Notice on the Publication of the Catalogue of Medical Waste Classification*. (2021). Available online at: http://www.gov.cn/zhengce/zhengceku/2021-12/02/content_5655394.htm (accessed August 18, 2022).

8. State Council of the People's Republic of China. *Medical Waste Management Regulations*. (2011). Available online at: http://www.gov.cn/zhengce/2020-12/26/content_5574566.htm (accessed August 18, 2022).

9. Li R, Yuan L. Current situation of insulin injection needle usage in outpaitent diabetes patients. *J Nurs*. (2014) 21:20–2. doi: 10.16460/j.issn1008-9969.2014.09.010

10. Fang S, Tang C, Huang D, Zhang Y, Pu Q. Survey on the current status of self-management of medical waste by home insulin injectors. *Chin Gen Pract Nurs*. (2016) 14:311–3. doi: 10.3969/j.issn.1674-4748.2016.03.041

11. Zhang L. *Study on the Status and Influence Factors of Self Injectin of Insulin in Diabetic Patients*. Dalian: Dalian Medical University (2017).

12. Atukorala KR, Wickramasinghe SI, Sumanasekera RDN, Wickramasinghe KH. Practices related to sharps disposal among diabetic patients in Sri Lanka. *Asia Pac Fam Med*. (2018) 17:12. doi: 10.1186/s12930-018-0049-7

13. Huang L, Katsnelson S, Yang J, Argyrou C, Charitou MM. Factors contributing to appropriate sharps disposal in the community among patients with diabetes. *Diabetes Spectr*. (2018) 31:155–8. doi: 10.2337/ds17-0033

14. Hasan UA, Mohd Hairon S, Yaacob NM, Daud A, Abdul Hamid A, Hassan N, et al. Factors contributing to sharp waste disposal at health care facility among diabetic patients in North-East Peninsular Malaysia. *Int J Environ Res Public Health*. (2019) 16:2251. doi: 10.3390/ijerph16132251

15. Hassan NM, Shalaby SES, Atalla AO, Younis EA. Toward safe environment: injection device disposal among diabetic patients attending tertiary care academic clinic in middle Delta, Egypt. *Environ Sci Pollut Res Int*. (2021) 28:23193–203. doi: 10.1007/s11356-021-12393-z

16. Hasan UA, Mohd Hairon S, Yaacob NM, Daud A, Abdul Hamid A, Hassan N, et al. Effectiveness of diabetes community sharp disposal education module in primary care: an experimental study in North-East Peninsular Malaysia. *Int J Environ Res Public Health*. (2019) 16:3356. doi: 10.3390/ijerph16183356

17. Zou H, Guo X. Nursing intervention on the disposal of medical waste at home for outpatients with diabetes in Liangshan Yi Nationality region. *Nurs J Chin People's Lib Army*. (2019) 36:78–80. doi: 10.3969/j.issn.1008-9993.2019.10.020

18. Moray KV, Manjunath K, Martina Shalini AJ, Pricilla SR, John SM, Prasad JH. The insulin sharps disposal study: evaluation of a structured patient education initiative in an urban community health Centre in India. *J Family Med Prim Care*. (2020) 9:6164–70. doi: 10.4103/jfmpc.jfmpc_1295_20

19. Tong G, Shen J, Wan G, Lv H. Management of disposal insulin pen-injector needle for rural diabetic patients. *J Nurs Sci*. (2020) 35:22–3. doi: 10.3870/j.issn.1001-4152.2020.01.022

20. Basazn Mekuria A, Melaku Gebresillassie B, Asfaw Erku D, Taye Haile K, Melese Birru E. Knowledge and Self-reported practice of insulin injection device disposal among diabetes patients in Gondar Town, Ethiopia: a cross-sectional study. *J Diabetes Res*. (2016) 2016:1897517. doi: 10.1155/2016/1897517

21. Khan AM, Al Ghamdi RA, Alswat KA. Knowledge, attitude and practice on disposal of sharps waste at home among patients with diabetes and their caregivers. *Curr Diabetes Rev*. (2021) 17:e170920186033. doi: 10.2174/1573399816999200917162514

22. Montoya JM, Thompson BM, Boyle ME, Leighton ME, Cook CB. Patterns of sharps handling and disposal among insulin-using patients with diabetes mellitus. *J Diabetes Sci Technol*. (2021) 15:60–6. doi: 10.1177/1932296819882926

23. Quiwa L, Jimeno C. Knowledge, attitudes and practices on the disposal of sharps in patients of the up-philippine general hospital diabetes clinic. *J ASEAN Fed of Endocr Soc*. (2014) 29:141–51. doi: 10.15605/jafes.029.02.07

24. Ishtiaq O, Qadri AM, Mehar S, Gondal GM, Iqbal T, Ali S, et al. Disposal of syringes, needles, and lancets used by diabetic patients in Pakistan. *J Infect Public Health*. (2012) 5:182–8. doi: 10.1016/j.jiph.2012.02.002

25. Kamrul-Hasan A, Paul AK, Amin MN, Gaffar MAJ, Asaduzzaman M, Saifuddin M, et al. Insulin injection practice and injection complications - results from the Bangladesh insulin injection technique survey. *Eur Endocrinol*. (2020) 16:41–8. doi: 10.17925/EE.2020.16.1.41

26. Administration UFD. *Dos and Don'ts of Proper Sharps Disposal*. (2021). Available online at: https://www.fda.gov/medical-devices/safely-using-sharps-needles-and-syringes-home-work-and-travel/dos-and-donts-proper-sharps-disposal (accessed August 18, 2022).

27. SafeNeedleDisposal.org. *How to Dispose of Used Sharps*. (2022). Available online at: https://safeneedledisposal.org/ (accessed August 18, 2022).

28. Kalra S, Mithal A, Sahay R, John M, Unnikrishnan AG, Saboo B, et al. Indian injection technique study: population characteristics and injection practices. *Diabetes Ther*. (2017) 8:637–57. doi: 10.1007/s13300-017-0243-x

29. Bao J. *Health Promotion and Health Education in Nursing*, 2nd ed. Hangzhou: Zhejiang University Press (2018).

30. Ji L, Guo X, Huang J, Ji Q, Jia W, Li L, et al. Guideline for diabetes drug injeciton technique in China (2016 edition). *Chin J Diabetes*. (2017) 9:79–105. doi: 10.3760/cma.j.issn.1674-5809.2017.02.005

31. Xiong Z, Yuan L, Guo X, Sun Z, Zhao F, Lou Q, et al. Effects of China diabetes educator training and its influencing factors. *Chin J Nurs*. (2017) 52:816–9. doi: 10.3761/j.issn.0254-1769.2017.07.010

32. Lin C, Aljuaid M, Tirada N. Needlestick injuries in radiology: prevention and management. *Clin Radiol*. (2022) 77:496–502. doi: 10.1016/j.crad.2022.03.021

frontiers | Frontiers in Public Health

TYPE Review
PUBLISHED 13 December 2022
DOI 10.3389/fpubh.2022.1008878

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 01 August 2022
ACCEPTED 28 November 2022
PUBLISHED 13 December 2022

CITATION
Mumtaz H, Hameed M, Sangah AB, Zubair A and Hasan M (2022) Association between smoking and non-alcoholic fatty liver disease in Southeast Asia.
Front. Public Health 10:1008878.
doi: 10.3389/fpubh.2022.1008878

Association between smoking and non-alcoholic fatty liver disease in Southeast Asia

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An estimated 8 million people die each year from tobacco smoking, with an increasing frequency recently being observed in Southeast Asian countries, which is a preventable risk factor for mortality. NAFLD, fibrosis, advancement of hepatocellular carcinoma, and prognosis for those with severe liver disease are all negatively influenced. NAFLD and cigarette usage seem to be a direct link. Oxidative stress and oncogenic signals have been implicated in cancer development in animal models and human clinical trials. The elevated risk of cardiovascular disease and malignancies in those with steatohepatitis and those who have had liver transplants is exacerbated by smoking. We found that smoking cessation may increase treatment response and fibrosis regression rates, decrease hepatocellular carcinoma incidence, and improve liver transplant outcomes. In the last segment, we'll look at electronic cigarettes, a hot subject in public health right now, as well as additional repercussions of smoking.

KEYWORDS

nonalcoholic fatty liver disease, smoking, hepatocellular carcinoma, electronic cigarette, depression, cardiovascular disease, Southeast Asia

Introduction

Although non-alcoholic fatty liver disease (NAFLD) was prevalent for decades in westerners, recent studies have shown the growing incidence of NAFLD in Southeast Asia, from 9% ranging to 45%, particularly in Pakistan, Sri Lanka, India, Nepal, Bangladesh, with the second largest proportion of cancer death attributable to HCC in East Asia (1, 2). South Korea also showed a rising frequency between 2006 (18.7%) and 2010 (27.3%) (3). Furthermore, a whopping 33.9% increase in NAFLD prevalence was reported between 2012 to 2017 in Southeast Asia (3). NAFLD affects an estimated 20–30% of Westerners (4, 5). NAFLD may lead to cirrhosis of the liver and hepatocellular cancer if it is not addressed. The name "NAFLD" encompasses all of these conditions (4–9). Type 2 diabetes mellitus, as well as waist circumferences >102 cm for men and 88 cm for women, have been linked to obesity (4–7, 9). Obese people have a 4.6-fold increase in the prevalence of NAFLD (7). NAFLD is linked not just to metabolic abnormalities but also bad lifestyle choices (5). Also, population aging accelerates the progression of

NAFLD (10, 11). Thus as evidenced by the abdominal age predictor, AbdAge model, which was developed on liver MRI images and revealed that with advanced age, the liver becomes darker, its volume diminishes, and blood flow declines (10). Smoking and, more recently, NAFLD have been identified as risk factors for reflux esophagitis (12). NAFLD is presently a significant financial burden on the global healthcare system.

The burden of tobacco abuse in the region of Southeast Asia has remarkably soared in recent years, with approximately 400 million users, and resulted in about 1.2 million deaths per year (13–17). Cigarettes contain nearly 4,000 hazardous compounds, many of which are liver-damaging and habit-forming (4). Chronic liver disease, such as alcoholic liver disease, primary biliary cirrhosis, hepatitis B and C, and other chronic liver diseases, may be accelerated by tobacco use in addition to cardiovascular disease, type 2 diabetes, and hepatocellular cancer. (6, 7, 11). It's still unclear how smoking contributes to nonalcoholic fatty liver disease (NAFLD). In this article, the pathophysiology of smoking and non-alcoholic fatty liver disease (NAFLD) is discussed, and evidence is drawn from related studies, with special emphasis on data related to Southeast Asia. A cause-and-effect relationship between smoking and NAFLD could be best explained by the negative effects of potential confounders. A map of Southeast Asia has been shown in Figure 1.

Smoking and NAFLD

Kishore et al. evaluated the frequency of hardcore smoking among three Southeast Asian countries, with India reporting the highest number of hardcore smokers as compared to Bangladesh, and Thailand, among a total of 31.3 million individuals (14). A serious public health issue, smoking kills more than 8 million people every year, and is a preventable cause of early disability and morbid mortality (15, 16). According to a 2017 research, the percentage of men and women who smoke every day is 25.0 percent and 5.4 percent, respectively. In 2015, smoking was directly responsible for the deaths of 6.4 million people, or 11.5% of the population (7). In the recent decade, several nations have seen an increase in the number of people who smoke (7). 36 percent of malignancies and 21 percent of all-cause fatalities in China have been linked to smoking cigarettes (11). Half of all males over the age of 18 in Europe smoke, ranging from 63% in Russia to 17% in Sweden (7). In developed countries, 24 percent of women smoke, compared to 7% in poor ones (7). Moreover, as the number of pack-years increased, the risk association also increased (10–19.9 pack-years: hazard ratio [HR] 1.25; 95% CI 1.21–1.29; >–20 pack-years: HR 1.36; 95% CI 1.30–1.42, compared to 0 pack-years) (4). According to demographics and health surveys, considering the Southeast Asian regions, among men, Indonesia ranked the highest smoking country (72.3%), whereas the percentages in Timor Leste, Bangladesh, and Maldives were 69.5, 60.0, and 47.3%, respectively (13). However, India, Pakistan, Cambodia, and Nepal reported the decreased trend with percentages as follows: 34.1, 31.6, 34.7, and 33.6% accordingly (13). While women smoked less frequently in every country than men, the studies reported Nepal the highest (9.8%), with Maldives (4.6%), Philippines (5.2%) and Pakistan (4.02%) following the trend (13). The latest epidemiologic data regarding the prevalence rates of smoking in Southeast Asia is shown in Figure 2 (17).

Several studies have reported the high NAFLD predominance in males. Around 17.7% of females and 41% of males reported NAFLD in a study done in Japan. Similarly, Williams et al. reported a NAFLD prevalence of 58.9% among males in a prospective study conducted in the United States (18). Nevertheless, the males demonstrated high prevalence rates of NAFLD at all ages than females, but increasing age strikingly raised the frequency among females, with 3.3% in the twenties to 31.3% beyond the sixties. Data from China demonstrated parallel trends (19). This could possibly be explained by a greater increase in AST/ALT ratio in women relative to NAFLD-diagnosed men, predisposing women to an enhanced inflammatory response as the disease progresses and an increased risk for advanced fibrosis (20). Furthermore, endocrine factors play a role in determining the propensity to develop NAFLD in males, whereas, in females, estrogen is protective during the fertile period of life while the risk raises exponentially in post-menopausal women (21). The prevalence rates of NAFLD concerning the vast region of Asia are summarized in Figure 3 (22).

The pathogenic processes associated with smoking are recognized at the cellular, histologic, systemic, and clinical levels, respectively, increasing hepatocarcinogenesis, hepatic fibrosis, metabolic fatty liver disorders, and negatively affecting liver-related outcomes (7, 16). Numerous studies show a link between smoking and cirrhosis, chronic hepatitis B (CHB) infection, however, the connection between smoking and NAFLD is still debatable (5). Southeast Asian regions are significantly reporting the risk of smoking as a leading cause of developing NAFLD. A cohort study conducted in Japan among non-alcoholics demonstrated that cigarette smoking is strongly linked with the development of NAFLD, insulin resistance being the culprit (23). Similarly, Liu et al. observed in a 40-year-old Chinese population that heavy active, as well as passive cigarette smoking, correlated with NAFLD (24). The result from several studies conducted in China, Japan, and South Korea for over a decade indicated that a dose exposure risk existed for hepatic disease and smoking even when confounding factors were adjusted (25). Smoking has been linked to NAFLD by research conducted in Kagoshima, Japan by Hamabe et al. (26). Researchers have found a strong link between smoking and increased risk of NAFLD-related hepatic fibrosis in a Chinese study published in JAMA Hepatology by Hongjie Ou et al. (5). Smoking is strongly linked to NAFLD, according to a

FIGURE 1
A map of Southeast Asia (35).

meta-analysis. Because stopping smoking increases weight and BMI, those who were smokers before are more likely to develop NAFLD (7). Passive smoking, on the other hand, raises the incidence of NAFLD by 1.38-fold because sidestream smoke includes more dangerous compounds than mainstream smoke (7). As a consequence of cigarette smoke's counterproductive estrogenic effects, which alter body fat composition, smoking-induced NAFLD may have an independent influence on BMI concerning NAFLD (7). On the basis of self-reports, pack-years, and urinary cotinine levels, a large South Korean cohort study conducted at Kangbuk Samsung Hospital concluded that current smoking was significantly and independently associated with an increased risk of NAFLD and fibrosis in healthy young and middle-aged men and women (6). Another Korean study by Kim et al. found a connection between NAFLD and urine cotinine confirmed smoking (4). NAFLD-affected women showed that current smoking led to a dramatic rise in NAFLD-related deaths as demonstrated by a cohort conducted among Thai civilians (27).

Numerous factors, some of which are yet understood, might relate smoking to NAFLD. Cytotoxic chemicals may accelerate the growth and proliferation of fibroblasts, which results in the formation of scar tissue (6). Moreover, nicotine strongly stimulates hepatic injury and subsequent fibrogenesis, *via* activation of nicotinic acetylcholine receptors (nAChR) (28). Hepatic stellate cells (HSCs) normally remain in a non-proliferative and inactive state, until injured by a harmful moiety. During the phase of nicotine-derived hepatocyte injury, transforming growth factor-β (TGF-β) is activated from multiple sources, including extracellular matrix (ECM), platelets, and macrophages. Consequently, activating and differentiating HSCs into myofibroblasts, which produce excessive fibrillar ECM

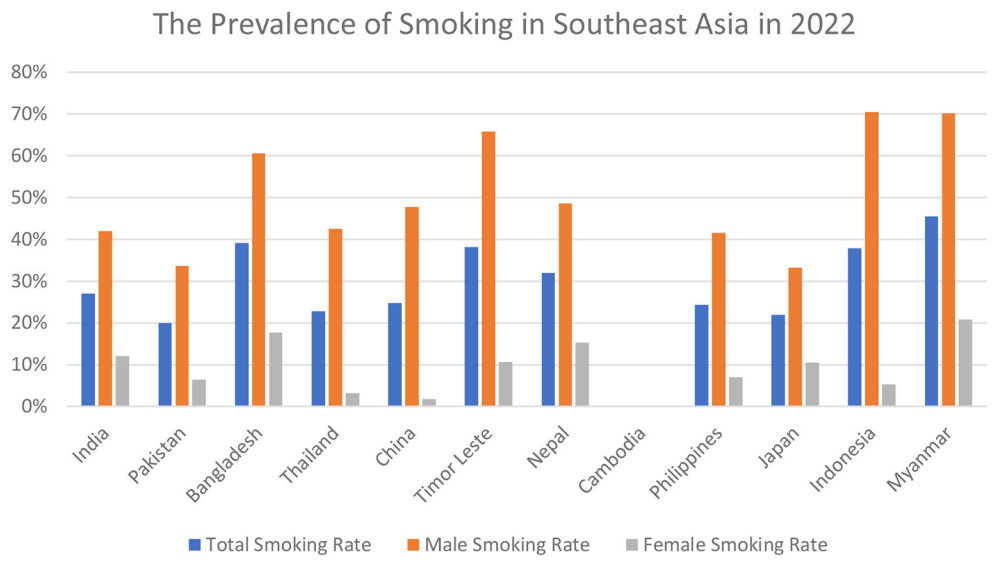

FIGURE 2
The latest 2022 prevalence rates of total smoking; male smoking; and female smoking in Southeast Asia.

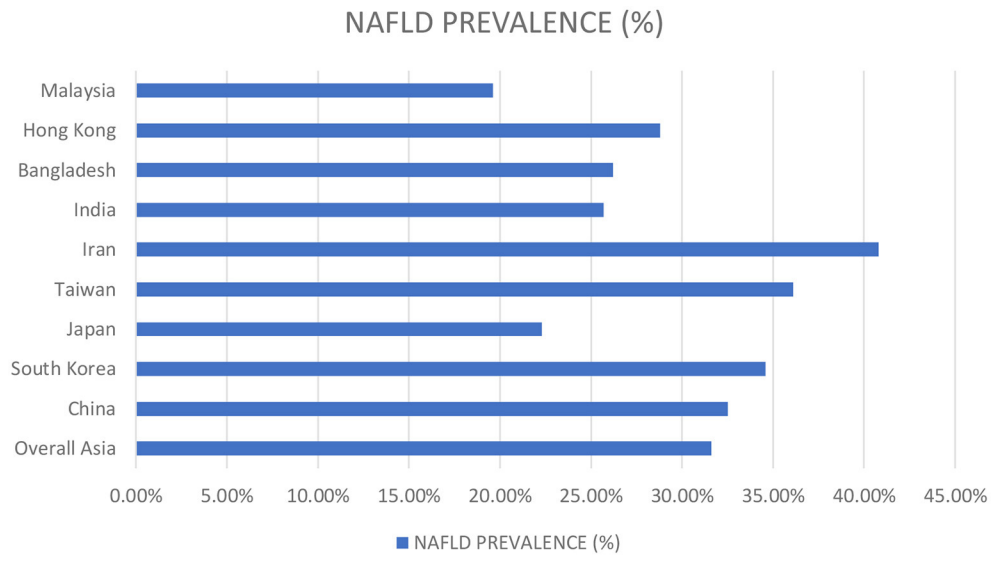

FIGURE 3
Demonstrates the prevalence of NAFLD in Asia.

proteins, leading to collagen I and III depositions in the space of Disse, thereby enhancing rapid fibrosis progression. Therefore, liver sinusoidal endothelial cells (LSEC), in a process called LSEC capillarization, defenestrate and form a basement membrane, subsequently predisposing to defective nutrient transport between hepatocytes and sinusoidal blood i.e., physiological disturbance (29). Likewise, Soeda and colleagues concluded that the use of the nAChR antagonist has shown promising outcomes in reversing the nicotine-mediated TGF-β production, therefore confirming the potential effect of TGF-β-induced fibrogenesis (30). Moreover, in response to microvasculature perturbations, like endothelial injury and subsequent hepatic tissue hypoxia, collagen-type I and vascular endothelial growth factor increase, thereby fibrosis ensues (16). Cigarette smoke also causes bacterial translocation following intestinal dysbiosis, and thus activates the Toll-like receptor 4 on the HSCs, enhancing fibrogenesis. Additionally, nicotine adversely affects the humoral and cell-mediated immune responses, leading to

suppressed antibody formation caused by lymphocyte apoptosis. Moreover, smoking decreases CD4+ cell, and increases CD8+ cytotoxic T cells, which could be reversed by smoking cessation (31). Smokers' NAFLD is exacerbated by elevated levels of proinflammatory cytokines such as interleukin-1, IL-6, and tumor necrosis factor (6). Increased levels of FFAs in the circulation are a result of alterations in fat metabolism that lead to extraordinarily high rates of lipolysis (11). In the liver and adipose tissue, eight Triglycerides are formed when FFAs are metabolized by fat cells insulin resistance (IR) (7). Fat buildup, skeletal muscle FFA generation, impaired glucose absorption, and delayed gluconeogenesis all contribute to IR in NAFLD patients (7). Even if you lose weight, smoking may raise your chance of developing central obesity because it affects the distribution of fat in your body (6). In addition to reduced lipoprotein lipase activity, higher 3-hydroxy-3-methylglutaryl CoA reductase activity, and a decreased glucose-6-phosphatase dehydrogenase activity all contribute to dyslipidemia (11). Therefore, smoking leads to NAFLD development by increasing the bloodstream production of insulin-antagonistic hormones such as catecholamine and glucagon, which may lead to insulin resistance (6, 11). The development of liver disease caused by a high-fat diet may be worsened as a result of this effect, which may include mechanisms such as an increase in oxidative stress and cell death in the liver, as well as a decrease in the activation of AMPK, fatty acid synthase (*de novo* liver steatosis), and the 1-c sterol response element binding protein, all of which are linked to the development of liver disease (6, 16).

The trend of NAFLD in India is especially attributed to various factors like central obesity, higher BMI, hypertension, hypercholesterolemia, hypertriglyceridemia, hyperinsulinemia, and diabetes, as reported by Nigam et al. (1). The urban society in Sri Lanka showed a 32.6% prevalence of NAFLD with the same risk factors playing the role as in India, in addition to, insulin resistance, transaminitis and acanthosis nigricans (1). Central obesity proved to be the biggest threat among all the factors associated with NAFLD in Bangladesh, where 92.6% NAFLD affected were females (1). A study conducted in Nepal by Mittal et al. conveyed that 17% of the population had NAFLD; attributable to increased concentrations of serum alanine aminotransferase and aspartate aminotransferase (1). Economic growth and urbanization have led to an increased prevalence of NAFLD in Pakistan, approximately 42% in upper societies, along with promoting factors such as type 2 diabetes, hypertriglyceridemia, transaminitis, hepatomegaly, and high BMI (1). In a study conducted in Peshawar, Pakistan, around 47% patients reported NAFLD, while other different studies reported 14% prevalence (32). In a cohort study in Japan, Liu reported that approximately 40% of females and 25% of males with nonalcoholic steatohepatitis were non-obese (lean NAFLD) (33). To date, the susceptibility to develop lean NAFLD was higher among Asians (20%) as compared to Westerners, owing to body fat and muscle distribution (33, 34). Thus, it is clear that NAFLD is expected to be the biggest threat to hepatic-related poor health and mortality in South East Asia in future years. Therefore, healthy lifestyle interventions are required to be implemented in the general population to mitigate the heavy burden of smoking related NAFLD.

Smoking and hepatocellular carcinoma

In recent years, Southeast and East Asia, reported an alarming rise in HCC cases according to Kim et al., with above 90% of primary liver cancers being diagnosed as HCCs (36, 37). Among Southeast Asian regions, Thailand reported a very high incidence of 22.3 per 100,000 in a year (38). In 2020, strikingly high percentages of HCC-related mortality around 545,202 and HCC incidence which was 590,952 were observed in the far east and Southeast Asia, especially in Cambodia, Thailand, and Mongolia, likely contributable to alcohol abuse, metabolic syndrome, and hepatitides B and C (3). Moreover, the rising trends were as follows: Vietnam (26,418), Thailand (27,394), Japan (45,663), and China (410,038) (3). In 2019, hepatocellular carcinoma (HCC) was the sixth most often diagnosed condition and the third leading cause of cancer deaths globally, according to the World Health Organization (39, 40). More than any other disease, HCC rates in the United States have tripled in the last 40 years and are expected to rise significantly in the next 20 years, unlike many other forms of cancer (40, 41). The causes include hepatitis B (HBV), hepatitis C (HCV), obesity, alcoholism, non-alcoholic fatty liver disease (NAFLD), cigarette use, hemochromatosis, aflatoxins in food, hereditary factors, and a variety of environmental carcinogens, such as arsenic and mercury (39–42). According to several studies in the United States, Europe, and Asia, smoking increases the chance of developing hepatocellular carcinoma (HCC) (42). Despite the fact that the hepatitis (especially HBV and HCV) and HCC are well-known, doctors may be reluctant to recognize the relationship between smoking and HCC. A Southeast Asian cohort study conducted among Chinese individuals assessed that individuals who never smoked were at a lower risk of developing HCC than those who smoked (43). Another study involving above 12 lac Korean individuals demonstrated a high-risk relationship of cigarette smoking with HCC related mortality in men (36). HCV/HCV-infected individuals with HCC who smoke are more likely to die than those who don't, according to a study in Bern, Switzerland (HR 2.99, 95 percent CI: 1.7–5.23, p 0.001) (42). 16 Smoking was directly responsible for 13% of all cases of hepatocellular cancer (41). Lee and colleagues found that the adjusted meta-RR for liver cancer in current smokers was 1.51 (95 percent confidence range 1.37–1.67) whereas it was 1.12 in former smokers, according to their research (95 percent confidence interval 0.78–1.60) (44). As many as 4,000 harmful components are included

in cigarettes, many of which are poisonous, mutagenic, and carcinogenic (40). The harmful compounds increase oxidative stress and activate stellate cells, which accelerates fibrosis (44). Furthermore, smoking leads to a diminished oxygen-carrying capacity of the blood, promoted by detrimentally high carboxyhemoglobin concentrations. Subsequently, this stimulates erythropoietin production and increased hematocrit, secondary polycythemia. A high rate of RBC destruction ensues, leading to increased erythropoietin production and secondary intestinal iron absorption. Iron, after being phagocytized by macrophages, gets concentrated in liver cells, thereby facilitating the oxidative stress and hepatic injury (31, 44). Manifold oncogenic constituents, such as vinyl chloride, tar, nitrosamine, and hydrocarbons are present in cigarette smoke. Further, a significant presence of 4-aminobiphenyl has been associated with the increased risk of hepatocellular carcinoma (31). The formation of reactive carcinogens is mediated by the metabolization of 4-ABP and PAH (16). Further, the surge of proinflammatory cytokines such as TNFα, IL-33, and IL-1β and telomere shortening also contribute to tumor formation and progression (16). The tumor-suppressing gene p53 is blocked by N-nitrosodimethylamine, 4-aminobiphenyl, and cadmium, which induce liver fibrosis and cancer (40, 44). The anti-hepatocarcinogenic action of geranylgeranoic acid may be reduced by smoking, which inhibits hepatic monoamine oxidase B (44). Smoking cessation may be an effective method of preventing early death in people with HCC. Treatment options for hepatocellular carcinoma (HCC) include surgical excision, local radiofrequency ablation, transcatheter artery chemoembolization (TACE), radioembolization, and systemic targeted medicines like sorafenib (39).

Non-alcoholic fatty liver disease associated hepatocellular carcinoma

Over two decades, from 1995 to 2015, the incidence of fatty liver in Shanghai, China raised a stunning percentage from 3.87 to 43.6% (3). HCC rates were 0.5% for NAFLD patients and 2.8% for NASH patients in long-term follow-up studies of non-alcoholic fatty liver disease (39). They've all been related to steatosis and its progression to necrosis and fibrous necrosis, as well as the development of liver cancer, including obesity and diabetes (39). A person's risk of NAFLD and/or cancer is increased by 1.5–4 times if their BMI exceeds 30 (39). The major cause of mortality in NAFLD is fibrosis (45). NAFLD-induced liver fibrosis (NAFLD-fibrosis) affects around 40% of morbidly obese persons (F1, range 13–97%) (45). Obese people with NAFLD-fibrosis have been shown to be at increased risk of smoking (45). There is a direct correlation between alcohol use and the advancement of fibrosis in people with related liver diseases (46). One of the most common indicators of diabetes-induced inflammation is the release of tumor necrosis factor (TNF), interleukin 6, and decreased production of adiponectin (IR) (39). Increased IGF-1 production is seen in IR patients with hyperinsulinemia, a growth factor that promotes cell proliferation while blocking apoptosis (39). Reactive oxygen species (ROS) and mitochondrial dysfunction are worsened when FFA levels rise (ROS) (39). Redox stress activates JNK1, which in turn blocks the p53 tumor suppressor gene and the nuclear respiratory factor 1 (Nrf1) 13 gene (39).

Electronic cigarette exposure and NAFLD

Tobacco is not igniting when a user inhales the nicotine from an e-cigarette, which is also called an electronic nicotine delivery system (ENDS) (47). In recent years, e-cigarettes have become more popular, particularly among young people (16). A cross-sectional study conducted in Malaysia demonstrated that the highest number of users were young college or university students (39%), with peer pressure playing a major role among many (70%) (48). Another study conducted in Surabaya, Indonesia reported the growing trend of e-cigarettes, intending to quit cigarette smoking (36%) and just to try (24%) (49). Threatening products are seen as a waste of time and money in attempts to de-normalize smoking (47). The misconception that vaping is a healthier alternative to cigarette smoking is one factor. As in Ronald A. Fisher's period, a paucity of data has made e-cigarettes a contentious topic in public health circles (16, 47). E-cigarettes and other vaping products include a number of substances that may be detrimental to the health of users. Liver function has been shown to be negatively impacted by a variety of chemicals, including carbon monoxide, metals, nicotine, and nitrosamines, among others (16). E-cigarettes have been linked to liver damage in several ways, according to research done in the lab and animals (16). In comparison to control mice, rats fed a western diet (NASH model) and exposed to e-cigarettes had significantly higher levels of hepatic lipid accumulation and hepatocyte mortality (47). Oxidative stress and necrosis, as well as changes in cholesterol and fat metabolism and circadian clock networks in the liver, are all related to the adverse effects of electronic cigarettes on the development of steatosis (47). It does not rely on AMPK signaling, unlike smoking (47). More than 400 additional genes showed significant differences in expression between the NASH model mice and controls who had not used e-cigarettes, including those involved in lipid metabolism and cholesterol synthesis, according to studies conducted on hepatic RNA sequencing in these animals (47). We hypothesize that in the setting of NAFLD, e-cigarettes may cause liver dysfunction and changes in lipogenesis (47). Even more harm is likely to be done as a result of mitochondrial dysfunction and damage to the DNA itself (16). Finally, the flavoring compounds employed in e-cigarettes may induce hepatocyte harm in their own right, as previously stated (16). We know that endothelial dysfunction

is an important step in the chain of events that leads to liver injury, fibrosis formation, and hemodynamic dysfunction (16). To put it another way, the endothelium damage caused by harmful chemicals in e-cigarettes might play a key role in the development of liver injury (16).

Other complications associated with smoking and NAFLD

A relationship between CVD and NAFLD may exist because of the documented metabolic and cardiovascular risk factors associated with NAFLD, such as pro-inflammatory and atherogenic molecules (9, 16). Steatosis with smoking may have a synergistic effect on cardiovascular disease (CVD) (9). Transient ischemic attacks and strokes have been connected to carotid stenosis and carotid plaques, as well (9). In a cross-sectional investigation of the Chinese population, a link between NAFLD and carotid stenosis was found (carotid artery disease) (9). Another Southeast Asian Chinese study by Zheng et al. also observed a link between NAFLD and subclinical atherosclerosis, as shown by CIMT and ba-PWV measurements of carotid intima-media thickness (50). This is why a study was done to show that the AST/ALT ratio and ba-PWV are independent predictors of cardiovascular disease. Greater levels of ba-PWV are linked to AST/ALT ratios above 13.1 (51). Moreover, a northwestern Malaysian study evaluated that among 180 subjects with hypercholesterolemia, 12.2 and 16.7% individuals reported high levels of ALT and AST, respectively (52).

A serious risk associated with smoking is primary biliary cholangitis (PBC), although limited evidence exists (31). The proinflammatory and immunosuppressive effects of smoking, with an increase of Th1 cells in the portal tracts, may aggravate liver fibrosis in PBC patients, according to one study (16, 53). For every pack-year increase in smoking intensity, there was a 3.2-fold increase in the probability of advanced fibrosis (95 percent CI: 2.018–6.294) (53).

Cirrhosis, the severe liver damage caused by cigarette smoking, increases a person's vulnerability to several kinds of infections throughout the body (54). Innate and adaptive immune responses are disrupted, the complement system malfunctions and the number of white blood cells drops as a consequence of cirrhosis (54). It was shown that cirrhotic persons were 2.5 times more likely to have peri-implant infections compared to non-cirrhotic people. Smokers were also more vulnerable to and more likely to develop serious infections (54).

67.5% of patients with biopsy-proven NAFLD had depressive symptoms, which were associated with the severity of the illness based on histology, according to a study (55). Study results show that more than 15% of NAFLD patients suffer from depression (OR: 1.29, 95 CI: 1.02–1.64) (55). Consequently, it may be argued that depression and NAFLD are connected (55). Many neurotransmitter pathways are affected by smoking, including those that are linked to the development of depression (55). Doctors should only use screening scores for mood disorders in patients with depression when clinically necessary since this has an adverse effect on treatment response (55).

The ALT-defined phenotype of metabolic dysfunction-related liver disease has been used by researchers to establish a link between NAFLD (MDLD) and an elevated risk of malignancies other than the liver, such as breast, colon, liver, lung, and prostate (MDLD) (8). It is NAFLD that drives the link between obesity and cancer (8).

Smoking and liver transplantation

Among Southeast Asian countries, India with amazing efforts of the National Organ and Tissue Transplant Organization, reported the development of 550 transplant centers and is the third most common country in terms of organ transplantation, with liver transplantation most common after kidneys (56). A cross-sectional study conducted in Thailand reported the use, safety, and efficacy of a newer procedure called living donor hepatectomy to treat end-stage liver disease (57). Tobacco use has been linked to mortality or the requirement for long-term treatment (LT) in patients with biopsy-proven NAFLD (HR 2.62; 95 percent CI 1.67–4.10) (16). Patients in the last stages of liver disease, particularly those with severe alcoholic liver disease, benefit greatly from liver transplantation (16, 46). Tobacco smoking has been linked to poor liver transplant results in several studies (15, 16). An increased risk of non-graft-related death is attributed to poor heart and lung function as well as infection susceptibility and immune system dysfunction (15, 16). The prevalence of active smoking among patients before and after liver transplantation is 52 and 44%, respectively (15). Among alcoholic liver disease liver transplant recipients, cardiovascular events and cancer are notably identified as the leading causes of death (15, 16). Smokers, on the other hand, had a 79 percent greater chance of dying than non-smokers (15). In order to reduce the risk of postoperative problems, quitting smoking 4 weeks before surgery is recommended (15). Patients who have not been able to quit smoking before LT should be offered smoking cessation programs that focus on preventing relapses in both alcohol and tobacco use while also improving overall health (15, 16). As a result, quitting smoking may reduce the chance of mortality and other unpleasant effects (15).

Conclusion

Smoking, being overweight, and insulin resistance all contribute to the growing worldwide pandemic known as NAFLD, which in recent years, has shifted toward increased prevalence in Southeast Asia, which causes the liver to

accumulate triglycerides and free fatty acids. Liver fibrosis is permanent and often indicates a dismal prognosis. Future physicians will gain knowledge and the chance to provide more focused care as a result of the declining cost of the highest quality and powerful genetic examination. The same is true for biochemical testing and the development of sophisticated imaging. There is mounting evidence that smoking contributes considerably to NAFLD and causes the side effects linked to liver transplantation. Therefore, it is important to urge these individuals to use cutting-edge treatment strategies for quitting and reducing their smoking, such as behavioral therapies and nicotine replacement therapy. Additionally, preventative measures including individual medical, physical, and nutritional counseling combined with education, heightened awareness among doctors and the public, and government initiatives to create an atmosphere more conducive to healthy lifestyle choices might have a hugely beneficial impact. Thus, there is a higher chance that treating the aforementioned modifiable risk factors may stop the development of NAFLD steatosis from fibrosis to cancer. As a result, this would be a crucial therapeutic target to lower the risk of CVDs. Thus, this research emphasizes smoking and NAFLD as major clinical issues that pose threats to world health with special emphasis on Southeast Asia. It is necessary to do further research to examine potential pathophysiological mechanisms behind the link between smoking and NAFLD.

Author contributions

All authors have contributed equally to the review and have approved the final draft for publication.

Acknowledgments

Resear-Ligent Limited UK. https://www.linkedin.com/company/researligent/, http://resear-ligent.co.

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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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References

1. Pati G, P Singh S. Nonalcoholic Fatty Liver Disease in South Asia. *Euroasian J Hepatogastroenterol.* (2016) 6:154–62. doi: 10.5005/jp-journals-10018-1189

2. Rawla P, Sunkara T, Muralidharan P, Raj JP. Update in global trends and aetiology of hepatocellular carcinoma. *Contemp Oncol (Pozn).* (2018) 22:141–50. doi: 10.5114/wo.2018.78941

3. Tran NH. Shifting epidemiology of hepatocellular carcinoma in far eastern and Southeast Asian patients: explanations and implications. *Curr Oncol Rep.* (2022) 24:187–93. doi: 10.1007/s11912-021-01160-5

4. Kim NH, Jung YS, Hong HP, Park JH, Kim HJ, Park D, et al. Association between cotinine-verified smoking status and risk of on alcoholic fatty liver disease. *Liver Int.* (2018) 38:1487–94. doi: 10.1111/liv.13701

5. Ou H, Fu Y, Liao W, Zheng C, Wu X. Association between smoking and liver fibrosis among patients with nonalcoholic fatty liver disease. *Can J Gastroenterol Hepatol.* (2019) 2019:6028952. doi: 10.1155/2019/6028952

6. Jung HS, Chang Y, Kwon MJ, Sung E, Yun KE, Cho YK, et al. Smoking and the risk of non-alcoholic fatty liver disease: a cohort study. *Am J Gastroenterol.* (2019) 114:453–63. doi: 10.1038/s41395-018-0283-5

7. Akhavan Rezayat A, Dadgar Moghadam M, Ghasemi Nour M, Shirazinia M, Ghodsi H, Rouhbakhsh Zahmatkesh MR, et al. Association between smoking andon-alcoholic fatty liver disease: a systematiceview and meta-analysis. *SAGE Open Med.* (2018) 6:205031211774522. doi: 10.1177/20503121177 45223

8. Taylor A, Siddiqui MK, Ambery P, Armisen J, Challis BG, Haefliger C, et al. Metabolic dysfunction-related liver disease as aisk factor for cancer. *BMJ* Open Gastroenterol. (2022) 9:e000817. doi: 10.1136/bmjgast-2021-000817

9. Guo YC, Zhou Y, Gao X, Yao Y, Geng B, Cui QH,et al. Association between nonalcoholic fatty liver disease and carotid artery disease in a community-based chinese population: a cross-sectional study. *Chin Med J (Engl).* (2018) 131:2269–76. doi: 10.4103/0366-6999.241797

10. le Goallec A, Diai S, Collin S, Prost JB, Vincent T, Patel CJ. Using deep learningo predict abdominal age from liver and pancreas magnetic resonance images. *Nat Commun.* 13:1979. doi: 10.1038/s41467-022-2 9525-9

11. Deng X, Wang P, Yuan H. Epidemiology risk factors across the spectrum of age-related metabolic diseases. *J Trace Elem Med Biol.* (2020) 1:61. doi: 10.1016/j.jtemb.2020.126497

12. Azer SA, Reddivari AKR. Reflux Esophagitis. In: *StatPearls*. Treasure Island, FL: StatPearls Publishing (2022). Available online at: https://www.ncbi.nlm.nih.gov/books/NBK554462/

13. Sreeramareddy CT, Pradhan PMS, MirA, Sin S. Smoking and smokelessobacco use inine South and Southeast Asian countries: prevalencestimates and social determinants from Demographic and Health Surveys. *Popul Health Metr.* (2014) 12:1. doi: 10.1186/s12963-014-0022-0

14. Kishore J, Jena PK, Bandyopadhyay C, Swain M, Das S, Banerjee. Hardcore smoking inhree South-East asian countries: results from the global aduld tobacco survey. *Asian Pac J Cancer Prev.* (2013) 14:625–30. doi: 10.7314/APJCP.2013.14.2.625

15. López-Lazcano AI, Gual A, Colmenero J, Caballería E, Lligoña A, Navasa M, et al. Clinical medicine active smoking before liver transplantation in patients with alcohol use disorder: risk factors and outcomes. *J Clin Med.* 9:2710. doi: 10.3390/jcm9092710

16. Marti-Aguado D, Clemente-Sanchez A, Bataller R. Cigarette smoking and liver diseases. *J Hepatol.* (2022). 77:191–205. doi: 10.1016/j.jhep.2022.01.016

17. World Population Review. *Smoking Rates by Country 2022*. World Population Review (2022). Available online at: https://worldpopulationreview.com (accessed December 2, 2022).

18. Williams CD, Stengel J, Asike MI, Torres DM, Shaw J, Contreras M, et al. Prevalence of nonalcoholic fatty liver disease and nonalcoholic steatohepatitis among a largely middle-aged population utilizing ultrasound and liver biopsy: a prospective study. *Gastroenterology*. (2011) 140:124–31. doi: 10.1053/j.gastro.2010.09.038

19. Toshikuni N, Tsutsumi M, Arisawa T. Clinical differences between alcoholic liver disease andonalcoholic fatty liver disease. *World J Gastroenterol*. (2014) 20:8393–406. doi: 10.3748/wjg.v20.i26.8393

20. Lazas DJ, Pontes A, O'Rourke J, Aldous M, Bachinski M, Barish RW, et al. S1052 understanding gender differences in nafld progression utilizing common liver biomarkers. *Am J Gastroenterol*. (2020) 115:S534–S534. doi: 10.14309/01.ajg.0000706256.24680.88

21. Bertolotti M, Lonardo A, Mussi C, Baldelli E, Pellegrini E, Ballestri S, et al. Nonalcoholic fatty liver disease and aging: Epidemiology to management. *World J Gastroenterol*. (2014) 20:14185. doi: 10.3748/wjg.v20.i39.14185

22. Riazi K, Azhari H, Charette JH, Underwood FE, King JA, Afshar EE, et al. The prevalence and incidence of NAFLD worldwide: a systematiceview and meta-analysis. *Lancet Gastroenterol Hepatol*. (2022).7:851–61. doi: 10.1016/S2468-1253(22)00165-0

23. Okamoto M, Miyake T, Kitai K, Furukawa S, Yamamoto S, Senba H, et al. Cigarette smoking is aisk factor forhe onset of fatty liver disease in nondrinkers: a longitudinal cohort study. *PLoS ONE*. (2018) 13:4. doi: 10.1371/journal.pone.0195147

24. Liu Y, Dai M, Bi Y, Xu M, Xu Y, Li M, et al. Active smoking, passive smoking, and risk of nonalcoholic fatty liver disease (NAFLD): a population-based study in China. *J Epidemiol*. (2013) 23:115–21. doi: 10.2188/jea.JE20120067

25. Premkumar M, Anand AC. Tobacco, cigarettes, and the liver: the smoking gun. *J Clin Exp Hepatol*. (2021) 11:700–12. doi: 10.1016/j.jceh.2021.07.016

26. Hamabe A, Uto H,mamura Y, Kusano K, Mawatari S, Kumagai K, et al. Impact of cigarette smoking on onset of nonalcoholic fatty liver disease over a 10-year period. *J Gastroenterol*. (2011) 46:769–78. doi: 10.1007/s00535-011-0376-z

27. Charatcharoenwitthaya P, Karaketklang K, Aekplakorn W. Cigarette smokingncreased risk of overall mortality in patients with non-alcoholic fatty liver disease: a nationwide population-based cohort study. *Front Med (Lausanne)*. (2020) 7:952. doi: 10.3389/fmed.2020.604919

28. Jensen K, Nizamutdinov D, Guerrier M, Afroze S, Dostal D, Glaser S. General mechanisms of icotine-induced fibrogenesis. *FASEB Journal*. (2012) 26:4778–87. doi: 10.1096/fj.12-206458

29. Dewidar B, Meyer C, Dooley S, Meindl-Beinker N. TGF-β in hepatic stellate cell activation and liver fibrogenesis—updated (2019). *Cells*. (2019) 8:11. doi: 10.3390/cells8111419

30. Soeda J, Morgan M, McKee C, Mouralidarane A, Lin CI, Roskams T, et al. Nicotine induces fibrogenic changes in human liver viaicotinic acetylcholin receptors expressed on hepatic stellate cells. Biochem Biophys Res Commun. (2012). 417:17–22. doi: 10.1016/j.bbrc.2011.10.151

31. Rutledge SM, Asgharpour A. smoking and liver disease. *Gastroenterol Hepatol*. (2020) 16:617.

32. Pak J, Assoc M, Abbas Z, Zaheer R. Non-alcoholic fatty liver disease: a real threat in Pakistan. *J Pak Med Assoc*. 70:2437–40. doi: 10.5455/JPMA.95891

33. Wong GLH, Wong VWS. Non-alcoholic fatty liver disease in Asia: How is it different from the West? *J Gastroenterol Hepatol*. (2019) 34:1267–8. doi: 10.1111/jgh.14813

34. Seto WK, Yuen MF. Nonalcoholic fatty liver disease in Asia: emerging perspectives. *Am J Gastroenterol*. (2016) 52:164–74. doi: 10.1007/s00535-016-1264-3

35. Map of South-East Asia - Nations Online Project. (2005). Available online at: https://www.nationsonline.org/oneworld/map_of_southeast_asia.htm (accessed June 17, 2022).

36. Young Kim Kwang-Hyub Han D, Han KH. Epidemiology and surveillance of hepatocellular carcinoma. *Liver Cancer*. (2012) 1:2–14. doi: 10.1159/000339016

37. Yu MC, Yuan JM, Govindarajan S, Ross RK. Epidemiology of hepatocellular carcinoma. *Can J Gastroenterol*. (2000) 14:703–9. doi: 10.1155/2000/371801

38. Chonprasertsuk S, Vilaichone RK. Epidemiology and treatment of hepatocellular carcinoma in Thailand. *Jon J Clin Oncol*. (2017) 47:294–7. doi: 10.1093/jack/hyw197

39. Suresh D, Srinivas AN, Kumar DP. Etiology of hepatocellular carcinoma: special focus on fatty liver disease. *Front Oncol*. (2020) 10:601710. doi: 10.3389/fonc.2020.601710

40. Tylor RP, Roy SK, Srivastava A, LaVeist TA, Shankar S, Srivastava RK. Assessment of risk factors, and racial and ethnic differences in hepatocellular carcinoma. *JGH Open*. (2020) 4:351–9. doi: 10.1002/jgh3.12336

41. Baecker A, Liu X, la Vecchia C, Zhang ZF. Worldwide incidence of hepatocellular carcinoma cases attributable to major risk factors. *Eur J Cancer Prev*. (2018) 27:205–12. doi: 10.1097/CEJ.0000000000000428

42. Kolly P, Knöpfli M, Dufour JF. Effect of smoking on survival of patients with hepatocellular carcinoma. *Liver Int*. (2017) 37:1682–7. doi: 10.1111/liv.13466

43. Luu HN, Behari J, Goh GBB, Wang R, Jin A, Thomas CE, et al. Composite score of healthy lifestyle factors and risk of hepatocellular carcinoma: findings from a prospective cohort study. *Cancer Epidemiol Biomarkers Prev*. (2021):380–7. doi: 10.1158/1055-9965.EPI-20-1201

44. Zelber-Sagi S, Noureddin M, Shibolet O. Lifestyle and hepatocellular carcinoma what is the evidence and prevention recommendations. *Cancers (Basel)*. (2021) 14:1. doi: 10.3390/cancers14010103

45. Lahelma M, Luukkonen PK, Qadri S, Ahlholm N, Lallukka-Brück S, Porthan K, et al. Assessment of lifestyle factors helpsodentify liver fibrosis dueo non-alcoholic fatty liver disease in obesity. *Nutrients*. (2021) 13:1–13. doi: 10.3390/nu13010169

46. Hagström H. Alcohol, smoking andhe liver disease patient. *Best Pract Res Clin Gastroenterol*. (2017). 31:537–43. doi: 10.1016/j.bpg.2017.09.003

47. Hasan KM, Friedman TC, Shao X, Parveen M, Sims C, Lee DL, et al. E-cigarettes and western diet: important metabolic risk factors for hepatic diseases. *Hepatology*. (2019) 69:2442–54. doi: 10.1002/hep.30512

48. Wong LP, Mohamad Shakir SM, Alias H, Aghamohammadi N, Hoe VC. Reasons for using electronic cigarettes and intentionso quit among electronic cigarette users in Malaysia. *J Community Health*. (2016) 41:1101–9. doi: 10.1007/s10900-016-0196-4

49. Lestari KS, Humairo MV, Agustina U. Formaldehyde vapor concentration in electronic cigarettes and health complaints of electronic cigarettes smokers Indonesia. *J Environ Public Health*. (2018) 2018:9013430. doi: 10.1155/2018/9013430

50. Zheng J, Zhou Y, Zhang K, Qi Y, An S, Wang S, et al. Association between nonalcoholic fatty liver disease and subclinical atherosclerosis: a cross-sectional study on population over 40 years old. *BMC Cardiovasc Disord*. (2018) 18:147. doi: 10.1186/s12872-018-0877-2

51. Liu Y, Zhao P, Cheng M, Yu L, Cheng Z, Fan L, et al. ASTo ALT ratio and arterial stiffness in on-fatty liver Japanese population: a secondary analysis based on a cross-sectional study. *Lipids Health Dis*. (2018) 17:275. doi: 10.1186/s12944-018-0920-4

52. Magosso E, Ansari MA, Gopalan Y, Bakar M, Khan N, Wang J, et al. Prevalence of non-alcoholic fatty liver in a hypercholesterolemic population of northwestern peninsular Malaysia. *Southeast Asian J Trop Med Public Health*. 41:936-42.

53. Mantaka A, Koulentaki M, Samonakis D, Sifaki-Pistolla D, Voumvouraki A, Tzardi M, et al. Association of smoking with liver fibrosis and mortality in primary biliary cholangitis. *Eur J Gastroenterol Hepatol*. (2018) 30:1461–9. doi: 10.1097/MEG.0000000000001234

54. Costa FO, Cortelli SC, Cortelli JR, Lages EJP, Pereira GHM, Costa AM, et al. Association between liver cirrhosis and peri-implant diseases: a case-control study on implant- and patient-related risk factors. *Clin Oral Investig*. (2022) 26:3563–72. doi: 10.1007/s00784-021-04324-6

55. Xiao J, Lim LKE, Ng CH, Tan DJH, Lim WH, Ho CSH, et al. Fatty liver associated with depression? a meta-analysis and systematic review on the prevalence, risk factors, and outcomes of depression and non-alcoholic fatty liver disease. *Front Med (Lausanne)*. (2021) 8:912. doi: 10.3389/fmed.2021.691696

56. Ramesh V, Pal C. Organ donation and transplantation in India in 2019. *Exp Clin Transplant*. (2021). 19:1313–21. doi: 10.6002/ect.2021.0105

57. Udomsin K, Lapisatepun W, Chotirosniramit A, Sandhu T, Ariyakachon V, Lorsomradee S, et al. Adult-to-adult living donor liver transplantation: postoperative outcomes and quality of life in liver donors: first report in Thailand. *Transplant Proc*. (2019) 51:2761–5. doi: 10.1016/j.transproceed.2019.03.080

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 December 2022
DOI 10.3389/fpubh.2022.1021495

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 17 August 2022
ACCEPTED 16 November 2022
PUBLISHED 16 December 2022

CITATION
Marzo RR, ElSherif M, Abdullah MSAMB, Thew HZ, Chong C, Soh SY, Siau CS, Chauhan S and Lin Y (2022) Demographic and work-related factors associated with burnout, resilience, and quality of life among healthcare workers during the COVID-19 pandemic: A cross sectional study from Malaysia. *Front. Public Health* 10:1021495. doi: 10.3389/fpubh.2022.1021495

Demographic and work-related factors associated with burnout, resilience, and quality of life among healthcare workers during the COVID-19 pandemic: A cross sectional study from Malaysia

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Introduction: The healthcare setting is a stressful and demanding work environment, and healthcare workers face a continuous expansion of their job roles and responsibilities. Past studies have shown that factors affecting burnout, resilience, and quality of life among healthcare workers merit further research, as there were inconsistent findings, especially with regards to the influence of demographic and work-related factors. Therefore, this study aims to determine whether demographic and work-related factors are associated with burnout, resilience, and quality of life among healthcare workers.

Method: This cross-sectional study was conducted between February 15, 2022 and March 15, 2022, among 394 healthcare workers from Putrajaya and Selangor hospitals, Malaysia. Maslach Burnout Inventory, World Health Organization Quality of Life-BREF 26 inventory, and Brief Resilience Scale were utilized to capture information on burnout, quality of life, and resilience, respectively.

Results: The mean score of physical health of participants who work more than 10 h (11.38) is lower than participants who work from 8 to 10 h (13.00) and participants who work 7 h daily (13.03), p-value < 0.001. Similarly, the mean

score of psychological health of participants who work more than 10 h (12.35) is lower than participants who work from 8 to 10 h (13.72) and participants who work 7 h daily (13.68), p-value = 0.001. Higher income levels were associated with high resilience and quality of life.

Conclusion: It is imperative that healthcare practitioners and policy makers adopt and implement interventions to promote a healthy workplace environment, address ethical concerns, and prevent burnout among healthcare workers during the COVID-19 pandemic. Managing the issue of long working hours could possibly result in improved resilience, burnout, and quality of life among healthcare workers. Despite this study able to tickle out some policy specific areas where interventions are needed, identifying effective solutions and evaluating their efficiency will require larger and interventional studies.

KEYWORDS

burnout, resilience, quality of life, influencing factors, healthcare workers, Malaysia

Introduction

The healthcare setting is a stressful and demanding work environment, and healthcare workers (HCWs) face a continuous expansion of their job roles and responsibilities, such as increasing bureaucratic tasks and computerization of the healthcare system (1, 2). With the advent of the coronavirus disease 2019 (COVID-19) pandemic, a worldwide medical emergency, additional stress was put upon the healthcare system, resulting in high levels of psychological distress and burnout among HCWs (3–7). General population across countries is also affected by COVID-19 pandemic in terms of their health (8–10). This study explored burnout, resilience, and quality of life (QoL) among HCWs in Malaysia.

Burnout refers to a state of exhaustion resulting from prolonged stress, and is typified by three syndromes, including emotional exhaustion (EE), depersonalization (DP), and personal accomplishment (PA) (11). An individual who experiences burnout would typically report physical and emotional overextension, feelings of cynicism and callousness toward his/her work, and a worse level of professional efficacy (11). In the latest version of the International Classification of Diseases-11 (12), burnout has now been redefined as a workplace phenomenon involving the three syndromes described above, rather than as a result of difficulty in the management broad life circumstances. The prevalence of burnout in the healthcare setting has been high, both before and during the COVID-19 pandemic (13, 14). During the COVID-19 pandemic, the level of burnout among HCWs was expected to be higher due to longer working hours, sleep deprivation, and the need to adhere to preventive measures against the virus (15, 16). The pooled prevalence of burnout found in thirty observational studies was 52.0%, with DP being the highest syndrome (52.0%), followed by EE (51.0%), and low PA (28.0%) (17).

Burnout is an important area for further investigation, as burnout syndrome among HCWs has been shown to have service implications such as worse patient safety (18). A number of factors are associated with burnout among HCWs. Systematic reviews showed that job stress, time pressure, high workload, long working hours, low job satisfaction, and low organizational support were factors associated with burnout (19, 20). Demographic factors associated with burnout were younger age, female sex, and marital status (20). A study in Malaysia during the COVID-19 pandemic showed that workload, uncertainties caused by the pandemic, challenging work-family balance, and stretched workplace relationships influenced burnout among HCWs (21).

As HCWs are among the professionals most affected by the COVID-19 pandemic, it is important to study how psychological resilience helped them to cope (22). Resilience refers to an individual's ability to adapt to and rebound from negative workplace stresses such as conflict, failure, and uncertainty (23, 24). Inculcating resilience involves developing coping strategies in order to pre-empt reactions to stressful situations (25). A study showed that nurses with a higher education (postgraduate degree vs. bachelor's degree) exhibited higher resilience against developing posttraumatic stress (26). Demographic factors were inconsistently associated with resilience. For example, systematic reviews among doctors and nurses found differing results in the significance of age, education level, income, marital status, work experience, and job status on resilience (27, 28). Other factors, such as burnout and high psychological distress, however, were consistently associated with lower resilience among HCWs (27, 28). During the COVID-19 pandemic, a study among Portuguese HCWs showed that psychological resilience had a mediating effect in the relationship between depression and burnout (29).

The World Health Organization (WHO) defines QoL as "the individual's perception of their position in life in the context of

the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (30). Apart from biomedical outcomes, QoL has been increasingly used as a yardstick to measure wellbeing in health research (31). However, while it has been used extensively among patients, there is less research on HCW's QoL. A study in Saudi Arabia showed that a high proportion of nurses reported good QoL (32). Another study in India during the COVID-19 pandemic showed that low QoL was prevalent among HCWs, at 45.0% (33). Factors associated with QoL among HCWs were not consistent across studies. For example, a study among Iranian nurses found that work experience, gender, job position and group of patients treated were unrelated with QoL (34). However, another study from Saudi Arabia showed that demographic and work factors such as age, marital status, having children, income, education, working experience, and department were associated with QoL (32).

Past studies have shown that factors affecting burnout, resilience, and QoL among HCWs merit further research, as there were inconsistent findings, especially with regards to the influence of demographic and work-related factors. During the COVID-19 pandemic, HCWs are also exposed to unique factors that may affect their levels of burnout, resilience, and QoL. COVID-19 infection status may affect an individual in all aspects of their lives. For example, an individual will experience negative physical symptoms, psychological fear, and social isolation when infected by the virus (35), thus affecting their QoL. Being infected by the COVID-19 will also exacerbate burnout symptoms (36). Therefore, it is important to study the association between COVID-19 infection status and HCWs' burnout, resilience, and QoL.

Due to the medical crisis of the COVID-19 pandemic, prolonging into an endemic, identification of factors affecting burnout, resilience, and QoL among HCWs could help to focus on specific points for intervention in order to build a strong healthcare workforce. Therefore, this study aims to determine whether gender, specialty, age, education level, income level, work duration, duration of socialization, and COVID-19 infection status are associated with burnout, resilience, and QoL among HCWs.

Materials and methods

Study population and sampling

This cross-sectional study was conducted between February 15, 2022 and March 15, 2022 to evaluate the level of burnout, QoL, and resilience among HCWs from Putrajaya and Selangor hospitals of Malaysia. The study was conducted during the fifth wave fuelled by the Omicron variant that led to maximum daily cases in February and March 2022 (37, 38), but is marked by lower numbers of hospitalizations and deaths than during the spread of the Delta variant (38). As of March 2022, the BA.2 Omicron sub-variant was projected to be the dominant strain in the country (39). The country's vaccination programme, which commenced in late February 2021 (40), has fully inoculated over 80% of the population and 97% of adults as of April 24, 2022 (41). On February 13, 2022, the total number of cases in Malaysia exceeded the 3 million mark, reaching 3,040,235 (41). By February 24, 2022, the total number of recoveries had reached the 3 million mark, reaching 3,018,172 (41).

The study used a convenience sampling method for recruitment. The online survey was disseminated *via* various social media platforms such as Instagram, Twitter, LinkedIn, Facebook, WhatsApp, and Telegram. The target population was adult Malaysian HCWs aged 18 years old and above. We invited Malaysian assistant medical officers, doctors, health inspectors, hospital food preparation personnel, medical laboratory technologists, nurses, paramedics, pharmacists, physicians, physiotherapists, dieticians, therapists, psychologists, counselors, radiographers, and social workers from public and private healthcare services to enroll in this study. All respondents were informed that their participation was anonymous and voluntary at the beginning of the survey. Consent was implied if the participants started answering the questionnaire. This research complied with the tenets of the Declaration of Helsinki.

Cochran's formula was used to calculate the minimum recommended sampling size (42). The minimal sample size required for this study with a confidence level of 95%, ± 5% precision and 0.5 estimated proportion was 385 study participants. A total of 394 completed responses were collected. The Institutional Review Board granted approval and the requirement for written informed consent was waived based on the recognition that answering the survey instrument implied consent. Participation was voluntary and anonymity was assured. All personal information was kept confidential. Furthermore, researchers analyzed only de-identified data.

Study instruments

Sociodemographic and work-related characteristics

The data collection instrument comprised of five parts. The first part of the tool asked questions pertaining sociodemographic and work-related characteristics. The choice of variables was informed by the available literature and inputs from the investigators. Participants were requested to indicate their age, gender, marital status, specialty, educational level, income, number of family members, job title, place of work, years of experience, hours of working, and socialization time per week. This section also asked whether the respondent had been attending COVID-19 patient directly, had been infected with

COVID-19, and their willingness to have another COVID-19 vaccine's booster doses in the future.

Maslach burnout inventory questionnaire

The second part of the study tool was a translated version of Maslach burnout inventory (MBI) (11). To limit the study to burnout related to COVID-19, the phrase "due to COVID-19" was added to each item. MBI is an internationally recognized, validated, self-report questionnaire for measuring the severity of workplace burnout, using the three dimensions of EE, DP, and PA. The questionnaire has 22 items and each item is answered on a seven-point Likert scale. This tool has been extensively used in many studies in different parts of the world and the Malaysian translation has also been validated previously (43, 44).

Burnout is expressed by scores of each of the three MBI subscales, with a high score meaning a high level of burnout. Each subscale score is calculated by adding up all scores of all items in that subscale, with the notion that the items on PA domain are reversely scored (11). Scores range from 0 to 54 for EE, from 0 to 30 for DP, and from 0 to 48 for PA subscale. Scales are scored such that higher scores indicate more of each construct. Higher scores on the EE and DP subscales indicate a higher burnout symptom burden; lower scores on the PA subscale indicate a higher burnout symptom burden. The standard cut-off values were used to define low, moderate, and high levels in each dimension (11). The Cronbach's alpha was 0.86.

WHO quality of life-BREF 26

The WHOQOL-BREF is a 26-item instrument consisting of four domains: physical health (seven items), psychological health (six items), social relationships (three items), and environmental health (eight items); it also contains QOL and general health items. Each individual item of the WHOQOL-BREF is scored from 1 to 5 on a response scale, which is stipulated as a five-point ordinal scale (45).

The physical health domain questions are based on daily activities, medical aid, energy, mobility, the extent of pain, sleeping pattern, and working capacity. The psychological domain focuses on participants' personal beliefs, positive and negative feelings, self-esteem, body image, thinking, and learning capabilities. The social relationships domain explores the respondent's overall satisfaction with their personal and social life. Lastly, the environment domain comprises questions about safety and security, contentment with one's property and physical surroundings, finances (does one have enough money to satisfy one's requirements), access to the necessary care, information, and transport. Moreover, the questionnaire has two specific questions regarding participants' opinions regarding their overall QoL and health. We used the Bahasa melayu validated version of the original WHOQOL-BREF questionnaire (46, 47). The Cronbach's alpha was 0.89.

Brief Resilience Scale

The last section is the Brief Resilience Scale (BRS) questionnaire to assess the perceived ability to bounce back or recover from stress (48). The scale was developed to assess a unitary construct of resilience, including both positively and negatively worded items.

The BRS has six items presented in Table 1. Items 1, 3, and 5 are positively worded, and items 2, 4, and 6 are negatively worded. The BRS is scored by reverse coding items 2, 4, and 6 and finding the mean of the six items. The following instructions are used to administer the scale: "Please indicate the extent to which you agree with each of the following statements by using the following scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree." The possible score range on the BRS is from 1 (low resilience) to 5 (high resilience). It composes of 6 questions with a score on interpretation 1.00–2.99 as low resilience, 3.00–4.30 as normal resilience and lastly 4.31–5.00 as high resilience. The Cronbach's alpha was 0.76.

Data analysis

At first, normality of the data was checked. Descriptive statistics are presented in the form of numbers and percentages for the categorical variables. Mean and standard deviation (SD) are reported for numerical variables. Chi square and exact test were used to compare categorical variables (burnout, resilience levels) across different variables. The independent samples *t*-test and one way ANOVA test were used to compare numerical variables (quality of life) across different variables. IBM SPSS 28 for windows software was used for the analysis, and a P-value < 0.05 is considered statistically significant.

Ethic statement

The study was designed and conducted in line with the declaration of Helsinki (49) and was approved by the Ethics Committee of Management and Science University (Ethics Code: MSU-RMC-02/FR01/09/L1/085). Respondents were informed that their participation was voluntary, and written consent was implied on the completion of the questionnaire. All participants were aged 18 years or older.

Results

A total of 394 respondents were included in this study. About 87.1% of the participants were females. Age of 43.1% of the

10.3389/fpubh.2022.1021495

TABLE 1 Socio-demographics of participants ($N = 394$).

	N	%
Gender		
Male	51	12.9
Female	343	87.1
Age		
Less than 25 years	81	20.6
From 25–35 years	170	43.1
From 35–55 years	123	31.2
More than 55 years	20	5.1
Specialty		
Doctor	55	14.0
Nurse	248	62.9
Others	91	23.1
Income level		
≤ RM 4,850	282	71.6
RM 4,850 – RM 10,959	100	25.4
≥ RM 10,959	12	3.0
Education background		
Primary	30	7.6
Secondary	178	45.2
Tertiary	186	47.2
Working experiences		
No experience	28	7.1
Less than 5 years	125	31.7
From 5–10 years	92	23.4
More than 10 years	149	37.8
Working duration		
Less than 7 h	4	1.0
7 h daily	117	29.7
From 8 to 10 h daily	216	54.8
More than 10 h	57	14.5
Family members		
Less than 5	152	38.6
5–10	220	55.8
More than 10	22	5.6
Socializing duration		
No time	12	3.0
Less than 5 h	95	24.1
From 5 to 10 h	129	32.7
More than 10 h	158	40.1
Dealing with COVID-19		
No	205	52.0
Yes	189	48.0
Infected with COVID-19		
No	213	54.1
Yes	181	45.9
COVID-19 vaccine booster		
Very unlikely	32	8.1
Unlikely	63	16.0
Somewhat unlikely	58	14.7
Somewhat likely	79	20.1
Likely	101	25.6
Very likely	61	15.5

participants ranged from 25 to 35 years, 31.2% from 36 to 55 years, 20.6% were <25 years, and 5.1% were more than 55 years. About 62.9% of participants were nurses, 14% were doctors, and the remaining were from other specialties in the medical field (Table 1).

As depicted in Table 2, burnout, resilience, and QoL levels showed no statistically significant differences between males and females.

Burnout showed no statistically significant differences between different specialties among the HCWs (Table 3). Levels of QoL and resilience showed statistically significant differences between different specialties. The mean score of physical health of nurses is higher than that of doctors (13.13 vs. 11.79, p-value ≤ 0.001). The mean score of psychological health of nurses is higher than doctors (13.78 vs. 12.70, p-value $= 0.009$). The mean score of social relationships of nurses is higher than doctors (14.61 vs. 13.24, p-value $= 0.003$). Of all the participants with low resilience, 19.1% of participants were doctors, 53.2% were nurses, and 27.7% were from other professions. Similarly, about 11.9% of participants who have normal resilience were doctors, 66.7% were nurses, and 21.4% were from other specialty (p-value $= 0.038$).

Burnout and resilience levels showed no statistically significant differences between different age groups (Table 4). The only variable that showed statistically significant differences between different age groups is the level of QoL. The mean score of physical health of participants from 25 to 36 years old (12.25) was lower than participants <25 years old (13.09) and participants from 36 to 55 years old (13.31; p-value < 0.001). Table 5 shows that burnout and resilience levels had no statistically significant differences between different levels of education. The only variable that showed statistically significant differences between different education levels was level of QoL. The mean score of physical health of participants who had secondary education was higher than participants who had tertiary education (13.12 vs. 12.44, p-value $= 0.020$). The mean score of psychological health participants who had secondary education was higher than participants who had tertiary education (13.91 vs. 13.26, p-value $= 0.013$). Table 6 depicts that burnout showed no statistically significant differences between different levels of income. The variables that showed statistically significant differences between different levels of income were

10.3389/fpubh.2022.1021495

TABLE 2 Differences in burnout, quality of life, and resilience levels based on gender.

		Male		Female		*P*-value
		N	%	*N*	%	
Burnout	Occupational exhaustion					0.176
	Low degree	1	2.90%	34	97.10%	
	Moderate degree	28	14.10%	171	85.90%	
	High degree	22	13.80%	138	86.30%	
	Degree of depersonalization					0.901
	Low degree	0	0.00%	5	100.00%	
	Moderate degree	4	10.50%	34	89.50%	
	High degree	47	13.40%	304	86.60%	
	Degree of personal accomplishment					0.159
	Low degree	34	11.30%	267	88.70%	
	Moderate degree	12	20.30%	47	79.70%	
	High degree	5	14.70%	29	85.30%	
Quality of life (mean, SD)	Physical health	12.41	2.66	12.83	2.28	0.230
	Psychological health	13.07	2.88	13.59	2.45	0.173
	Level of social	14.12	3.99	14.18	3.26	0.909
	Level of environment	13.93	2.86	14.27	2.58	0.396
Resilience	Low	10	10.6%	84	89.4%	0.729
	Normal	40	13.6%	254	86.4%	
	High	1	16.7%	5	83.3%	

TABLE 3 Differences in burnout, quality of life, and resilience levels based on specialty.

		Doctor		Nurse		Others		*P*-value
		N	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion							0.104
	Low degree	2	5.70%	24	68.60%	9	25.70%	
	Moderate degree	22	11.10%	132	66.30%	45	22.60%	
	High degree	31	19.40%	92	57.50%	37	23.10%	
	Degree of depersonalization							0.099
	Low degree	0	0.00%	5	100.00%	0	0.00%	
	Moderate degree	1	10.50%	28	73.70%	9	23.70%	
	High degree	54	13.40%	215	61.30%	82	23.40%	
	Degree of personal accomplishment							0.077
	Low degree	37	12.30%	197	65.40%	67	22.30%	
	Moderate degree	14	23.70%	28	47.50%	17	28.80%	
	High degree	4	11.80%	23	67.60%	7	20.60%	
Quality of life (mean, SD)	Physical health	11.79	1.72	13.13	2.36	12.42	2.37	≤0.001
	Psychological health	12.70	2.17	13.78	2.48	13.29	2.69	0.009
	Level of social	13.24	3.08	14.61	3.30	13.57	3.48	0.003
	Level of environment	13.99	2.17	14.46	2.71	13.71	2.57	0.049
Resilience	Low	18	19.1%	50	53.2%	26	27.7%	0.038
	Normal	35	11.9%	196	66.7%	63	21.4%	
	High	2	33.3%	2	33.3%	2	33.3%	

10.3389/fpubh.2022.1021495

TABLE 4 Differences in burnout, quality of life, and resilience levels based on age.

		Less than 25 years		From 25 to 35 years		From 36 to 55 years		More than 55 years		*P*-value
		N	%	*N*	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion									0.607
	Low degree	6	17.10%	13	37.10%	14	40.00%	2	5.70%	
	Moderate degree	44	22.10%	79	39.70%	65	32.70%	11	5.50%	
	High degree	31	19.40%	78	48.80%	44	27.50%	7	4.40%	
	Degree of depersonalization									0.700
	Low degree	1	20.00%	1	20.00%	3	60.00%	0	0.00%	
	Moderate degree	7	18.40%	14	36.80%	15	39.50%	2	5.30%	
	High degree	73	20.80%	155	44.20%	105	29.90%	18	5.10%	
	Degree of personal accomplishment									0.133
	Low degree	68	22.60%	119	39.50%	96	31.90%	18	6.00%	
	Moderate degree	9	15.30%	34	57.60%	15	25.40%	1	1.70%	
	High degree	4	11.80%	17	50.00%	12	35.30%	1	2.90%	
Quality of life (mean, SD)	Physical health	13.09	2.59	12.25	2.42	13.31	1.91	12.80	2.01	≤0.001
	Psychological health	13.64	2.86	13.05	2.53	14.01	2.18	14.03	2.21	0.009
	Level of social	13.53	3.34	13.96	3.37	14.82	3.30	14.67	3.09	0.034
	Level of environment	13.85	2.61	13.69	2.67	14.98	2.28	15.63	2.71	≤0.001
Resilience	Low	20	21.3%	47	50.0%	26	27.7%	1	1.1%	<0.001
	Normal	61	20.7%	122	41.5%	96	32.7%	15	5.1%	
	High	0	0.0%	1	16.7%	1	16.7%	4	66.7%	

TABLE 5 Differences in burnout, quality of life, and resilience levels based on education level.

		Primary education		Secondary education		Tertiary education		*P*-value
		N	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion							0.517
	Low degree	4	11.40%	18	51.40%	13	37.10%	
	Moderate degree	13	6.50%	94	47.20%	92	46.20%	
	High degree	13	8.10%	66	41.30%	81	50.60%	
	Degree of depersonalization							0.23
	Low degree	1	20.00%	2	40.00%	2	40.00%	
	Moderate degree	2	5.30%	23	60.50%	13	34.20%	
	High degree	27	7.70%	153	43.60%	171	48.70%	
	Degree of personal accomplishment							0.370
	Low degree	26	8.60%	135	44.90%	140	46.50%	
	Moderate degree	2	3.40%	24	40.70%	33	55.90%	
	High degree	2	5.90%	19	55.90%	13	38.20%	
Quality of life (mean, SD)	Level of physical	12.84	2.56	13.12	2.39	12.44	2.20	0.020
	Level of psychological	12.82	3.24	13.91	2.35	13.26	2.49	0.013
	Level of social	13.69	3.62	14.67	3.21	13.78	3.41	0.030
	Level of environment	13.70	2.44	14.37	2.60	14.17	2.67	0.408
Resilience	Low	6	6.4%	40	42.6%	48	51.1%	0.810
	Normal	24	8.2%	136	46.3%	134	45.6%	
	High	0	0.0%	2	33.3%	4	66.7%	

TABLE 6 Differences in burnout, quality of life, and resilience levels based on income level.

		≤ RM 4,850		RM 4,850 – RM 10,959		≥ RM 10,959		*P*-value
		N	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion							0.859
	Low degree	25	71.40%	9	25.70%	1	2.90%	
	Moderate degree	147	73.90%	46	23.10%	6	3.00%	
	High degree	110	68.80%	45	28.10%	5	3.10%	
	Degree of depersonalization							0.87
	Low degree	4	80.00%	1	20.00%	0	0.00%	
	Moderate degree	27	71.10%	11	28.90%	0	0.00%	
	High degree	251	71.50%	88	25.10%	12	3.40%	
	Degree of personal accomplishment							0.959
	Low degree	214	71.10%	77	25.60%	10	3.30%	
	Moderate degree	43	72.90%	14	23.70%	2	3.40%	
	High degree	25	73.50%	9	26.50%	0	0.00%	
Quality of life (mean, SD)	Level of physical	12.82	2.39	12.66	2.24	12.81	1.71	0.844
	Level of psychological	13.49	2.58	13.52	2.33	14.28	2.44	0.567
	Level of social	14.12	3.27	14.25	3.67	14.89	2.53	0.713
	Level of environment	13.93	2.60	14.82	2.55	16.08	2.20	0.001
Resilience	Low	68	72.3%	24	25.5%	2	2.1%	0.001
	Normal	213	72.4%	74	25.2%	7	2.4%	
	High	1	16.7%	2	33.3%	3	50.0%	

TABLE 7 Differences in burnout, quality of life, and resilience levels based on work duration.

		Less than 7 h		7 h daily		From 8 to 10 h		More than 10 h		*P*-value
		N	%	*N*	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion									0.368
	Low degree	0	0.00%	14	40.00%	18	51.40%	3	8.60%	
	Moderate degree	2	1.00%	64	32.20%	108	54.30%	25	12.60%	
	High degree	2	1.30%	39	24.40%	90	56.30%	29	18.10%	
	Degree of depersonalization									0.35
	Low degree	0	0.00%	2	40.00%	3	60.00%	0	0.00%	
	Moderate degree	1	2.60%	13	34.20%	22	57.90%	2	5.30%	
	High degree	3	0.90%	102	29.10%	191	54.40%	55	15.70%	
	Degree of personal accomplishment									0.188
	Moderate degree	4	1.30%	29.20%	29.20%	171	56.80%	38	12.60%	
	High degree	0	0.00%	15	25.40%	29	49.20%	15	25.40%	
	High degree	0	0.00%	14	41.20%	16	47.10%	4	11.80%	
Quality of life (mean, SD)	Level of physical	13.71	2.84	13.03	2.42	13.00	2.20	11.38	2.13	<0.001
	Level of psychological	15.00	3.46	13.68	2.46	13.72	2.39	12.35	2.74	0.001
	Level of social	14.00	4.15	14.55	3.23	14.38	3.28	12.65	3.54	0.003
	Level of environment	15.38	1.31	14.21	2.46	14.56	2.57	12.87	2.80	<0.001
Resilience	Low	1	1.1%	28	29.8%	45	47.9%	1	1.1%	0.325
	Normal	3	1.0%	88	29.9%	167	56.8%	3	1.0%	
	High	0	0.0%	1	16.7%	4	66.7%	0	0.0%	

levels of QoL and resilience. The mean score of environment level of participants who took <RM 4,850 was lower than participants who took between RM 4,850 and RM 10,959 and participants who took more than RM 10,959 per month (p-value < 0.001). About 16.7% of participants who had high resilience took <RM 4,850, 33.3% took RM 4,850 to RM 10,959, and 50.0% took more than RM 10,959 per month (p-value $= 0.001$).

Table 7 shows that burnout and resilience levels had no statistically significant differences between participants with different work duration. The only variable that showed statistically significant differences between different work duration was level of QoL. The mean score of physical health of participants who worked more than 10 h (11.38) was lower than participants who worked from 8 to 10 h (13.00) and participants who worked for 7 h daily (13.03; p-value < 0.001). The mean score of psychological health of participants who worked more than 10 h (12.35) was lower than participants who worked from 8 to 10 h (13.72) and participants who worked 7 h daily (13.68; p-value $= 0.001$). The mean score of social relationships of participants who worked more than 10 h (12.65) was lower than participants who worked from 8 to 10 h (14.38) and participants who worked 7 h daily (14.55), p-value $= 0.003$. The mean score of environment level in participants who worked more than 10 h (12.87) was lower than participants who worked 7 h daily (14.21) and participants who worked from 8 to 10 h (14.56; p-value < 0.001).

Differences in burnout, quality of life, and resilience levels based on socializing duration were also measure in Table 8. No statistically significant differences were however found. Burnout, QoL, and resilience levels showed no statistically significant differences between HCWs who were infected and not infected with COVID-19 as shown in Table 9.

Discussion

This study aimed to determine whether gender, specialty, age, education level, income level, work duration, duration of socialization, and COVID-19 infection status were associated with burnout, resilience, and QoL among HCWs. To summarize, the bivariate analyses found that in terms of resilience, there was a significant difference between males and females, and number of hours socializing. In terms of QoL, level of physical health was different in terms of specialty, age, education level, and work duration; levels of psychological and social health were associated with specialty, age, education level, and work duration; level of environment was associated with only specialty, age, and income level. No significant differences were found among the demographic categories in terms of burnout.

An interesting finding of our study was that more females reported low resilience compared to males. The results are in contrast with a study from the UK among HCWs, which found females to have a higher resilience level than males (50). Likewise, during the COVID-19 pandemic, female HCWs showed higher resilience in the domain of social support compared to males (51). However, a study among radiology workers from China showed that females had lower resilience scores than males (52). Moreover, a meta-analysis on gender and resilience found that males had higher resilience scores than females (53). According to Hirani et al. (54), females usually scored lower on resilience measures due to existing definitions of resilience not adequately reflect how various factors (e.g., gender roles, social factors, and the environment) interact to shape women's experience of and responses to facing difficulties in life (54).

Meanwhile, we found that a higher proportion among those who spent the highest number of hours socializing (>10 h) reported low resilience. It has been shown in a number of studies that social support is an integral aspect of resilience (55, 56). The results found in this study shows that the number of hours spent socializing may not equal social support, as social support includes elements such as a subjective perception of how much an individual is being supported by others (57). In contrast, an individual who spends high number of hours socializing (i.e. more than 10 h) may find that their energy and time are depleted due to excessive socializing. There is a need to further investigate in future studies the content of one's socialization activities which contributes to one's resilience.

QoL in terms of physical health, psychological health and social relationships of nurses was higher than doctors in this study. The results are not consistent with another study by Çelmeçe and Menekay (58), who found no difference in the QoL of nurses and doctors in Turkey during the COVID-19 pandemic (58). On the other hand, another study conducted in Spain during the COVID-19 pandemic found that primary care doctors had lower professional QoL compared to nurses (59). Doctors who are responsible for significant clinical decisions may report lower QoL due to assuming greater responsibilities during this period in time. In addition, according to Li et al. (60), doctors undergo more negative work-related experiences compared with nurses (60). These may be possible reason that the participant doctors suffered from lower QoL in all domains in this study, and it warrants further examination.

In terms of age, QoL of older HCWs were generally higher than that of younger HCWs in all aspects of QoL. The findings are consistent with another study on QoL among nurses in Saudi Arabia, where nurses who were older consistently reported higher QoL in comparison to those who were younger (<30 years old) (32). During the COVID-19 pandemic, a study among COVID-19 recovered HCWs in Bangladesh indicated that QoL was also higher among those with older age (61). Older age may be associated with higher QoL because increase in experience in professional work usually grows in tandem with age; greater experience at work has been proposed to be a factor leading to higher QoL (62).

TABLE 8 Differences in burnout, quality of life, and resilience levels based on socializing duration.

		No time		Less than 5 h		From 5 to 10 h		More than 10 h		*P*-value
		N	%	*N*	%	*N*	%	*N*	%	
Burnout	Occupational exhaustion									0.774
	Low degree	1	2.90%	7	20.00%	16	45.70%	11	31.40%	
	Moderate degree	6	3.00%	48	24.10%	61	30.70%	84	42.20%	
	High degree	5	3.10%	40	25.00%	52	32.50%	63	39.40%	
	Degree of depersonalization									0.292
	Low degree	1	20.00%	0	0.00%	1	20.00%	3	60.00%	
	Moderate degree	0	0.00%	12	31.60%	12	31.60%	14	36.80%	
	High degree	11	3.10%	83	23.60%	116	33.00%	141	40.20%	
	Degree of personal accomplishment									0.39
	Low degree	8	2.70%	70	23.30%	99	32.90%	124	41.20%	
	Moderate degree	1	1.70%	18	30.50%	20	33.90%	20	33.90%	
	High degree	3	8.80%	7	20.60%	10	29.40%	14	41.20%	
Quality of life (mean, SD)	Level of physical	12.43	2.89	12.66	2.38	12.77	2.30	12.89	2.29	0.833
	Level of psychological	12.44	3.59	13.38	2.58	13.58	2.43	13.64	2.45	0.410
	Level of social	13.33	4.02	13.59	3.28	14.34	3.45	14.46	3.25	0.161
	Level of environment	13.75	2.12	13.74	2.48	14.19	2.79	14.58	2.56	0.090
Resilience	Low	3	3.2%	25	26.6%	3	3.2%	25	26.6%	0.858
	Normal	9	3.1%	69	23.5%	9	3.1%	69	23.5%	
	High	0	0.0%	1	16.7%	0	0.0%	1	16.7%	

TABLE 9 Differences in burnout, quality of life, and resilience levels between health worker who were infected and not infected with COVID-19.

		Not infected		Infected		*P*-value
		N	%	*N*	%	
Burnout	Occupational exhaustion					0.180
	Low degree	16	45.70%	19	54.30%	
	Moderate degree	102	51.30%	97	48.70%	
	High degree	95	59.40%	65	40.60%	
	Degree of depersonalization					0.830
	Low degree	2	40.00%	3	60.00%	
	Moderate degree	21	55.30%	17	44.70%	
	High degree	190	54.10%	161	45.90%	
	Degree of personal accomplishment					0.318
	Low degree	157	52.20%	144	47.80%	
	Moderate degree	34	57.60%	25	42.40%	
	High degree	22	64.70%	12	35.30%	
Quality of life (mean, SD)	Level of physical	12.76	2.44	12.80	2.20	0.865
	Level of psychological	13.63	2.49	13.39	2.54	0.341
	Level of social	14.19	3.26	14.16	3.47	0.924
	Level of environment	14.26	2.64	14.18	2.60	0.767
Resilience	Low	49	52.1%	45	47.9%	0.368
	Normal	159	54.1%	135	45.9%	
	High	5	83.3%	1	16.7%	

We found an inverse relationship between participants' education level and QoL, where participants with a secondary education reported higher QoL in all aspects in comparison with participants with a tertiary education. Studies have reported that individuals with higher educational level reported higher QoL (63–65), possibly due to the beneficial influence of higher health literacy among those with more educational years (66). However, a study among HCWs in Malaysia during the COVID-19 pandemic showed that there were no differences in all QoL domains in terms of education level (67). In our study, individuals with a tertiary education may have lower QoL due to assuming responsibilities and making decisions which would more directly impact patients, in comparison with those who had secondary education. The greater responsibility assumed in patient healthcare may have contributed to lower QoL due to experiencing more job-related stress.

All domains of QoL were lower among HCWs who worked more than 10 h per day. To cope with the rising demands for healthcare during the COVID-19 pandemic, accompanied by the depletion of HCWs due to infection of COVID-19 virus, there were a number of strategies used to increase HCW capacity (68). The most common strategy reported was extending the working hours of HCWs, and this includes working overtime, canceling leaves, and allowing back-to-back shifts (69). The length of working hours among HCWs has been associated with a number of negative physical, psychological, and safety outcomes among HCWs, such as musculoskeletal pain (70), fatigue and isolation (71), and less time to participate in social activities (69). All this may have negatively affected the QoL of the HCWs who worked for longer hours.

In this study, HCWs who earned <RM 4,850 reported lower QoL in their environmental level in comparison with those who earned more per month. The results are consistent with past studies, in which individuals from a lower-income background may suffer from lower environment QoL (61, 72–74). For example, a large-scale survey in Malaysia with 18,607 rural residents found that compared with individuals with low income, those enjoying middle and high income had higher perceived QoL in all four domains (75). Environmental QoL may be lower among HCWs with low income due to poorer living conditions, financial issues, and physical insecurities (61, 73).

The study results showed that there were no differences in terms of burnout, resilience, and QoL among HCWs who had been infected or not infected by the COVID-19 virus. The results are not consistent with extant literature, where those who had been infected by the COVID-19 virus reported higher burnout levels (36, 76). Infection status may also lead to physical and psychological ramifications, eventually leading to lower QoL (35). However, a study conducted among the Italian general population found that COVID-19 infection did not significantly predict resilience (77). As this study was carried out during the later stages of the COVID-19 pandemic when most HCWs had been vaccinated against the virus, having been infected by the virus may not have affected the HCWs in terms of their burnout, resilience, and QoL.

The results of this study have significance on identifying HCWs who may be at risk of burnout, low resilience, and low QoL during the COVID-19 pandemic and beyond. It is important to identify the related demographic and work factors in order to more effectively screen HCWs for the presence of these conditions, and to provide age-, gender-, and specialty-appropriate interventions. Healthcare authorities should be mindful of the negative consequences of long working hours on HCW's QoL. Attention should be paid to younger HCWs' and doctors' QoL, to find out the specific work, physical or psychological characteristics contributing to lower QoL. Issues pertaining to the environmental health of HCWs with lower income should also be identified and addressed.

This study has a few limitations. Being a cross-sectional study, we could not infer a cause-and-effect relationship between the variables. Since the participants were not randomly sampled, we could not rule out the presence of bias in this study. Other aspects which possibly contribute to burnout, resilience, and QoL among HCWs were not explored, such as the influence of religion, workload, and psychological distress. Future studies can be conducted to understand the role of resilience and coping in mediating burnout and QoL among HCWs. A combination of quantitative and qualitative methodology in future studies would be able to provide in-depth information on the possible causes that led to our findings.

Conclusion

This study explored demographic and work-related factors associated with burnout, resilience, and QoL among HCWs in Malaysia during the COVID-19 pandemic. The findings of this study call out for some specific interventions from policy makers. Nurses were more prone to report poor scores on burnout and resilience than doctors. However, they reported higher mean score on various dimensions of QoL than doctors. Age of the HCWs was an important factor in determining resilience as HCWs with higher age reported high resilience. Though inferential but low age of the HCWs means they are new to the profession and therefore overburdened and not experienced as compared to their senior counterparts who have years of experience, that works as a coping strategy for them. The study confirmed that higher income level leads to better resilience and longer work duration leads to low level of QoL. It is imperative that healthcare practitioners and policy makers adopt and implement interventions to promote a healthy workplace environment, address ethical concerns, and prevent burnout among healthcare workers during and beyond the COVID-19 pandemic. Managing the issue of long working hours could possibly result in improved resilience, burnout, and QoL

among HCWs. Though this study may be able to inform some policy specific areas where interventions are needed, identifying effective solutions and evaluating their effectiveness will require larger and interventional studies.

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

Author contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas, took part in drafting, revising, or critically reviewing the article, gave final approval of the version to be published, have agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Special Projects of the Central Government Guiding Local Science and Technology Development, China (No. 2021L3018). The funder was not involved in study design, in the collection, analysis and interpretation of data, in the writing of the manuscript, and nor in the decision to submit the manuscript for publication.

Conflict of interest

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

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References

1. Kanchanachitra C, Lindelow M, Johnston T, Hanvoravongchai P, Lorenzo FM, Huong NL, et al. Human resources for health in Southeast Asia: shortages, distributional challenges, and international trade in health services. *Lancet.* (2011) 377:769–81. doi: 10.1016/S0140-6736(10)62035-1

2. Reith TP. Burnout in United States healthcare professionals: a narrative review. *Cureus.* (2018) 10:3681. doi: 10.7759/cureus.3681

3. Chew QH, Chia FLA, Ng WK, Lee WCI, Tan PLL, Wong CS, et al. Perceived stress, stigma, traumatic stress levels and coping responses amongst residents in training across multiple specialties during COVID-19 pandemic—a longitudinal study. *Int J Environ Res Public Health.* (2020) 17:6572. doi: 10.3390/ijerph17186572

4. Chirico F, Ferrari G, Nucera G, Szarpak Ł, Crescenzo P, Ilesanmi O. Prevalence of anxiety, depression, burnout syndrome, and mental health disorders among healthcare workers during the COVID-19 pandemic: a rapid umbrella review of systematic reviews. *J Health Soc Sci.* (2021) 6:209–20. Available online at: https://journalhss.com/wp-content/uploads/jhhs_62_209-220.pdf

5. Shechter A, Diaz F, Moise N, Anstey DE, Ye S, Agarwal S, et al. Psychological distress, coping behaviors, and preferences for support among New York healthcare workers during the COVID-19 pandemic. *Gen Hosp Psychiatry.* (2020) 66:1–8. doi: 10.1016/j.genhosppsych.2020.06.007

6. Kamberi F, Sinaj E, Jaho J, Subashi B, Sinanaj G, Jaupaj K, et al. Impact of COVID-19 pandemic on mental health, risk perception and coping strategies among health care workers in Albania - evidence that needs attention. *Clin Epidemiol Glob Health.* (2021) 12:824. doi: 10.1016/j.cegh.2021.100824

7. Htay MNN, Marzo RR, Bahari R, AlRifai A, Kamberi F, El-Abasiri RA, et al. How healthcare workers are coping with mental health challenges during COVID-19 pandemic? - a cross-sectional multi-countries study. *Clin Epidemiol Glob Health.* (2021) 11:759. doi: 10.1016/j.cegh.2021.100759

8. Marzo RR, Singh A, Mukti RF. A survey of psychological distress among Bangladeshi people during the COVID-19 pandemic. *Clin Epidemiol Glob Health.* (2021) 10:693. doi: 10.1016/j.cegh.2020.100693

9. Marzo RR, Vinay V, Bahari R, Chauhan S, Ming DAF, Fernandez SFAN, et al. Depression and anxiety in Malaysian population during third wave of the COVID-19 pandemic. *Clin Epidemiol Glob Health.* (2021) 12:868. doi: 10.1016/j.cegh.2021.100868

10. Marzo RR, Khanal P, Ahmad A, Rathore FA, Chauhan S, Singh A, et al. Quality of life of the elderly during the COVID-19 pandemic in Asian countries: a cross-sectional study across six countries. *Life.* (2022) 12:365. doi: 10.3390/life12030365

11. Maslach C, Jackson SE, Leiter MP. Maslach burnout inventory. 3rd ed. In: MD Lanham, editor, Evaluating Stress: A Book of Resources. Lanham, MD: Scarecrow Education (1997). p. 191–218.

12. WHO. *ICD-11.* Available online at: https://icd.who.int/en (accessed November 14, 2022).

13. Rotenstein LS, Torre M, Ramos MA, Rosales RC, Guille C, Sen S, et al. Prevalence of burnout among physicians: a systematic review. *J Am Med Assoc.* (2018) 320:1131–50. doi: 10.1001/jama.2018.12777

14. Woo T, Ho R, Tang A, Tam W. Global prevalence of burnout symptoms among nurses: a systematic review and meta-analysis. *J Psychiatr Res.* (2020) 123:9–20. doi: 10.1016/j.jpsychires.2019.12.015

15. Amanullah S, Ramesh Shankar R. The impact of COVID-19 on physician burnout globally: a review. *Healthcare.* (2020) 8:421. doi: 10.3390/healthcare8040421

16. Ching SM, Ng KY, Lee KW, Yee A, Lim PY, Ranita H, et al. Psychological distress among healthcare providers during COVID-19

in Asia: systematic review and meta-analysis. *PLoS ONE.* (2021) 16:e0257983. doi: 10.1371/journal.pone.0257983

17. Ghahramani S, Lankarani KB, Yousefi M, Heydari K, Shahabi S, Azmand S, et al. Systematic review and meta-analysis of burnout among healthcare workers during COVID-19. *Front Psychiatry.* (2021) 12:758849. doi: 10.3389/fpsyt.2021.758849

18. de Garcia CL, de Abreu LC, Ramos JLS, de Castro CFD, Smiderle FRN, dos Santos JA, et al. Influence of burnout on patient safety: systematic review and meta-analysis. *Medicina.* (2019) 55:553. doi: 10.3390/medicina55090553

19. Dugani S, Afari H, Hirschhorn LR, Ratcliffe H, Veillard J, Martin G, et al. Prevalence and factors associated with burnout among frontline primary health care providers in low- and middle-income countries: a systematic review. *Gates Open Res.* (2018) 2:4. doi: 10.12688/gatesopenres.12779.1

20. Amoafo E, Hanbali N, Patel A, Singh P. What are the significant factors associated with burnout in doctors? *Occup Med.* (2015) 65:117–21. doi: 10.1093/occmed/kqu144

21. Roslan NS, Yusoff MSB, Asrenee AR, Morgan K. Burnout prevalence and its associated factors among Malaysian healthcare workers during covid-19 pandemic: an embedded mixed-method study. *Healthcare.* (2021) 9:10090. doi: 10.3390/healthcare9010090

22. Bozdag F, Ergün N. Psychological resilience of healthcare professionals during COVID-19 pandemic. *Psychol Rep.* (2021) 124:2567–86. doi: 10.1177/0033294120965477

23. Luthans F. The need for and meaning of positive organizational behavior. *J Organ Behav.* (2002) 23:695–706. doi: 10.1002/job.165

24. Rushton CH, Batcheller J, Schroeder K, Donohue P. Burnout and resilience among nurses practicing in high-intensity settings. *Am J Crit Care.* (2015) 24:412–20. doi: 10.4037/ajcc2015291

25. Schreiber M, Cates DS, Formanski S, King M. Maximizing the resilience of healthcare workers in multi-hazard events: lessons from the 2014–2015 Ebola Response in Africa. *Milit Med.* (2019) 184(Suppl.1):114–20. doi: 10.1093/milmed/usy400

26. Mealer M, Jones J, Meek P. Factors affecting resilience and development of posttraumatic stress disorder in critical care nurses. *Am J Crit Care.* (2017) 26:184–92. doi: 10.4037/ajcc2017798

27. McKinley N, Karayiannis PN, Convie L, Clarke M, Kirk SJ, Campbell WJ. Resilience in medical doctors: a systematic review. *Postgrad Med J.* (2019) 95:140–7. doi: 10.1136/postgradmedj-2018-136135

28. Yu F, Raphael D, Mackay L, Smith M, King A. Personal and work-related factors associated with nurse resilience: a systematic review. *Int J Nurs Stud.* (2019) 93:129–40. doi: 10.1016/j.ijnurstu.2019.02.014

29. Serrão C, Duarte I, Castro L, Teixeira A. Burnout and depression in portuguese healthcare workers during the COVID-19 pandemic—the mediating role of psychological resilience. *Int J Environ Res Public Health.* (2021) 18:636. doi: 10.3390/ijerph18020636

30. WHO. *WHOQOL - Measuring Quality of Life*. (2022). Available online at: https://www.who.int/tools/whoqol (accessed August 2, 2022).

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

32. Ibrahim NK, Alzahrani NA, Batwie AA, Abushal RA, Almogati GG, Sattam MA, et al. Quality of life, job satisfaction and their related factors among nurses working in king Abdulaziz University Hospital, Jeddah, Saudi Arabia. *Contemp Nurse.* (2016) 52:486–98. doi: 10.1080/10376178.2016.1224123

33. Suryavanshi N, Kadam A, Dhumal G, Nimkar S, Mave V, Gupta A, et al. Mental health and quality of life among healthcare professionals during the COVID-19 pandemic in India. *Brain Behav.* (2020) 10:e01837. doi: 10.1002/brb3.1837

34. Aalaa M, Sanjari M, Tootee A, Mirzabeigi G, Salemi S. Assessment of quality of life of Iranian nurses. *Nurs Rep.* (2012) 2:e10. doi: 10.4081/nursrep.2012.e10

35. Jin YH, Huang Q, Wang YY, Zeng XT, Luo LS, Pan ZY, et al. Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers in a tertiary acute care hospital in Wuhan: a cross-sectional survey. *Milit Medical Res.* (2020) 7:24. doi: 10.1186/s40779-020-00254-8

36. Chavez S, Long B, Koyfman A, Liang SY. Coronavirus Disease (COVID-19): a primer for emergency physicians. *Am J Emerg Med.* (2021) 44:220–9. doi: 10.1016/j.ajem.2020.03.036

37. Noorshahrizam SA. *As Omicron Cases Spike, Health Coalition Calls for Reinforced Plan Against COVID-19.* (2022). Available online at: https://malaysia.news.yahoo.com/omicron-cases-spike-health-coalition-040155133.html (accessed July 31, 2022).

38. New Straits Times. *KJ: Malaysia Fully Into Omicron Wave.* NST Online. (2022). Available online at: https://www.nst.com.my/news/nation/2022/02/769160/kj-malaysia-fully-omicron-wave (accessed July 31, 2022).

39. Ying TP. *Omicron BA.2 to Become Dominant Coronavirus Variant in Malaysia.* NST Online. (2022). Available online at: https://www.nst.com.my/news/nation/2022/03/781780/omicron-ba2-become-dominant-coronavirus-variant-malaysia (accessed July 31, 2022).

40. Anand R. *PM Muhyiddin Receives First COVID-19 Vaccine as Malaysia Kicks Off Mass Inoculation Campaign*. The Straits Times. (2021). Available online at: https://www.straitstimes.com/asia/se-asia/pm-muhyiddin-receives-first-covid-19-vaccine-as-malaysia-kicks-off-mass-inoculation (accessed July 31, 2022).

41. Ministry of Health, Malaysia. *COVIDNOW in Malaysia*. (2021). Available online at: https://covidnow.moh.gov.my/ (accessed July 31, 2022).

42. Cochran WG. Note on an approximate formula for the significance levels of z. *Ann Math Statist.* (1940) 11:93–5. doi: 10.1214/aoms/1177731945

43. Chen WS, Haniff J, Siau CS, Seet W, Loh SF, Jamil MHA, et al. Translation, cross-cultural adaptation and validation of the Malay version of the Maslach Burnout Inventory (MBI) in Malaysia. *Int J Soc Sci Stud.* (2014) 2:66. doi: 10.11114/ijsss.v2i2.309

44. Chen WS, Haniff J, Siau CS, Seet W, Loh SF, Jamil MHA. Pilot study of the Malay maslach burnout inventory and Malay work-related quality of life scale in Malaysia. *Stud Asian Soc Sci.* (2014) 1:20–6. doi: 10.5430/sass.v1n1p20

45. WHO. *WHOQOL-BREF: Introduction, Administration, Scoring and Generic Version of the Assessment: Field Trial Version, December 1996.* Geneva: World Health Organization (1996).

46. Cheung YB, Yeo KK, Chong KJ, Khoo EY, Wee HL. Reliability and validity of the English-, Chinese-and Malay-language versions of the World Health Organization quality of life (WHOQOL-BREF) questionnaire in Singapore. *Ann Acad Med Singap.* (2017) 46:461–9. doi: 10.47102/annals-acadmedsg.V46N12p461

47. Hasanah CI, Naing L, Rahman ARA. World Health Organization quality of life assessment: brief version in Bahasa Malaysia. *Med J Malaysia.* (2003) 58:79–88. Available online at: http://www.e-mjm.org/2003/v58n1/WHO_Quality_of_Life_Assessment.pdf

48. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med.* (2008) 15:194–200. doi: 10.1080/10705500802222972

49. World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. *Bullet World Health Org.* (2001) 79:373. Available online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2566407/pdf/11357217.pdf

50. Sull A, Harland N, Moore A. Resilience of health-care workers in the UK; a cross-sectional survey. *J Occup Med Toxicol.* (2015) 10:20. doi: 10.1186/s12995-015-0061-x

51. Coco M, Guerrera CS, Santisi G, Riggio F, Grasso R, Di Corrado D, et al. Psychosocial impact and role of resilience on healthcare workers during COVID-19 pandemic. *Sustainability.* (2021) 13:7096. doi: 10.3390/su13137096

52. Huang L, Wang Y, Liu J, Ye P, Cheng B, Xu H, et al. Factors associated with resilience among medical staff in radiology departments during the outbreak of 2019 novel coronavirus disease (COVID-19): a cross-sectional study. *Med Sci Monit.* (2020) 26:e925669. doi: 10.12659/MSM.925669

53. Gök A, Kogar EY. A meta-analysis study on gender differences in psychological resilience levels. *Kibris Türk Psikiyatri ve Psikoloji Dergisi.* (2021) 3:132–43. doi: 10.35365/ctjpp.21.2.15

54. Hirani S, Lasiuk G, Hegadoren K. The intersection of gender and resilience. *J Psychiatr Ment Health Nurs.* (2016) 23:455–67. doi: 10.1111/jpm.12313

55. Wilks SE. Resilience amid academic stress: the moderating impact of social support among social work students. *Adv Soc Work.* (2008) 9:106–25. doi: 10.18060/51

56. Ong HL, Vaingankar JA, Abdin E, Sambasivam R, Fauziana R, Tan ME, et al. Resilience and burden in caregivers of older adults: moderating and mediating effects of perceived social support. *BMC Psychiatry.* (2018) 18:27. doi: 10.1186/s12888-018-1616-z

57. Wang J, Mann F, Lloyd-Evans B, Ma R, Johnson S. Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC Psychiatry.* (2018) 18:156. doi: 10.1186/s12888-018-1736-5

58. Çelmeçe N, Menekay M. The effect of stress, anxiety and burnout levels of healthcare professionals caring for COVID-19 patients on their quality of life. *Front Psychol.* (2020) 11:597624. doi: 10.3389/fpsyg.2020.597624

59. Ortega-Galán ÁM, Ruiz-Fernández MD, Lirola MJ, Ramos-Pichardo JD, Ibáñez-Masero O, Cabrera-Troya J, et al. Professional quality of life and perceived stress in health professionals before COVID-19 in Spain: primary and hospital care. *Healthcare.* (2020) 8:484. doi: 10.3390/healthcare8040484

60. Li Y, Zhang H, Feng Z, Chen S, Liu T, Chen X, et al. Life events, anxiety and depression among doctors and nurses in the emergency department: a study from eleven General Hospital in Hunan Province, China. *J Psychiatry Brain Sci.* (2016) 1:2. doi: 10.20900/jpbs.20160002

61. Rashid MU, Khan MAS, Dalal K, Sagar SK, Hossian M, Barsha SY, et al. Quality of life (QoL) among COVID-19 recovered healthcare workers in Bangladesh. *BMC Health Serv Res.* (2022) 22:716. doi: 10.1186/s12913-022-07961-z

62. Hayne AN, Gerhardt C, Davis J. Filipino nurses in the United States: recruitment, retention, occupational stress, and job satisfaction. *J Transcult Nurs.* (2009) 20:313–22. doi: 10.1177/1043659609334927

63. Arora S, Kalra R. Quality of life (QOL) of people living with substance users in urban and rural community of Delhi. *Curr Med Res Practice.* (2018) 8:96–9. doi: 10.1016/j.cmrp.2018.05.010

64. Asante JO Li MJ, Liao J, Huang YX, Hao YT. The relationship between psychosocial risk factors, burnout and quality of life among primary healthcare workers in rural Guangdong province: a cross-sectional study. *BMC Health Serv Res.* (2019) 19:1–10. doi: 10.1186/s12913-019-4278-8

65. Gholami A, Jahromi LM, Zarei E, Dehghan A. Application of WHOQOL-BREF in measuring quality of life in health-care staff. *Int J Prev Med.* (2013) 4:809. Available online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775221/pdf/IJPVM-4-809.pdf

66. Zheng M, Jin H, Shi N, Duan C, Wang D, Yu X, et al. The relationship between health literacy and quality of life: a systematic review and meta-analysis. *Health Qual Life Outcomes.* (2018) 16:1–10. doi: 10.1186/s12955-018-1031-7

67. Woon LSC, Mansor NS, Mohamad MA, Teoh SH, Leong Bin Abdullah MFI. Quality of life and its predictive factors among healthcare workers after the end of a movement lockdown: the salient roles of COVID-19 stressors, psychological experience, and social support. *Front Psychol.* (2021) 12:652326. doi: 10.3389/fpsyg.2021.652326

68. Williams GA, Maier CB, Scarpetti G, de Belvis AG, Fattore G, Morsella A, et al. What strategies are countries using to expand health workforce surge capacity during the COVID-19 pandemic? *Eurohealth.* (2020) 26:51–7. Available online at: https://apps.who.int/iris/bitstream/handle/10665/336296/Eurohealth-26-2-51-57-eng.pdf

69. Fu C, Wang G, Shi X, Cao F. Social support and depressive symptoms among physicians in tertiary hospitals in China: a cross-sectional study. *BMC Psychiatry.* (2021) 21:1–11. doi: 10.1186/s12888-021-03219-w

70. Arca M, Dönmezdil S, Durmaz ED. The effect of the COVID-19 pandemic on anxiety, depression, and musculoskeletal system complaints in healthcare workers. *Work.* (2021) 69:47–54. doi: 10.3233/WOR-205014

71. Wang J, Zhou M, Liu F. Reasons for healthcare workers becoming infected with novel coronavirus disease 2019 (COVID-19) in China. *J Hosp Infect.* (2020) 105:2. doi: 10.1016/j.jhin.2020.03.002

72. González-Blanch C, Hernández-de-Hita F, Muñoz-Navarro R, Ruíz-Rodríguez P, Medrano LA, Cano-Vindel A. The association between different domains of quality of life and symptoms in primary care patients with emotional disorders. *Sci Repo.* (2018) 8:1–10. doi: 10.1038/s41598-018-28995-6

73. Gou Z, Xie X, Lu Y, Khoshbakht M. Quality of Life (QoL) survey in Hong Kong: Understanding the importance of housing environment and needs of residents from different housing sectors. *Int J Environ Res Public Health.* (2018) 15:219. doi: 10.3390/ijerph15020219

74. Moutinho ILD, Lucchetti ALG, da Silva Ezequiel O, Lucchetti G. Mental health and quality of life of Brazilian medical students: incidence, prevalence, and associated factors within two years of follow-up. *Psychiatry Res.* (2019) 274:306–12. doi: 10.1016/j.psychres.2019.02.041

75. Thangiah G, Said MA, Majid HA, Reidpath D, Su TT. Income inequality in quality of life among rural communities in Malaysia: a case for immediate policy consideration. *Int J Environ Res Public Health.* (2020) 17:8731. doi: 10.3390/ijerph17238731

76. Asghar MS, Akram M, Yasmin F, Najeeb H, Naeem U, Gaddam M, et al. Comparative analysis of neutrophil to lymphocyte ratio and derived neutrophil to lymphocyte ratio with respect to outcomes of in-hospital coronavirus disease 2019 patients: a retrospective study. *Front Med.* (2022) 9:951556. doi: 10.3389/fmed.2022.951556

77. Sampogna G, Del Vecchio V, Giallonardo V, Luciano M, Albert U, Carmassi C, et al. What is the role of resilience and coping strategies on the mental health of the general population during the COVID-19 pandemic? Results from the Italian multicentric comet study. *Brain Sci.* (2021) 11:1231. doi: 10.3390/brainsci11091231

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 21 December 2022
DOI 10.3389/fpubh.2022.1053183

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 25 September 2022
ACCEPTED 05 December 2022
PUBLISHED 21 December 2022

CITATION
Yang TB, Lin XJ, Lin JL, Chen W-T and Huang FF (2022) Influencing factors of cancer prevention and control among urban and rural adults in Fujian, China: A cross-sectional survey. *Front. Public Health* 10:1053183. doi: 10.3389/fpubh.2022.1053183

Influencing factors of cancer prevention and control among urban and rural adults in Fujian, China: A cross-sectional survey

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Objective: Cancer burden can be reduced when the population's knowledge of cancer prevention and control measures is increased. However, current epidemiological research investigating cancer prevention and control knowledge in China is limited. This study aimed to examine the core knowledge levels of cancer prevention and control measures as well as its influencing factors among adults in Fujian, China.

Study design: A cross-sectional study.

Methods: From September to December 2021, a total of 2,440 Chinese urban and rural adults from Fujian Province, located in Southeastern China, were randomly selected for this cross-sectional study. The probability proportionate approach to sampling was used. A 38-item questionnaire that covered demographics and basic knowledge of cancer, including concepts, screening, therapy, and rehabilitation-related key points was used to measure knowledge levels of cancer prevention and control measures among 2,074 participants. The level of each participants' core knowledge of cancer prevention and control measures was defined as a rate calculated by the number of correct answers divided by the total number of questions. The binary logistic regression model was used to determine if influencing factors were associated with core knowledge awareness.

Results: In total, 1,290 participants (62.2%) were in the low knowledge group and 784 (37.8%) were in the high knowledge group. The average knowledge rate of cancer prevention and control measures among all participants was 56.01%. Participants from urban areas, who held white-collar jobs, were married, had a bachelor's degree or above, had a family history of cancer, or self-rated their health level as good or average were associated with higher rates of cancer prevention and control core knowledge (overall $p < 0.05$).

Conclusion: These findings may assist healthcare providers and/or researchers in designing effective primary preventive interventions to enhance the general population's cancer prevention and control knowledge, and subsequently decrease the cancer burden in China.

KEYWORDS

awareness, cancer prevention, core knowledge, survey, China

Introduction

Cancer is a major public health problem worldwide (1). In China, the rates of age-adjusted incidence and mortality of cancer have increased gradually since 2000 (2, 3), because of the increasing trend of urbanization and the accumulated effects of risk-factor exposure (4). However in developed countries, such as the United States and some European countries, cancer mortality rates and age-adjusted rates of cancer incidence in men have generally decreased since the early 1990s (2). Decreasing trends in cancer burden may be linked to progress in cancer research, prevention, and care in Western countries.

By some estimates, up to half of all cancer cases can be prevented or avoided (5). Since 2015, China has made efforts to confront its rapidly increasing cancer burden by implementing a series of plans and policies focused on cancer control (6, 7), in which primary and secondary prevention is always the first line of action (8). This includes improving the general population's knowledge regarding cancer prevention (5, 9). Although knowledge alone will not prevent cancer, it is necessary before one can take action (10).

Cancer prevention and control core knowledge refers to essential knowledge of actions to minimize individual cancer risk and methods used to reduce cancer burden, such as basic knowledge regarding cancer prevention, treatment, and management of the disease (5). Currently, the awareness of basic cancer prevention is reported as suboptimal, and even as low as 20% in certain Chinese populations (10–13). Li et al. (5) and Yu and Baade (14) have reported that individuals with lower levels of core prevention knowledge of cancer had more diagnoses of cancer after a median follow-up of 3.3 years. Low levels of cancer prevention core knowledge negatively impact individuals' attitudes, healthy lifestyles, and positive health behaviors (9, 15). These negative effects may be more prevalent in Eastern cultures, where people tend to reason holistically, believe in the relatedness of objects and events, and consider things to be constantly changing cyclically in everyday life (i.e., naïve dialecticism) (16).

Previous studies in China on core knowledge of cancer prevention and control measures were either conducted in a single area (urban or rural), with specific cancer populations, or with small samples, all of which limited the generalizability of their findings (5, 10–13). Reliable information on rates of core knowledge of cancer prevention and control measures, as well as its influencing factors, are required to provide further insight into what measures may be taken to reduce the heavy burden of cancer in China. This study aimed to examine the rates of core knowledge of cancer prevention and control measures as well as its influencing factors among urban and rural adults in Fujian Province, China.

2. Methods

2.1 Study design and participants

From September to December of 2021, a large-scale cross-sectional study was conducted among urban and rural adults in Fujian Province, which lies on the southeastern coast of China. As of 2021, Fujian Province had a registered population of ∼41.87 million within its nine major cities and rural areas. A five-stage probability proportionate to size (PPS) sampling approach was applied to select 2,440 participants. The study's recruitment process is detailed in Figure 1. Household members were eligible to participate in this study if they: (1) were locally registered residents; (2) lived in the targeted district/county for at least 6 months before the survey; (3) were aged 18–69 years old; (4) had no cognitive disorders; and (5) no cancer history.

After obtaining written informed consent, each participant was asked to complete a face-to-face interview and questionnaire regarding their core knowledge of cancer prevention and control measures and socio-demographic characteristics. This study was approved by the Ethics Review Committee of the Fujian Provincial Centers for Disease Control and Prevention (Grant number: K2021-101-01). All personally identifiable information was removed before data analysis. The study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement (17).

2.2 Measures

The questionnaire regarding core knowledge of cancer prevention and control measures was developed by an expert panel led by the National Cancer Center of China (18, 19). The questionnaire comprised 13 single-item questions, 12 multiple-item questions, and 13 true-or-false questions that covered basic knowledge of cancer, including concepts, screening, therapy, and rehabilitation-related key points. Expert panel members assigned a numeric score to each answer provided in the study questionnaire. For the true-or-false and single-answer questions, "1 point" was assigned to a correct answer and "0 points" to an incorrect answer. For the multiple-item questions, "2 points" were assigned if the answer was exactly correct, otherwise "0 points" were assigned. The total score ranged from 0 to 50 for each participant. The total score was converted into a percentage, yielding cancer prevention and control core knowledge scores ranging from 0 to 100 points. In this study, Cronbach's α of the questionnaire was found to be 0.899.

The demographic information collected in the questionnaire included age, gender, residential area, marital status, educational level, occupation, number of family members living in the household, yearly income of the household, family history

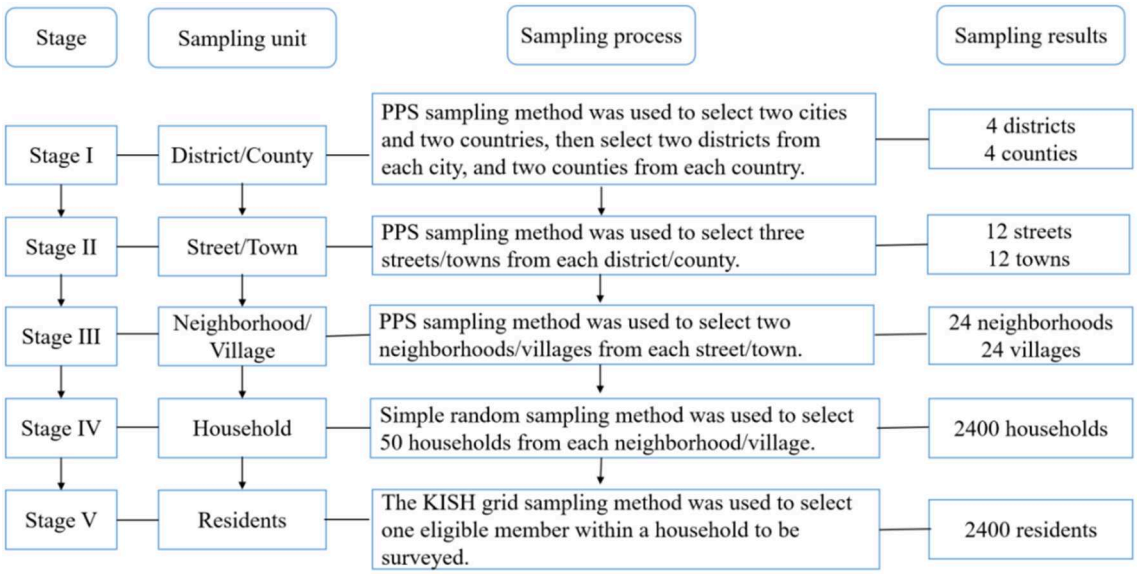

FIGURE 1
The five-stage probability proportionate to size sampling process.

of cancer, body mass index (BMI, weight/height^2, Kg/m^2), smoking status, and self-evaluated health status.

2.3 Data analyses

Data analyses were conducted using SPSS 26.0 (IBM, Armonk, NY, USA). Approximately 5% of missing data were replaced using mean value substitution, and $p \leq 0.05$ was considered statistically significant. The data met the assumptions of normality, with a one-sample Kolmogorov-Smirnov test yielding non-significance. Continuous variables were expressed as means with standard deviations (SDs) and categorical variables were expressed as proportions or percentages.

The level of each participants' core knowledge of cancer prevention and control measures was defined as a rate calculated by the number of correct answers divided by the total number of questions. The average knowledge rate (%) of all participants was defined as the sum of all knowledge rates divided by the total number of participants. [knowledge rate (%) = number of subjects with all correct answers/total number of subjects *100.] Core knowledge levels with rates of <60% were considered to be in the low knowledge group (LKG), while rates of ≥60% were considered to be in the high knowledge group (HKG). A binary logistic regression model with a forward conditional method was used to determine the influencing factors associated with the core knowledge of cancer prevention and control measures. The outcome variable was the knowledge group and demographic variables served as independent variables. The result estimates are expressed as odds ratios (OR) (95% confidence intervals, CIs).

3. Results

A total of 2,440 eligible participants were recruited and 2,074 completed the survey, with a response rate of 86.42% over the 4-month period of the study. The main reasons for study drop-outs were participants had no interest or time to do the survey. No significant differences were found in age, gender, or residential area between the two knowledge level groups, and the age of participants ranged from 18 to 69 years, matching the local general population. The mean age of participants was 47.81 years (SD = 13.20), the average BMI was 23.21 kg/m^2 (SD = 3.09), and the average number of family members was 3.56 (SD = 1.75). Table 1 shows the demographic characteristics of all participants by knowledge level group.

3.1 Participants' knowledge of cancer prevention and control measures

In total, there were 1,290 participants (62.2%) in the LKG and 784 participants (37.8%) in the HKG. The average knowledge rate of cancer prevention and control measures among all participants was 56.0%. Up to half of the participants (ranging from 36.4 to 50.9%) knew the basic concepts about cancer, physical rehabilitation methods, cancer warning signs, cancer early detection methods, and cancer risk factors. More

10.3389/fpubh.2022.1053183

TABLE 1 Rates of core knowledge level by demographic characteristics of participants ($n = 2,074$).

Variables	Total *n* (%)	HKG ($n = 784$) *n* (%)	LKG ($n = 1,290$) *n* (%)
Gender			
Male	935 (45.1)	356 (44.1)	589 (45.7)
Female	1,139 (54.9)	428 (55.9)	701 (54.3)
Residence area			
Urban	1,412 (68.1)	562 (71.7)	850 (65.9)
Rural	662 (31.9)	222 (28.3)	440 (34.1)
Marital status			
Living alone (e.g., unmarried, divorced, and widowed)	208 (10.0)	68 (8.6)	140 (10.8)
Married	1,866 (90.0)	716 (91.4)	1,150 (89.1)
Educational level			
Primary school degree or below	693 (33.4)	178 (22.7)	515 (39.9)
Junior high school degree	615 (29.7)	211 (26.9)	404 (31.3)
Senior high school degree (including technical training)	415 (20.0)	194 (24.7)	221 (17.1)
Junior college diploma	205 (9.9)	124 (15.8)	81 (6.3)
Bachelor's degree or higher	146 (7.0)	77 (9.8)	69 (5.3)
Occupation			
White collar	296 (14.3)	171 (21.8)	125 (9.7)
Blue collar	1,438 (69.4)	441 (56.3)	997 (77.3)
Students	37 (1.8)	22 (2.8)	15 (1.2)
Unemployment	212 (10.2)	94 (12.0)	118 (9.2)
Retired	89 (4.3)	56 (7.0)	34 (2.6)
The yearly income per household (yuan, RMB)			
<1,000	560 (28.2)	181 (24.6)	379 (30.3)
1,000–2,000	593 (29.9)	225 (30.6)	368 (29.4)
2,000–3,000	432 (21.8)	170 (23.1)	262 (21.0)
3,000–4,000	121 (6.1)	50 (6.8)	71 (5.7)
4,000–5,000	149 (7.5)	59 (8.0)	90 (7.2)
5,000+	130 (6.5)	50 (6.8)	80 (6.4)
Family history of cancer			
Yes	275 (13.3)	113 (14.4)	162 (12.6)
No	1,640 (79.1)	644 (82.1)	996 (77.2)
Don't know	159 (7.7)	27 (3.4)	132 (10.2)
BMI (kg/m^2)			
<18.5 (underweight)	97 (4.8)	41 (5.3)	56 (4.4)
18.5–24.9 (normal weight)	1,188 (58.3)	462 (60.2)	726 (57.1)
≥25 (overweight)	754 (37.0)	264 (34.4)	490 (38.5)

(Continued)

TABLE 1 (Continued)

Variables	Total *n* (%)	HKG (*n* = 784) *n* (%)	LKG (*n* = 1,290) *n* (%)
Smoking status			
Current smoker	454 (21.9)	167 (21.3)	287 (22.2)
Former smoker	133 (6.4)	42 (5.4)	91 (7.1)
Never smoked	1,487 (71.7)	575 (73.3)	912 (70.3)
Self-evaluated health			
Very good	876 (42.2)	310 (39.5)	566 (43.9)
Good	787 (37.9)	304 (38.8)	483 (37.4)
Average	379 (18.3)	160 (20.4)	219 (17.0)
Bad	24 (1.2)	6 (0.8)	18 (1.4)
Very bad	8 (0.4)	4 (0.5)	4 (0.3)

BMI, body mass index; LKG, low knowledge group; HKG, high knowledge group.
White-collar = office workers, teachers, healthcare providers, academic researchers, and government officials.
Blue-collar = farmer, factory worker, forestry worker, fisher, service staff, salesperson, house-worker, and driver.

than 70.0% were aware of the meaning of early cancer detection and early treatment as well as common therapy methods (see Table 2). Regarding cancer prevention and control core knowledge items (see Supplementary Appendix A), the five lowest knowledge rates (below 30.0%) included responses to the questions: "What are breast cancer warning symptoms?" (16.5%); "Which of the following biological factors increase the risk of cancer" (22.3%); "What's the correct description of cancer prevention and therapy?" (22.7%); "Which of the following unhealthy lifestyle habits can increase the risk of cancer?" (26.7%); and "What's the correct description of cancer pain?" (27.2%). More than 70.0% of participants demonstrated basic cancer knowledge, its common treatment methods, and the meaning of early cancer detection and early treatment.

3.2 Factors associated with cancer prevention and control core knowledge

As shown in Table 3 and Figure 2, after adjusting for confounding factors, including gender, number of family members in the household, the yearly income of the household, BMI, and smoking status, the logistic regression analysis indicated the main predictors influencing the level of cancer prevention and control core knowledge were: residing in urban areas, being married, unclear family history of cancer, and self-evaluated average or good health. For example, participants who had an unclear family history of cancer were 0.309 times more likely to have core cancer knowledge than individuals with a known family history of cancer (OR = 0.309, 95% CI 0.194–0.492). Participants who had a blue-collar occupation, were unemployed, had a junior high school degree or below, or were older had lower rates of core knowledge. Participants who were unemployed had an OR of 0.616 demonstrating a higher rate of core knowledge when compared to those who were in white-collar occupations (OR = 0.616, 95% CI 0.417–0.910).

4. Discussion

Cancer prevention and control core knowledge is crucial as it influences individuals' attitudes and practices to improve health-seeking behaviors and thereby significantly reduces cancer burden (5). However, the current epidemiological research investigating cancer prevention knowledge is limited in China (5, 10–12). This population-based study aimed to better understand cancer prevention and control core knowledge levels and its influencing factors among urban and rural adults in Fujian, China. The findings show the overall average rate of core knowledge of cancer prevention and control measures among adults was 56.01%, lower than other similar studies (11, 12), but higher than studies with smaller sample sizes. Most importantly, the study's average knowledge rate is lower than the nationally expected knowledge rate, which is at 70% for the general Chinese population by 2022 as set out by the Chinese Department of Health 2017–2025 short-term and long-term plan for the prevention and treatment of chronic diseases (6). This finding provides evidence for the need to develop a campaign to enhance cancer prevention and control knowledge in Southeastern China.

Interestingly, we found that although most adults in our study knew the significance of cancer secondary prevention (73.75%), less than half had sufficient knowledge of many areas of cancer including early clinical symptoms of cancer, major risk factors for developing cancer (e.g., unhealthy lifestyle habits, infectious factors), early detection or preventive

TABLE 2 Rates of cancer prevention and control core knowledge by survey domain (n = 2,074).

Core knowledge domain	Corresponding item (s)	Knowledge rate (%)
1. Cancer basic concepts	A1, C9, B1, B10, A12	47.72
2. Cancer basic knowledge	A2, B2, B5, C1	62.23
3. Cancer risk factors	A7, C5, B9, C2, A13	50.86
4. Cancer prevention measures	A5, B8, C6, C8	58.38
5. Early detection and early treatment meaning	A8, B17	73.75
6. Recognition of cancer warning signs	A9, B16, C11–12	50.15
7. Cancer early detection	B11, C10, C13	49.77
8. Timely medical treatment	A10, B19	61.50
9. Standardized treatment	A6, B20, A11	63.20
10. Following doctors' requirements to check regularly	B12, B21	68.35
11. Common treatment methods for cancer	A3	80.70
12. Physical rehabilitation	C14, C15	36.40
13. Psychological rehabilitation	A4	52.70

TABLE 3 Odds ratios and 95% confidence intervals for having a high cancer prevention and control core knowledge by sociodemographic and other factors in Fujian Province, China.

Variable	Crude OR	Adjust OR	95%CI
Occupation (White collar as reference)			
Blue collar	0.319	0.309	0.233–0.411
Unemployment	0.639	0.616	0.417–0.910
Marital status (Living alone as reference)			
Married	1.571	1.803	1.234–2.636
Educational level (Bachelor's degree or higher as reference)			
Primary school degree or below	0.258	0.199	0.121–0.326
Junior high school degree	0.440	0.306	0.195–0.480
Senior high school degree (including technical training)	0.760	0.623	0.399–0.972
Family history of cancer (yes as reference)			
Unclear	0.348	0.309	0.194–0.492
Residence area (rural as reference)			
Urban	1.897	1.789	1.405–2.278
Self-evaluated health (very good as reference)			
Average	1.922	1.954	1.459–2.617
Good	1.442	1.471	1.171–1.847
Age (years)	0.986	0.986	0.977–0.996

SE, standard error; OR, odds ratio; CI, confidence interval.

measures, or basic concepts about cancer. The findings indicate that in order to reduce the future cancer burden in China, increasing the level of public awareness of cancer primary and secondary prevention measures should remain a priority through the provision of detailed information on cancer risk factors, preventive measures, cancer symptoms or signs, in addition to identifying opportunities to change individual behaviors (14).

This study found a significant association between cancer prevention and control core knowledge levels and participants'

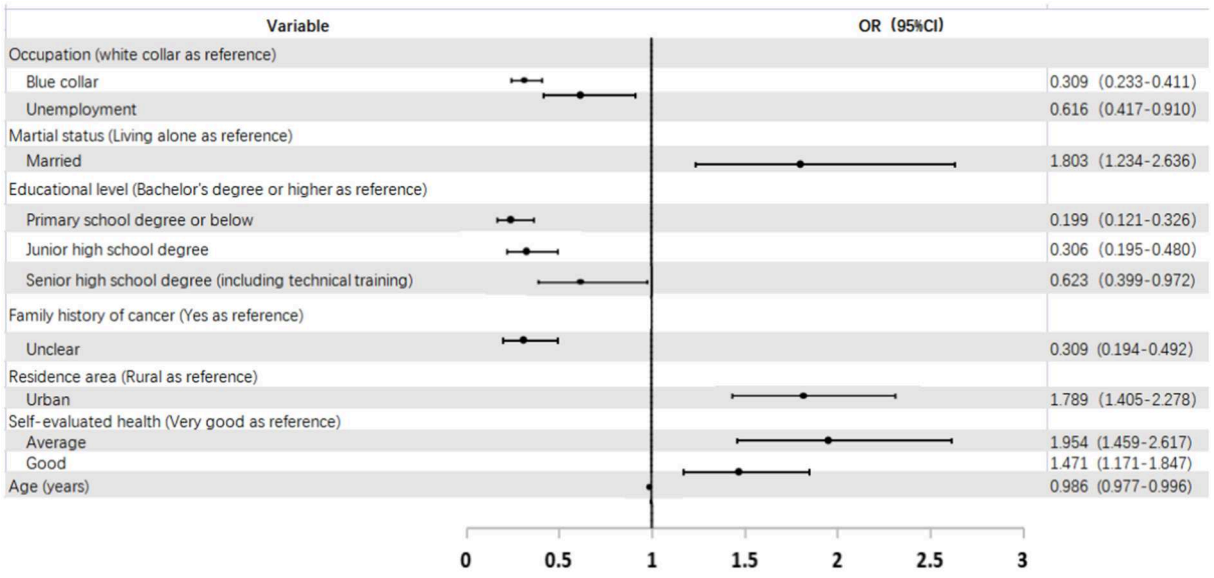

FIGURE 2
Forest plot of OR (95% CI) for having a high cancer prevention and control core knowlegde by sociodemographic and other factors in Fujian Province in China.

area of residence, occupation, educational level, marital status, family history of cancer, and self-evaluated health status. Regarding occupation, the current evidence regarding the association between occupation and cancer core knowledge is mixed, which might be due to the various definitions and classifications of occupations (11, 15). In this study, adults with white-collar occupations were more likely to have higher rates of core knowledge than adults with blue-collar occupations, or those who were unemployed. The possible explanations include white-collar workers usually have higher educational levels (bachelor's degree or higher), focus more on their health status, have insurance coverage, and have more opportunities to access social resources and healthcare-related information, all of which help them improve their cancer core knowledge levels (11, 15). Furthermore, blue-collar participants are more likely to be exposed to hazards, such as dust and noise in construction work or ultraviolet radiation in welding work (5). Taken together, blue-collar workers with junior high school or less of education should be identified as a target population for community-level cancer prevention interventions.

In line with previous studies (5, 9, 11), we also found that residents in urban areas or with a family history of cancer were more likely to have a higher core knowledge rate. The differences seen when comparing areas of residence can be explained by the urban-rural disparity in access to health services and exposure to certain risk factors (20). Currently in China, urban-rural disparities are obvious, with people living in urban areas having greater cancer knowledge as well as higher cancer rates (21). In addition, a family history of cancer may reflect genetic as well as behavioral and environmental risks shared by family members (9). Health promotion theories, such as the Health Belief Model and protection motivation, predict that people are more likely to take preventive actions when they perceive their risk of negative health outcomes to be high (16). Furthermore, the Chinese philosophy of "destiny" may motivate people who have a family history of cancer to participate in emotional control, self-care activities, and active cancer prevention measures (22). Thus, the development of an effective cancer prevention program should consider cultural and geographical factors.

Results show a significantly higher core knowledge rate among married adults or people with a self-rated good or average health status. This is consistent with the Learning Partner Model (23), which claims that partners' adequate core knowledge transfers to others in their social network, mostly to their family, and thus improves others' core knowledge level of cancer prevention and control measures. A previous study found that married men's knowledge and support also has a positive effect on wives' cancer screening knowledge (24). As stated by the Salutogenic Model (25), people whose self-rated health levels were average or good can be motivated to increase their core knowledge in order to improve their self-care activities. Finally, the negative association between age and cancer knowledge might be explained by the older study participants being more likely to avoid any discussion of illness including cancer, owing to the fear of bringing about unlucky

karma (22), therefore decreasing opportunities to gain cancer prevention knowledge.

There are some limitations of this study. Firstly, this study was a cross-sectional survey and therefore did not allow us to infer causality to explain the relationship between cancer prevention and control measures and core knowledge and socio-demographic characteristics. Thus, future longitudinal studies are needed to address this important issue. Secondly, study participants were recruited from one province which is not representative of the entire Chinese population. However, because this is a population sampling study, its results can inform basic strategies for stakeholders to use in designing a provincial intervention to enhance cancer prevention and control measures knowledge. Thirdly, our participants were not stratified by high- and low-risk groups, a stratification that should be considered by future related studies in order to provide a clearer picture of cancer prevention and control measures core knowledge.

5. Conclusion

The overall average rate of core knowledge of cancer prevention and control measures among adults in Fujian Province was below the 70% target set out by the Chinese Department of Health. Adults who were residents of urban areas, held white-collar jobs, married, had a bachelor's degree or above, a family history of cancer, and were self-rated as having a good health status were associated with a higher core knowledge level of cancer prevention and control measures. These findings may help healthcare providers and policy stakeholders design effective primary prevention interventions to enhance the general population's cancer prevention and control knowledge and subsequently decrease cancer burden.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: the data that support the findings of this study are availabe from the corresponding author upon reasonable request. Requests to access these datasets should be directed to FH, pt860315@163.com.

Ethics statement

The studies involving human participants were reviewed and approved by this study was approved by the Ethics Review Committee of Fujian Provincial Centers for Disease Control and Prevention (Grant Number: K2021-101-01). The patients/participants provided their written informed consent to participate in this study.

Author contributions

FH and W-TC was responsible for the research design and revisions to the manuscript. TY contributed to data analysis and initial writing of the manuscript. XL and JL contributed to data collection and analysis. All authors have contributed to the conception and design of the study, drafted or have been involved in revising this manuscript, reviewed the final version of this manuscript before submission, and agree to be accountable for all aspects of the work.

Funding

This work was supported by the General Project of Fujian Provincial Nature Science Foundation, with Grant Number [2021J01246].

Acknowledgments

We gratefully acknowledge all the study participants, as without them, it would not be possible to complete the study.

Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1053183/full#supplementary-material

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 Countries. *CA Cancer J Clin.* (2021) 71:209–49. doi: 10.3322/caac.21660

2. Xia C, Dong X, Li H, Cao M, Sun D, He S, et al. Cancer statistics in China and United States, 2022: profiles, trends, and determinants. *Chin Med J.* (2022) 135:584–90. doi: 10.1097/CM9.0000000000002108

3. Tai CG, Hiatt RA. The population burden of cancer: research driven by the catchment area of a cancer center. *Epidemiol Rev.* (2017) 39:108–22. doi: 10.1093/epirev/mxx001

4. Tsoi KK, Hirai HW, Chan FC, Griffiths S, Sung JJ. Cancer burden with ageing population in urban regions in China: projection on cancer registry data from World Health Organization. *Br Med Bull.* (2017) 121:83–94. doi: 10.1093/bmb/ldw050

5. Li H, Zeng H, Zheng R, Zou X, Cao M, Sun D, et al. Association of cancer awareness levels with the risk of cancer in rural China: A population-based cohort study. *Cancer.* (2020) 126:4563–71. doi: 10.1002/cncr.33029

6. The State Council of the People's Republic of China. *State Council Issues Plan to Prevent Chronic Diseases*. Beijing: The State Council of the People's Republic of China. Available online at: http://english.gov.cn/policies/latest_releases/2017/02/14/content_281475567482818.htm (accessed July 20, 2022).

7. The State Council of the People's Republic of China. *Opinions of the State Council on Carrying Out Health China Operation*. Beijing: The State Council of the People's Republic of China. Available online at: http://www.gov.cn/xinwen/2019-07/15/content-5409694.htm (accessed July 20, 2022).

8. Soerjomataram I, Bray F. Planning for tomorrow: global cancer incidence and the role of prevention 2020–2070. *Nat Rev Clin Oncol.* (2021) 18:663–72. doi: 10.1038/s41571-021-00514-z

9. Karasiewicz M, Chawłowska E, Lipiak A, Wi?ckowska B. How to improve cancer prevention knowledge? A way to identify gaps and tackle the limited availability of health education services in primary health care using the European code against cancer. *Front Public Health.* (2022) 10:878703. doi: 10.3389/fpubh.2022.878703

10. Wang K, Liu CC, Mao AY, Shi JF, Dong P, Huang HY, et al. Analysis on the demand, access, and related factors of cancer prevention and treatment knowledge among urban residents in China from 2015 to 2017. *Chin J Prev Med.* (2020) 54:84–91. doi: 10.3760/cma.j.issn.0253-9624.2020.01.016

11. Li HC, Liu S, Yang L, Zhang X, Zhang Q, Wang N, et al. Analysis on status of awareness of cancer prevention and treatment knowledge and its influencing factors among residents in Beijing. *Chin J Prev Med.* (2021) 55:737–41. doi: 10.3760/cma.j.cn112150-20200628-00935

12. Ding GH, Liu YQ Li B, Jia SX, Liu SZ, Wang JL, et al. Investigation and analysis on the awareness rate and influencing factors of cancer prevention and control core knowledge in the high incidence area of upper gastrointestinal cancer in China in 2018. *Chin J Cancer Prev Treat.* (2021) 28:1599–605. doi: 10.16073/j.cnki.cjcpt.2021.21.01

13. Odukoya O, Fayemi M. A rural–urban comparison of knowledge, risk-factors and preventive practices for colorectal cancer among adults in Lagos State. *Asian Pac J Cancer Prev.* (2019) 20:1063–71. doi: 10.31557/APJCP.2019.20.4.1063

14. Yu XQ, Baade P. Cancer prevention: When knowledge of cancer prevention is not enough. *Cancer.* (2020) 126:4451–4. doi: 10.1002/cncr.33090

15. Chen W, Ren H, Wang N, Xiong Y, Xu F. The relationship between socioeconomic position and health literacy among urban and rural adults in regional China. *BMC Public Health.* (2021) 21:527. doi: 10.1186/s12889-021-10600-7

16. Kim HK, Lwin MO. Cultural effects on cancer prevention behaviors: fatalistic cancer beliefs and risk optimism among Asians in Singapore. *Health Commun.* (2017) 32:1201–9. doi: 10.1080/10410236.2016.1214224

17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg.* (2014) 12:1495–9. doi: 10.1016/j.ijsu.2014.07.013

18. National Cancer Center. *The questionaire of core knowledge of cancer prevention and control*. Available online at: http://www.chinancpcn.org.cn (accessed July 20, 2022).

19. National Health Commission of the People's Republic of China. *Core Knowledge of Cancer Prevention and Control*. Beijing: National Health Commission of the People's Republic of China. Available online at: http://www.chinancpcn.org.cn/ (accessed July 20, 2022).

20. Wang H, Hua X, Yao N, Zhang N, Wang J, Anderson R, et al. The urban–rural disparities and associated factors of health care utilization among cancer patients in China. *Front Public Health.* (2022) 10:842837. doi: 10.3389/fpubh.2022.842837

21. Li J, Shi L, Liang H, Ding G, Xu L. Urban–rural disparities in health care utilization among Chinese adults from 1993 to 2011. *BMC Health Serv Res.* (2018) 18:102. doi: 10.1186/s12913-018-2905-4

22. He R, Li Y. Media exposure, cancer beliefs, and cancer-related information-seeking or avoidance behavior patterns in China. *Int J Environ Res Public Health.* (2021) 18:3130. doi: 10.3390/ijerph18063130

23. Okedo-Alex IN, Uneke CJ, Uro-Chukwu HC, Akamike IC, Chukwu OE. "It is what I tell her that she will do": A mixed methods study of married men's knowledge and attitude towards supporting their wives' cervical cancer screening in rural South-East Nigeria. *Pan Afr Med J.* (2020) 36:156. doi: 10.11604/pamj.2020.36.156.21157

24. Yako-Suketomo H, Oura A, Katayama K, Saito K, Ohashi K, Navarro AM. The effect of a learning partner model-based program on spreading cancer prevention knowledge using community health volunteers in Japan. *J Prim Care Commun Health.* (2022) 13:21501319221110682. doi: 10.1177/21501319221110682

25. Bhattacharya S, Pradhan KB, Bashar MA, Tripathi S, Thiyagarajan A, Srivastava A, et al. Salutogenesis: A bona fide guide towards health preservation. *J Family Med Prim Care.* (2020) 9:16–9. doi: 10.4103/jfmpc.jfmpc_260_19

frontiers | Frontiers in Public Health

TYPE Community Case Study
PUBLISHED 04 January 2023
DOI 10.3389/fpubh.2022.1069255

OPEN ACCESS

EDITED BY
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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 13 October 2022
ACCEPTED 08 December 2022
PUBLISHED 04 January 2023

CITATION
Masquillier C, Van Royen K, Van Pelt P, Onsea D and Bastiaens H (2023) Development and implementation of a community health literacy hub, 'Health Kiosk'—A grassroots innovation. *Front. Public Health* 10:1069255. doi: 10.3389/fpubh.2022.1069255

Development and implementation of a community health literacy hub, 'Health Kiosk'—A grassroots innovation

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Being health literate is important to get sufficient health information, to navigate the health system, to access appropriate care and to be able to self-manage health. As such it is a key determinant of health. There is a need for innovative measures to improve health literacy among people living in socioeconomically vulnerable circumstances. Literature shows that this innovation needs to: have "low-threshold access" to health resources in a community-based, outreaching way; be adapted to the needs of the target group; provide reliable and understandable health information adapted to the target population, and support people in developing confidence to act on that knowledge. In response to this need, this article describes—guided by the principles underpinning the Integrated Community Care (ICC) framework—the development and implementation process of a grassroots innovation, namely "Health Kiosk" in a socioeconomically vulnerable area in the northern part of a Belgian city. To be able to focus on the core activity of the Health Kiosk—i.e., stimulating healthy living and health literacy—community building and considering the spatial environment of the neighborhood formed a fundamental basis. Several core ingredients of the Health Kiosk are important to stimulate health literacy among socioeconomically vulnerable groups, namely: (1) working in a community-based, outreaching way; (2) providing accessible health information and support to act on that knowledge; and (3) working in a flexible and independent way to adapt to local needs. As such, the Health Kiosk forms a community health literacy hub with low-threshold access for people living in socioeconomically vulnerable circumstances.

KEYWORDS

Health Kiosk, health literacy, healthy living, grassroots innovation, socioeconomically vulnerable groups, outreach working, integrated community care framework

1. Introduction

Decades of research underscore the strong relationship between socioeconomic position and health (1). People living in socioeconomic vulnerable circumstances are at higer risk of poor health than the general population (2). In addition, those who are often most in need of care, are amongst the least likely to receive it (2). Ensuring that no one is left behind in terms of health (1) is not only achievable through healthcare policy, but through an intersectoral approach addressing social determinants of health (3). Addressing these social determinants of health is fundamental to improving health and reducing long-standing inequities in health care (4).

Important in enabling people to overcome barriers to health and to improve social determinants of health is health literacy (5–8). Health literacy is a complex notion which entails competencies related to the process of accessing, understanding, appraising and applying health-related information. It influences health behavior and the use of health services (7). People with higher health literacy scores are more likely to get sufficient health information, are less likely to engage in risky behaviors and are more likely to report good self-rated health (5, 6). Evidence indicates that people with low health literacy engage more in risky health-behavior, have difficulty navigating the health system, have poorer health and higher mortality rates (5, 9). Thereby increasing health literacy may reduce health inequalities (10).

Literature shows that people living in socioeconomically vulnerable circumstances have lower levels of health literacy (5, 6). Authors conclude in a World Health Organization (WHO) report that "limited health literacy follows a social gradient and can further reinforce existing inequalities" [5: p. 19]. Targeted initiatives to improve health literacy can help address health inequities (5). However, a systematic review concludes there is "a lack of health literacy interventions for vulnerable social groups" [6: p. 54]. Therefore, innovative measures in real-world implementation research are needed to improve health literacy among people living in socioeconomically vulnerable circumstances and organizations working with them (5, 6, 9, 11).

Existing research regarding approaches targeting people living socioeconomically vulnerable circumstances, indicated that this innovation needs to adhere to the following principles. Firstly, community-based outreach initiatives are important, as research has shown that initiatives grounded in settings of everyday life are needed to reach the target group (5, 9, 12). As stated by Kickbush and colleagues, "communities are key settings for health literacy" [5: p. 40]. Daily health-related decisions are made in their homes and communities—usually acting as the primary source of health information (5). Secondly, the innovation needs to provide low-threshold access to health resources to ensure reaching the most excluded and to restore trust in the health system (6, 13). Besides providing reliable and understandable health information (5), it is important to support people in developing confidence to act on the required knowledge (5, 12), best achieved through more personal forms of communication (12). Interventions focusing on "capacity to act" [(14): p. 10] to improve a person's ability to gain access, understand and appropriately apply information are more likely to result in more effective health behavior (12). Thirdly, the innovation needs to be adapted to the needs of the target group, by being sensitive to and considering the diversity of the target population in terms of language, cultural, educational and socioeconomic characteristics (5, 6, 9).

This article describes the development and implementation process of a grassroots innovation, namely a community health literacy hub—"Health Kiosk"—aiming to improve health literacy for socioeconomically vulnerable populations.

2. Context

The Health Kiosk has been installed on a square in a socioeconomically vulnerable area in the northern part of a Belgian city. This area has a population of around 43,000 individuals in ∼21,000 households, with a very high concentration of socioeconomically vulnerable groups (i.e., the target population of the Health Kiosk). The area is characterized by a high level of poverty, with more than half of newborns (58.5%) growing up in an economically vulnerable household. Almost half the population (47.7%) has right to increased compensation for healthcare costs. About three quarters (73.5%) of inhabitants has a migration background. In terms of healthcare usage, almost a third (32.1%) of inhabitants postponed a visit to a GP because they could not afford the care they needed (15). Local authorities requested the founder of the Health Kiosk to locate it on this square:

> *The local policy makers have asked—because that was an explicit request—to set it on [name square], which is a square right next to the railway, one of the most difficult squares in [name city] with a high crime rate. So, we knew in advance that it was absolutely not an easy neighborhood, also because, there's quite a bit of drug use. But the explicit request was to set it up there, because something like a Health Kiosk, well, health could have a positive effect on the whole situation.*
> *Founder of the Health Kiosk.*

3. Theoretical framework: Integrated community care framework

We will describe the Health Kiosk guided by the principles underpinning the Integrated Community Care (ICC) framework—designed by the Transnational Forum on

10.3389/fpubh.2022.1069255

TABLE 1 Effectiveness principles of the ICC framework [(16): p. 9–10].

Number	Effectiveness principle
Co-develop health and wellbeing, enable participation	
1	"Value and foster the capacities of all actors, including citizens, in the community to become change agents and to co-produce health and wellbeing. This requires the active involvement of all actors, with extra sensitivity to the most vulnerable ones."
2	"Foster the creation of local alliances among all actors which are involved in the production of health and wellbeing in the community. Develop a shared vision and common goals. Actively strive for balanced power relations and mutual trust within these alliances."
3	"Strengthen community-oriented primary care that stimulates people's capabilities to maintain health and/or to live in the community with complex chronic conditions. Take people's life goals as the starting point to define the desired outcomes of care and support."
Build resilient communities	
4	"Improve the health of the population and reduce health disparities by addressing the social, economic and environmental determinants of health in the community and investing in prevention and health promotion."
5	"Support healthy and inclusive communities by providing opportunities to bring people together and by investing in both social care and social infrastructure."
6	"Develop the legal and financial conditions to enable the co-creation of care and support at community level."
Monitor, evaluate and adapt	
7	"Evaluate continuously the quality of care and support the status of health and wellbeing in the community by using methods and indicators which are grounded within the foregoing principles and documented by participatory 'community diagnosis' involving all stakeholders. Provide opportunities for joint learning. Adapt policies, services and activities in accordance with the evaluation outcomes."

Integrated Community Care (i.e., TransForm) (16). The ICC framework aims to improve quality of care and quality of life for individuals, families and communities by paying specific attention to "move beyond 'delivery' of health and social care systems to genuine "co-development" with the individuals and communities that are traditionally seen as recipients" [16: p. 18]. The authors identify a typology based on three main dimensions distilled from collective reflection on real-world innovations: (1) main initiators and drivers; (2) center of focus; and (3) core ingredients. In addition, the ICC model proposes seven effectiveness principles to turn integrated community care aspirations into reality, as presented in Table 1.

4. Programmatic elements

In what follows we will describe each of the three main dimensions of the Health Kiosk and its applicable effectiveness principles.

4.1. Main initiators and drivers

The Health Kiosk was founded by a grassroots initiator working at a local health network organization. Before applying for seed funding, the grassroots initiator contacted local organizations for collaboration, namely: a local college and a local university; local policy makers; a local school; a community health center; city sport services; local non-governmental organizations working around inclusiveness and solidarity; a community center and a local primary care network. These partners, which were mainly professionals and grassroots organizations, held several meetings during the start-up phase to further shape the concept of the Health Kiosk. During the start-up phase, the core steering group supported the initiator to create a support base in the community and to build trust among local organizations.

> *I think that the period of creating support base was very important and the fact that we didn't set up the kiosk on the square immediately. I think it was a very important phase that we needed to go through. It also gave us the time to get to know the partners in the area, to sit down with them and to find out how they work, what the needs are and how they see things. We also want to take this into account when working with them, because they have been there longer than we have. They could also give us an idea of what the neighborhood is like and what we can expect.*
> *Person running daily operations at the Health Kiosk.*

In line with ICC framework Principle 1 (see Table 1) (16), this core steering group has been critical not only for its support of the Health Kiosk in the start-up phase, but also during the daily operations for running the Health Kiosk: providing financial support; providing support for administrative and practical matters, such as financial administration; facilitating access to the public space; providing visual printed information materials, such as posters or leaflets on healthy eating and exercise; facilitating activities; providing advice; or organizing internships for students. Interns from the Bachelor in Social Work or from the Bachelor in Teacher Training for Physical Education and Exercise Recreation proved to be very important for the daily operations at the Health Kiosk by supporting the person managing the Health Kiosk. This person is essential for the daily operations at the Health Kiosk and helps bring all the organizations together, further embedding the project in the community and facilitating activities at the Health Kiosk. Those working at the Health Kiosk had to have a certain profile with specific personal traits and social skills, such as good networking skills, genuine interest in the target population, ability to build trust and give a warm welcome, and good organizational skills. The local community center was key to have access to electricity, toilets and Wi-Fi. Seed funding for the Health Kiosk was provided by a philanthropic organization, and later by

local policymakers and a university research project. Regarding the latter, a collaboration with the European-funded SPICES research project from a local university facilitated documenting the activities of the Health Kiosk and gave credibility to the Health Kiosk as a new project.

4.2. Center of focus

To be able to focus on the core activity of the Health Kiosk—i.e., stimulating healthy living and health literacy—community building and considering the spatial environment of the neighborhood formed a fundamental basis.

4.2.1. Community building

Building mutual trust in the community is essential and central to the success of the Health Kiosk in different ways—in line with ICC framework Principle 2 (see Table 1) (16). This trust basis was needed to embed the Health Kiosk in the community and to successfully reach local community members. Also by word of mouth did people from the community find their way to the Health Kiosk.

To embed the Health Kiosk in the community, building relationships with local community members and organizations who were respected in the neighborhood was crucial. For instance, at first the Health Kiosk was vandalized, but in collaboration with respected local community members this challenge was overcome. However, local organizations with a negative reputation could hinder the Health Kiosk embedding in the local community. For example, after the initial start-up phase, the initiators of the Health Kiosk realized that the community center, from where the initiators of the Health Kiosk started their activities, lacked trust from the community. This might have inhibited the initial integration into the community. Slowly trust was built by creating a presence on the square by distributing free fruit and soup; organizing small activities such as a partner day, a compliment day, a neighborhood day; a bench building workshop and many others. This slow social process to build trust is needed to become embedded in the community, but also for collaboration with local organizations:

> *It's good that we have a partner who knows the neighborhood well, but you must be careful that it's a partner who has a positive [reputation]. This is a lesson to teach to others. It's something you don't know that from the start. It's really a matter of trial and error.*
> *Person running daily operations at the Health Kiosk.*

The creation of local alliances between the organizations also facilitated collaboration among them to start-up health-related activities together. The person running daily operations at the Health Kiosk calls it "*connecting the dots*," bringing partners together to organize activities where community members, local policy makers and members of the local organizations can participate. In addition, partner organizations started collaboration among themselves as well. Not all partners focus on health; some are more focused on welfare, youth, community, culture or employment. By collaborating with the Health Kiosk, health was brought to their attention as well—taking first steps toward improving health literacy among organizations.

> *Alliances are also formed there, between those partners. They look for ways to work together, and we always try to add the health element to that. One of those goals is to increase resilience of that neighborhood and to reduce health inequities. [. . .]Well, that's actually the ultimate goal in the long term. And the kiosk is like a lever to work across those sectors. That's actually the kind of discussions that we want to start.*
> *Founder of the Health Kiosk.*

4.2.2. Spatial environment

After the first steps were taken to build trust in the community, a physical Health Kiosk was placed in the public space. The central idea of the Health Kiosk is to work in an outreaching way, by being present in the public space with a small wooden structure that can be fully opened, without a door (see Figure 1). The open structure in a public space makes it approachable and stimulates community involvement. Additionally, a bench was installed next to the Health Kiosk that can be used for physical activity exercises. A local illustrator was invited to add illustrations to the doors showcasing health-related topics. These illustrations were also used for communication materials aimed at the local community.

4.2.3. Care and wellbeing

The Health Kiosk's center of focus is related to the theme of care and wellbeing. In line with ICC framework Principle 4 (see Table 1) (16), the Health Kiosk aims to stimulate healthy living practices and health literacy among socioeconomically vulnerable groups. The focus is mainly on healthy living, but this can be understood in its broadest sense. Community members can discuss healthy eating and exercise, and join activities related to these topics. Additionally, attention is paid to mental health, healthy living space, dental health and parenting. Various health promotion activities were undertaken in collaboration with the core steering group as well as new partners who joined the project later. These will be further discussed in Section "Core ingredients".

4.2.4. Population reached

The Health Kiosk mainly reached people living in the community, both children and adults. The person managing the Health Kiosk summarizes that the Health Kiosk mainly

FIGURE 1
The Health Kiosk.

reaches people "*who are vulnerable and who then live under the radar*." In most cases, people live at a crossroads of different vulnerabilities: e.g., people living in poverty; people with a migration background; elderly people; people who have limited or no literacy; people living with a psychological vulnerability; people living on the streets; people who have a limited or no social network. Furthermore, because of its collaboration with local organizations, such as welfare organizations or organizations that work with newly-arrived migrants, the Health Kiosk also reached people living in socioeconomically vulnerable circumstances outside the community. Not specifically targeting certain vulnerable groups and leaving the door open to everyone who is curious or interested, contributed to reaching people:

> *We must always make sure to establish a certain level of trust. I think you can do that much more easily in a smaller, simple environment, where people can come and go as they want.*
> *Founder of the Health Kiosk.*

4.3. Core ingredients

Several core ingredients of the Health Kiosk are important to successfully stimulate health literacy among socioeconomically vulnerable groups: (1) working in a community-based, outreaching way; (2) providing accessible health information and support to act on that knowledge; and (3) working in a flexible and independent way to adapt to local needs.

4.3.1. A community-based, outreaching way of working

The first core ingredient is that the Health Kiosk is an outreaching, low-threshold meeting place open to everyone. The open structure of the Health Kiosk (see Figure 1) in the middle of the square facilitates interaction. By working in an outreaching way, the aim is to reach people who live in socioeconomically vulnerable circumstances and empower them to take actions for their own health.

> *Just standing there on the square without a door. All those shutters are open: it's just open. Otherwise you have to go to that door. Open that door. Go inside. Whereas now, we're just there. Very often there are questions like "What do you guys actually do? Who are you? Or what is this place?" Then you have a starting point and you can talk. The fact that there's free fruit, or that there's any fruit at all, that's also something different. I usually talk to people when they're just looking. It's different from sitting inside a building, which is much less accessible.*
> *Person running daily operations at the Health Kiosk.*

First steps are taken to adhere to the ICC framework Principle 5 (see Table 1) [(16): p. 10]. The Health Kiosk forms a hub or meeting place connecting people and organizations in two ways: by referring people depending on their needs, or by providing space for organizations to work in an outreaching way by being present at the Health Kiosk.

> *The kiosk is a binding agent. A binding agent between all those different partners in the neighborhood, but also a binding agent between the organizations and the neighborhood residents.*
> *Founder of the Health Kiosk.*

4.3.2. Accessible health information provision and support to act on that knowledge

The Health Kiosk facilitates low-threshold communication of evidence-based health information and supports people in putting this knowledge into practice.

4.3.2.1. Low-threshold communication of evidence-based health information

Low-threshold communication of evidence-based health information was provided by making use of visual materials provided by other organizations, such as illustrated posters. For instance, a poster showing the number of sugar cubes in several types of drinks, such as soft drinks. Another example is the use of "Kamishibai," a form of storytelling just using images. Exchange students created "Kamishibai" about healthy living and dental health, as part of their internship at the Health Kiosk. However, given the lack of easily understandable visual communication materials, it was challenging to inform to people with low literacy skills or who spoke a different language (a wide variety of languages are spoken in the community). To further overcome the language barrier, a collaboration was arranged with interns who speak languages common in the community. One of the interns at the Health Kiosk was a student in Social Work who fled Afghanistan. Due to her presence, the Afghan community was more engaged. If the people or interns running the Health Kiosk could not find a common language or communicated with people who have low literacy levels, body language or a translation app was used to inform people about healthy living. Moreover, the collaboration with a community health worker project further facilitated this low-threshold communication, given that they are members of the local community familiar with various languages.

> *If you want to convey very important information to people, you have to translate it. You can do that through leaflets or through apps that allow people to hear the information in their own language. Many people are illiterate so they can't read: not even in their own language, nor are they able to write in their own language. That makes it very difficult, so if you can work with people from the communities and have them share the information, isn't that worth its weight in gold?*
> *Founder of the Health Kiosk.*

A trust basis was essential to reach the target population. At first, people often visited just for a short conversation and to receive free produce. This then allowed further conversation, either during the same visit or during a next conversation, in which health information is provided and—if needed—referrals are made to health professionals present at the Health Kiosk or other local organizations. Others approached the Health Kiosk with a specific need or request for support or information.

> *A very important point: if someone feel they can't trust you and the first conversation doesn't go well, they won't come again. They need to have a good feeling about you in order to keep coming. If they don't, then not many people will come to the kiosk and it won't work.*
> *Intern at the Health Kiosk.*

4.3.2.2. Facilitation to put health information into practice

Besides providing information, an important element of the Health Kiosk is helping people put this information into practice. This was achieved by distributing free produce and by providing free access to healthcare professionals. First, free produce was distributed, which often served as a first contact point with community members. As a result of a collaboration with a local wholesaler, the Health Kiosk receives free fresh produce weekly to distribute for free.

> *It's actually a meeting place where that people can get information around health in a very accessible way. It's very simple. A place where they can come to ask questions, where they can get a piece of fruit, where they are welcome.*
> *Founder of the Health Kiosk.*

Second, first steps were taken to provide people with guidance along the healthcare continuum—from prevention to care. Each of the activities organized for this goal were adjusted to suit the needs of people living in socioeconomically vulnerable circumstances. Community members were invited to free screening days—in collaboration with medical students from a local university—where they received free measurements of the following parameters: blood pressure, abdominal girth, fat percentage and Body Mass Index, glycemic index, cholesterol, resting heart rate and post-exercise heart rate. These measurements form the basis for receiving advice on eating and exercise and/or further referral. For instance, people can be referred to a free dietician and movement coach who come to the Health Kiosk every month, or to the community health workers who can facilitate access to affordable healthcare.

> *The kiosk is a meeting place. At the same time, it's a place from which we organize a number of things, such as the medical students who will now come every month to measure parameters, a dietician who will be present every month from February, a movement coach who will be present every month. [. . .] The community health workers who have their base there visit once or twice a week. It's just a meeting place for people, for organizations, but also a place where you can find information or ask questions or seek help for problems, for someone in pain, for all kinds of things.*
> *Founder of the Health Kiosk.*

4.3.3. Flexible and independent way of working to adapt to local needs

To establish the Health Kiosk, a lot of flexibility was required from the team members, funders and partner organizations. As such, it became a space for creative experimenting to respond to local needs by taking the time to listen and observe the community. For instance, in the beginning information sessions

about healthy eating were organized but few or no people showed up—this taught the organizers that the same message needed to be conveyed in other ways.

> *Now I see it more as an experimentation place or a lab where all kinds of things can develop and grow, where ideas of people come together and lead to something.*
> *Founder of the Health Kiosk.*

The Health Kiosk's independence—i.e., being unrelated to any specific organization—has allowed it to be very flexible and to develop its organization and activities bottom-up, and made it easy to adapt to local needs of community members. Collaborating with organizations from different backgrounds provided different types of expertise. However, this independence also presented practical challenges: there is no policy-level regulatory framework in which the Health Kiosk could operate and finding funding to sustain the Health Kiosk was difficult, among others.

5. Discussion

This paper described the development and implementation process of a community health information hub with "low-threshold access" for people living in socioeconomically vulnerable circumstances. To be able to focus on the core activity of the Health Kiosk—i.e., stimulating healthy living and health literacy—community building and considering the spatial environment of the neighborhood formed a fundamental basis. Several core ingredients of the Health Kiosk are important to successfully stimulate health literacy among socioeconomically vulnerable groups, namely: (1) working in a community-based, outreaching way; (2) providing accessible health information and support to act on that knowledge; and (3) working in a flexible and independent way to adapt to local needs.

The Health Kiosk is an example of a grassroots innovation, which is "a network of activists and organizations generating novel bottom–up solutions for sustainable development and sustainable consumption; solutions that respond to the local situation and the interests and values of the communities involved" [(17): p. 1]. The concept of the Health Kiosk evolved by experimenting in the field and by collaborating with local organizations. It was a space for experimentation to discover what works for whom and which strategies should not be continued. Flexibility was required from the organizers, but also from the funders to allow for adaptation along the way. After the philanthropic and research funding ended, it proved to be challenging to find sustainable funding. This is in line with previous research on community-based care initiatives that stated that "governments and development groups may favor investment in interventions with easily measurable indicators and may underinvest in the more intangible social processes and community participation that are critical to longer-term success and sustainability" [(18): p. 8].

The analysis of the Health Kiosk was guided by the principles underpinning the ICC framework (16); Principles 1, 2, 4 and 5 (see Table 1) were applicable to some extent. In line with Principle 2, the set-up of the Health Kiosk was similar to other community-based care programs: a "slower social process [. . .] can be required for establishing stronger ties" with the community [(18): p. 8]. In this process, it is important to collaborate with organizations who are already embedded and trusted by the community—a finding in line with the implementation of other outreach programs (19). Furthermore, it is important to have a dedicated person facilitating this slow social process of embedding the Health Kiosk in the community, and who manages the Health Kiosk. This person is important in setting up the Health Kiosk and engaging all potential partners in the neighborhood at different levels—ranging from the socioeconomically vulnerable groups, to welfare and health actors, and local policy makers. However, unlike Principle 1 articulates (16), community members themselves were not actively involved in the decision-making processes of the Health Kiosk. Future development of the Health Kiosk could focus on collaborating with volunteers who share a lived experience with members of the target population. These volunteers understand local knowledge and attitudes about health (20) and have a unique understanding of the experiences, language, culture and socioeconomic realities of the people they support (21, 22). Proper guidance and follow-up for these volunteers is essential, as the conversations held in the Health Kiosk can be emotionally taxing. By involving the socioeconomically vulnerable groups in the development of the Health Kiosk, this project could become a grassroots innovation that is also inclusive. Recently, scholars have argued that "inclusive innovation provides an avenue to address challenges related to poverty, inequality and exclusion by bringing people and organizations who were out of the spotlight, to the mainstream development activity" [(23): p. 2].

ICC framework Principles 3, 6 and 7 were not yet applicable to the Health Kiosk (see Table 1) (16), but these principles provide avenues for future aspirations. In line with Principle 3, it would be very valuable if the Health Kiosk could focus on strategies that integrate people's life goals into its activities to stimulate motivation and encourage long-term behavior changes (24, 25). Furthermore, closer collaboration with primary healthcare actors forms an additional future focus point, so that people can easily be referred from the Health Kiosk and vice versa. In line with Principle 6, co-creation with members of the neighborhood and involving them in the decision-making processes of the Health Kiosk's activities and vision are important focus points—aiming to create more community ownership. Moreover, it would be interesting to investigate whether the workings of the physical Health Kiosk could be supported by technological innovations, such as a referral platform to health and welfare organizations—as done

at a "Gesundheitskiosk" in Germany (26). First steps were taken to adhere to ICC framework Principle 7 (see Table 1) (16). The workings of the Health Kiosk were adapted along the way by learning from experiences in the field—in line with the ICC's vision on measuring progress, maintaining a longitudinal view and vision to leave room for "the inevitable but very necessary learning curve" [(16): p. 11].

6. Conceptual and methodological constraints

An important limitation of this paper is the methodological constraints. Only a limited number of in-depth interviews was conducted—after obtaining written informed consent. The following key actors of the Health Kiosk participated in an in-depth interview: the founder of the Health Kiosk; the person running the daily operations; and an intern. The interviews were audiotaped, which allowed us to produce detailed interview transcripts. The transcripts were imported into NVivo (version 1.5) for thematic analysis. Data was carefully analyzed by reading and re-reading the field notes and transcripts of interviews. First, the data was open coded. In this phase of data analysis, primary information categories which remain close to the original data were constructed. These open codes were then categorized in the axial coding phase to identify patterns and regularities emerging from the data. The categories which emerged from the axial coding were integrated in the subsequent phase of selective coding. Concepts were systematically refined as the data were collected and analyzed. In this process, specific attention was paid to remaining close to the gathered data (27). These findings were additionally complemented by documents, such as meeting notes. Even though considered as a potential bias, the close involvement of the research team in all the steps of the development of the Health Kiosk allowed them to document the development and implementation process from a participatory point of view. At the time of the in-depth interviews, the researcher, who conducted the interviews and analysis had not been involved in the development of the Health Kiosk, providing her with a more independent role as a researcher. In addition, respondent validation was conducted by returning the synthesized analyzed results to the respondents to verify accuracy and responance with their experiences (28, 29).

This important methodological limitation also reflects the challenges of monitoring and evaluating this initiative (see ICC framework Principle 7, Table 1) (16). As part of a larger research project, which provided financial and substantive support to the Health Kiosk, a diary study was initiated. In this study, the person managing the Health Kiosk and local organizations present at the Health Kiosk were invited to fill in a diary. However, this research method proved to be difficult to complete by the members of the Health Kiosk during their day-to-day work, causing this research method to be stopped. Currently, a "city loyalty card scanner" is present in the Health Kiosk, where people can scan their city cards, with which they can receive access to various free activities (e.g., a ticket for the swimming pool). At the same time, this "city loyalty card stand" anonymously measures who visits the Health Kiosk. A future avenue for research could be finding innovative ways to monitor the activity at the Health Kiosk, also integrating the vision of those reached and those involved in the daily operations of the Health Kiosk. Methods, such as, participatory research methods with socioeconomically vulnerable community members and participatory observation could serve as a starting point for the evaluation (16).

Another limitation of the Health Kiosk is that it currently does not specifically address different health literacy competencies (7). For future iterations, it is important to focus on stimulating the "competencies related to the process of accessing, understanding, appraising and applying health-related information" [(7): p. 9]. Furthermore, future research could explore whether health information and practices are shared within families and households after a person visits the Health Kiosk for produce or a conversation about health. Moreover, research is needed to investigate the way in which the Health Kiosk can be aligned more with the health system.

Despite its current limitations, the Health Kiosk forms a promising innovation to improve health literacy among people living in socioeconomically vulnerable circumstances and organizations working with them—both in high-income countries, such as the setting of this paper, as well as in low-and middle-income countries. The Health Kiosk is a grassroots innovation that responds to the need recently identified in a systematic literature review that "intervention programmes for minority populations with low rates of literacy are scarce and little known" [(6): p. 61].

Data availability statement

The datasets presented in this article are not readily available because protection of the respondents' privacy. Requests to access the datasets should be directed to caroline.masquillier@uantwerpen.be.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Antwerp University Hospital (B300201940009). The patients/participants provided their written informed consent to participate in this study.

Author contributions

Grassroots innovators: PV and DO. Methodology: CM, KV, and HB. Formal analysis, investigation, and writing—original draft preparation: CM. Funding acquisition: HB. Writing—review and editing: all authors.

Funding

The authors would like to thank the funder: Horizon 2020, which funded the SPICES project (Grant Agreement ID: 733356), as well as the Koning Boudewijnstichting, LOGO Antwerp and the district of Borgerhout. These funding sources had no role in the design of this study, nor during its execution, analyses, interpretation of the data, or decision to submit results.

Acknowledgments

The research team would like to thank all local organizations contributing to the development and implementation process of the Health Kiosk, as well as all people living in socioeconomically vulnerable circumstances visiting the Health Kiosk. Furthermore, they would like to thank the funder: Horizon 2020, which funded the SPICES project (Grant Agreement ID: 733356), as well as the Koning Boudewijnstichting, LOGO Antwerp and the district of Borgerhout.

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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References

1. World Health Organization. *Evidence and resources to act on health inequities, social determinants and meet the SDGs*. Geneva, Switzerland: World Health Organization. Regional Office for Europe (2019).

2. Onyango D, Schatz E, Lazarus J. Nobody left behind: Taking a 'people-centred'approach to improving access to health care for underserved groups in Europe. *Eurohealth.* (2017) 23:23–7. Available online at: https://apps.who.int/iris/handle/10665/332628

3. Bouckaert N, Maertens de Noordhout C., Van de Voorde C. *De performantie van het Belgische Gezondheidssysteem: Evaluatie van de Bilijkheid*. (2020). Available at: KCEReports334As.D/2020/10.273/28, https://kce.fgov.be/sites/default/files/atoms/files/KCE_334A_Billijkheid_Belgisch_gezondheidssysteem_Synthese.pdf.

4. World Health Organization. *Social Determinants of Health*. (2022). Available online at: https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1 (accessed September 15, 2022).

5. Kickbusch I, Pelikan JM, Apfel F, Tsouros A. *Health Literacy*. Geneva, Switzerland: WHO Regional Office for Europe (2013).

6. Fernández-Gutiérrez M, Bas-Sarmiento P, Albar-Marín MJ, Paloma-Castro O, Romero-Sánchez J. Health literacy interventions for immigrant populations: a systematic review. *Int Nurs Rev.* (2018) 65:54–64. doi: 10.1111/inr.12373

7. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health.* (2012) 12:1–13. doi: 10.1186/1471-2458-12-80

8. Rowlands G, Shaw A, Jaswal S, Smith S, Harpham T. Health literacy and the social determinants of health: a qualitative model from adult learners. *Health Promot Int.* (2017) 32:130–8. doi: 10.1093/heapro/dav093

9. Rondia K, Adriaenssens J, Van Den Broucke S, Kohn L. Health literacy: what lessons can be learned from the experiences of other countries? *Int J Health Plann Manage.* (2019) 37:886–901. doi: 10.1002/hpm.3382

10. Gibney S, Bruton L, Ryan C, Doyle G, Rowlands G. Increasing health literacy may reduce health inequalities: evidence from a national population survey in Ireland. *Int J Environ Res Public Health.* (2020) 17:5891. doi: 10.3390/ijerph17165891

11. Arrazola de. Oñate W, editor. *Volksgezondheid en wijkontwikkeling*. Bruxelles, Belgium: Academic & Scientific Publishers (2022).

12. Nutbeam D. The evolving concept of health literacy. *Soc Sci Med.* (2008) 67:2072–8. doi: 10.1016/j.socscimed.2008.09.050

13. Burns R, Graversen P, Xenou E, Offe J, Martin S, et al. *Unheard, Unseen, and Untreated: Health Inequalities in Europe Today*. Stockholm (2021).

14. Rademakers J, Heijmans M. Beyond reading and understanding: Health literacy as the capacity to act. *Int J Environ Res Public Health.* (2018) 15:1676. doi: 10.3390/ijerph15081676

15. Stad Antwerpen. *Stad In Cijfers*. (2020). Available online at: https://stadincijfers.antwerpen.be/dashboard (accessed August 18, 2022).

16. Vandenbroeck P, Braes T. Integrated community care for all: seven principles for care. *Strategy paper to move ICC forward Brussels* (2020).

17. Hossain M. Grassroots innovation: The state of the art and future perspectives. *Technol Soc.* (2018) 55:63–9. doi: 10.1016/j.techsoc.2018.06.008

18. LeBan K, Kok M, Perry HB. Community health workers at the dawn of a new era: 9. CHWs' relationships with the health system and communities. *Health Res. Policy Syst.* (2021) 19:1–19. doi: 10.1186/s12961-021-00756-4

19. Masquillier, Cosaert, Wouters. *Community Health Workers in België—Rapport 2021*. Antwerp (2022). Contract No.: ISBN: 9789057287343.

20. Glenton C, Javadi D, Perry HB. Community health workers at the dawn of a new era: 5. Roles and tasks. *Health Res Policy Syst.* (2021) 19:1–16. doi: 10.1186/s12961-021-00748-4

21. Javanparast S, Windle A, Freeman T, Baum F. Community health worker programs to improve healthcare access and equity: are they only relevant to low-and middle-income countries? *Int. J. Health Policy Manage.* (2018) 7:943. doi: 10.15171/ijhpm.2018.53

22. Damio G, Ferraro M, London K, Pérez-Escamilla R, Wiggins N. Addressing social determinants of health through community health workers: A call to action. *Connecticut December: Hispanic Health Council Policy Brief Hartford* (2017) p. 22.

23. Patnaik J, Bhowmick B. Promise of inclusive innovation: a Re-look into the opportunities at the grassroots. *J Clean Prod.* (2020) 259:121124. doi: 10.1016/j.jclepro.2020.121124

24. Turner-McGrievy GM, Wright JA, Migneault JP, Quintiliani L, Friedman RH. The interaction between dietary and life goals: using goal

systems theory to explore healthy diet and life goals. *Health Psychol Behav Med Open Access J.* (2014) 2:759–69. doi: 10.1080/21642850.2014.927737

25. Orehek E, Vazeou-Nieuwenhuis A. Sequential and concurrent strategies of multiple goal pursuit. *Rev Gener Psychol.* (2013) 17:339–49. doi: 10.1037/a0032584

26. Billstedt/Horn I. *Health for Billstedt-Horn Hamburg, Germany.* (2021). Available online at: https://transform-integratedcommunitycare.com/wp-content/uploads/2019/03/billstedthorn_summarycasestudy.pdf (accessed September 15, 2022).

27. Böhm A. Theoretical coding: Text analysis in grounded theory. In: Flick U, Kardoff E, Steinke I, editors. *A Companion to Qualitative Research Içinde*. (2004). p. 270–5.

28. Harvey L. Beyond member-checking: A dialogic approach to the research interview. *Int J Res Method Educ.* (2015) 38:23–38. doi: 10.1080/1743727X.2014.914487

29. Birt L, Scott S, Cavers D, Campbell C, Walter F. Member checking: a tool to enhance trustworthiness or merely a nod to validation? *Qual Health Res.* (2016) 26:1802–11. doi: 10.1177/1049732316654870

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 04 January 2023
DOI 10.3389/fpubh.2022.1090101

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 04 November 2022
ACCEPTED 07 December 2022
PUBLISHED 04 January 2023

CITATION
Villavicencio EA, Maldonado A, Crocker RM, Guan Y, Stallman C and Garcia DO (2023) Communicating *PNPLA3* genetic risk status for NAFLD among Mexican-origin men. *Front. Public Health* 10:1090101. doi: 10.3389/fpubh.2022.1090101

Communicating *PNPLA3* genetic risk status for NAFLD among Mexican-origin men

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Introduction: The burden of non-alcoholic fatty liver disease (NAFLD) continues to disproportionately impact under-resourced communities in the U.S., particularly Mexican-origin populations. Genetic polymorphisms such as the rs738409 C/G variant in patatin-like phospholipase domain-containing 3 (*PNPLA3*) have been associated with higher prevalence of and progression along the NAFLD spectrum. This qualitative study conducted in the U.S. Southwest aimed to assess Mexican-origin men's experience receiving genetic testing for *PNPLA3* risk carrier status.

Methods: Semi-structured interviews were conducted with 17 Mexican-origin men whose NAFLD status and genetic predisposition were determined as part of a previous cross-sectional study. The interview guide included questions exploring participants' insights on how genetic risk status was delivered, how the information influenced their motivation for lifestyle modification to reduce NAFLD risk, and any knowledge sharing that occurred with family members after learning of their *PNPLA3* risk status. Interviews were conducted and audio recorded in English (n = 6) and Spanish (n = 11) and uploaded into NVivo software for data analysis and interpretation. Guided by the Health Belief Model, a thematic analysis approach was used to identify primary themes.

Results: Results highlighted men's preference for receiving this type of genetic risk information through a letter sent to their homes. General comprehension of *PNPLA3* risk status was deemed high and most men stated sharing their genetic predisposition to NAFLD with their immediate family members. Participants also indicated that family and awareness of this genetic risk acted as primary motivators for implementing behavior changes (e.g., diet, physical activity) toward the prevention of more severe liver conditions.

Discussion: Findings from this qualitative study suggest the feasibility of communicating genetic risk for NAFLD among Mexican-origin men. Future strategies for the dissemination of genetic risk results among Mexican-origin individuals should consider familial and cultural appropriate strategies.

KEYWORDS

NAFLD, genetic risk, *PNPLA3*, Mexican-origin, men's health

Introduction

As the most common liver disease in United States (U.S.), non-alcoholic fatty liver disease (NAFLD) affects ∼25% of the U.S. population (1). NAFLD is a multifaceted disease resulting from a complex interplay of genetic, environmental, metabolic and microbial factors disproportionately impacting Mexican-origin adults (2). Compared to non-Hispanic Blacks (21.6%), non-Hispanic Whites (30.6%), and other Hispanic subpopulations (27.6%), NAFLD rates are the highest among Mexican-origin adults (42.8%) (3). The differences among racial and ethnic groups are partially explained by obesity status, sex differences (higher rates among men), and genetic polymorphisms such as the rs738409 C/G variant in patatin-like phospholipase domain-containing 3 (*PNPLA3*) (4).

The single nucleotide polymorphism (SNP) represents an Ile148Met substitution (C > G) in the *PNPLA3* gene (5). Specifically, differences in the C and G variants are due to changes in an amino acid from isoleucine (I) to methionine (M) at the position 148 (I1e148 Met) of the protein, which is associated with high frequency of fat cells in the liver (6). *PNPLA3* is associated with an increased risk for NAFLD across the full spectrum of the disease including age of diagnosis, steatosis, fibrosis, and hepatocellular carcinoma (HCC) (7, 8). Romeo et al. (9) were among the first to show individuals carrying two copies of the risk allele displayed levels of hepatic fat content that was greater than two-fold higher than non-carriers. In addition, this study found that Hispanic descent individuals had a higher frequency (49%) of *PNPLA3* compared to European Americans (23%) and African Americans (17%) (9). More recently, Martínez et al. (10) found Mexicans living in Mexico carrying two copies of the risk allele had 3.8 times higher risk of having NASH and 2.3 times higher risk of fibrosis. This is concerning as estimates from Mexican-origin populations suggest the frequency of the G risk allele is up to 77% (10, 11). Despite the significant genetic basis for *PNPLA3* testing for Mexican-origin adults, there are currently no recommendations for routine testing of this genetic variant in screening or clinical care of the disease. However, this may change as more evidence becomes available (12), making the examination of appropriate and effective genetic risk communication strategies a critical step toward the widespread communication of *PNPLA3* susceptibility.

While the importance of genetic testing has recently emerged within the context of personalized medicine, there have been limited studies on genetic testing strategies for Mexican-origin adults and no studies to date specifically for men (13–16). However, low levels of knowledge and awareness about genetic testing have previously been reported (16), and prior findings demonstrate that Hispanics may not understand risk within the context of genetics due to limited genetic literacy defined as the ability to obtain, process, understand, and use genetic information (17, 18). This may be due in part to limited health care access and health information faced by many Hispanics in the U.S. (19). Lower awareness and exposure to genetic testing is also most prominent among Hispanics with lower levels of acculturation (20, 21). In addition, barriers to the adoption of genetic testing for Hispanics have been identified such as concerns about misuse of genetic information, personal utility (behavioral and lifestyle implications), and adverse emotional responses (fear of receiving an alarming result) (16). Practical barriers identified include finances (related to the costs of genetic testing and necessary follow-up medical care), a lack of access and knowledge about where to get a genetic test, a lack of a family history of disease, and difficulties related to language proficiency and educational level (16). Despite these barriers, existing results indicate that Hispanics have an interest in and favorable attitudes toward genetic testing (16, 22).

Efforts to promote genomic risk communication is often limited to single-gene disorders (e.g., BRCA1 or BRCA2 for breast and ovarian cancer prevention) (23). Further, screening efforts focused on genomic risks presume that knowledge of risk levels should promote risk-appropriate uptake of health prevention behaviors. However, understanding complex and unfamiliar concepts associated with genomic risk can be challenging. Given the genetic heritability of NAFLD and the fact that lifestyle modification is the cornerstone of treatment for risk reduction (24), efforts to improve knowledge and awareness of *PNPLA3* risk status are important to inform therapeutic lifestyle strategies. This qualitative study conducted in the U.S. Southwest aimed to assess Mexican-origin men's experience receiving genetic testing for *PNPLA3* risk carrier status. The interview guide included questions exploring participants' insights on how genetic risk status was delivered, how the information influenced their motivation for lifestyle modification to reduce NAFLD risk, and any knowledge sharing that occurred with family members after learning of their *PNPLA3* risk status.

Methods

Design, study sample and recruitment

Participants were recruited from a pool of eligible individuals who had given informed consent to participate in further research during a previous cross-sectional study (11). Eligible participants: (1) were carriers of *PNPLA3* (G/GG genotype); and (2) had NAFLD status identified by continuous attenuation parameter (≥248 dB/m) using a FibroScan® (25), a modality of vibration-controlled transient elastography. Of the 103 prospective participants, 72 were excluded for not meeting the initial eligibility criteria (e.g., *PNPLA3* non-carriers). Out of the 31 eligible participants, research staff were unable to contact nine and unable to schedule an interview with an additional five due to time constraints, resulting in the final sample of

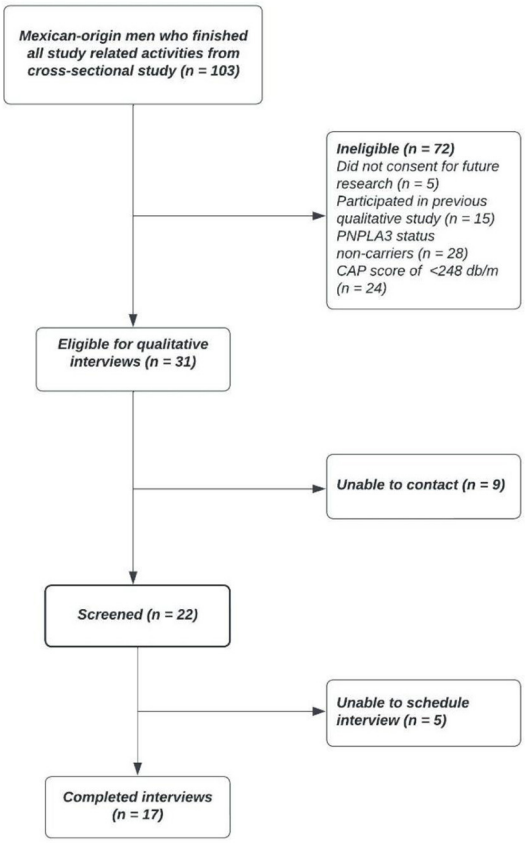

FIGURE 1
Flowchart of recruitment for in-person qualitative interviews.

17 Mexican-origin men (Figure 1). All study procedures were approved by the University of Arizona Institutional Review Board (IRB# 1911187047).

Data collection

Dissemination of *PNPLA3* genetic risk

Data collection occurred from September 2021 to April 2022. Genetic risk communication was disseminated following standard protocols (26). The investigative team with expertise in genetic counseling (CS), genetic risk communication (YG) and Hispanic men's health (DG, EV) developed the initial communication content. To reduce literacy demand, we considered health literacy criteria from CDC Clear Communication Index (e.g., readability, action orientation, positive tone) (27). Additionally, we developed communication content based on cultural tailoring (28). For example, we used evidential tailoring to provide evidence specific to Hispanic men based on our previous work (29). We conducted an exploratory pre-test with two community members (i.e., Mexican-origin men) and two stakeholders (i.e., community partners) and asked them to provide feedback on acceptability, appropriateness, and feasibility. The communication content was then revised and finalized based on input from community members.

Eligible and interested participants received their *PNPLA3* genetic risk status enclosed in a one-page letter mailed to their homes upon agreement of receiving such results. The use of the genetic risk letter was hypothesized to initiate disease susceptibility conversations between participants and their family members. The use of a printed letter has previously been tested and deemed optimal and preferred to disclose genetic mutations to individuals and their families (30). Two weeks after the letter was mailed, participants were contacted to ensure the letter had been received and scheduled an in-person appointment to complete the interview. The 2-week period was determined by the study to allow participants to process their genetic information and allow them to have sufficient time to share information with others if desired.

Semi-structured interviews

In-person semi-structured interviews were conducted in participants' preferred language (English or Spanish) by the first author (EV), a bicultural and bilingual male. This ensured a high level of cultural and gender appropriateness to maintain participant engagement and interest in the study. Data collection occurred until theoretical saturation was achieved (31). To ensure quality and precision of data collection procedures, all interviews were digitally audio-recorded and transcribed verbatim by a professional transcription service. Guided by the health belief model (HBM) (32), an interview guide was developed to gather information about Mexican-origin men's experience on receiving genetic risk results, understanding of genetic risk for NAFLD, and family communication about genetic risk (Supplemental material). Genetic counselors endorsed and contributed to the development of this interview guide to ensure questions about genetic risk were adequately prompted for participants. Upon completion of the interview, participants answered a demographics questionnaire and received a physical assessment where height, weight, and a FibroScan® were completed to reassess NAFLD status. Eleven interviews (64.7%) were completed in Spanish and six (35.3%) in English. All interview sessions lasted ∼30–45 min and occurred in a private room at the University of Arizona's Collaboratory for Metabolic Disease Prevention and Treatment. Participants received a $25 as a cash incentive for their time contributions to the study.

Data analysis

Thematic analysis was used to conduct the analysis of interview transcripts (33, 34). A team-based approach

10.3389/fpubh.2022.1090101

was used to improve the rigor of the analytical process. Discrepancies in coding were discussed by EV, AM, and DG and revisions were made to the codebook based on the initial analysis and discussions among the coding team. Interrater agreement between the three coders was found to be adequate with a minimal percentage agreement of 80%. All final codes were sorted into themes and provided descriptive definitions and labels. To aid in the analysis process, descriptive matrix displays were created to identify code overlap and relationships among codes (35). All transcripts were analyzed in their original language to avoid misrepresentation or loss of meaning. Analyses were conducted using QSR International's NVivo qualitative data analysis software (36).

Study findings

Demographic characteristics

Seventeen Mexican-origin men completed the qualitative interviews. Most of the sample was identified as having the CG genotype of the *PNPLA3* risk allele (64.7%). Participants' mean age was 47.1 ± 9.1 years with an average of 22.6 ± 16.5 years living in the U.S. Mean body mass index (BMI) was 33.8 ± 6.7 kg/m^2. Nearly half of the sample (47.1%) reported an annual household income of <$29,999 and indicated having obtained education at the level of a high school diploma/GED equivalent or less (47.0%). Most men reported having access to a primary care provider (76.5%) or health insurance coverage (70.6%). Detailed participant demographic characteristics are reported in Table 1.

TABLE 1 Participant characteristics for Mexican-origin men who completed qualitative interviews.

Characteristics	*n*/mean	%/range
***PNPLA3* status**		
CG	11	64.7%
GG	6	35.3%
Language		
Spanish	11	64.7%
English	6	35.3%
Age (years)	47.1 ± 9.1	(27–61)
Years in the US (years)	22.6 ± 16.5	(2–60)
Weight (kg)	99.6 ± 19.5	(72.2–135.7)
Body mass index (kg/m^2)	33.8 ± 6.7	(27.0–47.5)
Educational level		
Grades 1–8	4	23.5%
Attended some high school	1	5.9%
Graduated high school/GED	3	17.6%
Some college	3	17.6%
Bachelor's degree	4	23.5%
Graduate degree or higher	2	11.8%
Income (US)		
<$29,999	8	47.1%
$30,000–$59,999	4	23.5%
>$60,000	5	29.4%
Employed		
Yes	15	88.2%
No	2	11.8%
Family cancer history		
Yes	10	58.8%
No	7	41.2%
Access to a primary care provider		
Yes	13	76.5%
No	4	23.5%
Health insurance		
Yes	12	70.6%
No	5	29.4%

Thematic analysis

Five major themes emerged from the data including (1) assessment of delivery method; (2) understanding of genetic risk and NAFLD; (3) perceptions of genetic risk for NAFLD; (4) sharing of genetic risk information; and (5) motivators for risk reduction. We support and illustrate themes with relevant quotes from participants. Selected quotes are shown under a pseudonym to maintain participant's anonymity.

Assessment of delivery method

Most participants (n = 15) gave positive feedback about the genetic risk letter that was sent to their homes. In fact, 11 men identified the genetic risk letter as their method of choice for learning this type of genetic information. Ricardo (Spanish, 59) provided the following on the didactics of the letter:

> "Everything was well explained, it is in the language that I understand, and everything was very clear. It is understandable to the point."

However, two men emphasized their preference for an in-person session after receiving the genetic risk letter. Miguel

(Spanish, 44) integrated the cultural attributes of Hispanics and emphasized the importance of one-on-one interactions when obtaining genetic related information. He explained:

> "…perhaps a consultation or an interview, where you explain what the results are, especially since we are talking about the Hispanic population and you know that the Hispanic population is not the type to read the entire document, and as Hispanics it makes us feel very good to have person to person contact, transmitting information face to face, especially when we have the opportunity to ask questions."

Participants did not express strong opinions about who should communicated their genetic risk information, as long as the person was knowledgeable and capable of answering questions about how genetic risk can impact NAFLD-related outcomes. One man described:

> "If you are the right person for this, go ahead, I understand, but if there is a doctor that you want to refer us to, if you send me with doctor so-and-so or to this specialist in this disease to inform us, we will also go there. Wherever you want us to go, we will go." Rigoberto (Spanish, 52)

Further, when asked about ways to improve the dissemination of this genetic risk information, five men mentioned that having a family member present during a follow up appointment would not only facilitate their genetic risk comprehension but also create a space to receive information about NAFLD preventive measures that would benefit the family unit. Diego (Spanish, 53) stated:

> "If you can have three people at the same time, then you are reaching more than one person. Like, I think giving the person the option like 'hey, you can bring your wife, your kids, or whoever you want to talk about this.' Yeah, and if the whole family can come, that's even better."

Understanding of genetic risk and NAFLD

Despite participants' comprehension of their genetic predisposition for NAFLD being high ($n = 14$), a few men ($n = 3$) expressed confusion with understanding scientific terminology used in the genetic risk letter. Particularly, participants cited the expression "genetic risk" as confusing and what being carriers of the *PNPLA3* risk allele meant. Enrique (Spanish, 49) spoke about how he would have understood the concept of genetic risk better if language within the letter had included fewer medical terms. He mentioned,

> "… to speak medical terms such as the so-and-so gene – many times we are not familiar with such terms, medical ones; but if it were something simpler to explain, like genes from your family or something like that, it would be easier to understand."

Another participant suggested that the word "genetic" should be replaced by "hereditary," which he said was more commonly used in Mexico.

> "Sometimes it is a matter of word choice, instead of talking about genetic disease, they say hereditary disease and in fact in the Mexican environment… that is the most common word. It is a hereditary disease that is transmitted in the family, it is not a genetic issue." (Miguel, Spanish, 44)

By contrast, nearly all men ($n = 15$) demonstrated modest knowledge of other genetic diseases that were described as "hereditary" or diseases that participants understood being "prone to" based on their family history. A total of 12 men recognized type 2 diabetes as a hereditary condition, eight made a reference to different types of cancer, and four mentioned other cardiovascular conditions. Antonio (English, 60) explained how cancer can run in families and shared about how his mother has been diagnosed with breast cancer.

> "What could be hereditary? I guess cancer. What I understand, cancer – if somebody has it in your family, then you might get tested for it because you might have the same gene in there or something like that. My mom had breast cancer, but nobody else in the family had it."

Perceptions of genetic risk for NAFLD

Men were also prompted to share about their insights to receiving their genetic risk information and whether they viewed it as something positive or negative toward the way they view their health status. Most participants ($n = 15$) viewed receiving their genetic risk information as beneficial, as it generated awareness of their susceptibility to the more advanced stages of the NAFLD spectrum. Emilio (English, 27) described how learning about his genetic risk could aid him in reversing the progression of NAFLD.

> "I think it's a good benefit to know. Sometimes it can be kind of scary because you don't know what you're seeing. For me, it was like 'oh, man, something can happen to me.' I could be more likely to be with fatty liver disease, or anything like that. At the same time, being informed, I can start looking for ways to help myself."

Of these 15 men who felt it was beneficial, 13 indicated that being made aware of their genetic risk gave them an opportunity to change their behaviors and lead a healthier lifestyle. For instance, Jose Luis (Spanish, 46) acknowledged that the process enabled him to make more conscious decisions about his physical activity and dietary habits.

> "It is giving it a little bit more importance, it is giving me choice. I am aware that choices, primarily when it comes to eating habits and physical activity, can impact you at a greater to lesser degree. So with this study I am now more conscious about that."

Sharing of genetic risk information

It is noteworthy that all but one participant ($n = 16$) shared information about their genetic risk results with somebody from their immediate family. Thirteen men shared this information with their spouses and emphasized the importance of sharing health related information with partners. Miguel (Spanish, 44) described how cultural and gender norms played an important role in him having shared this information with his wife.

> "Because you know that this matter is very cultural. The wife is the one who tells us to eat well, to not go overboard with this and that. Even when many times here in the U.S. when both of the parents work, the wife traditionally continues to be the one in charge of the kitchen."

Additionally, three of these men shared their genetic information with at least one of their children, two shared it with at least one of their parents, and four shared it with other family members including cousins and siblings. Emilio (English, 27) explained that he shared his genetic predisposition to NAFLD with his mother because of the way her lifestyle had influenced his behaviors and both of their health statuses.

> "My mom more because, obviously, I picked up my lifestyle from her…So, if it's affecting me, you know, she's older, and so it could be affecting her as well and not even knowing about it."

Diego (Spanish, 53) provided some insights on why he decided to share this information with his children highlighting the importance of taking action and implementing lifestyle changes toward reversing the progression of NAFLD.

> "I chose [my children] because we are family and at the moment I found out, I told them it is something that has to be taken care of and that there must be some changes in the way we live. Though it is not as serious right now, it can become much serious later if you don't do something to take care of yourself."

When expanding upon participants' risk communication patterns, men were asked if they believed anyone in their families would be interested in learning about their own genetic risk for NAFLD. A total of 15 participants responded yes, suggesting a high interest in familial genetic risk testing for *PNPLA3* status among Mexican-origin adults. In fact, family members of six participants expressed immediate interest in getting genetic testing for themselves after participants shared information about their NAFLD predisposition. Emilio (English, 27) stated his mom conveyed interest in learning about her own genetic status:

> "My mom felt that it was relevant to her too, because she says, 'oh, maybe I want to get checked up as well because maybe I could have been – it could be from me going down to you, to my kids or my brothers and you'."

Motivators for risk reduction

Nearly all participants ($n = 15$) expressed being motivated to lower their NAFLD risk after receiving their genetic risk letter. Considering his age and high risk for developing complications of NAFLD and other chronic liver conditions, Sebastian (English, 40) highlighted that discovering his genetic predisposition motivated him to look for better approaches to take care of himself and focus on disease prevention strategies.

> "Most important part is that I gotta take care of myself. I'm already, I guess, half of my life; I'm 40 years old so, it's not something that I'm worried to a point where I have to do something right away. I'm not worried, I don't feel that it's gonna affect my life, as long as I have a good lifestyle and eating habits."

Nearly half ($n = 7$) of the men referenced their family as the main source of motivation for improving their lifestyle behaviors. Carlos (English, 38) highlighted his children as his main source of motivation for adopting strategies to help prevent NAFLD complications.

> "Me, I'm a single father with three kids, no mother, my wife passed away, and my youngest is in first grade. And the liver can take you out very fast. So I don't know a lot about liver disease, I don't know a lot about it, but I know that once you get it, it goes fast. And I'm not prepared to leave my kids like that, so it's something I really gotta start looking into."

Emilio (English, 27) also recognized the value of making lifestyle changes as an opportunity to improve his quality of life and be a part of his family's future.

> "I have kids and I want to be able to see them get old. And I don't want to know that I have a higher risk of getting fatty liver disease and possibly affecting my liver so much where I'm not gonna be able to be there for them. Definitely it's something that wants to make me change my lifestyle."

Some men described emotional responses after receiving genetic risk information and noted that these feelings served as a motivator for disease prevention through lifestyle changes. For instance, some men expressed feeling surprised ($n = 4$) and scared ($n = 2$) when first reading the letter and learning about their genetic predisposition. However, several men ($n = 6$) appeared to transition those feelings into a sense of hope when they used their genetic risk as a motivator to adopt healthier behaviors. Rigoberto (Spanish, 52) described this spectrum of emotions, when he stated,

> "It is another life opportunity that is being presented to me when you told me 'You know what? You are prone to being sick,' but if I know that I can do better at this, I am – it is a matter of how I am at the moment that I can resolve the situation, by just moving forward. That is all I have to do."

Of note, all participants communicated being motivated and interested in participating in a prospective weight loss program focused on NAFLD health risk tailored for Mexican-origin men and provided consent to being contacted in the future for an intervention of this nature.

Discussion

Given the influence of *PNPLA3* in the progression of liver disease and the frequency of this genetic predisposition among Mexican-origin adults (10), the current study aimed to identify appropriate strategies to communicate *PNPLA3* risk status to Mexican-origin men as a means to promote NAFLD prevention. Our study is among the first to assess Mexican-origin men's perspectives and attitudes on the delivery of genetic risk, particularly to *PNPLA3*, and the threat this conveys to the progression of the NAFLD spectrum. Participants expressed their preference in obtaining genetic risk results through a mailed letter with an optional in-person follow-up appointment with a trained health professional. In addition, almost all men were able to understand the basic implications of being carriers of the *PNPLA3* risk allele and how this affects their NAFLD risk. Overall, most participants stated that it was beneficial to learn about their genetic risk and had shared this information with at least one family member. These findings provide new evidence on how communicating *PNPLA3* risk status may help standardize the delivery of genetic testing to guide preventative measures to reduce the burden of NAFLD in this high-risk population.

Overall, men in this study supported the use of a mailed letter for communicating genetic risk, supporting prior findings for this method of delivery (30). In addition, the Spanish speaking men highlighted the importance of receiving results in their preferred language, as has been previously reported in studies centered on BRCA1/2 (14, 17). Mexican-origin men expressed their interest in having an optional appointment with either a study staff member or a health professional with sufficient knowledge on *PNPLA3* and its influence on NAFLD progression. Preference for in-person appointment is reflective of the importance of face-to-face interactions in Hispanic/Latino culture as conveyed by the construct of *personalismo* in relation to interpersonal exchanges of information (37). Parallel preferences toward face-to-face interactions were found in a study performed in rural areas in the Midwestern U.S. were Hispanic/Latino immigrants preferred obtaining clarification on health information in Spanish at in-person settings such as schools, churches, and community centers (38). As well, U.S. born Hispanic/Latinos in Cristancho et al.'s (38) cohort opted for mailed printed materials as their second preferred strategy to receive health related information. Taken together these data indicate that the initial delivery of genetic risk through a letter appears to be feasible when used with Mexican-origin men as long as consultations for further inquiries are available.

Mexican-origin men showed high levels of understanding of their genetic predisposition to NAFLD upon receiving the letter containing their *PNPLA3* risk status. In general, men demonstrated moderate awareness levels on other commonly known genetic conditions (e.g., type 2 diabetes, other cancers) but referred to them as "hereditary" rather than genetic diseases. The concept of "genetic risk" was labeled as too scientific or even confusing by participants when referring to conditions they also recognized as running in their families. Similar viewpoints were reported by Hamilton et al. (16), were Latino men and women described genetic testing as a type of blood test relating to family history or for illnesses that can be passed down from one generation to another. Independent of Hamilton's work, our sample was only composed of men from Mexican decent which allows for the development and application of culturally and gender tailored interventions and programs. Adopting gender- and culturally-specific approaches has been demonstrated to be effective in men from this population (39) and holds favorable projections with the incorporation of genetic testing (40, 41).

According to participants' testimonies, discovering their *PNPLA3* status allowed them to assess their risk for liver diseases and the implications to more severe stages of disease in the NAFLD continuum. As derived from the HBM, participants in our study acknowledged that their newfound perceptions of NAFLD risk may influence the adoption of disease prevention strategies such as changes in diet and physical activity. Most

participants of this study considered learning about their genetic risk status as a definite benefit to their health given the potential improvement, they can achieve by implementing such lifestyle changes. Similar actionable health information were observed in Hamilton et al. (16), in which both, Latino men and women anticipated genetic risk as a source of additional information for them to protect their health and their children's through the engagement of new healthier behaviors.

Men in our study had comparably familial views as they believed sharing their genetic risk information with family members would allow their entire family to become aware of the disease and come together and partake in lifestyle modification efforts. This finding relates closely to the cultural value of *familismo*, a core component of Latino/Hispanic individuals characterized as the strong interconnectedness and attachment with nuclear and extended family members (42, 43). All but one participant testified to have shared information about their genetic risk predisposition to at least one close family member. Though this was an expected finding, we found that the propagation of participants' genetic risk generated interest in family members indicating that genetic testing in Mexican-origin adults might be more viable than anticipated. This finding along with the presence of *familismo* could help inform the utilization of family-based approaches for the use and delivery of genetic testing to communicate NAFLD risk and disease reduction strategies for Mexican-origin families.

Findings from this sample of Mexican-origin men suggest a clear preference for learning about the role genetics plays in determining NAFLD risk. They expressed high levels of motivation to reduce their NAFLD progression with main motivators identified as improving their health status and being present in their children's life for much longer. Similar conclusions were seen in a previous qualitative study where familial and cultural attitudes appeared to enhance perceived risk for NAFLD progression in Mexican-origin men (44).

Lastly, it is important to consider emotional vulnerability when delivering genetic testing results to inform disease risk, and how emotions may motivate or discourage positive change. Limited evidence has shown the relevance of emotional screening in this population, but has particularly focused on women (45). A few men in our study reported initially feeling surprised and afraid of the news of being genetically predisposed to NAFLD, and using those feelings as an opportunity to gain self-confidence tied to their ability to change their health status and reduce their odds of progressing to more serious stages of liver disease. Similar emotional responses were evidenced in another sample of Mexican-origin men and women from our initial recruitment cohort in which participants were interviewed to measure NAFLD awareness, knowledge and perceptions of disease after receiving their results from a FibroScan® (46). Consistent with information processing theories (47), credible health risk information can activate emotional responses such as distress and fear. Taking opportunities to encourage pro-health behaviors to lower distress could results in greater uptake of recommended actions (e.g., lifestyle changes).

Strengths and limitations

This qualitative study presents several strengths. This is the first known study to communicate *PNPLA3* risk status to Mexican-origin men. The process of genetic risk communication is critical considering the high and growing burden of NAFLD in this subpopulation along with the forthcoming rise of utilizing genetic testing as an opportunity to promote disease prevention. Another asset of our study design was having an interdisciplinary approach, including community members and stakeholders, guiding the development of the genetic risk letter, adding a further degree of value to the study's validity. In addition, our qualitative study design offers a nuanced exploration of the lived experiences of Mexican-origin men. However, the study has several limitations, including the variations in time between when participants become aware of their genetic predisposition through the letter and the time, they attended interview sessions. Due to availability conflicts, some men ($n = 4$) were unable to schedule their interview time by the two-week mark determined by the study and attended their interview up to 3 months after receiving the letter. This could have impacted participants' retention of information and cause recall bias surrounding the experiences they had lived since becoming aware of their genetic risk. Another limitation relates to men's previous exposure to NAFLD knowledge because of their participation in the initial cross-sectional study. This previous involvement would also consider all 17 participating men as part of the highest risk group to NAFLD due to the implications of the initial eligibility criteria from such study (e.g., body mass index > 25.0 kg/m^2). Lastly, it is important to acknowledge cost considerations related to genetic testing as a barrier for the general population to obtain this kind of testing. Particularly, *PNPLA3* genetic testing is not publicly available and may hinder efforts to widely scale result dissemination (48). Future studies should consider the evaluation of delivering *PNPLA3* risk status to low-risk individuals considered at lower risk, other Hispanic subpopulations, and women to compare views on risk susceptibility and severity.

Conclusions

This qualitative analysis provides preliminary outcomes on the benefit of integrating genetic risk communication of *PNPLA3* status as a component of disease prevention in a high-risk subpopulation. The overall experiences of these men indicate high levels of interest and feasibility in the delivery of genetic risk status to Mexican-origin men. The development of

relevant family-based interventions that are culturally tailored for this high-risk group warrants further research to evaluate its effectiveness in decreasing the burden of NAFLD and overall liver cancer mortality.

Data availability statement

The datasets presented in this article are not readily available because data is protected under the National Institutes of Health's Certificate of Confidentiality to protect participants confidentiality. Requests to access the datasets should be directed at: davidogarcia@arizona.edu.

Ethics statement

The studies involving human participants were reviewed and approved by University of Arizona Institutional Review Board (IRB# 1911187047). The patients/participants provided their written informed consent to participate in this study.

Author contributions

DG, EV, RC, YG, and CS designed the research. EV and DG conducted the research. EV, DG, and AM analyzed data. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Funding

This work was supported by the National Institute on Minority Health and Health Disparities (award number K01MD014761 to DG), the Emory Cancer Prevention and Control Research Network (CPCRN) (U48 DP006413 to YG), the National Cancer Institute of the National Institutes of Health under the awards for the Partnership of Native American Cancer Prevention U54CA143924 (UACC), and University of Arizona Core Facilities Pilot Program (to DG).

Acknowledgments

The authors would like to acknowledge all participants for partaking in this study. As well, we would like to thank the University of Arizona Collaboratory for Metabolic Disease Prevention and Treatment for the space to complete the semi-structured interviews.

Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1090101/full#supplementary-material

References

1. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease—meta-analytic assessment of prevalence, incidence, and outcomes. *Hepatology.* (2016) 64:73–84. doi: 10.1002/hep.28431

2. Martin K, Hatab A, Athwal VS, Jokl E, Piper Hanley K. Genetic contribution to non-alcoholic fatty liver disease and prognostic implications. *Curr Diab Rep.* (2021) 21:1–8. doi: 10.1007/s11892-021-01377-5

3. Shaheen M, Pan D, Schrode KM, Kermah D, Puri V, Zarrinpar A, et al. Reassessment of the Hispanic disparity: hepatic steatosis is more prevalent in Mexican Americans than other Hispanics. *Hepatol Commun.* (2021) 5:2068–79. doi: 10.1002/hep4.1775

4. Dongiovanni P, Anstee QM, Valenti L. Genetic predisposition in NAFLD and NASH: impact on severity of liver disease and response to treatment. *Curr Pharm Des.* (2013) 19:5219–38. doi: 10.2174/13816128113199990381

5. Bruschi FV, Tardelli M, Claudel T, Trauner M. PNPLA3 expression and its impact on the liver: current perspectives. *Hepat Med.* (2017) 9:55–66. doi: 10.2147/HMER.S125718

6. Dongiovanni P, Donati B, Fares R, Lombardi R, Mancina RM, Romeo S, et al. PNPLA3 I148M polymorphism and progressive liver disease. *World J Gastroenterol.* (2013) 19:6969–78. doi: 10.3748/wjg.v19.i41.6969

7. Anstee QM, Darlay R, Cockell S, Meroni M, Govaere O, Tiniakos D, et al. Genome-wide association study of non-alcoholic fatty liver and steatohepatitis in a histologically characterised cohort(?). *J Hepatol.* (2020) 73:505–15. doi: 10.1016/j.jhep.2020.04.003

8. Walker RW, Belbin GM, Sorokin EP, Van Vleck T, Wojcik GL, Moscati A, et al. A common variant in PNPLA3 is associated with age at diagnosis of NAFLD in patients from a multi-ethnic biobank. *J Hepatol.* (2020) 72:1070–81. doi: 10.1016/j.jhep.2020.01.029

9. Romeo S, Kozlitina J, Xing C, Pertsemlidis A, Cox D, Pennacchio LA, et al. Genetic variation in PNPLA3 confers susceptibility to nonalcoholic fatty liver disease. *Nat Genet.* (2008) 40:1461–5. doi: 10.1038/ng.257

10. Martínez LA, Larrieta E, Calva JJ, Kershenobich D, Torre A. The expression of PNPLA3 polymorphism could be the key for severe liver disease in NAFLD in Hispanic population. *Ann Hepatol.* (2018) 16:909–15. doi: 10.5604/01.3001.0010.5282

11. Garcia DO, Morrill KE, Lopez-Pentecost M, Villavicencio EA, Vogel RM, Bell ML, et al. Nonalcoholic fatty liver disease and associated risk factors in a community-based sample of mexican-origin adults. *Hepatol Commun.* (2022) 6:1322–35. doi: 10.1002/hep4.1896

12. Cusi K, Isaacs S, Barb D, Basu R, Caprio S, Garvey WT, et al. American Association of Clinical Endocrinology Clinical Practice guideline for the diagnosis and management of nonalcoholic fatty liver disease in primary care and endocrinology clinical settings: co-sponsored by the American Association for the Study of Liver Diseases (AASLD). *Endocr Pract.* (2022) 28:528–62. doi: 10.1016/j.eprac.2022.03.010

13. Mora DC, Sandberg JC, Howard TD, Hsu FC, Quandt SA, Arcury TA. Genetic knowledge and communication among mexican farmworkers and non-farmworkers in North Carolina. *J Immigr Minor Health.* (2021) 23:1026–34. doi: 10.1007/s10903-020-01136-w

14. Chalela P, Pagán JA, Su D, Muñoz E, Ramirez AG. Breast cancer genetic testing awareness, attitudes and intentions of Latinas living along the US-Mexico border: a qualitative study. *J Community Med Health Educ.* (2012) 2:1000152. doi: 10.4172/2161-0711.1000152

15. Withers M, Sayegh P, Rodriguez-Agudelo Y, Ernstrom K, Raman R, Montoya L, et al. A mixed-methods study of cultural beliefs about dementia and genetic testing among Mexicans and Mexican-Americans at-risk for autosomal dominant Alzheimer's disease. *J Genet Couns.* (2019) 28:921–32. doi: 10.1002/jgc4.1133

16. Hamilton JG, Shuk E, Arniella G, González CJ, Gold GS, Gany F, et al. Genetic testing awareness and attitudes among Latinos: exploring shared perceptions and gender-based differences. *Public Health Genomics.* (2016) 19:34–46. doi: 10.1159/000441552

17. Kinney AY, Gammon A, Coxworth J, Simonsen SE, Arce-Laretta M. Exploring attitudes, beliefs, and communication preferences of Latino community members regarding BRCA1/2 mutation testing and preventive strategies. *Genet Med.* (2010) 12:105–15. doi: 10.1097/GIM.0b013e3181c9af2d

18. Subasic K, Kronk R, Mantione A, Vital M. Exploring genetic literacy in a small hispanic population. *J Transcult Nurs.* (2021) 32:344–9. doi: 10.1177/1043659620938127

19. Becerra D, Androff D, Messing JT, Castillo J, Cimino A. Linguistic acculturation and perceptions of quality, access, and discrimination in health care among Latinos in the United States. *Soc Work Health Care.* (2015) 54:134–57. doi: 10.1080/00981389.2014.982267

20. Heck JE, Franco R, Jurkowski JM, Sheinfeld Gorin S. Awareness of genetic testing for cancer among United States Hispanics: the role of acculturation. *Community Genet.* (2008) 11:36–42. doi: 10.1159/000111638

21. Vadaparampil ST, Wideroff L, Breen N, Trapido E. The impact of acculturation on awareness of genetic testing for increased cancer risk among Hispanics in the year 2000 National Health Interview Survey. *Cancer Epidemiol Biomarkers Prev.* (2006) 15:618–23. doi: 10.1158/1055-9965.EPI-05-0378

22. Canedo JR, Miller ST, Myers HF, Sanderson M. Racial and ethnic differences in knowledge and attitudes about genetic testing in the US: systematic review. *J Genet Couns.* (2019) 28:587–601. doi: 10.1002/jgc4.1078

23. Kurian AW, Li Y, Hamilton AS, Ward KC, Hawley ST, Morrow M, et al. Gaps in incorporating germline genetic testing into treatment decision-making for early-stage breast cancer. *J Clin Oncol.* (2017) 35:2232–9. doi: 10.1200/JCO.2016.71.6480

24. Chalasani N, Younossi Z, Lavine JE, Charlton M, Cusi K, Rinella M, et al. The diagnosis and management of nonalcoholic fatty liver disease: practice guidance from the American Association for the Study of Liver Diseases. *Hepatology.* (2018) 67:328–57. doi: 10.1002/hep.29367

25. Karlas T, Petroff D, Sasso M, Fan J-G, Mi Y-Q, de Lédinghen V, et al. Individual patient data meta-analysis of controlled attenuation parameter (CAP) technology for assessing steatosis. *J Hepatol.* (2017) 66:1022–30. doi: 10.1016/j.jhep.2016.12.022

26. Haga SB, Mills R, Pollak KI, Rehder C, Buchanan AH, Lipkus IM, et al. Developing patient-friendly genetic and genomic test reports: formats to promote patient engagement and understanding. *Genome Med.* (2014) 6:1–11. doi: 10.1186/s13073-014-0058-6

27. Health Literacy Online. *Office of Disease Prevention and Health Promotion.* (2016). Available online at: https://health.gov/healthliteracyonline/ (accessed September 1, 2022).

28. Neuhauser L, Kreps GL. Online cancer communication: meeting the literacy, cultural and linguistic needs of diverse audiences. *Patient Educ Couns.* (2008) 71:365–77. doi: 10.1016/j.pec.2008.02.015

29. Garcia DO, Valdez LA, Bell ML, Humphrey K, Hingle M, McEwen M, et al. A gender-and culturally-sensitive weight loss intervention for Hispanic males: the ANIMO randomized controlled trial pilot study protocol and recruitment methods. *Contemp Clin Trials Commun.* (2018) 9:151–63. doi: 10.1016/j.conctc.2018.01.010

30. Ratnayake P, Wakefield CE, Meiser B, Suthers G, Price MA, Duffy J, et al. An exploration of the communication preferences regarding genetic testing in individuals from families with identified breast/ovarian cancer mutations. *Fam Cancer.* (2011) 10:97–105. doi: 10.1007/s10689-010-9383-0

31. Creswell JW, Poth CN. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. London: Sage Publications (2016).

32. Glanz K, Rimer BK, Viswanath K. *Health Behavior and Health Education: Theory, Research, and Practice*. Hoboken, NJ: John Wiley & Sons. (2008).

33. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* (2006) 3:77–101. doi: 10.1191/1478088706qp063oa

34. Braun V, Clarke V. *Thematic Analysis*. Washington, DC: American Psychological Association (2012). doi: 10.1037/13620-004

35. Averill JB. Matrix analysis as a complementary analytic strategy in qualitative inquiry. *Qual Health Res.* (2002) 12:855–66. doi: 10.1177/104973230201200611

36. Edwards-Jones A. *Qualitative Data Analysis with NVIVO*. Milton Park: Taylor & Francis. (2014). doi: 10.1080/02607476.2013.866724

37. Cuellar I, Arnold B, Gonzalez G. Cognitive referents of acculturation: assessment of cultural constructs in Mexican Americans. *J Community Psychol.* (1995) 23:339–56. doi: 10.1002/1520-6629(199510)23:4<339::AID-JCOP2290230406>3.0.CO;2-7

38. Cristancho S, Peters K, Garces M. Health information preferences among Hispanic/Latino immigrants in the US rural Midwest. *Glob Health Promot.* (2014) 21:40–9. doi: 10.1177/1757975913510727

39. Garcia DO, Valdez LA, Aceves B, Bell ML, Humphrey K, Hingle M, et al. A gender- and culturally sensitive weight loss intervention for hispanic men: results from the animo pilot randomized controlled trial. *Health Educ Behav.* (2019) 46:763–72. doi: 10.1177/1090198119853011

40. Julian-Reynier C, Welkenhuysen M, Hagoel L, Decruyenaere M, Hopwood P. Risk communication strategies: state of the art and effectiveness in the context of cancer genetic services. *Eur J Hum Genet.* (2003) 11:725–36. doi: 10.1038/sj.ejhg.5201037

41. Thompson HS, Wahl E, Fatone A, Brown K, Kwate NOA, Valdimarsdottir H. Enhancing the readability of materials describing genetic risk for breast cancer. *Cancer Control.* (2004) 11:245–53. doi: 10.1177/107327480401100406

42. Sabogal F, Marín G, Otero-Sabogal R, Marín BV, Perez-Stable EJ. Hispanic familism and acculturation: what changes and what doesn't? *Hisp J Behav Sci.* (1987) 9:397–412. doi: 10.1177/07399863870094003

43. Campos B, Kim HS. Incorporating the cultural diversity of family and close relationships into the study of health. *American Psychologist.* (2017) 72:543. doi: 10.1037/amp0000122

44. Villavicencio EA, Crocker RM, Garcia DO. A qualitative analysis of Mexican-origin men's knowledge and cultural attitudes toward non-alcoholic fatty liver disease and interest in risk reduction. *Am J Mens Health.* (2021) 15:15579883211063335. doi: 10.1177/15579883211063335

45. Mella S, Muzzatti B, Dolcetti R, Annunziata MA. Emotional impact on the results of BRCA1 and BRCA2 genetic test: an observational retrospective study. *Hered Cancer Clin Pract.* (2017) 15:1–7. doi: 10.1186/s13053-017-0077-6

46. Crocker RM, Morrill KE, Villavicencio EA, Garcia DO. How Mexicans' emotional responses to non-alcoholic fatty liver disease can help inform culturally congruent health care. *J Transcult Nurs.* (2022) 33:615–23. doi: 10.1177/10436596221101923

47. Wiebe DJ, Korbel C. Defensive denial, affect, and the self-regulation of health threats. In: Leventhal H, Cameron LD, editors. *The Self-Regulation of Health and Illness Behaviour*. London: Routledge (2003), p. 184–203.

48. Fogleman AJ, Zahnd WE, Lipka AE, Malhi RS, Ganai S, Delfino KR, et al. Knowledge, attitudes, and perceived barriers towards genetic testing across three rural Illinois communities. *J Community Genet.* (2019) 10:417–23. doi: 10.1007/s12687-019-00407-w

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 10 January 2023
DOI 10.3389/fpubh.2022.1043197

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 13 September 2022
ACCEPTED 20 December 2022
PUBLISHED 10 January 2023

CITATION
Tian CY, Mo PK-H, Dong D, Cheung AW-l and Wong EL-Y (2023) Development and validation of a comprehensive health literacy tool for adults in Hong Kong.
Front. Public Health 10:1043197.
doi: 10.3389/fpubh.2022.1043197

Development and validation of a comprehensive health literacy tool for adults in Hong Kong

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Introduction: Health literacy (HL) refers to an individual's ability to process and use health information to make health-related decisions. However, previous HL scales did not fully cover all aspects of this concept. This study aimed to develop a comprehensive Hong Kong HL scale (HLS-HK) and evaluate its psychometric properties among Chinese adults.

Methods: A scale of 31-item covering Nutbeam's framework, namely functional and interactive HL (FHL and IHL), and critical HL (CHL) within three subdomains: critical appraisal of information, understanding of social determinants of health, and actions to address social determinants of health, was developed based on previous literature review and Delphi survey. Cognitive interviews were performed to examine all items' face validity in terms of three aspects: comprehensiveness, clarity, and acceptability. A cross-sectional survey was conducted to investigate the scale's psychometric properties, including its internal consistency reliability, factorial structure validity, convergent validity, and predictive validity.

Results: Nine interviewees participated in the cognitive interviews in October 2021. Based on the input from respondents, two items were deleted, two items were combined, and several items' wording was revised. The other items were clear and readable. Finally, 28 items remained. A total of 433 adults completed the questionnaire survey between December 2021 and February 2022. After excluding one item with low inter-item correlations, the scale's internal consistency reliability was acceptable, with a Cronbach's alpha of 0.89. Exploratory factor analysis produced a five-factor model, as shown in the original theoretical framework. These factors accounted for 53% of the total variance. Confirmatory factor analysis confirmed that the fit indices for this model were acceptable (comparative fit index = 0.91, root mean square error of approximation = 0.06, and root mean square residual = 0.06). The scale is also significantly correlated with theoretically selected variables, including education and self-rated health.

Conclusion: The HLS-HK is a valid and reliable tool for evaluating HL. Compared with existing tools, this scale extended the operationalization of FHL, IHL, and CHL and fully operationalized the CHL *via* three subdomains.

It can be used to understand the difficulties and barriers that people may encounter when they use health-related information and services.

KEYWORDS

health literacy scale, scale development, scale validation, Hong Kong Chinese adults, factor analysis

Introduction

Health literacy (HL) is crucial to empower individuals to make informed health decisions. It is usually described as one individual's ability to process and use health information to promote health (1). Previous studies suggested that people with limited HL skills tend to have poorer health outcomes (2–4), less utilization of preventive health services (5), higher hospitalizations (6), and healthcare costs (7, 8). One survey in eight European countries reported that at least 1 out of 10 participants had inadequate HL skills (9). There are challenges in embedding HL-related skills into effective disease prevention and health self-management. Assessing HL at a population level provides great potential to recognize populations most in need of support, deliver tailored interventions, and achieve better health outcomes in communities.

The measurement instrument is essential to understand people's HL levels. More than one hundred HL measurements have been developed during the last decades (10). The early HL measurement tools were criticized for their narrow focus on the capacity to read and understand written health information in a medical context (11–13). For example, the most commonly used HL tools, including the Test of Functional Health Literacy in Adults (TOFHLA) (11) and the Newest Vital Sign (NVS) (12), solely assess the reading ability of health-related materials through medical term recognition and numeracy test. Along with advancements in technology and the complex demands of health in modern society, scholars have realized that a broader set of competence is needed to access and use health-related information in everyday life. Align with this, several HL tools (14–17) expended to measure information seeking, communication skills, decision making, and critical thinking. However, recent systematic reviews highlighted that there is still no widely adopted measurement tool that could thoroughly reflect the current understanding of HL (18–22). Taking the lately dominant scales as examples, the Health Literacy Questionnaire (HLQ) (15) and the European Health Literacy Survey Questionnaire (HLS-EU) (23) did not include the skills necessary to address health concerns through civic engagement, which are essential HL skills to understand the social constructal cause of health-related issues and promote individual and community health. The ongoing evolution of HL measurement tools indicated the complexity of this concept and a demand for a comprehensive and reliable measure in this research field.

The construct underlying the measure is one of the most critical aspects of choosing and developing an appropriate measure. Nutbeam's framework of HL is widely cited as the conceptual basis and is seen by many HL researchers as useful in analyzing HL skills required in various contexts (24). This framework divides the primary skills of HL into three levels: functional health literacy (FHL), referring to individuals' basic literacy and numeracy skills for them to function effectively in their daily life; interactive health literacy (IHL), referring to individuals' cognitive and social skills to extract information from all kinds of forms of communication and to use this information for achieving better health outcomes; and critical health literacy (CHL), that is, individuals' higher level of cognitive and social skills which can be applied to critically analyze information and to use this information to gain better control over life events that affect health. The integrated model of HL proposed by Sørensen et al. is another vital framework in this research area. It described the competencies needed to access, understand, judge, and apply health information across the domains of health care, disease prevention, and health promotion (25).

Nutbeam's model was selected as the theoretical basis for the study because of its multifaceted understanding of CHL. Applying CHL has never been more needed than in these days when people have greater access to information and are expected to be actively engaged in healthcare. Compared with Sørensen's framework, Nutbeam emphasized that CHL includes the ability to question information and the awareness of the social determinants of health and the actions to modify these determinants (24). This emphasis is more explicitly linked to the latest understanding of CHL, that is, a range of abilities to read health-related information in a critical, active, and reflective manner to achieve an in-depth understanding of the world and explore political and social change in daily life (26–29). Taking the current pandemic of COVID-19 as an example, individuals need to know how to critically assess information when they are overwhelmed by the abundance of information, as well as how to make

informed decisions to sacrifice some part of one's benefits for the sake of public good when they are asked to take certain interventions (e.g., vaccination and quarantine) to control infection. Therefore, CHL is needed to be seen in relation to critical consciousness and social responsibilities in promoting community health (27).

However, current HL measures using Nutbeam's framework and targeting adults failed to capture the full breadth of the ideas embedded in CHL. Previous scales (14, 30–35) mainly included the ability to question information quality as the component of CHL. For example, the 14-items HL scale (HLS-14) (30), which is widely cited in this research area, adopted items to measure subjects' ability to judge the quality of the information in terms of its reliability, validity, credibility, and applicability. Other competencies involved in CHL, namely realizing social and structural factors influencing health and taking social responsibilities for public health, were rarely addressed, and their operationalizations are still in progress. Chinn and colleagues made efforts to cover all aspects of CHL. But they faced the challenges of building items to thoroughly assess understandings of and ability to act on social determinants of health. They simply adopted three items involved in the capabilities for community empowerment and social engagement for health to reflect these abilities (14). The above revealed that the operationalization of CHL remains underexplored and more discussion is needed to explicitly link the theory and measurement in this domain.

Additionally, there is no rigorously validated HL scale for the general population in Hong Kong. Although several studies explored HL in the local community, the scales they used were either disease-specific or population-specific (36–40) or directly translated from existing ones without psychometric testing (41, 42). Hong Kong is facing the challenges posed by the increasing disease burden from chronic diseases and has a dual-track healthcare system encompassing public and private sectors. This system has been criticized for the long waiting times in public hospitals and high healthcare costs in private hospitals (43, 44). Under such circumstances, patients with chronic diseases are expected to actively engage in self-management, which requires adequate HL skills. With this respect, one reliable and valid HL scale will be useful to identify the attributes and barriers related to HL.

With all these in mind, our goal was to develop a new Chinese Hong Kong version of HL scale (HLS-HK) based on Nutbeam's framework and evaluate its psychometric properties among Chinese adults. Given that the theory and measurements of HL are still in the exploratory stage, our work would be feedback loops to improve the underlying theory of HL. We also expect that the scale would provide regional-level information related to health competency and facilitate more efforts to understand HL skills and their impact on health outcomes in Hong Kong.

Methods

A four-stage research approach was adopted, including literature review, Delphi study, individual cognitive interview, and cross-sectional survey to develop and validate a comprehensive scale for HL. In the first stage, we conceptualized the framework of HLS-HK by conducting two scoping reviews (45, 46). In the next stage of the Delphi study (47), we deductively generated items based on the framework resulting from the first stage and invited stakeholders (i.e., healthcare providers and healthcare consumers) to assess the content validity of all draft items and provide additional items. The face validity accessed *via* individual cognitive interviews and psychometric analysis using a cross-section survey were reported in this paper.

Cognitive interview

The cognitive interviews were conducted to test the face validity of the 31 items derived from previous literature reviews and the Delphi survey. In the interviews, interviewees were first asked to complete the scale and then were invited to give feedback on all items' comprehensiveness, clarity, and acceptability. Participants were recruited through a convenience sampling strategy. The eligibilities of participants were as follow: (a) permanent Hong Kong citizen; (b) aged 18 and above; (c) understand Cantonese. To keep the recruitment costs low, we sought the participation of individuals working or visiting our school to participate in the interview. To achieve a representative sample, we selected interviewees by considering a balance of gender, age, educational attainment, and income. The sample size for cognitive interviews was set between 5 and 15 subjects (48). Participant recruitment stopped when data saturation reached (48, 49).

Cross-sectional validation survey

A psychometric evaluation was performed to examine the internal consistency, factorial structural validity, convergent validity, and predictive validity of the revised version of HLS-HK.

Participants

Participants were recruited from registrants of an internet research service company Qualtrics to complete an online survey. Quota sampling was used to match the distribution of participants by gender, age group, and living district (i.e., New Territories, Kowloon, Hong Kong Island) to the results of the 2020 Hong Kong census (50). Facing resource constraints and

challenges to reach the fixed quotas, the flexibility on all quotas was ±5%. The recommendation for a sample size used to scale validation should be at least 10 participants per item of the scale (51, 52). Therefore, in the present study, the sample size should be over 310 (=31*10). To ensure sufficient evidence for the reliability and validity of the newly developed scale and also consider the budget, the sample size of our survey was expected to be 400 participants.

Measures

The questionnaire consisted of two parts: (1) health literacy assessment; (2) social demographic and health factors. It was built on Qualtrics survey software (version Dec 2021). All questions were designed to force response. We also set up one attention check question to maintain data quality by excluding respondents who were not paying close attention to survey questions.

Health literacy assessment

Participants' HL levels were measured using our newly developed scale HLS-HK and the 12-item short-form of the health literacy questionnaire (HL-SF12) (53). Regarding HLS-HK, items were rated on a 5-point Likert Scale, and the scores were summed. A sample item was "How often do you need help when you fill out medical forms?". The item responses ranged from 1 = always to 5 = never. The HL-SF12 was developed based on Sørensen and colleagues' framework of HL (25). It is the short version of the HLS-EU (23) and has been validated in six Asia countries (54). Given the importance of Sørensen's framework in this research area, we used HL-SF12 as the reference scale. We contacted the authors of HL-SF12 and got their approval to use it in our study. In HL-SF12, the perceived difficulty of each health-related task was rated on 4-point Likert scales (ranging from 1 = very difficult to 4 = very easy). Example items included "On a scale from very easy to very difficult, how easy would you say it is to judge the advantages and disadvantages of different treatment options."

Social demographic and health factors

The following social demographic characteristics were collected from the respondents: age, gender, district, education attainment, occupation, and monthly household income. Participants were also asked to self-report their health status and health behaviors. Health status was examined by participants' responses to the questions "In general, how would you rate your health" with five outcomes (1–5, ranging from "poor" to "excellent"). This question is often used to assess a person's overall wellbeing in terms of social, biological, and psychological health in epidemiological health field surveys (55, 56). Health behaviors were assessed by asking about participants' lifestyles related to smoking, physical activity, and alcohol use.

Data analysis

Descriptive statistics were used to summarize study participants' demographic information and other health-related variables. Continuous variables were shown as mean and standard deviation (SD), and categorical variables were presented as numbers and frequencies. The reliability and validity analyses were performed to examine the psychometric properties of the HLS-HK. Data were analyzed using the SPSS (version 23) and R software ("psych" and "lavaan" package). The statistical significance level was set at a $p < 0.05$.

Reliability analysis

In reliability analysis, we focused on the internal consistency of the scale and subscales by testing Cronbach's alpha values. An alpha coefficient of 0.70 or greater is considered acceptable for reliability (57). Furthermore, corrected item-total correlations were tested. Two levels of inter-item correlations were suggested as acceptable: 0.2 (58, 59) and 0.3 (60, 61). We used the more liberal level of $\geq$ 0.2 in this study in order not to exclude some items on which some participants got high scores while others got low scores due to the heterogeneity within social demographic and health factors among subjects.

Validity analysis

We used exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to assess the construct validity of HLS-HK. The sample was randomly split into two independent subsets to undertake separate EFA and CFA analysis.

EFA was first performed to discover the common factor influencing a group of measured variables of HLS-HK. Before performing an EFA, we used Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) test to evaluate whether the data was worth factor analysis. If the probability of Bartlett's Test of Sphericity is <0.05 or KMO is >0.7, we can move to the EFA (62). Next, EFA was performed using principal component analysis, oblimin rotation, and parallel analysis. The criterion for selecting the optimal number of factors is based on: eigenvalue >1 and scree test (57). It is recommended that the retain items have factor loading of 0.4 and above and without significant cross-loading onto other factors (i.e., those that load on over one factor were excluded) (57, 63, 64).

CFA was then performed using maximum likelihood estimation to validate the factor structure of the HLS-HK. In the present study, the following indices of model fitness were used: comparative fit index (CFI), root mean square error of approximation (RMSEA), and root mean square residual

(SRMR). A CFI value ≥0.90 indicated an acceptable model fit; an RMSEA value ≤0.08 shows a good fit; and an SRMR value ≤0.08 can be considered a good fit, based on suggestions in previous literature (57, 65).

Bivariate analysis

We performed the bivariate analysis between the HLS-HK scores and HL-SF12 scores to examine the convergent validity using Pearson correlation coefficients. In the present study, HL-SF12 was considered as the reference. We expected the two scales produce similar results. Namely, a participant who got a high score of HLS-HK is likely to have a high score of HL-SF12. In addition, as both HLS-HK and HL-SF12 measured the main skills related to HL, all subscales from the two scales should be somewhat related.

Regarding predictive validity, we examine the relationship between HLS-HK and other theoretically selected variables (including age, education attainment, income, self-rated health status, and health behaviors) using the Mann-Whitney U test (two samples) or Kruskal-Wallis test (more than two samples). Given previous studies highlighted that people with low HL skills were likely to be older (66, 67), less educated (67, 68), with lower-income (68, 69), poorer self-rated health status (69, 70), and less healthy behaviors (70, 71), we hypothesized that HLS-HK levels were significantly correlated with the above variables.

Ethical consideration

The Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong accessed the protocol of this study and approved the study (Reference No. SBRE-20-793). The protocol for this study conformed to the principles embodied in the Declaration of Helsinki.

Results

The results of the first two stages were published elsewhere (45–47) and briefly presented below. In the first stage, five content areas that we aimed to measure were identified, including FHL, IHL, and the following three subdomains of CHL: CHL-1: "critical appraisal of information" means an individual's ability to evaluate the quality of information; CHL-2: "understanding of social determinants of health" coveys an individual's understanding of the social structural factors that influence health outcomes; CHL-3: "actions to address social determinants of health" focuses on an individual's competency to translate knowledge into action to address the modifiable determinants of health (45, 46). In the second stage, the Delphi study was completed (47). We generated the first draft of the HLS-HK consisting of 34 items. A diverse panel of professionals (n = 12) and laypeople (n = 12) rated the relevance of all 34 items. The consensus, which was predefined as ≥70% of participants agreeing that the individual item is relevant in Round 3, was reached for 31 items with excellent content validity. This HLS-HK with 31 items was used to test its face validity in cognitive interviews.

Cognitive interviews

Data saturation was achieved after nine interviews in October 2021. Table 1 presents the social demographic characteristics of the participants. Based on the input from interviewees, we deleted one item in FHL and one item in CHL-2, combined two items in CHL-3, and made a minor revision on several items' wording to make the scale concise. The other items were comprehensive, clear, and acceptable. Detailed results of cognitive interviews are presented in Appendix 1. Finally, a total of 28 items remained (Table 2). The revised version of HLS-HK within 28 items was adopted to test its psychometric properties in the following cross-sectional survey.

Cross-sectional validation survey

Social-demographic and health-related characteristics

The questionnaire survey was performed from December 2021 to February 2022. A total of 433 valid responses were collected after excluding those with data entry errors and speeders (i.e., respondents who completed the survey much more rapidly compared to others). In this study, we defined the cut-off point of speeders' completion time according to a soft launch of the survey (n = 40). In the soft launch, the median time to completion is 7.8 min, and we added half of the median completion time (i.e., 4 min) as the speeding check. The participants' social-demographic characteristics are displayed in Table 3.

Reliability

According to the corrected item-total correlations (see Table 2), one item with low inter-item correlations (i.e., q18, item-total correlation <0.2) was deleted. Table 4 summarizes the means, SD, and internal consistency for the scale and subscales without q18. Cronbach's alpha of the total score scale was 0.89, which is satisfactory. The Cronbach's alpha of the subscales ranged from 0.79 to 0.90. The internal consistencies of all subscales are satisfactory. Finally, the scale was composed of 27 items.

TABLE 1 Characteristics of interviewees.

Subjects	Gender	Age group	Education	Income (HKD)
1	Male	≥65	Primary and below	≥18,400
2	Female	≥65	Primary and below	<18,400
3	Female	45–64	Primary and below	<18,400
4	Male	18–44	Secondary and above	≥18,400
5	Female	18–44	Secondary and above	≥18,400
6	Female	18–44	Secondary and above	<18,400
7	Male	18–44	Secondary and above	<18,400
8	Female	≥ 65	Primary and below	<18,400
9	Female	≥ 65	Primary and below	<18,400

Validity

The dataset was randomly split into two subsets: for the EFA ($n = 216$), and the other for the CFA ($n = 217$). The sample size for each subsample satisfied the requirement for the sample size, which is larger than 5 times the number of variables for EFA (72), and at least 200 cases for CFA (73).

The KMO test showed a score of 0.86, which is above the required 0.70 for conducting EFA. Bartlett's test of sphericity was significant (chi-square = 2,772.356, $p < 0.000$). Therefore, our dataset is suitable for EFA. Regarding the results of EFA, the parallel analysis and scree plot examination suggested five factors with eigenvalues (7.36, 3.15, 2.78, 1.84, and 1.39, respectively) >1, accounting for 53% of the variance (14, 10, 10, 10, and 9%, respectively). Table 5 presents the factor structure of HLS-HK. The four items of FHL all loaded onto the third factor, and seven items of IHL loaded on the first factor. Among the items of CHL, six items of CHL-1 loaded on the second and five items of CHL-2 loaded on the fifth factor, and five items of CHL-3 loaded on the fourth factor. The CFA analysis revealed an acceptable fit of the five-factor model (see Figure 1), with a CFI = 0.91, SRMR =0.06, and RMSEA = 0.06.

Bivariate analysis

The bivariate analysis showed a strong correlation between the HLS-HK and the HL-SF12 ($r = 0.67, p < 0.001$). All subscales of the two scales were significantly associated with each other (Table 6). Compared with FHL (r: 0.35–0.46, $p = 0.000$) and IHL (r: 0.51–0.64, $p = 0.000$), the three subdomains of CHL (r: 0.12–0.35, $p = 0.000$) had lower correlations with the subscales of HL-SF12. The scores on the HLS-HK were significantly associated with education level (H = 7.292, $p < 0.05$), as well as self-rated health status (H = 32.292, $p < 0.001$). However, there was no association between HLS-HK scores and age, income, and health behaviors (Table 7). We further examined the association between these selected variables and scores on the subscales of HLS-HK. There were statistically significant differences in physical activity groups' scores of IHL and age groups' scores of CHL-1 (Table 7).

Discussion

We proposed a scale within 27 items encompassing a range of HL competencies and addressed the shortage of HL measurement in Hong Kong. In the scale development process, we generated the original items by systematically searching the published literature relevant to the construct of HL to cover its full breadth and depth. We invited healthcare users and providers to examine the newly developed scale's content validity and face validation. The scales' two novel aspects related to Nutbeam's framework are discussed in the below section.

Scale novelty

First, compared with previous scales (14, 30–35), this scale fully operationalized the three domains identified by Nutbeam. In the domain of FHL, we formulated five items to examine subjects' abilities to read and understand health-related information in clinical and non-clinical settings. To measure IHL, seven items were generated to examine the abilities that people need to gain health-related information in daily life as well as healthcare consulting. Regarding CHL, this scale is more explicitly linked to the latest understanding of this domain. As introduced, scholars advocated that CHL is more than the ability to analyze health-related information critically and should reflect societal influences on health knowledge, beliefs, and behaviors (26–28, 74, 75). Therefore, we built a set of items to thoroughly measure this domain and divided them into three categories. Specifically, in CHL-1, we drew items from existing research to examine subjects' skills to judge the quality

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TABLE 2 Items resulting from cognitive interviews.

Domain	Items	Corrected item-total correlations	Cronbach's alpha if item deleted
FHL	How often do you[a]:		
	q1 …need help when you fill out medical forms	0.36	0.88
	q2 ... find that characters cannot understand when you read instructions or leaflets from hospitals or clinics	0.50	0.88
	q3 …feel that the content is too difficult to understand when you read instructions or leaflets from hospitals or clinics	0.52	0.88
	q4 ... have problems understanding health-related written information	0.55	0.88
IHL	How easy would you say it is to[b]:		
	q5 …find related information when you are ill and have questions on disease or health problems	0.59	0.88
	q6 ... find related information when you are not ill but want to do something to further improve your health	0.59	0.88
	When you talk to a doctor, nurse, or pharmacist, how difficult would you say it is to[b]:	0.54	0.88
	q7 …give all the information they need	0.57	0.88
	q8 …ask the questions you want to ask	0.58	0.88
	q9 …ask further explain anything that you do not understand after they answer your questions	0.61	0.88
	q10 …extract the information you want	0.60	0.88
	q11 …understand the obtained information		
CHL-1	When you get information for health in daily life, how often do you consider the following[c]:		
	q12 …whether the information source is credible	0.46	0.88
	q13 …whether the information content is valid and reliable	0.45	0.88
	q14 …whether the publish time is appropriate	0.50	0.88
	q15 …whether other reliable sources support the facts or conclusions of this source	0.52	0.88
	q16 …whether the person or organization that produced the information have a bias	0.39	0.88
	q17 …whether the information is applicable to you	0.50	0.88
CHL-2	How do you agree about the following[d]:		
	q18 …socioeconomic status affects health	0.16*	0.89
	q19 …stress affects health	0.23	0.88
Domain	HLS-HK items	Corrected item-total correlations	Cronbach's alpha if item deleted
	q20 …being isolated from the community and workplace impacts health	0.31	0.88
	q21 …having little control over one's work impacts health	0.29	0.88
	q22 …poor childhood experience has an impact on one's physical/mental health when he or she becomes an adult	0.20	0.89
	q23 …good social relations contribute to health	0.31	0.88
CHL-3	How often do you[e]:		
	q24 …promote government to launch programmes about health promotion and disease prevention	0.28	0.88
	q25 …participate in community's or non-governmental organizations' initiatives in health promotion and disease prevention	0.24	0.89
	q26 …help your family members or a friend when they had questions concerning health issues	0.48	0.88

(Continued)

TABLE 2 (Continued)

Domain	HLS-HK items	Corrected item-total correlations	Cronbach's alpha if item deleted
	q27 . . . seek information from others when you come up with questions concerning a health issue	0.37	0.88
	q28 . . . share and communicate your opinion about illness when you talk to a family member or friend	0.43	0.88

[a]Response options range from "1 = always" to "5 = never".
[b]Response options range from "1 = very difficult" to "5 = very easy".
[c]Response options range from "1 = never" to "5 = always".
[d]Response options range from "1 = strongly disagree" to "5 = strongly agree".
[e]Response options range from "1 = never" to "5 = always".
*The corrected item-total correlations lower than 0.2.

of information; In CHL-2, we selected the most fundamental and non-medical causes of individuals' lifestyles from the WHO report to test people's knowledge of SDH (76); In CHL-3, we examined people's activities to address SDH at the social level and interpersonal level.

Second, this scale provides new insights into the domain of CHL in Nutbeam's framework, as it was developed in non-western countries. Previous studies (74, 77–79) emphasized the importance of collective action to address social determinants of health to measure CHL. They argued that individuals with sufficient CHL skills tended to participate in social and political movements for change, including informed voting and advocacy for health issues. However, we proposed that the action should not be narrowed to this social level. This is because solely focusing on participation in collective action may not fully capture the CHL level of certain population groups with limited resources to participate in political action to shape a better society, such as Hong Kong people. In fact, emerging studies (28, 80–84) recognized the importance of interpersonal-level activities to address social determinants of health. It can be assumed that people with sufficient CHL skills may transfer the knowledge of social structural factors of health into actions to get peer support or build a supportive environment for health at the interpersonal level. For instance, one newly developed scale focusing on adolescents' CHL also included individuals' ability to provide social support and participate in democratic actions about health as its component (84). In HLS-HK, we formulated three questions (i.e., q26-q28) to complement the measurement of interpersonal-level actions to address social determinants of health and, in turn, increase this domain's cultural sensitivity across different cultures.

Scale validation

Overall, the scale is reliable and valid. The internal consistency for the scale and subscales are satisfactory. EFA produced a five-factor solution, and CFA revealed an acceptable fit of the five-factor model. These results confirmed that the 27-item of HLS-HK represents the framework as initially designed. The convergent validity of HLS-HK was achieved by using HL-SF12 as the reference tool. Further, we compared the correlation between the subscales from the two scales. The three domains under the CHL level rather than FHL or IHL, had weak relationships with the subscales of HL-SF12. This may be because our scale measured several HL skills missed in HL-SF12. This result supports the research gap mentioned at the beginning: limited operationalization of CHL in previous scales.

The q18 was excluded because of its low item-total correlation. Our previous Delphi study already showed divergent opinions on this item among health professionals and laypeople. Although laypeople acknowledged the influence of socioeconomic factors on health, they tended to believe personal lifestyle substantially affects health. In contrast, health professionals can fully understand the effect of social structural factors on health, which can be more important than lifestyle choices at some point. Regarding this divergence, previous studies highlighted that laypeople might be more likely to understand and express the idea about social disadvantage and health through a contextualized narrative description of their own experiences compared with answering fixed choice questions (74). Hence, it is not surprising that we did not get concise answers on this item, which caused its low correlation with other items.

This study showed that HLS-HK is significantly associated with education. It was possible to observe a higher proportion of individuals with a high level of education (i.e., post-secondary) among those with a better score on HLS-HK. This finding is similar to studies elsewhere (85, 86). There are two potential explanations for this finding. First, highly educated groups have access to information and resources needed for better health outcomes, while low-educated groups often lack these resources. Second, advanced education usually provides a higher level of cognitive skills to process and use information compared with primary education. For instance, in Hong Kong, health promotion programmes under the Healthy School Policy in primary and secondary schools mainly cover basic health

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TABLE 3 Characteristics of survey participants.

Variables	Total ($n = 433$)		2020 Hong Kong census
	n	%	%
Gender			
Male	217	50.1	44.9
Female	216	49.9	55.1
Age groups			
18–24	53	12.2	9.90
25–34	80	18.5	15.6
35–44	70	16.2	17.8
45–54	87	20.1	17.2
≥55	143	33.0	39.5
District			
HK island	78	18.0	16.6
Kowloon	140	32.3	30.6
New Territories	215	49.7	52.8
Education attainment			
Primary and below	10	2.3	
Secondary	118	27.3	
Post-secondary (non-degree course)	75	17.3	
Post-secondary (degree course)	230	53.1	
Employment status			
Full-time	315	72.7	
Part-time	43	9.9	
Retired/housewives	44	10.2	
Unemployed	15	3.5	
Other	16	3.7	
Marital status			
Never married	166	38.3	
Married	241	55.7	
Widow	18	4.2	
Divorced	7	1.6	
Separated	1	0.2	
Self-rated health status			
Poor	26	6.0	
Fair	172	39.7	
Good	142	32.8	
Very good	82	18.9	
Excellent	11	2.5	
Physical activity			
Low[a]	302	69.7	
High[b]	131	30.3	
Smoking			
Yes	50	11.5	
No	383	88.5	
Drinking			
Yes[c]	227	52.4	
No[d]	206	47.6	
Monthly household income(HKD)			
<10,000	15	3.5	
10,000–14,999	27	6.2	
15,000–19,999	24	5.5	
20,000–29,999	60	13.9	
30,000–39,999	128	29.6	
≥40,000	179	41.3	

[a]Five days or over, at least 60 mins vigorous or moderate activities or walking; [b]Not meeting the criteria for the "High" group; [c]Consuming alcoholic drinks during the last year; [d]Consuming zero alcoholic drink during the last year.

knowledge (87–89). Contrarily, health education among local university students focuses on problem-solving skills for a range of health issues (90, 91), which are beneficial for them to develop sophisticated HL skills. Hence, it is crucial to set up systems for universal access to health-related sources and create easy-to-understand health education materials for the general public. Moreover, HL is dynamic, not unchangeable. It can be improved by providing information, effective communication, and structured health education programs. In this respect, HL is a critical concept for reducing health inequalities.

Besides, a positive association between HLS-HK and self-rated health was obtained. This result is consistent with previous studies (9, 92, 93). However, there is no association between the whole scores of HL and health behaviors, age, and income in our study. It is still unclear how health literacy competencies might contribute to individual or community health outcomes and how such competencies might be affected by social status factors. Several conceptual models of the pathways linking HL to health outcomes have been proposed (94, 95). As noted in the models, the paths among antecedent factors (e.g., income and age), HL, and health-related behaviors and outcomes are complicated (94). Health system-level moderators (e.g., healthcare system and healthcare providers) and societal-level

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TABLE 4 Internal consistency of the HLS-HK (27items).

Domain	No. of items	Range of scores	Mean	SD	Cronbach's alpha
FHL	4	4–20	13.49	3.17	0.84
IHL	7	8–35	24.79	5.15	0.90
CHL-1	6	9–30	20.30	3.93	0.84
CHL-2	5	7–25	20.78	2.80	0.80
CHL-3	5	7–25	14.82	3.55	0.79
HLS-HK	27	51–129	94.18	12.19	0.89

TABLE 5 Item scores and factor loadings of HLS-HK (27 items).

Domain	Items	Factor loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
FHL	q1	0.12	0.07	**0.61**	−0.21	0.05
	q2	−0.08	0.02	**0.93**	0.07	−0.04
	q3	0.12	−0.03	**0.73**	−0.03	0.06
	q4	0.14	0.03	**0.61**	0.00	0.03
IHL	q5	**0.45**	0.04	0.31	0.06	0.05
	q6	**0.48**	0.03	0.32	0.05	−0.01
	q7	**0.71**	−0.08	0.09	−0.05	0.05
	q8	**0.85**	−0.03	−0.07	0.00	0.04
	q9	**0.66**	0.09	−0.02	0.10	−0.08
	q10	**0.71**	0.09	0.04	−0.01	−0.03
	q11	**0.74**	0.08	0.02	0.00	−0.01
CHL-1	q12	−0.02	**0.77**	0.07	0.04	−0.04
	q13	−0.02	**0.87**	−0.02	−0.11	−0.01
	q14	0.16	**0.47**	0.01	0.15	0.07
	q15	0.14	**0.66**	−0.06	0.08	0.04
	q16	0.01	**0.46**	0.16	0.11	−0.08
	q17	0.04	**0.48**	0.03	0.17	0.06
CHL-2	q19	−0.10	0.06	0.08	−0.07	**0.66**
	q20	0.08	−0.06	−0.04	−0.01	**0.74**
	q21	−0.04	0.06	0.07	−0.01	**0.60**
	q22	0.01	−0.07	−0.04	−0.03	**0.69**
	q23	0.02	0.01	−0.02	0.11	**0.61**
CHL-3	q24	0.05	−0.08	0.04	**0.80**	−0.14
	q25	0.02	−0.03	−0.02	**0.78**	−0.08
	q26	0.00	0.11	0.13	**0.53**	0.29
	q27	−0.07	0.08	−0.06	**0.65**	0.20
	q28	0.02	0.19	−0.02	**0.62**	0.07

Factor loading in bold are over than 0.40.

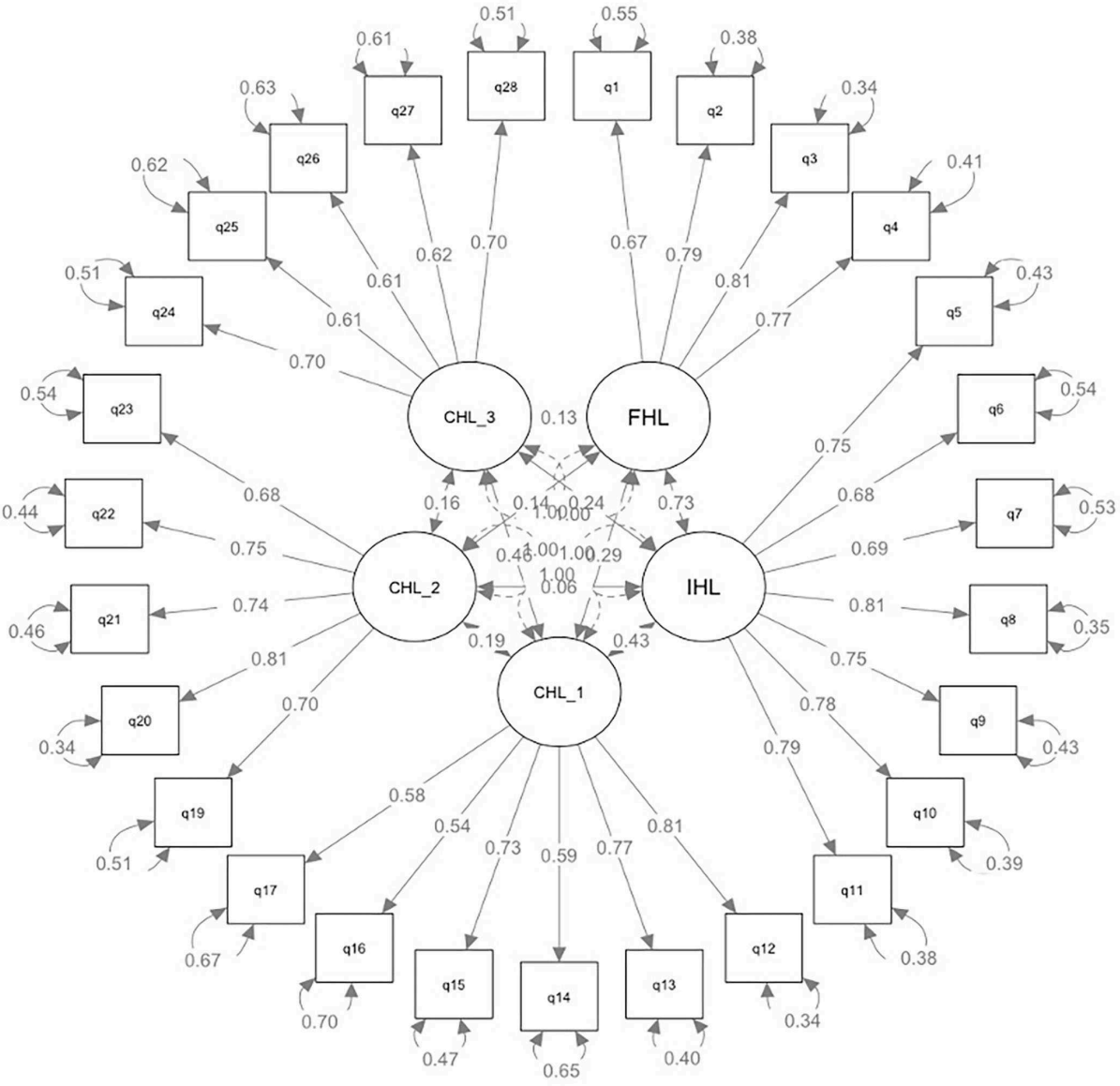

FIGURE 1
Path diagrams of the CFA model (27 items).

moderators (e.g., culture, community resources, and family) can affect the pathway between HL and health outcomes (94). In the present study, the association between these health-related variables and scores on the subscales of HL provided more details on the paths. For instance, the negative association between CHL-1 and age was evidenced in the study. It seems reasonable that critically analyzing information is more difficult for older individuals because of age-related cognitive decline. To summarize, comprehensive knowledge of HL in the general population is essential to guide health systems and organizations to achieve better health outcomes. More empirical studies are warranted to better understand the pathways and guide effective health promotion policies and programs in the future.

Study limitations

Several limitations of this study should be noted. First, selection biases might exist. The study subjects were recruited from an online questionnaire platform registers who may be better at seeking and understanding information and are interested in health issues. It is not surprising that in the present dataset, most participants were highly educated or

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TABLE 6 Bivariate relationships of HLS-HK scores and HL-SF12.

Variables	HL-SF12		FHL		IHL		CHL-1		CHL-2		CHL-3	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
HL-SF12	0.67	<0.001*	0.47	0.000*	0.68	0.000*	0.37	0.000*	0.14	0.003*	0.38	0.000*
Health care	0.63	0.000*	0.46	0.000*	0.64	0.000*	0.35	0.000*	0.12	0.013*	0.32	0.000*
Disease prevention	0.61	0.000*	0.41	0.000*	0.62	0.000*	0.33	0.000*	0.12	0.016*	0.35	0.000*
Health promotion	0.53	0.000*	0.35	0.000*	0.51	0.000*	0.30	0.000*	0.14	0.003*	0.33	0.000*

*$p < 0.005$.

have high incomes who may have more resources to access and use information, and healthy people who may often use the Internet to search for healthy lifestyle advice. Moreover, because we set up an attention check question, older adults who were more easily distracted may have failed to return a complete form and therefore were excluded from the analysis. Further study is needed to examine whether the HLS-HK is acceptable to people with a wide range of HL levels. Second, respondents may overestimate their HL using a self-reported scale. Due to resource limitations, the present study did not use a performance-based measure as the comparison scale, so the overestimation effect needs to be further explored. Third, it might be possible that some aspects of CHL were not included in the measure due to the complexity of this domain. Although we used a deductive approach *via* literature review to generate items, more diverse views may be considered to reflect more comprehensive perspectives of this domain. For example, further research to study residents' insights about transferring knowledge into action to address social determinants of health *via* focus groups may be needed.

Implications for policy and practice

Despite its limitations, the implication of this study should be highlighted. First, this scale HLS-HK can be used to comprehensively measure FHL, IHL, and CHL. The true promise of one HL scale is not to simply screen people according to their HL level but also should be to inform and tailor future interventions to enhance their HL. Therefore, using a comprehensive HL measurement such as HLS-HK can benefit healthcare workers, policymakers, and researchers to better understand the difficulties and barriers that service users may encounter when they use health-related information and services (e.g., found difficulty in understanding medical jargon, embarrassed to ask questions during medical consultation, overwhelmed by information overload, didn't realize the societal benefit of vaccination, and low interests to take action for public health) and further design interventions to address these issues. Next, a further possible use of HLS-HK is as a tool to explore the path between HL and health outcomes. A clear link between HL and health outcomes could result in higher quality and more effective interventions. As noted, more empirical studies (e.g., cross-sectional survey and longitudinal study) are needed to examine the impacts of HL on healthcare, such as how HL leads to healthy behaviors across different age groups and different utilization rates of screening programmes by place of residence in Hong Kong. Finally, HL is an evolving construct, and there is no consensus on its components. We hope our work could contribute to a more comprehensive understanding of HL as a social construct rather than a set of skills related to information transmission. Of course, the scale needs to undergo rigorous testing with diverse population groups so that it can be used

TABLE 7 Bivariate relationships of HLS-HK scores and other variables.

Variables	HLS-HK		FHL		IHL		CHL-1		CHL-2		CHL-3	
	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*
Age												
18–54	94.8	0.052	13.5	0.850	24.9	0.590	20.6	0.010*	20.7	0.680	15.0	0.251
≥55	92.9		13.4		24.5		19.7		20.9		14.5	
Education attainment												
Secondary and below	92.0	0.021*	13.4	0.652	24.4	0.430	19.4	0.001*	20.7	0.631	14.1	0.004*
Post-secondary	95.1		13.6		25.0		20.7		20.8		15.1	
Monthly household income												
<10,000	90.1	0.364	12.7	0.121	23.8	0.066	19.3	0.650	20.6	0.273	13.6	0.363
10,000–39,999	94.9		13.8		25.4		20.2		20.6		15.0	
≥40,000	93.5		13.2		24.0		20.5		21.1		14.7	
Self-rated health												
Poor	86.9	0.000*	11.9	0.016*	20.7	0.000*	20.0	0.214	21.2	0.031*	13.2	0.000*
Fair	92.2		13.3		23.8		19.9		21.2		14.1	
Good	94.6		13.8		25.3		20.3		20.5		14.6	
Very good	98.3		13.7		27.0		20.9		20.1		16.7	
Excellent	105.8		15.1		27.6		22.5		21.8		18.9	
Physical activities												
Low[a]	94.3	0.551	13.6	0.745	25.1	0.049*	20.3	0.774	20.7	0.574	14.7	0.187
High[b]	93.8		13.4		24.1		20.2		21.0		15.2	
Smoking												
Yes	93.1	0.508	12.8	0.134	24.5	0.659	20.0	0.303	20.9	0.800	14.9	0.859
No	94.3		13.6		24.8		20.4		20.8		14.8	
Drinking												
Yes[c]	94.6	0.324	13.6	0.776	25.1	0.193	20.3	0.885	20.8	0.995	14.9	0.707
No[d]	93.8		13.4		24.5		20.3		20.8		14.8	

*$p < 0.05$; [a]Five days or over, at least 60 mins vigorous or moderate activities or walking; [b]Not meeting the criteria for the "High" group; [c]Consuming alcoholic drinks during the last year; [d]consuming zero alcoholic drink during the last year.

10.3389/fpubh.2022.1043197

to evaluate and compare HL across cultures. Other researchers can use or amend this scale for their research interests and target populations' needs. For example, scholars in a democratic country can use this scale to learn how citizens transfer their understanding of health into actions for personal health and community health in depth. For scholars in an autocratic society, however, they may need to contextualize the items of CHL as residents might have low motivation and resources for social participation for health.

Conclusion

The HLS-HK is valid and reliable for evaluating HL in Hong Kong. This scale can measure FHL, IHL, and CHL in clinical and public health contexts. It also extended the operationalization of the above domains and fully operationalized the CHL *via* three subdomains. HLS-HK, with a testable framework and multifaceted attributes, will be validated in more countries and populations to advance this field of science further.

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 human participants were reviewed and approved by Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong. The patients/participants provided their written informed consent to participate in this study.

Author contributions

EW, PM, DD, and CT designed the study. CT collected and analyzed the data, wrote the draft manuscript, and critically revised the manuscript. EW was responsible for data curation and project administration. DD and PM were incharge of project administration and supervision. AC assisted with the funding acquisition and project administration. EW, PM, and DD commented and edited the whole draft. All authors read and approved the final manuscript.

Funding

The study was funded by the Direct Grant from The Chinese University of Hong Kong (Reference No. 2020.027).

Acknowledgments

The authors would like to thank all participants who participated in this study.

Conflict of interest

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

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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.2022.1043197/full#supplementary-material

References

1. Nutbeam D. Health promotion glossary. *Health Promot Int.* (1998) 13:349–64. doi: 10.1093/heapro/13.4.349

2. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med.* (2011) 155:97–107. doi: 10.7326/0003-4819-155-2-201107190-00005

3. Baker DW, Parker RM, Williams MV, Clark WS, Nurss J. The relationship of patient reading ability to self-reported health and use of health services. *Am J Public Health.* (1997) 87:1027–30. doi: 10.2105/AJPH.87.6.1027

4. Song L, Mishel M, Bensen JT, Chen RC, Knafl GJ, Blackard B, et al. How does health literacy affect quality of life among men with newly diagnosed clinically localized prostate cancer? Findings from the North Carolina-Louisiana Prostate Cancer Project (PCaP). *Cancer.* (2012) 118:3842–51. doi: 10.1002/cncr.26713

5. Scott TL, Gazmararian JA, Williams MV, Baker DW. Health literacy and preventive health care use among Medicare enrollees in a managed care organization. *Med Care.* (2002) 40:395–404. doi: 10.1097/00005650-200205000-00005

6. Baker DW, Gazmararian JA, Williams MV, Scott T, Parker RM, Green D, et al. Functional health literacy and the risk of hospital admission among Medicare managed care enrollees. *Am J Public Health.* (2002) 92:1278–83. doi: 10.2105/AJPH.92.8.1278

7. Rasu RS, Bawa WA, Suminski R, Snella K, Warady B. Health literacy impact on national healthcare utilization and expenditure. *Int J Health Policy Manag.* (2015) 4:747–55. doi: 10.15171/ijhpm.2015.151

8. Eichler K, Wieser S, Brügger U. The costs of limited health literacy: a systematic review. *Int J Public Health.* (2009) 54:313–24. doi: 10.1007/s00038-009-0058-2

9. Sørensen K, Pelikan JM, Röthlin F, Ganahl K, Slonska Z, Doyle G, et al. Health literacy in Europe: comparative results of the European health literacy survey (HLS-EU). *Eur J Public Health.* (2015) 25:1053–8. doi: 10.1093/eurpub/ckv043

10. Shed HLT. *Health Literacy Tool Shed*. (2022). Available online at: https://healthliteracy.bu.edu/ (accessed October 01, 2022).

11. Parker RM, Baker DW, Williams MV, Nurss JR. The test of functional health literacy in adults. - a new instrument for measuring patients literacy skills. *J Gen Intern Med.* (1995) 10:537–41. doi: 10.1007/BF02640361

12. Weiss BD, Mays MZ, Martz W, Castro KM, DeWalt DA, Pignone MP, et al. Quick assessment of literacy in primary care: the newest vital sign. *Ann Fam Med.* (2005) 3:514–22. doi: 10.1370/afm.405

13. Chew LD, Bradley KA, Boyko EJ. Brief questions to identify patients with inadequate health literacy. *Health.* (2004) 588:594. Retrieved from https://journals.stfm.org/familymedicine/

14. Chinn D, McCarthy C. All Aspects of Health Literacy Scale (AAHLS): developing a tool to measure functional, communicative and critical health literacy in primary healthcare settings. *Patient Educ Counsel.* (2013) 90:247–53. doi: 10.1016/j.pec.2012.10.019

15. Osborne RH, Batterham RW, Elsworth GR, Hawkins M, Buchbinder R. The grounded psychometric development and initial validation of the Health Literacy Questionnaire (HLQ). *BMC Public Health.* (2013) 13:658. doi: 10.1186/1471-2458-13-658

16. Jordan JE, Buchbinder R, Briggs AM, Elsworth GR, Busija L, Batterham R, et al. The health literacy management scale (HeLMS): a measure of an individual's capacity to seek, understand and use health information within the healthcare setting. *Patient Educ Counsel.* (2013) 91:228–35. doi: 10.1016/j.pec.2013.01.013

17. Tavousi M, Haeri-Mehrizi A, Rakhshani F, Rafiefar S, Soleymanian A, Sarbandi F, et al. Development and validation of a short and easy-to-use instrument for measuring health literacy: the Health Literacy Instrument for Adults (HELIA). *BMC Public Health.* (2020) 20:1–11. doi: 10.1186/s12889-020-08787-2

18. Haun JN, Valerio MA, McCormack LA, Sørensen K, Paasche-Orlow MK. Health literacy measurement: an inventory and descriptive summary of 51 instruments. *J Health Commun.* (2014) 19:302–33. doi: 10.1080/10810730.2014.936571

19. Liu H, Zeng H, Shen Y, Zhang F, Sharma M, Lai W, et al. Assessment tools for health literacy among the general population: a systematic review. *Int J Environ Res Public Health.* (2018) 15:1711. doi: 10.3390/ijerph15081711

20. Guzys D, Kenny A, Dickson-Swift V, Threlkeld G. A critical review of population health literacy assessment. *BMC Public Health.* (2015) 15:215. doi: 10.1186/s12889-015-1551-6

21. Pleasant A, Maish C, O'Leary C, Carmona R. Measuring health literacy in adults: An overview and discussion of current tools. *Int Handb Health Lit.* (2019) 67. doi: 10.51952/9781447344520.ch005

22. Urstad KH, Andersen MH, Larsen MH, Borge CR, Helseth S, Wahl AK. Definitions and measurement of health literacy in health and medicine research: a systematic review. *BMJ Open.* (2022) 12:e056294. doi: 10.1136/bmjopen-2021-056294

23. Sørensen K, Van den Broucke S, Pelikan JM, Fullam J, Doyle G, Slonska Z, et al. Measuring health literacy in populations: illuminating the design and development process of the European Health Literacy Survey Questionnaire (HLS-EU-Q). *BMC Public Health.* (2013) 13:1–10. doi: 10.1186/1471-2458-13-948

24. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promot Int.* (2000) 15:259–67. doi: 10.1093/heapro/15.3.259

25. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health.* (2012) 12:80. doi: 10.1186/1471-2458-12-80

26. Renwick K, editor Critical health literacy in 3D. *Front Educ.* (2017) 2:1–5. doi: 10.3389/feduc.2017.00040

27. Abel T, McQueen D. Critical health literacy and the COVID-19 crisis. *Health Promot Int.* (2020) 35:1612–3. doi: 10.1093/heapro/daaa040

28. De Wit L, Fenenga C, Giammarchi C, Di Furia L, Hutter I, de Winter A, et al. Community-based initiatives improving critical health literacy: A systematic review and meta-synthesis of qualitative evidence. *BMC Public Health.* (2018) 18:1–11. doi: 10.1186/s12889-017-4570-7

29. Pavelić A, Špiranec S. Critical health literacy and critical information literacy: bridging research discourses from different domains. In: European Conference on Information Literacy. Paris: Springer. (2022).

30. Suka M, Odajima T, Kasai M, Igarashi A, Ishikawa H, Kusama M, et al. The 14-item health literacy scale for Japanese adults (HLS-14). *Environ Health Prev Med.* (2013) 18:407–15. doi: 10.1007/s12199-013-0340-z

31. Kang SJ, Lee TW, Paasche-Orlow MK, Kim GS, Won HK. Development and evaluation of the Korean health literacy instrument. *J Health Commun.* (2014) 19:254–66. doi: 10.1080/10810730.2014.946113

32. Chung MH, Chen LK, Peng LN, Chi MJ. Development and validation of the health literacy assessment tool for older people in Taiwan: Potential impacts of cultural differences. *Arch Gerontol Geriatr.* (2015) 61:289–95. doi: 10.1016/j.archger.2015.06.015

33. Intarakamhang U, Kwanchuen Y. The development and application of the ABCDE-health literacy scale for Thais. *Asian Biomedicine.* (2016) 10:587–94. doi: 10.5372/1905-7415.1006.527

34. Abel T, Hofmann K, Ackermann S, Bucher S, Sakarya S. Health literacy among young adults: a short survey tool for public health and health promotion research. *Health Promot Int.* (2015) 30:725–35. doi: 10.1093/heapro/dat096

35. Steckelberg A, Hülfenhaus C, Kasper J, Rost J, Mühlhauser I. How to measure critical health competences: Development and validation of the Critical Health Competence Test (CHC Test). *Adv Health Sci Educ.* (2009) 14:11–22. doi: 10.1007/s10459-007-9083-1

36. Wong HM, Bridges SM, Yiu CK, McGrath CP, Au TK, Parthasarathy DS. Development and validation of Hong Kong rapid estimate of adult literacy in dentistry. *J Investig Clin Dent.* (2012) 3:118–27. doi: 10.1111/j.2041-1626.2012.00113.x

37. Wong HM, Bridges SM, Yiu CKY, McGrath CPJ, Au TK, Parthasarathy DS. Validation of the Hong Kong oral health literacy assessment task for paediatric dentistry (HKOHLAT-P). *Int J Paediatr Dent.* (2013) 23:366–75. doi: 10.1111/ipd.12021

38. Leung AYM, Cheung MKT, Lou VWQ, Chan FHW, Ho CKY, Do TL, et al. Development and validation of the chinese health literacy scale for chronic care. *J Health Commun.* (2013) 18(Suppl. 1):205–22. doi: 10.1080/10810730.2013.829138

39. Chau PH, Leung AYM, Li HLH, Sea M, Chan R, Woo J. Development and validation of Chinese Health Literacy Scale for low salt consumption - Hong Kong population (CHLSalt-HK). *PLoS ONE.* (2015) 10. doi: 10.1371/journal.pone.0132303

40. Leung AY, Yu EY, Luk JK, Chau P, Levin-Zamir D, Leung IS, et al. Rapid Estimate of Inadequate Health Literacy (REIHL): development and validation of a practitioner-friendly health literacy screening tool for older adults. *Hong Kong Med J.* (2020) 26:404–12. doi: 10.12809/hkmj208395

41. Zhang F, Or PPL, Chung JWY. The effects of health literacy in influenza vaccination competencies among community-dwelling older adults in Hong Kong. *BMC Geriatr.* (2020) 20:1–7. doi: 10.1186/s12877-020-1504-5

42. Or PPL, Wong BYM, Chung JWY. To investigate the association between the health literacy and hand hygiene practices of the older adults to help them fight against infectious diseases in Hong Kong. *Am J Infect Control.* (2020) 48:485–9. doi: 10.1016/j.ajic.2019.12.021

43. Tsui YM, Fong BY. Waiting time in public hospitals: case study of total joint replacement in Hong Kong. *Public Adm Policy.* (2018) 21:120–33. doi: 10.1108/PAP-10-2018-009

44. Lee CP. Health care system and pharmacy practice in Hong Kong. *Can J Hosp Pharm.* (2018) 71:140. doi: 10.4212/cjhp.v71i2.1865

45. Tian CY, Xu RH, Mo PKH, Dong D, Wong ELY. Generic health literacy measurements for adults: a scoping review. *Int J Environ Res Public Health.* (2020) 17:7768. doi: 10.3390/ijerph17217768

46. Tian CY, Ng CW, Xu RH, Mo PKH, Dong D, Wong ELY. Critical health literacy in the Post-COVID-19 Era. *Hong Kong College of Community Medicine Annual Scientific Meeting.* Hong Kong (2021). p. 75. Available online at: http://www.hkccm.org.hk/pdffile/210924093700422.pdf

47. Tian CY, Wong ELY, Xu RH, Cheung AWL, Dong D, Mo PKH. Developing a comprehensive health literacy scale for adults in Hong Kong: a modified e-Delphi study in healthcare consumers and providers. *Health Expect.* (2022) 1–11. doi: 10.1111/hex.13651

48. Willis GB. *Cognitive Interviewing: A Tool for Improving Questionnaire Design*. National Cancer Institute: Sage Publications. (200)4.

49. Ryan K, Gannon-Slater N, Culbertson MJ. Improving survey methods with cognitive interviews in small-and medium-scale evaluations. *Am J Eval.* (2012) 33:414–30. doi: 10.1177/1098214012441499

50. Census and Statistics Department TGotHKSAR. Hong Kong in Figures (Latest Figures). 2020 Available from: https://www.censtatd.gov.hk/hkstat/hkif/index.jsp. (accessed August 01, 2022).

51. Anthoine E, Moret L, Regnault A, Sébille V, Hardouin JB. Sample size used to validate a scale: a review of publications on newly-developed patient reported outcomes measures. *Health Qual Life Outcomes.* (2014) 12:1–10. doi: 10.1186/s12955-014-0176-2

52. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quiñonez HR, Young SL. Best practices for developing and validating scales for health, social, and behavioral research: a primer. *Front Public Health.* (2018) 6:149. doi: 10.3389/fpubh.2018.00149

53. Van Duong T, Chang PW, Yang SH, Chen MC, Chao WT, Chen T, et al. A new comprehensive short-form health literacy survey tool for patients in general. *Asian Nurs Res.* (2017) 11:30–5. doi: 10.1016/j.anr.2017.02.001

54. Duong TV, Aringazina A, Kayupova G. Nurjanah, Pham TV, Pham KM, et al. Development and validation of a new short-form health literacy instrument (HLS-SF12) for the general public in six Asian countries HLRP. *Health Lit Res Pract.* (2019) 3:e91–e102. doi: 10.3928/24748307-20190225-01

55. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life: a conceptual model of patient outcomes. *JAMA.* (1995) 273:59–65. doi: 10.1001/jama.1995.03520250075037

56. Idler EL. Self-assessed health and mortality: a review of studies. *Int Rev Health Psychol.* (1992) 1:33–54.

57. Kline P. *The Handbook of Psychological Testing*. London: Psychology Press. (2000).

58. Jatau Abubakar I, Wimmer BC, Bereznicki LR, Dwan C, Black JAM, Bezabhe W, et al. Development and Validation of an Atrial Fibrillation Knowledge Assessment Tool (AFKAT). *Int J Environ Res Public Health.* (2020) 17:1721. doi: 10.3390/ijerph17051721

59. Kliemann N, Wardle J, Johnson F, Croker H. Reliability and validity of a revised version of the General Nutrition Knowledge Questionnaire. *Eur J Clin Nutr.* (2016) 70:1174–80. doi: 10.1038/ejcn.2016.87

60. Lang L, Zhang L, Zhang P, Li Q, Bian J, Guo Y. Evaluating the reliability and validity of SF-8 with a large representative sample of urban Chinese. *Health Qual Life Outcomes.* (2018) 16:1–8. doi: 10.1186/s12955-018-0880-4

61. Cristobal E, Flavian C, Guinaliu M. Perceived e-service quality (PeSQ): Measurement validation and effects on consumer satisfaction and web site loyalty. *Manag Serv Qual.* (2007) 17:317–40. doi: 10.1108/09604520710744326

62. Child D. The essentials of factor analysis. *A&C Black*. (2006) 152–8.

63. Kebede Y, Alemayehu G, Abebe L, Sudhakar M, Birhanu Z. Messenger students' engagement scale: Community perspectives on school-based malaria education in Ethiopia. *Health Soc Care Community.* (2021) 29:1391–400. doi: 10.1111/hsc.13193

64. Ogedegbe G, Mancuso CA, Allegrante JP, Charlson ME. Development and evaluation of a medication adherence self-efficacy scale in hypertensive African-American patients. *J Clin Epidemiol.* (2003) 56:520–9. doi: 10.1016/S0895-4356(03)00053-2

65. Hu Lt, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct Equ Model.* (1999) 6:1–55. doi: 10.1080/10705519909540118

66. Baker DW, Gazmararian JA, Sudano J, Patterson M. The association between age and health literacy among elderly persons. *J Gerontol Ser B.* (2000) 55:S368–S74. doi: 10.1093/geronb/55.6.S368

67. Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd RR. The prevalence of limited health literacy. *J Gen Intern Med.* (2005) 20:175–84. doi: 10.1111/j.1525-1497.2005.40245.x

68. Wu Y, Wang L, Cai Z, Bao L, Ai P, Ai Z. Prevalence and risk factors of low health literacy: a community-based study in Shanghai, China. *Int J Environ Res Public Health.* (2017) 14:628. doi: 10.3390/ijerph14060628

69. Wolf MS, Feinglass J, Thompson J, Baker DW. In search of 'low health literacy': Threshold vs. gradient effect of literacy on health status and mortality. *Soc Sci Med.* (2010) 70:1335–41. doi: 10.1016/j.socscimed.2009.12.013

70. Jayasinghe UW, Harris MF, Parker SM, Litt J, van Driel M, Mazza D, et al. The impact of health literacy and life style risk factors on health-related quality of life of Australian patients. *Health Qual Life Outcomes.* (2016) 14:1–13. doi: 10.1186/s12955-016-0471-1

71. Wolf MS, Gazmararian JA, Baker DW. Health literacy and health risk behaviors among older adults. *Am J Prev Med.* (2007) 32:19–24. doi: 10.1016/j.amepre.2006.08.024

72. Heckler CE. A *Step-by-step Approach to Using the SAS^{TM} System for Factor Analysis and Structural Equation Modeling*. Taylor & Francis. SAS Institute, Inc. (1996).

73. Kyriazos TA. Applied psychometrics: sample size and sample power considerations in factor analysis (EFA, CFA) and SEM in general. *Psychology.* (2018) 9:2207. doi: 10.4236/psych.2018.98126

74. Chinn D. Critical health literacy: a review and critical analysis. *Soc Sci Med.* (2011) 73:60–7. doi: 10.1016/j.socscimed.2011.04.004

75. Sykes S, Wills J, Rowlands G, Popple K. Understanding critical health literacy: a concept analysis. *BMC Public Health*. (2013) 13:1–10. doi: 10.1186/1471-2458-13-150

76. Organization WH. *Social Determinants of Health: The Solid Facts*. World Health Organization. Regional Office for Europe. (2003). p. 7–10. Available online at: https://www.euro.who.int/_data/assets/pdf_file/0005/98438/e81384.pdf

77. Corcoran T. Critical psychologies for critical health literacies. *Asia Pac J Health Sport Phys Educ.* (2014) 5:281–95. doi: 10.1080/18377122.2014.940813

78. Wang RT. Critical health literacy: a case study from China in schistosomiasis control. *Health Promot Int.* (2000) 15:269–74. doi: 10.1093/heapro/15.3.269

79. Crondahl K, Karlsson LE. *The Nexus Between Health Literacy and Empowerment: A Scoping Review*. Denmark: Sage Open. (2016). p. 6.

80. Levin-Zamir D, Peterburg Y. Health literacy in health systems: perspectives on patient self-management in Israel. *Health Promot Int.* (2001) 16:87–94. doi: 10.1093/heapro/16.1.87

81. Fredriksen EH, Harris J, Moland KM, Sundby J. "They ask whether this is real or fake": A qualitative norwegian study of pregnancy complaints and access to social benefits. *Health Care Women Int.* (2014) 35:266–84. doi: 10.1080/07399332.2013.794463

82. Liu C, Wang D, Liu C, Jiang J, Wang X, Chen H, et al. What is the meaning of health literacy? A systematic review and qualitative synthesis. *Fam Med Community Health.* (2020) 8:e000351. doi: 10.1136/fmch-2020-000351

83. Guo S, Davis E, Yu X, Naccarella L, Armstrong R, Abel T, et al. Measuring functional, interactive and critical health literacy of Chinese secondary school students: reliable, valid and feasible? *Glob Health Promot.* (2018) 25:6–14. doi: 10.1177/1757975918764109

84. Haugen ALH, Riiser K, Esser-Noethlichs M, Hatlevik OE. Developing Indicators to Measure Critical Health Literacy in the Context of Norwegian Lower Secondary Schools. *Int J Environ Res Public Health.* (2022) 19:3116. doi: 10.3390/ijerph19053116

85. Huang CH, Talley PC, Lin CW, Huang RY, Liu IT, Chiang IH, et al. Factors associated with low health literacy among community-dwelling women in Taiwan. *Women Health.* (2020) 60:487–501. doi: 10.1080/03630242.2019.1662872

86. Jansen T, Rademakers J, Waverijn G, Verheij R, Osborne R, Heijmans M. The role of health literacy in explaining the association between educational attainment and the use of out-of-hours primary care services in chronically ill people: a survey study. *BMC Health Serv Res.* (2018) 18:1–13. doi: 10.1186/s12913-018-3197-4

87. Li MH, Sit CHP, Wong SHS, Wing YK, Ng CK, Sum RKW. Promoting physical activity and health in Hong Kong primary school children through a blended physical literacy intervention: protocol and baseline characteristics of the "Stand+ Move" randomized controlled trial. *Trials.* (2021) 22:1–15. doi: 10.1186/s13063-021-05925-y

88. Sobko T, Jia Z, Kaplan M, Lee A, Tseng Ch. Promoting healthy eating and active playtime by connecting to nature families with preschool children: Evaluation of pilot study "Play&Grow". *Pediatr Res.* (2017) 81:572–81. doi: 10.1038/pr.2016.251

89. Education Bureau TgotHKSAR. *Healthy School Policy*. (2022). Available online at: https://www.edb.hk/en/edu-system/primary-secondary/healthy-sch-policy/index.html (accessed December 10, 2022).

90. Ahorsu DK, Sánchez Vidaña DI, Lipardo D, Shah PB, Cruz González P, Shende S, et al. Effect of a peer-led intervention combining mental health promotion with coping-strategy-based workshops on mental health awareness, help-seeking behavior, and wellbeing among university students in Hong Kong. *Int J Ment Health Syst.* (2021) 15:1–10. doi: 10.1186/s13033-020-00432-0

91. Mak WW, Chan AT, Cheung EY, Lin CL, Ngai KC. Enhancing Web-based mindfulness training for mental health promotion with the health action process approach: randomized controlled trial. *J Med Internet Res.* (2015) 17:e3746. doi: 10.2196/jmir.3746

92. Storey A, Hanna L, Missen K, Hakman N, Osborne RH, Beauchamp A. The association between health literacy and self-rated health amongst Australian university students. *J Health Commun.* (2020) 25:333–43. doi: 10.1080/10810730.2020.1761913

93. Levin-Zamir D, Baron-Epel OB, Cohen V, Elhayany A. The association of health literacy with health behavior, socioeconomic indicators, and self-assessed health from a national adult survey in Israel. *J Health Commun.* (2016) 21:61–8. doi: 10.1080/10810730.2016.1207115

94. Squiers L, Peinado S, Berkman N, Boudewyns V, McCormack L. The health literacy skills framework. *J Health Commun.* (2012) 17:30–54. doi: 10.1080/10810730.2012.713442

95. Poureslami I, Tregobov N, Shum J, McMillan A, Akhtar A, Kassay S, et al. A conceptual model of functional health literacy to improve chronic airway disease outcomes. *BMC Public Health.* (2021) 21:1–16. doi: 10.1186/s12889-021-10313-x

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 January 2023
DOI 10.3389/fpubh.2022.1102590

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 19 November 2022
ACCEPTED 29 December 2022
PUBLISHED 16 January 2023

CITATION
Wang Y, Chen Y and Bao S (2023) The impact of exposure to HPV related information and injunctive norms on young women's intentions to receive the HPV vaccine in China: A structural equation model based on KAP theory. *Front. Public Health* 10:1102590. doi: 10.3389/fpubh.2022.1102590

The impact of exposure to HPV related information and injunctive norms on young women's intentions to receive the HPV vaccine in China: A structural equation model based on KAP theory

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Background: The HPV vaccination is a crucial line of defensing against cervical cancer. As a result of government support and positive publicity from the majority of media, a craze for HPV vaccination has occurred in China. Besides, the intentions to get the HPV vaccine among women of appropriate age is also influenced by families' and friends' attitudes and perceptions toward HPV vaccine. Therefore, the purpose of this study was to investigate how HPV related information exposure and injunctive norms affect young Chinese women's intentions to receive the HPV vaccine.

Methods: A structural equation model was developed based on KAP theory, and 567 effective questionnaires were collected through an online survey. We used SPSS 26.0 for the reliability and validity analysis and the differential testing of demographic characteristics, and Amos 26.0 for the goodness-of-fit analysis and paths testing of the model.

Results: Our findings showed that (1) intention to receive HPV vaccine differed significantly in age ($P = 0.046$), educational background ($P = 0.001$), and occupation ($P = 0.004$). (2) Exposure to HPV related information positively affected knowledge about HPV ($\beta = 0.316$, $P < 0.001$) and intention to receive HPV vaccine ($\beta = 0.141$, $P < 0.001$). (3) Knowledge about HPV positively affected attitude toward HPV vaccine ($\beta = 0.341$, $P < 0.001$), but negatively affected intention to receive HPV vaccine ($\beta = -0.148$, $P < 0.05$), and attitude toward HPV vaccine positively affected intention to receive HPV vaccine ($\beta = 0.594$, $P < 0.001$). (4) Injunctive norms positively affected attitude toward HPV vaccine ($\beta = 0.362$, $P < 0.001$) and intention to receive HPV vaccine ($\beta = 0.420$, $P < 0.001$).

Conclusions: Exposure to HPV related information influenced young Chinese women's intentions to receive the HPV vaccine and related knowledge, that is, the more frequently they were exposed to HPV related information, the stronger their intentions to receive the vaccine and the higher their HPV knowledge. Also, the perception and support of HPV vaccination by people around them will further influence their attitudes and intentions to receive the HPV vaccine.

KEYWORDS

intention to receive the HPV vaccine, Chinese young women, HPV related information exposure, injunctive norms, structural equation model, KAP theory

1. Introduction

HPV, known as human papilloma virus, is the most common sexually transmitted virus worldwide. HPV infection is usually unnoticed, and persistent infection with high-risk HPV types in particular is the leading cause of diseases such as penile cancer, anal cancer, precancerous cervical lesions and cervical cancer (1, 2). According to the statistics, 604,000 new cases of cervical cancer and 342,000 deaths occurred globally in 2020 (3). More than 85% of these cervical cancer cases and deaths occurred in developing countries, and as the world's largest developing country, China has 110,000 new cases and a high mortality rate of 55% per year (4). To prevent various health problems caused by HPV infection, HPV vaccination has become one of the most important countermeasures (5). In recent years, the Chinese government has been actively promoting the scientific publicity and pilot work of HPV vaccination, such as facilitating Guangdong, Hainan and Fujian provinces to successively launch the implementation of free and voluntary domestic bivalent HPV vaccination for girls of appropriate age in the whole province, while some cities have provided them flat-rate subsidies for HPV vaccination.

However, awareness of HPV and the vaccine remains at a relatively low level. A meta-analysis showed that the pooled awareness and knowledge rates about HPV vaccination were 15.95 % and 17.55 % respectively (6). And the current HPV vaccine coverage in China was low, with <3% for the adolescent population and <6% for the entire population (7).[1] This number is significantly lower than the global HPV vaccine coverage (15%) announced by the World Health Organization for 2020 (8).

In the era of social media, the vast amount of information sources related to HPV vaccine provides more and more channels for the public to know about HPV, which may implicitly influence the public's attitudes and beliefs, and then may influence their behaviors (9). And the behavioral decisions of the public are also influenced by factors in the social environment including their perceived social norms. Numerous studies in recent years have emphasized that vaccination decisions should be comprehended in a broader sociocultural context and, in particular, should take the effects of social norms into account (10, 11). China's unique cultural context also provides special conditions for examining the relationship between social norms and intention to receive HPV vaccine. Hofstede noted that China scores higher on the values of collectivism than many western countries (12). Chinese society has a strong collectivistic culture atmosphere, and compared with an individualistic culture, people raised in a collectivistic culture show more conformity to injunctive norms. Therefore, this study focuses on the influential mechanism of injunctive norms on the intentions to receive HPV vaccine among Chinese women of appropriate age under the special cultural context of China.

Given the above background, the aim of this study was to investigate how exposure to HPV related information and injunctive norms affect the intentions to receive HPV vaccine among the young women in China. The Knowledge-Attitude-Practice Theory, a classical theory in the field of health communication, was also adopted to construct a structural equation model in an attempt to verify the influence paths of information exposure and injunctive norms on HPV vaccination intention among the Chinese women of appropriate age.

1 http://gdspma.org.cn/sep-info/849.html

2. Literature review and hypotheses

2.1. Exposure to HPV related information

Previous studies into health information exposure mainly include three aspects: first, studies on the source types of health information exposure. In the Internet era, people's access to information is diversified and complicated, and information from different channels has different impacts on people's attitudes and behaviors (13–15). Second, studies on the types of health information exposure behaviors. Lambert et al. and Wilson classified health information behavior (HIB) into three types: active HIB (conscious and goal-oriented seeking of information), passive HIB (someone encounters a certain type of information without consciously searching for it), and avoidance HIB (the conscious decision not to search for and encounter a certain type of information) (16–19). Different patterns of information exposure also have different effects on individual behavior (20). Third, studies on the impacts of health information exposure on health behaviors. A series of observational studies found that frequent exposure to health information was associated with healthier behaviors, such as regular physical exercise, fruit and vegetable intake, and smoking and alcohol quitting (21).

Existing studies have explored the relationship between exposure to HPV information and intention to receive HPV vaccine in many countries. For example, in a study of parents' intention to vaccinate their children against HPV, McRee et al. (22) found that parents' access to HPV related health information through the Internet was positively associated with their intention to vaccinate their children, and repeated exposure to controversial information about the HPV vaccine would reduce the public support for the vaccine. Moreover, several lines of evidence also suggested that HPV information exposure is closely related to the promotion of related health knowledge. Ortiz and Lyson have pointed out that exposure to HPV related social media content is associated with increased HPV awareness and knowledge, and the use of social media for health interventions is considered an effective means to increase HPV knowledge among adolescents (23, 24). Li et al. (25) also found that participants' frequency of using professional sources to search for information could influence their level of knowledge about HPV and HPV vaccine. Therefore, we made the following hypotheses:

H1: Exposure to HPV related information positively affects the knowledge level about HPV among young women.
H2: Exposure to HPV related information positively affects the intention to receive the HPV vaccine among young women.

2.2. Knowledge-attitude-practice theory

Knowledge-attitude-practice theory (KAP Theory) is used to explain the relationships between the three levels of health behavior change (26). And it has become a research tool for developing public health strategies by exploring the knowledge, attitudes, and health behaviors of populations with health problems. This theory emphasizes the key role of knowledge and attitude in behavioral decision making, explains the generation and change of

health behaviors, and in turn provides important guidance for the implementation of health education and behavioral interventions. Since it was proposed, this theory has been widely applied and verified in various fields, including infectious diseases such as AIDS (27) and hepatitis B (28), cancers such as breast cancer (28, 29), chronic diseases such as diabetes (30) and hypertension (31), food control (32, 33) and diet nutrition (34, 35), etc.

On the topic of vaccination, Chen et al. (36) investigated influenza vaccination among healthcare workers in Chongqing and noted that influenza-related knowledge was positively associated with attitude and vaccination practice, with a strong mediating effect of attitude between knowledge and practice. In a survey on the current knowledge, attitude and practice of HPV vaccination among female college students in Hong Kong, Leung and Law (37) found that female college students with high HPV vaccine knowledge and positive attitude toward HPV vaccine were more likely to receive the HPV vaccine. Additionally, individuals with high levels of knowledge are more likely to recognize the efficacy of vaccines and thus have a positive attitude toward HPV vaccination. Likewise, a systematic review pointed out that immigrant parents with generally low knowledge of HPV related diseases and vaccines tend to have a negative attitude toward vaccinating their children against HPV (38). Hence, we made the following hypotheses:

H3: Knowledge about HPV positively affects the intention to receive HPV vaccine among young women.
H4: Knowledge about HPV positively affects the attitude toward HPV vaccine among young women.
H5: Attitude toward HPV vaccine positively affects the intention to receive HPV vaccine among young women.

2.3. Injunctive norms

Injunctive norms are one kind of social norms that refers to the perception of social approval for a certain behavior, which reflects the pressure of individuals to comply with it (39). If the majority approves or supports a behavior, the likelihood of individuals performing the same behavior increases. The effect mechanism of injunctive norms on behavior is based on the external social sanctions and incentives. Behavior that is consistent with the majority's views can obtain the expected spiritual or material benefits from the group. The injunctive norms essentially reflect the mainstream values of society, that is, the value judgment tendency of the majority (40).

Current studies have found that injunctive norms have a significant role in advising behaviors such as smoking cessation, alcohol cessation, and healthy eating (41–44). Likewise, several studies demonstrated that injunctive norms also had an effect on individuals' intention to receive the HPV vaccine. Using a comparison of HPV vaccination intentions among young women in China and the United States, Pan et al. (45) concluded that contradictory information and injunctive norms from social media positively affected attitudes and intentions toward HPV vaccination. Meanwhile, it has also been demonstrated that parents' intentions to vaccinate adolescents against HPV are significantly associated with the perceived injunctive norms (46). Hence, we made the following hypotheses:

H6: Injunctive norms positively affect the intention to receive the HPV vaccine among young women.
H7: Injunctive norms positively affect the attitude toward HPV vaccine among young women.

The research model is shown in Figure 1, which contains five main variables and seven hypotheses.

3. Materials and methods

3.1. Participants

The World Health Organization classifies young people as being aged 15–44 years (47), an age group similar to the age at which the HPV vaccine is indicated (women aged 9–45 years) (48); therefore, participants in this study were required to be women aged 15–44 years who had not received the HPV vaccine. Additionally, this study focused on the impact of HPV related information exposure on vaccination intentions, participants who are unaware of the HPV vaccine will be excluded from the final sample by the question "Have you heard of the HPV vaccine?" in the questionnaire.

3.2. Data collection

This study adopted a random online questionnaire method, relying on Wenjuanxing (www.wjx.cn), an online questionnaire platform in China, to design the questionnaire and deliver it to the target population through social media such as WeChat and QQ. The privacy of questionnaire participants will be strictly protected. Data collection was carried out in two stages:

The first stage was a pre-survey. Before the formal survey, the preliminary analysis of the reliability and validity of the questionnaire was conducted. In this stage, a total of 136 questionnaires were collected and 78 were effectively completed, and the questionnaire items were adjusted and modified according to the analysis results.

The second stage was the formal survey. This stage started on October 16, 2022 and ended on October 31, 2022, with a total of 1,169 questionnaires collected. The second stage was the formal survey. This stage started on October 16, 2022 and ended on October 31, 2022, with a total of 1,169 questionnaires collected. After eliminating 602 invalid questionnaires with <60 s of response time, incomplete answers, too many extreme answers, contradictory answers, and completed by participants who did not meet the requirements of this study, the final number of effective questionnaires obtained was 567, and the effective rate was 48.5%.

The demographic characteristics of the participants are shown in Table 1. In this study, the demographic information of the participants mainly included their age, educational background, profession, occupation, and monthly income. The 567 valid participants were mainly distributed in the 20–24 age group (49.6%), followed by the 15–19 age group (27%) and the 25–29 age group (14.5%). The majority of participants held a bachelor's degree or above, with 62.1% holding a bachelor's degree and 20.3% holding a master's degree or above. Only 17 participants (3%) had a medical background. As for occupation, the majority were students (65.6%), followed by enterprise employees (12.7%). Since most of the participants were students, 66.3% of them had a monthly income of $\leq$3,000 yuan, followed by 3,001–6,000 yuan (18.7%). On the whole,

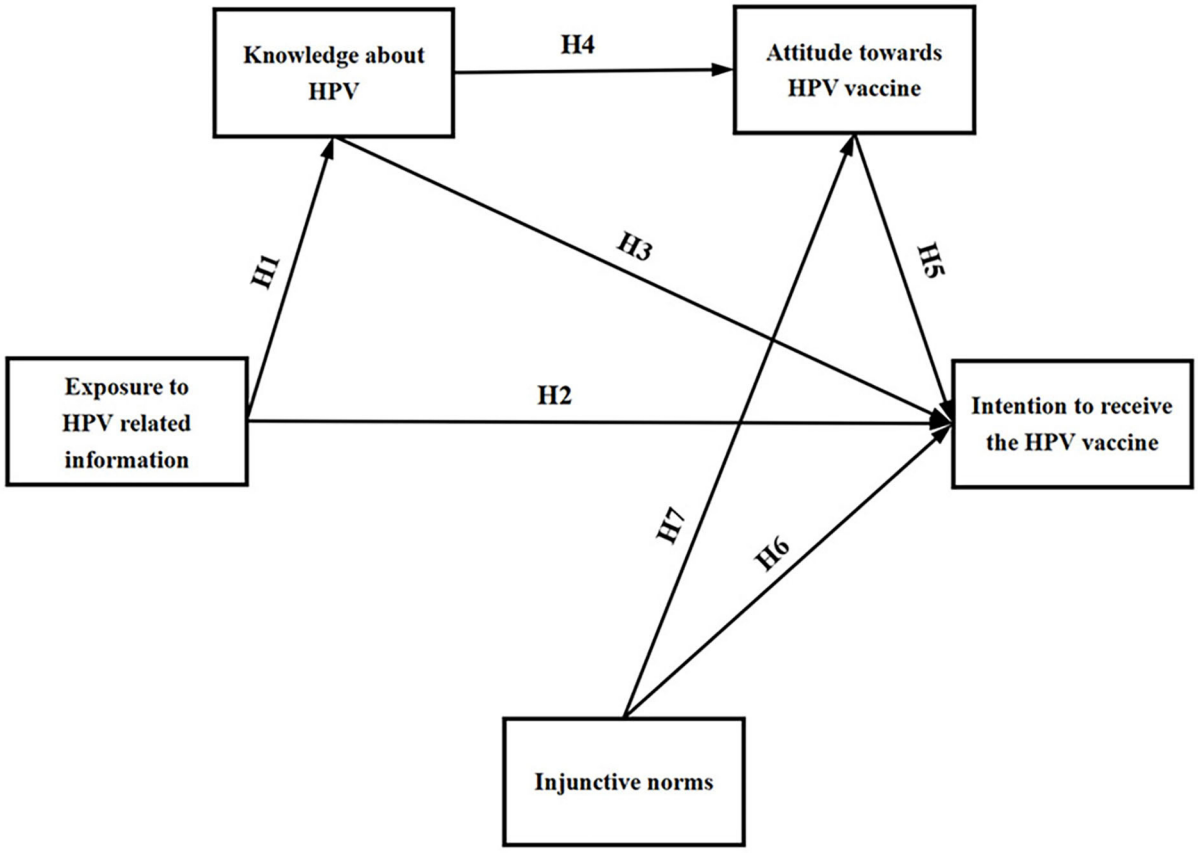

FIGURE 1
Research model.

the samples met the characteristics requirements of the target group in our study.

3.3. Measures

3.3.1. Exposure to HPV related information

The measure of exposure to HPV related information was adapted from Mars et al. (49). The scale measures information exposure in both active and passive ways, and consists of three items: "Have you ever come across and viewed HPV-related information on Weibo, WeChat, Zhihu, Douban or other online media?", "Have you ever looked for HPV-related information using the search function of WeChat or other search engines?" and "Have you ever discussed HPV with others through WeChat, QQ or other channels?". These items use five-point Likert scales ranging from 1 "never" to 5 "always". And the Cronbach's Alpha was good, >0.8 ($\alpha = 0.826$, $M = 3.434$, $SD = 0.850$).

3.3.2. Knowledge about HPV

Knowledge about HPV was measured by eight items, adapted from Waller et al. (50). The original scale contains three parts: HPV knowledge, HPV examination and HPV vaccine. In this study, 4 items were selected in each part of HPV knowledge and HPV vaccine, a total of 8 items were translated into Chinese. Participants were asked about their opinions on the following 8 items in the questionnaire: "There are many types of HPV," "HPV can cause cervical cancer," "HPV can be passed on during sexual intercourse," "Men can also get HPV," "The HPV vaccines offer protection against most cervical cancers," "Girls who have had the HPV vaccine still need a regular (Pap test/Smear test/Pap smear test) when they are older," "The HPV vaccines are most effective if given to people who have never had sex," and "The higher the valent of the HPV vaccine, the more types of HPV it can prevent." These items use five-point Likert scales ranging from 1 "strongly disagree" to 5 "strongly agree." The Cronbach's Alpha was much higher than the original scale ($\alpha = 0.904$, $M = 4.173$, $SD = 0.645$).

3.3.3. Attitude toward HPV vaccine

The measure of attitude toward HPV vaccine was adapted from Askelson et al. (51) and consisted of five items: "Vaccinating is necessary," "Vaccinating is a good idea," "Vaccinating is beneficial," "Vaccinating is safe" and "Vaccinating is important." These items use five-point Likert scales ranging from 1 "strongly disagree" to 5 "strongly agree." The Cronbach's Alpha was excellent ($\alpha = 0.961$, $M = 4.428$, $SD = 0.682$).

TABLE 1 Demographic characteristics of the participants ($N = 567$).

Characteristic	Demographic information	Frequency	%
Age	15–19	153	27
	20–24	281	49.6
	25–29	82	14.5
	30–34	24	4.2
	35–39	18	3.2
	40–44	9	1.6
Education background	Junior college or lower	100	17.6
	Bachelor's degree	352	62.1
	Master's degree or higher	115	20.3
Major	Medical	17	3
	Non-medical	550	97
Occupation	Students	372	65.6
	Civil servants or public institution personnel	44	7.8
	Employees of enterprises	72	12.7
	Self-employed or private owners	25	4.4
	Medical practitioners	4	0.7
	others	50	8.8
Monthly income (CNY)	≤3,000	376	66.3
	3,001–6,000	106	18.7
	6,001–9,000	46	8.1
	9,001–12,000	17	3
	≥12,001	22	3.9

CNY, China Yuan.

TABLE 2 Differential testing of demographic characteristics in intention to receive the HPV vaccine ($N = 567$).

Characteristic	Demographic information	Mean	SD	*P*
Age	15–19	4.1765	0.734	0.046
	20–24	4.4033	0.673	
	25–29	4.3252	0.851	
	30–34	4.2500	0.744	
	35–39	4.3333	0.915	
	40–44	4.0000	1.014	
Education background*	Junior college or lower	4.0500	0.845	0.001
	Bachelor's degree	4.3561	0.712	
	Master's degree or higher	4.4232	0.669	
Major	Medical	4.2353	0.984	0.649
	Non-medical	4.3182	0.731	
Professional*	Students	4.2751	0.722	0.005
	Civil servants or public institution personnel	4.6515	0.639	
	Employees of enterprises	4.2917	0.859	
	Self-employed or private owners	4.0000	0.977	
	Medical practitioners	4.6667	0.471	
	Other	4.4867	0.491	
Monthly income (CNY)	≤3,000	4.2580	0.740	0.067
	3,001–6,000	4.4277	0.635	
	6,001–9,000	4.5217	0.635	
	9,001–12,000	4.2353	1.177	
	≥12,001	4.3939	0.877	

Variables with "*" indicate the heterogeneity of variance, using the Welch ANOVA.
SD, standard deviation.

3.3.4. Injunctive norms

Injunctive norms mainly refer to the attitudes and perceptions of people around you regarding HPV vaccination. And this variable was measured by four items, adapted from Lee and Su (52): "How likely it is that your family members would feel about you get the HPV vaccine?", "How likely it is that your close friends would feel about you get the HPV vaccine?", "How likely it is that your classmates or colleagues would feel about you get the HPV vaccine?" and "How likely it is that people of your age would feel about you get the HPV vaccine?". These items use five-point Likert scales ranging from 1 "strongly disapprove" to 5 "strongly approve". And the Cronbach's Alpha was excellent ($\alpha = 0.900$, $M = 4.312$, $SD = 0.691$).

3.3.5. Intention to receive the HPV vaccine

Intention to receive the HPV vaccine was measured by three items, adapted from Nan and Madden (53) and Fazekas et al. (54): "How likely would you be to get the HPV vaccine sometime soon?", "How likely would you be to actually get the HPV vaccine once it is available?" and "How likely would you be to get the HPV vaccine if it is provided for free in the next three years?". These items use five-point Likert scales ranging from 1 "very unlikely" to 5 "very likely". The Cronbach's Alpha was acceptable ($\alpha = 0.767$, $M = 4.316$, $SD = 0.739$).

3.4. Data analysis methods

In this study, IMB-SPSS 26.0 and IBM-SPSS-Amos 26.0 were used for data processing and analysis. We used SPSS for descriptive statistical analysis, reliability analysis and one-way analysis of variance (one-way ANOVA). Amos was used for confirmatory factor analysis (CFA), goodness-of-fit testing and path testing of the structural equation model.

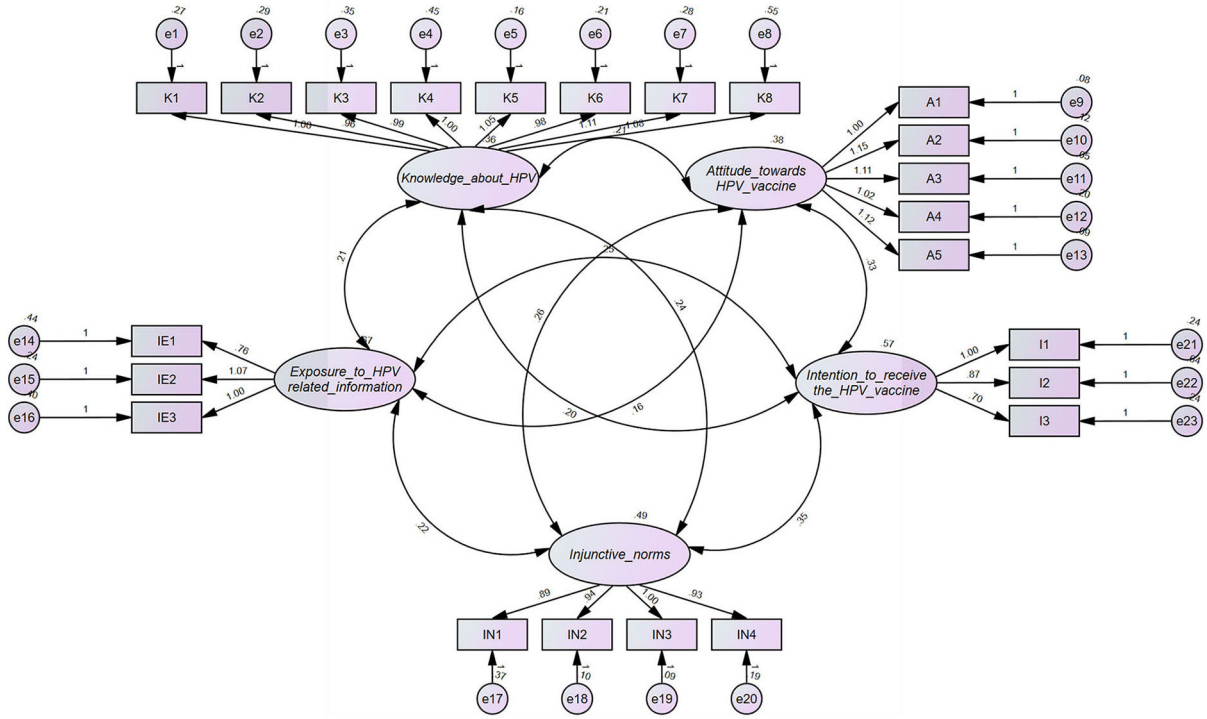

FIGURE 2
Confirmatory factor analysis.

4. Data analysis results

4.1. Differential testing of demographic characteristics

To examine differences in intention to receive the HPV vaccine among demographic characteristics, we performed a one-way ANOVA using SPSS. The precondition of one-way ANOVA is to ensure the homogeneity of variance of each independent group, so the homogeneity of variance should be tested first. In the homogeneity of variance testing results, if the $P > 0.05$, the result of ANOVA is taken as the final result; if the $P < 0.05$, the variance is not homogeneous (55). According to Liu's suggestion (56), Welch ANOVA can be applied in this case when the variance is not homogeneous. Therefore, this study used Welch ANOVA to perform differential test differences among groups with heterogeneous variances. Table 2 shows the results of ANOVA. The variances of education background and occupation are not homogeneous, so Welch method was adopted for testing. The results showed that the three control variables (age, educational background and occupation) had significant differences in HPV vaccination intention ($P < 0.05$). Specifically, people aged 20–24, those with a master's degree or above, medical practitioners, civil servants and those working in public institutions were more likely to get HPV vaccine.

4.2. Confirmatory factor analysis

In order to measure the variables in the model, we referred to the maturity scale of previous studies, and adapted it to fit within the scope of this study. And its validity was tested by confirmatory factor analysis (CFA) method (see Figure 2). Confirmatory factor analysis is the process of using sample data to verify whether the structural models (the corresponding relationships between scale items and latent variables, the relationships between latent variables) which has been made according to some theories and prior knowledge are consistent with the actual data. This method was operated in Amos, and by running all the latent variables in the software, the factor loadings for each item were obtained. As shown in Table 3, the factor loadings of each item are from 0.631 to 0.95, all of which are >0.6, indicating that the measures of each latent variable have high correlation and high convergent validity, and the items designed in the questionnaire are reasonable.

4.3. Reliability and validity testing

In this study, Cronbach's Alpha was used as the evaluation criterion of reliability. Fornell and Larcker (57) point out that when the α is >0.7, the internal reliability of the questionnaire items is considered acceptable. The Cronbach's Alpha values for each variable

TABLE 3 Factor loadings.

Latent Variables		Items	Factor loadings
Exposure to HPV related information	IE1	Have you ever come across and viewed HPV-related information on Weibo, WeChat, Zhihu, Douban or other online media?	0.688
	IE2	Have you ever looked for HPV-related information using the search function of WeChat or other search engines?	0.873
	IE3	Have you ever discussed HPV with others through WeChat, QQ or other channels?	0.793
Knowledge about HPV	K1	There are many types of HPV	0.754
	K2	HPV can cause cervical cancer	0.731
	K3	HPV can be passed on during sexual intercourse	0.705
	K4	Men can also get HPV	0.667
	K5	The HPV vaccines offer protection against most cervical cancers	0.841
	K6	Girls who have had the HPV vaccine still need a regular (Pap test/Smear test/Pap smear test) when they are older	0.783
	K7	The HPV vaccines are most effective if given to people who have never had sex	0.781
	K8	The higher the valent of the HPV vaccine, the more types of HPV it can prevent	0.660
Attitude toward HPV vaccine	A1	Vaccinating is necessary	0.909
	A2	Vaccinating is a good idea	0.900
	A3	Vaccinating is beneficial	0.950
	A4	Vaccinating is safe	0.815
	A5	Vaccinating is important	0.921
Injunctive norms	IN1	How likely it is that your family members would feel about you get the HPV vaccine?	0.717
	IN2	How likely it is that your close friends would feel about you get the HPV vaccine?	0.897
	IN3	How likely it is that your classmates or colleagues would feel about you get the HPV vaccine?	0.915
	IN4	How likely it is that people of your age would feel about you get the HPV vaccine?	0.833
Intention to receive the HPV vaccine	I1	How likely would you be to get the HPV vaccine sometime soon?	0.839
	I2	How likely would you be to actually get the HPV vaccine once it is available?	0.631
	I3	How likely would you be to get the HPV vaccine if it is provided for free in the next 3 years?	0.732

TABLE 4 Reliability and convergence validity testing results.

Latent variables	Cronbach's Alpha	CR	AVE
Intention to receive the HPV vaccine	0.767	0.781	0.546
Exposure to HPV related information	0.826	0.830	0.621
Injunctive norms	0.900	0.907	0.711
Attitude toward HPV vaccine	0.961	0.955	0.810
Knowledge about HPV	0.904	0.907	0.551

CR, composite reliability; AVE, average variance extracted.

in Table 4 are between 0.767 and 0.961, all <0.7, suggesting good reliability and strong internal consistency of the measurement items in this study.

The validity testing includes content validity, convergent validity and discriminant validity. Firstly, this study was based on validated scales and adequate pre-research, so the content validity was well guaranteed. Secondly, according to the results in Tables 3, 4, the factor loadings of each item was greater than the recommended value of 0.6 (58), the composite reliability (CR) of each latent variable was greater than the recommended value of 0.7 (57), and the average variance extraction value (AVE) was greater than the recommended value of 0.5 (59). All the three criteria of convergent validity were satisfied, indicating that all the measured items had good convergent validity. The discriminant validity is evaluated by the comparison between the square root of AVE and the correlation coefficient between latent variables. As shown in Table 5, the square root of AVE (bolded values) of all latent variables involved in this study was greater than the correlation coefficient between this latent variable and other latent variables, which suggested that the measurement items in this study were of good discriminant validity.

Through the above analysis, it can be seen that the questionnaire design of this study was reasonable and had good reliability and validity. To measure the valid and proper design of the structural equation model, further model fitting analysis can be conducted.

4.4. Model fitting

In this study, the structural equation model was constructed and evaluated using Amos. And the following suggested criteria from Hooper et al. (60) were adopted for the model fit: (1) The chi-square to degree of freedom ratio (x^2/df), should be between 1 and 5; (2) The root means square error of approximation (RMSEA), should be <0.08; (3) The standardized root means square residual (SRMR), should be <0.08; (4) Tucker-Lewis index (TLI), should be >0.95; (5) The normed fit index (NFI), should be >0.9; (6) Comparative fit index (CFI), should be >0.9.

The initial model fit was evaluated with the following results: x^2/df = 3.504, RMSEA = 0.067, SRMR = 0.097, TFI = 0.933, NFI = 0.920, CFI = 0.941. Two indexes, SRMR and TFI, did not meet the suggested criteria, so the initial model was less than ideal and needed to be modified. According to the Modification index (MI) in the Amos output, covariant relationships were established to reduce the chi-square value and further fit the model. The results of the model

TABLE 5 Discriminant validity testing results.

Latent variables	Intention to receive the HPV vaccine	Exposure to HPV related information	Injunctive norms	Attitude toward HPV vaccine	Knowledge about HPV
Intention to receive the HPV vaccine	**0.739**				
Exposure to HPV related information	0.249	**0.788**			
Injunctive norms	0.354	0.217	**0.843**		
Attitude toward HPV vaccine	0.326	0.16	0.259	**0.900**	
Knowledge about HPV	0.202	0.213	0.237	0.208	**0.742**

The bold values indicate the square root of AVE.

TABLE 6 Model fitting indexes after modification.

Index	x^2/df	RMSEA	SRMR	TLI	NFI	CFI
Observed value	2.782	0.056	0.039	0.952	0.937	0.958
Ideal value	<5	<0.08	<0.08	>0.95	>0.9	>0.9

RMSEA, root means square error of approximation; SRMR, standardized root means square residual; TLI, Tucker-Lewis index; NFI, normed fit index; CFI, comparative fit index.

fit after modification are shown in Table 6: x^2/df = 2.782, RMSEA = 0.056, SRMR = 0.039, TFI = 0.952, NFI = 0.937, and CFI = 0.958. All the indexes after modification met the fit criteria, and the model is good in fitting effect and well adapted to the sample data.

4.5. Hypothesis testing

There are seven paths in this study. Amos was used to analyze the paths, and then the research hypotheses were tested. The final path coefficient of proposed model and hypotheses testing results are presented in Figure 3, Table 7. The results showed that all the seven paths were at the significant level of $P < 0.05$, indicating that the connectivity of the paths could be supported. Exposure HPV related information positively affected knowledge about HPV ($\beta = 0.316$, $P < 0.001$) and intention to receive the HPV vaccine ($\beta = 0.141$, $P < 0.001$), so H1 and H2 were supported. Knowledge about HPV positively affected attitude toward HPV vaccine ($\beta = 0.341$, $P < 0.001$), but negatively affected intention to receive the HPV vaccine ($\beta = -0.148$, $P < 0.05$). H4 was supported, but H3 was not. Attitude toward HPV vaccine positively affected intention to receive the HPV vaccine ($\beta = 0.594$, $P < 0.001$), and H5 was supported. Injunctive norms positively affected attitude toward HPV vaccine ($\beta = 0.362$, $P < 0.001$) and intention to receive the HPV vaccine ($\beta = 0.420$, $P < 0.001$), H6 and H7 were supported.

5. Discussion

5.1. The effect of exposure to HPV related information on knowledge about HPV and intention to receive the HPV vaccine

In recent years, the incidence and mortality rate of cervical cancer in China has been on the rise, posing a serious threat to the lives of Chinese women. And HPV vaccination, as a primary prevention measure, is the most crucial line of defense against cervical cancer. This study aimed to investigate how exposure to HPV related information and injunctive norms affect young Chinese women's intention to receive the HPV vaccine. Foremost, our results provided evidence to positive effect of HPV related information exposure on the knowledge about HPV, which is in line with previous studies (61). Furthermore, we also found that exposure to HPV related information positively affected intention to receive HPV vaccine. This finding echoes the existing studies related to HPV vaccines, as demonstrated in the research by Chen et al. (62), which confirmed that people with more knowledge about HPV vaccines had more positive attitudes and similarly had stronger behavioral intentions to get vaccinated. In another cross-sectional study of intention to receive COVID-19 vaccine, it was also concluded that exposure to information about COVID-19 vaccine was a significant predictor of vaccination intention (63).

Information exposure plays a prominent role in determining the HPV-related knowledge level and intention to vaccinate among the public. This study verified the applicability of the above two findings in mainland China and provided implications for how to improve HPV vaccination coverage among Chinese women of appropriate age, also highlighted the potential role of HPV information exposure in preventive medicine and public health strategies. Ortiz et al. (24) suggested that adolescents are generally interested in receiving information about HPV and the vaccine through social media channels, as long as their privacy is protected and the source is considered credible. It has also been demonstrated that HPV awareness can be increased through brief participation in an online social media platform and receipt of tailored health messages (23). Therefore, public health communication should be further encouraged to deliver HPV and vaccine related information to target groups by taking advantage of the social media, as one of the intervention routes to improve HPV vaccine awareness and further expand HPV vaccine coverage in China. These two findings could further be examined in other studies related to the effect of information exposure on intention to receive other vaccines in China to expand their applicability.

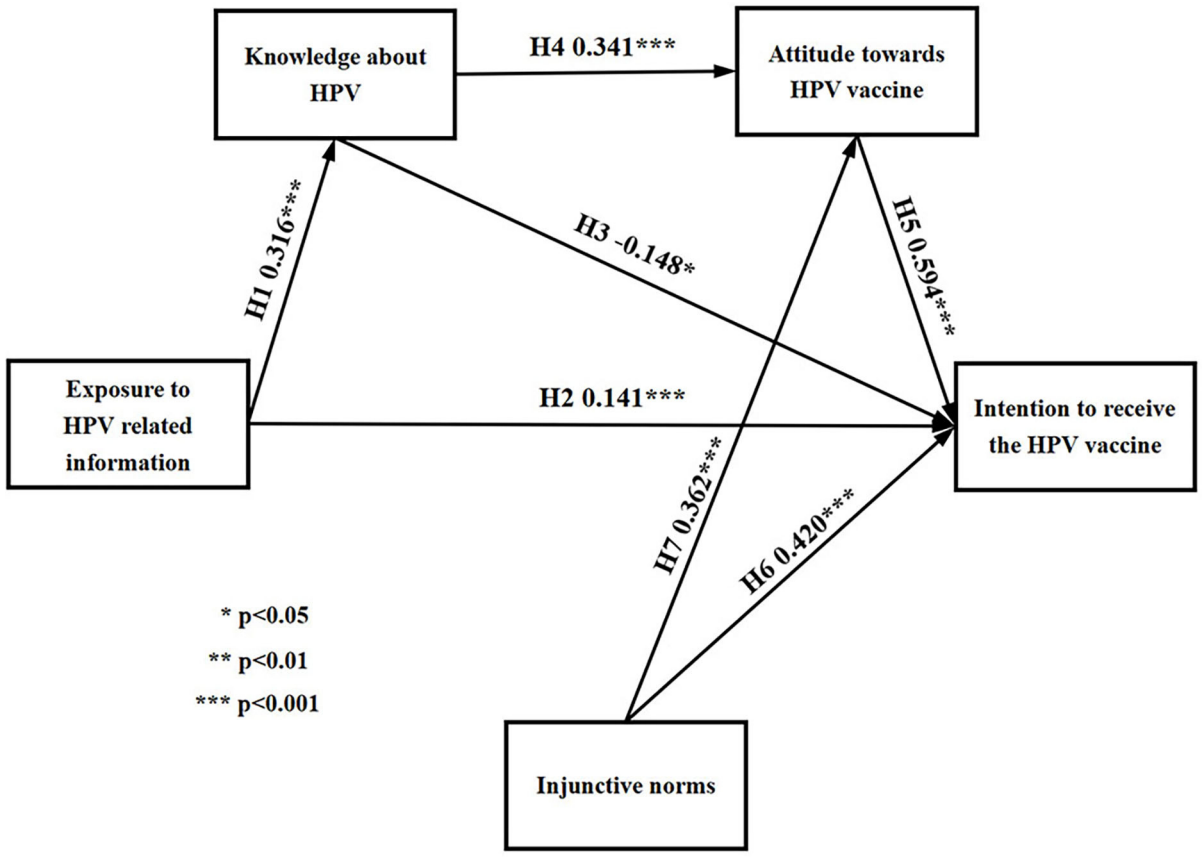

FIGURE 3
Path coefficients of the proposed model. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 7 Hypothesis testing results.

Hypotheses	Paths	Path coefficients (β)	*T*-statistics	*P*	Results
H1	Exposure to HPV related information → Knowledge about HPV	0.316	8.783	<0.001	Supported
H2	Exposure to HPV related information → Intention to receive the HPV vaccine	0.141	3.572	<0.001	Supported
H3	Knowledge about HPV → Intention to receive the HPV vaccine	−0.148	−2.335	0.020	Not supported
H4	Knowledge about HPV → Attitude toward HPV vaccine	0.341	7.22	<0.001	Supported
H5	Attitude toward HPV vaccine → Intention to receive the HPV vaccine	0.594	9.826	<0.001	Supported
H6	Injunctive norms → Intention to receive the HPV vaccine	0.420	7.644	<0.001	Supported
H7	Injunctive norms → Attitude toward HPV vaccine	0.362	9.142	<0.001	Supported

5.2. The relationships between knowledge about HPV, attitude toward HPV vaccine and intention to receive the HPV vaccine

We developed a structural equation model using KAP theory and then explored the influence paths of HPV related information exposure, namely, whether increased knowledge about HPV after exposure to HPV information would influence attitude toward HPV vaccine and intention to receive HPV vaccine. KAP theory divided the generation process of individual behavior into three stages: knowledge accumulation (K), attitude formation (A), and behavior promotion (*P*). According to the theory, there is a

positive and progressive relationship between knowledge, attitude and practice, that is, knowledge enhances attitude and attitude promotes practice. Our study results suggested that knowledge about HPV was positively related to attitude toward HPV vaccine, and that attitude toward HPV vaccine positively affected the intention to receive HPV vaccine. This result is in accordance with the basic logic of KAP theory and also ties well with other previous vaccine studies using this theory. For example, a KAP survey about pediatric vaccine among pregnant women in the city of Rome found that a good level of knowledge was the strongest predictor of positive attitude toward vaccination, which in turn influenced the majority of respondents' intentions to vaccinate (64).

Surprisingly, a negative association between knowledge about HPV and intention to receive HPV vaccine was found in the results, which was contrary to prior studies (36). Firstly, some authors have speculated that this may be related to individual knowledge about relevant side-effects or adverse reactions of vaccines. In a research on HPV knowledge, behavior and attitude among nursing students in Turkey, Bal-Yilmaz and Koniak-Griffin (65) found a high level of HPV knowledge, however, this was accompanied by a low level of HPV vaccine acceptance at a rate of 14.4%, with a lack of confidence in vaccine efficacy and safety concerns as the most common causes of vaccine refusal. This result was also supported by several studies on parents' intentions to vaccinate their children against HPV (66–68). One of the most frequent reasons for vaccine hesitancy reported to WHO by countries around the world during 2014–2016 was the issue of vaccine safety (69). It is clear that the safety issue has always been a very significant factor affecting vaccination. With the increase in reports of adverse vaccine events in recent years, the level of public trust in vaccine safety has been impacted time and again. For instance, after the Changsheng vaccine incident in 2018, the public in China became skeptical about the vaccine safety and the reliability of vaccine suppliers, especially domestic vaccine manufacturers, and public confidence in the vaccination management system once dropped to a historically low level (70). The "Hong Kong gray-market HPV vaccines" incident in May 2019 has once again caused public doubts about HPV vaccine safety (71), which will seriously hamper the public vaccination in the future. Therefore, the relevant authorities need to consider the public's concerns about the vaccine by not only carrying out studies to test the safety and efficacy of vaccine, but also improving transparency on issues such as vaccine-related injuries and adverse reactions (72), thereby enhancing public trust in vaccine safety and reducing HPV vaccine hesitation.

Secondly, we also speculated that this result might be explained by the perceived cost to the individual, with studies demonstrating that the high price of vaccines was a major cause of vaccine hesitancy, and that even if people were better informed about vaccines, the perceived high cost in terms of time, price, and availability would deter their vaccination (73). However, at this stage, there are still few pilot cities in China where girls of appropriate age can receive the domestic bivalent HPV vaccine for free, and the age is basically limited to women under 18 years old, so most women still need to pay for the HPV vaccine themselves. The domestic supply of HPV vaccine still relies on imports, and the price of imported vaccine is around 1,800–3,900 Yuan (253–548 USD), while the per capita disposable income in China in 2022 is only 3,072 Yuan (432 USD) according to the National Bureau of Statistics (74).[2] The cost of vaccination may be a greater financial burden for some women of appropriate age, which may become one of the barriers to their HPV vaccination. Our speculation was also proven in some studies related to HPV vaccination in developing countries, a study by Joshi et al. (75) reported that high cost of the vaccine and unavailability of proper and convincing information about the vaccine would be the chief reasons for poor acceptability of HPV vaccine. Therefore, relevant authorities should further facilitate the free HPV vaccination policy to achieve larger population coverage, and also increase multi-sectoral collaboration to address the shortage of HPV vaccine supply and better meet the needs of vaccination.

5.3. The effect of injunctive norms on attitude toward HPV vaccine and intention to receive the HPV vaccine

It is notable that our study found that injunctive norms positively affected the attitude toward HPV vaccine and the intention to receive HPV vaccine. This finding is similar to previous studies from other countries, such as a cross-sectional study of HPV vaccination among US college students, which noted that US college students' perception of being expected by their parents and health care providers to get the HPV vaccine influenced their attitudes toward HPV vaccine and further influenced their intentions to get the vaccine (76). In past studies on social norms, scholars have mostly focused on exploring the effects of descriptive norms on individual behaviors, while injunctive norms have received less attention. Through a review of previous literature, Chung and Rimal argued that the two kinds of social norms were more influential in different situations, respectively, depending on whether the behaviors people engage in were positive or negative. Specifically, descriptive norms are more effective in encouraging prosocial behaviors (e.g., health promotion, energy conservation and environmental protection), whereas injunctive norms are more effective in inhibiting various undesirable behaviors (e.g., smoking, alcohol abuse, drug use) (77). However, the results of this study demonstrated the significant effectiveness of injunctive norms in changing young women's attitudes toward HPV vaccine and promoting HPV vaccination as a positive behavior. This may explain the phenomenon of "vaccine fever" in the context of China's unique collectivistic culture. The deep-rooted Confucianism in Chinese culture emphasizes the collectivistic values of "family and nation as one" and "group before individual," resulting in a strong collectivistic atmosphere in China (78). In this cultural context, the intention to receive HPV vaccine comes not only from self-orientation but also from social orientation, and the vaccination reflects the responsibility and obligation under the social expectation to a greater extent.

However, behind the "vaccine fever," we should see more clearly that some domestic women of the right age are blind and irrational about HPV vaccination, pursuing the quadrivalent and nine-valent vaccines, and in turn missing the best vaccination period as a result of waiting for quadrivalent and nine-valent

2 https://data.stats.gov.cn/english/easyquery.htm?cn=B01

vaccines that are currently in short supply. The WHO recommended that the best time for HPV vaccination was between the ages of 9 and 14 years, and therefore, HPV vaccination should be given as early as possible to achieve better effects. Accordingly, in the subsequent promotion of HPV vaccine, a four-level linkage of "government-healthcare sector-community-family" should be applied to health education. It is important to encourage women of the appropriate age to actively receive HPV vaccine under the role of social culture and social norms, as well as to improve HPV-related knowledge among them to reduce irrational vaccination.

Additionally, peer education is one of the key tools to increase vaccine awareness and promote vaccination. Peer-led education programming is currently a prevailing strategy for adolescent sexual and reproductive health education (79), and a series of established studies have demonstrated that using peer education and training not only helps to increase awareness and prevention of HPV and cervical cancer among youth (80), but also has a significant effect on facilitating HPV vaccination (81, 82). Mellanby et al. (83) also found that peer influence is strong within adolescent relationships, and peers may be seen as a more credible source than adult health educators. Also, Chinese women are relatively conservative about sex-related topics, and using the accessibility of peer education can make up for young women's shyness about sex-related topics in adult health education. Selecting appropriate groups for training on HPV knowledge, and then having them disseminate and educate among their peers, can play a supplementary role in the promotion of HPV vaccine to a certain extent.

6. Conclusions

Under the context of the HPV vaccination craze, this study was designed to investigate the effects of HPV related information exposure and injunctive norms on young Chinese women's intention to receive the HPV vaccine. On the basis of KAP theory, we proposed a structural equation model containing the influence paths of information exposure and injunctive norms. Through a questionnaire survey and the model testing, we found that exposure to HPV related information had an impact not only on young women's intention to receive HPV vaccine, but also on their knowledge level about HPV. The more frequently they were exposed to HPV related information, the stronger their intentions to get vaccinated and the higher their level of relevant knowledge. Also, the perception and approval of HPV vaccination by those around them further influenced their attitudes and intentions to receive the vaccine. Furthermore, this study confirmed the relationship between knowledge, attitudes, and practice regarding HPV vaccination, with results indicating that good possession of HPV knowledge led to more positive attitudes toward HPV vaccine, and in turn strengthened the intention to receive HPV vaccine. However, a negative association between knowledge level of HPV and intention to be vaccinated was also unexpectedly found, and we speculated that this result might be related to public concerns about vaccine safety issues and the high price of HPV vaccine in China. The findings of this study are of important practical implications for the public health departments and health information service providers to carry out HPV related health education and propel HPV vaccination policies.

7. Limitations and future work

Despite the theoretical values and practical significance of this study, there are several limitations that need further improvement in the future research. First, this study was analyzed based on the cross-sectional data obtained from a questionnaire survey, and the study can be deepened in the future by combining qualitative interviews and other methods to explain the individual differences and enhance the dependability of causal inferences. Second, the items measuring information exposure contained both active and passive exposure, and different kinds of information exposure may have different effects on HPV vaccination. Therefore, future research should be undertaken to subdivide the variable of information exposure and explore the different effects of active and passive information exposure. Third, the positive association between HPV knowledge and intention to receive the vaccine was not supported in this study, and factors such as exposure to negative vaccine information and perceived cost could be considered for inclusion in future studies and explored for their moderating effects on the relationship between HPV knowledge and intention to receive the vaccine.

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 human participants were reviewed and approved by Academic Committee of School of Journalism and Communication, Huaqiao University. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

YW and YC contributed to conception and design of the study. YC wrote the first draft of the manuscript, designed the model and questionnaires, and performed the data analysis. YW and SB collected the data and revised and edited the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

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

Publisher's note

References

1. Sammarco ML, Del Riccio I, Tamburro M, Grasso GM, Ripabelli G. Type-specific persistence and associated risk factors of human papillomavirus infections in women living in Central Italy. *Eur J Obstet Gynecol Reprod Biol.* (2013) 168:222–6. doi: 10.1016/j.ejogrb.2013.01.012

2. Sammarco ML, Ucciferri C, Tamburro M, Falasca K, Ripabelli G, Vecchiet J. High prevalence of human papillomavirus type 58 in HIV infected men who have sex with men: a preliminary report in central Italy. *J Med Virol.* (2016) 88:911–4. doi: 10.1002/jmv.24406

3. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: globocan estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA-Cancer J Clin.* (2021) 71:209–49. doi: 10.3322/caac.21660

4. Li J, Huang R, Schmidt JE, Qiao YL. Epidemiological features of human papillomavirus (HPV) infection among women living in Mainland China. *Asian Pac J Cancer Prev.* (2013) 14:4015–23. doi: 10.7314/apjcp.2013.14.7.4015

5. Falcaro M, Castanon A, Ndlela B, Checchi M, Soldan K, Lopez-Bernal J, et al. The effects of the national HPV vaccination programme in England, UK, on cervical cancer and grade 3 cervical intraepithelial neoplasia incidence: a register-based observational study. *Lancet.* (2021) 398:2084–92. doi: 10.1016/s0140-6736(21)02178-4

6. Zhang YR, Wang Y, Liu L, Fan YZ, Liu ZH, Wang YY, et al. Awareness and knowledge about human papillomavirus vaccination and its acceptance in China: a meta-analysis of 58 observational studies. *BMC Public Health.* (2016) 16:15. doi: 10.1186/s12889-016-2873-8

7. Guangdong Preventive Medicine Association. Guangdong expert consensus on HPV vaccine application for the elimination of cervical cancer. Available online at: http://gdspma.org.cn/sep-info/849.html (accessed December 30, 2021).

8. Bruni L, Saura-Lazaro A, Montoliu A, Brotons M, Alemany L, Diallo MS, et al. HPV vaccination introduction worldwide and WHO and UNICEF estimates of national Hpv immunization coverage 2010–2019. *Prev Med.* (2021) 144:12. doi: 10.1016/j.ypmed.2020.106399

9. Carling P, Fung T, Killion A, Terrin N, Barza M. Favorable impact of a multidisciplinary antibiotic management program conducted during 7 years. *Infect Control Hosp Epidemiol.* (2003) 24:699–706. doi: 10.1086/502278

10. Casiday RE. Children's health and the social theory of risk: insights from the british measles, mumps and rubella (MMR) controversy. *Soc Sci Med.* (2007) 65:1059–70. doi: 10.1016/j.socscimed.2007.04.023

11. Hobson-West P. Understanding vaccination resistance: moving beyond risk. *Health Risk Soc.* (2003) 5:273–83. doi: 10.1080/1369857031000160697 8

12. Hofstede GH, Hofstede G. *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*. London: Sage (2001).

13. Casillas A, Singhal R, Tsui J, Glenn BA, Bastani R, Mangione CM. The impact of social communication on perceived HPV vaccine effectiveness in a low-income, minority population. *Ethn Dis.* (2011) 21:495–501.

14. Guess AM, Nyhan B, O'Keeffe Z, Reifler J. The sources and correlates of exposure to vaccine-related (mis)information online. *Vaccine.* (2020) 38:7799–805. doi: 10.1016/j.vaccine.2020.10.018

15. Lai DJ, Bodson J, Davis FA, Lee D, Tavake-Pasi F, Napia E, et al. Diverse families' experiences with HPV vaccine information sources: a community-based participatory approach. *J Commun Health.* (2017) 42:400–12. doi: 10.1007/s10900-016-0269-4

16. Lambert SD, Loiselle CG. Health information—seeking behavior. *Qual Health Res.* (2007) 17:1006–19. doi: 10.1177/1049732307305199

17. Lambert SD, Loiselle CG, Macdonald ME. An in-depth exploration of information-seeking behavior among individuals with cancer Part 1: understanding differential patterns of active information seeking. *Cancer Nurs.* (2009) 32:11–23. doi: 10.1097/01.NCC.0000343372.24517.bd

18. Lambert SD, Loiselle CG, Macdonald ME. An in-depth exploration of information-seeking behavior among individuals with cancer Part 2: understanding patterns of information disinterest and avoidance. *Cancer Nurs.* (2009) 32:26–36. doi: 10.1097/01.Ncc.0000343373.01646.91

19. Wilson TD. Information behaviour: an interdisciplinary perspective. *Inf Process Manag.* (1997) 33:551–72. doi: 10.1016/S0306-4573(97)00028-9

20. Cheung EKH, Lee S, Lee SS. Pattern of exposure to information and its impact on seasonal influenza vaccination uptake in nurses. *J Hosp Infect.* (2017) 97:376–83. doi: 10.1016/j.jhin.2017.08.005

21. Shen C, Wang MP, Wan A, Viswanath K, Chan SSC, Lam TH. Health information exposure from information and communication technologies and its associations with health behaviors: population-based survey. *Prev Med.* (2018) 113:140–6. doi: 10.1016/j.ypmed.2018.05.018

22. McRee AL, Reiter PL, Brewer NT. Parents' internet use for information about HPV vaccine. *Vaccine.* (2012) 30:3757–62. doi: 10.1016/j.vaccine.2011.11.113

23. Lyson HC, Le GM, Zhang JW, Rivadeneira N, Lyles C, Radcliffe K, et al. Social media as a tool to promote health awareness: results from an online cervical cancer prevention study. *J Cancer Educ.* (2019) 34:819–22. doi: 10.1007/s13187-018-1379-8

24. Ortiz RR, Shafer A, Cates J, Coyne-Beasley T. Development and evaluation of a social media health intervention to improve adolescents' knowledge about and vaccination against the human papillomavirus. *Global Pediatr Health.* (2018) 5:2333794X18777918. doi: 10.1177/2333794x18777918

25. Li J, Kang JS, Mao YM, Zheng PP, Abdullah AS, Wu GL, et al. Investigating HPV- and HPV vaccine-related knowledge, perceptions, and information sources among health care providers in three big cities in China. *Vaccines.* (2020) 8:12. doi: 10.3390/vaccines8030499

26. Bettinghaus EP. Health promotion and the knowledge-attitude-behavior continuum. *Prev Med.* (1986) 15:475–91. doi: 10.1016/0091-7435(86)90025-3

27. Tarekegne M, Adera A, Haile K, Guyo D. Knowledge, attitude, and practice of HIV/AIDS among workers at china first highway engineering company at Bilibila Sokota Road project, Sokota, Ethiopia. *Hum Antibodies.* (2018) 26:63–73. doi: 10.3233/hab-170322

28. Adenlewo OJ, Adeosun PO, Fatusi OA. Medical and dental students' attitude and practice of prevention strategies against Hepatitis B virus infection in a Nigerian University. *Pan Afr Med J.* (2017) 28:33. doi: 10.11604/pamj.2017.28.33.11662

29. Kwok C, Tranberg R, Lee FC. Breast cancer knowledge, attitudes and screening behaviors among Indian-Australian women. *Eur J Oncol Nurs.* (2015) 19:701–6. doi: 10.1016/j.ejon.2015.05.004

30. Gautam A, Bhatta DN, Aryal UR. Diabetes related health knowledge, attitude and practice among diabetic patients in Nepal. *BMC Endocr Disord.* (2015) 15:8. doi: 10.1186/s12902-015-0021-6

31. Gupta RK, Hussain S, Parveen Z, Raina SK, Langer B, Kumari R. Does being under treatment improve knowledge attitude practice for hypertension: a hospital-based study from North India. *J Fam Med Prim Care.* (2017) 6:279–83. doi: 10.4103/2249-4863.220040

32. Kwol VS, Eluwole KK, Avci T, Lasisi TT. Another look into the knowledge attitude practice (Kap) model for food control: an investigation of the mediating role of food handlers' attitudes. *Food Control.* (2020) 110:8. doi: 10.1016/j.foodcont.2019.107025

33. Lopez-Calvo R, Hidalgo-Viquez C, Mora-Villalobos V, Gonzalez-Vargas M, Alvarado R, Pena-Vasquez M, et al. Analysis of knowledge, attitude, and practices (Kap) regarding food allergies in social network users in Costa Rica. *Food Control.* (2022) 138:10. doi: 10.1016/j.foodcont.2022.109031

34. Huang Z, Li H, Huang J. Analysis of Chinese consumers' nutrition facts table use behavior based on knowledge-attitude-practice model. *Int J Environ Res Public Health.* (2021) 18:12247. doi: 10.3390/ijerph182212247

35. Zhao A, Szeto IMY, Wang Y, Li C, Pan M, Li T, et al. Knowledge, attitude, and practice (Kap) of dairy products in Chinese urban population and the effects on dairy intake quality. *Nutrients.* (2017) 9:10. doi: 10.3390/nu9070668

36. Chen SY, Jiang YM, Tang XJ, Gan L, Xiong Y, Chen T, et al. Research on knowledge, attitudes, and practices of influenza vaccination among healthcare workers in Chongqing, china-based on structural equation model. *Front Public Health.* (2022) 10:8. doi: 10.3389/fpubh.2022.853041

37. Leung JTC, Law CK. Revisiting knowledge, attitudes and practice (Kap) on human papillomavirus (HPV) vaccination among female university students in Hong Kong. *Human Vaccines Immunother.* (2018) 14:924–30. doi: 10.1080/21645515.2017.1415685

38. Netfa F, Tashani M, Booy R, King C, Rashid H, Skinner SR. Knowledge, attitudes and perceptions of immigrant parents towards human papillomavirus (HPV) vaccination: a systematic review. *Trop Med Infect Dis.* (2020) 5:18. doi: 10.3390/tropicalmed5020058

39. Cialdini RB, Reno RR, Kallgren CA, A. Focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. *J Pers Soc Psychol.* (1990) 58:1015–26. doi: 10.1037/0022-3514.58.6.1015

40. Jacobson RP, Mortensen CR, Cialdini RB. Bodies obliged and unbound: differentiated response tendencies for injunctive and descriptive social norms. *J Pers Soc Psychol.* (2011) 100:433–48. doi: 10.1037/a0021470

41. LaBrie JW, Hummer JF, Neighbors C, Larimer ME. Whose opinion matters? The relationship between injunctive norms and alcohol consequences in college students. *Addict Behav.* (2010) 35:343–9. doi: 10.1016/j.addbeh.2009.12.003

42. Neighbors C, O'Connor RM, Lewis MA, Chawla N, Lee CM, Fossos N. The relative impact of injunctive norms on college student drinking: the role of reference group. *Psychol Addict Behav.* (2008) 22:576–81. doi: 10.1037/a0013043

43. Sharps MA, Fallon V, Ryan S, Coulthard H. The role of perceived descriptive and injunctive norms on the self-reported frequency of meat and plant-based meal intake in UK-based adults. *Appetite.* (2021) 167:105615. doi: 10.1016/j.appet.2021.105615

44. Zaleski AC, Aloise-Young PA. Using peer injunctive norms to predict early adolescent cigarette smoking intentions. *J Appl Soc Psychol.* (2013) 43:E124–E31. doi: 10.1111/jasp.12080

45. Pan SY, Zhang D, Zhang JW. Caught in the crossfire: how contradictory information and norms on social media influence young women's intentions to receive HPV vaccination in the United States and China. *Front Psychol.* (2020) 11:14. doi: 10.3389/fpsyg.2020.548365

46. Balogun FM, Omotade OO. Parental intention to vaccinate adolescents with HPV vaccine in selected communities in Ibadan, Southwest Nigeria: an application of integrated behavioral model. *Human Vaccines Immunother.* (2022) 18:9. doi: 10.1080/21645515.2022.2069959

47. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. *Age Standardization of Rates: A New Who Standard, Vol. 9*. Geneva: World Health Organization. (2001), p. 1–14.

48. LI MZ CQ. Chinese Expert consensus on clinical application of human papillomavirus vaccine. *Chin J Clin Obstet Gynecol.* (2021) 22:225–34.

49. Mars B, Heron J, Biddle L, Donovan JL, Holley R, Piper M, et al. Exposure to, and searching for, information about suicide and self-harm on the internet: prevalence and predictors in a population based cohort of young adults. *J Affect Disord.* (2015) 185:239–45. doi: 10.1016/j.jad.2015.06.001

50. Waller J, Ostini R, Marlow LA, McCaffery K, Zimet G. Validation of a measure of knowledge about human papillomavirus (HPV) using item response theory and classical test theory. *Prev Med.* (2013) 56:35–40. doi: 10.1016/j.ypmed.2012.10.028

51. Askelson NM, Campo S, Lowe JB, Smith S, Dennis LK, Andsager J. Using the theory of planned behavior to predict mothers' intentions to vaccinate their daughters against HPV. *J Sch Nurs.* (2010) 26:194–202. doi: 10.1177/1059840510366022

52. Lee TK, Su LYF. When a personal HPV story on a blog influences perceived social norms: the roles of personal experience, framing, perceived similarity, and social media metrics. *Health Commun.* (2020) 35:438–46. doi: 10.1080/10410236.2019.1567440

53. Nan X, Madden K. HPV vaccine information in the blogosphere: how positive and negative blogs influence vaccine-related risk perceptions, attitudes, and behavioral intentions. *Health Commun.* (2012) 27:829–36. doi: 10.1080/10410236.2012.661348

54. Fazekas KI, Brewer NT, Smith JS. HPV vaccine acceptability in a rural southern area. *J Womens Health.* (2008) 17:539–48. doi: 10.1089/jwh.2007.0489

55. Brown MB, Forsythe AB. Robust tests for the equality of variances. *J Am Stat Assoc.* (1974) 69:364–7. doi: 10.1080/01621459.1974.10482955

56. Liu H. *Comparing Welch Anova, a Kruskal-Wallis Test, and Traditional Anova in Case of Heterogeneity of Variance*. Richmond, VA: Virginia Commonwealth University (2015).

57. Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. *J Market Res.* (1981) 18:39–50. doi: 10.1177/002224378101800104

58. Fornell C, Larcker DF. Structural equation models with unobservable variables and measurement error: algebra and statistics. *J Market Res.* (1981) 18:382–8. doi: 10.1177/002224378101800313

59. Hulland J. Use of partial least squares (PLS) in strategic management research: a review of four recent studies. *Strateg Manag J.* (1999) 20:195–204. doi: 10.1002/(SICI)1097-0266(199902)20:2<195::AID-SMJ13>3.0.CO;2-7

60. Hooper D, Coughlan J, Mullen MR. Structural equation modelling: guidelines for determining model fit. *Electron J Bus Res Methods.* (2008) 6:53–60. doi: 10.21427/D7CF7R

61. Dosunmu GT, Onyeaka H, Kyeremeh E, Jalwa M, Onaku E, Ofori J, et al. The Role of health information technology in improving awareness of HPV and HPV vaccine among US adults: insights from the health information national trends survey. *J Clin Oncol.* (2022) 40:1. doi: 10.1200/jco.2022.40.16_suppl.10535?af=r

62. Chen L, Zhang YF, Young R, Wu XW, Zhu G. Effects of vaccine-related conspiracy theories on Chinese young adults' perceptions of the HPV vaccine: an experimental study. *Health Commun.* (2021) 36:1343–53. doi: 10.1080/10410236.2020.1751384

63. Ruiz JB, Bell RA. Predictors of intention to vaccinate against COVID-19: results of a nationwide survey. *Vaccine.* (2021) 39:1080–6. doi: 10.1016/j.vaccine.2021.01.010

64. Rosso A, Massimi A, De Vito C, Adamo G, Baccolini V, Marzuillo C, et al. Knowledge and attitudes on pediatric vaccinations and intention to vaccinate in a sample of pregnant women from the city of Rome. *Vaccine.* (2019) 37:1954–63. doi: 10.1016/j.vaccine.2019.02.049

65. Bal-Yilmaz H, Koniak-Griffin D. Knowledge, behaviors, and attitudes about human papilloma virus among nursing students in Izmir, Turkey. *J Cancer Educ.* (2018) 33:814–20. doi: 10.1007/s13187-017-1163-1

66. De Visser R, McDonnell E. Correlates of parents reports of acceptability of human papilloma virus vaccination for their school-aged children. *Sex Health.* (2008) 5:331–8. doi: 10.1071/SH08042

67. Ogilvie GS, Remple VP, Marra F, McNeil SA, Naus M, Pielak KL, et al. Parental intention to have daughters receive the human papillomavirus vaccine. *Can Med Assoc J.* (2007) 177:1506. doi: 10.1503/cmaj.071022

68. Yu Y, Xu M, Sun J, Li R, Li M, Wang J, et al. Human papillomavirus infection and vaccination: awareness and knowledge of HPV and acceptability of HPV vaccine among mothers of teenage daughters in Weihai, Shandong, China. *PLoS ONE.* (2016) 11:e0146741. doi: 10.1371/journal.pone.0146741

69. Lane S, MacDonald NE, Marti M, Dumolard L. Vaccine hesitancy around the globe: analysis of three years of WHO/UNICEF joint reporting form data-2015–2017. *Vaccine.* (2018) 36:3861–7. doi: 10.1016/j.vaccine.2018.03.063

70. Zhou M, Qu S, Zhao L, Kong N, Campy KS, Wang S. Trust collapse caused by the changsheng vaccine crisis in China. *Vaccine.* (2019) 37:3419–25. doi: 10.1016/j.vaccine.2019.05.020

71. Yuan J, Xie W, Lan G, Li X, Zhu X. Research on the current situation and coping strategies for cervical cancer in China. *Highlights Sci Eng Technol.* (2022) 2:24–9. doi: 10.54097/hset.v2i.551

72. Hijazi R, Gesser-Edelsburg A, Feder-Bubis P, Mesch GS. Hesitant and anti-vaccination groups: a qualitative study on their perceptions and attitudes regarding vaccinations and their reluctance to participate in academic research-an example during a measles outbreak among a group of jewish parents in Israel. *Front Public Health.* (2022) 10:12822. doi: 10.3389/fpubh.2022.1012822

73. Nguyen ATL, Le XTT, Do TTT, Nguyen CT, Nguyen LH, Tran BX, et al. Knowledge, preference, and willingness to pay for hepatitis B vaccination services among woman of reproductive age in Vietnam. *Biomed Res Int.* (2019) 2019:7. doi: 10.1155/2019/9154918

74. National Bureau of Statistics. *Per Capita Disposable Income Nationwide*. Available online at: https://data.stats.gov.cn/english/easyquery.htm?cn=B01 (accessed November 12, 2022).

75. Joshi SV, Chaudhari HR, Chaudhari NA. Effect of education on awareness, knowledge, and willingness to pay for hepatitis B vaccination services among woman of reproductive age in Vietnam. *J Cancer Educ.* (2020) 35:61–8. doi: 10.1007/s13187-018-1440-7

76. Koskan A, Stecher C, Helitzer D. College males' behaviors, intentions, and influencing factors related to vaccinating against HPV. *Human Vaccines Immunother.* (2021) 17:1044–51. doi: 10.1080/21645515.2020.1819101

77. Chung A, Rimal RN. Social norms: a review. *Rev Commun Res.* (2016) 4:1–28. doi: 10.12840/issn.2255-4165.2016.04.01.008

78. Yao X. Confucianism and its modern values: confucian moral, educational and spiritual heritages revisited. *J Beliefs Values.* (1999) 20:30–40. doi: 10.1080/1361767990200103

79. Benton AD, Santana A, Vinklarek AJ, Lewis CM, Sorensen JM, Hernandez A. Peer-led sexual health education: multiple perspectives on benefits for peer health educators. *Child Adolesc Social Work J.* (2020) 37:487–96. doi: 10.1007/s10560-020-00661-9

80. Sadoh AE, Okonkwo C, Nwaneri DU, Ogboghodo BC, Eregie C, Oviawe O, et al. Effect of peer education on knowledge of human papilloma virus and cervical cancer among female adolescent students in Benin City, Nigeria. *Ann Glob Health.* (2018) 84:121–8. doi: 10.29024/aogh.24

81. Esaggoff A, Cohen, Samuel, Chang G, Equils O, Orman SV, Burnett A. 2531. Using peer-to-peer education to increase awareness and uptake of HPV vaccine among Chinese international students. *Open Forum Infect Dis.* (2019) 6(Supplement_2):S879–80. doi: 10.1093/ofid/ofz360.2209

82. Madrigal JM, Johnson CA, Green J, Patel A. Using peer health educators to conduct community level surveillance of HPV vaccination status: findings among women who live in medically underserved areas of Chicago. *J Community Health.* (2020) 45:1043–9. doi: 10.1007/s10900-020-00828-6

83. Mellanby AR, Rees JB, Tripp JH. Peer-led and adult-led school health education: a critical review of available comparative research. *Health Educ Res.* (2000) 15:533–45. doi: 10.1093/her/15.5.533

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 February 2023
DOI 10.3389/fpubh.2023.1017300

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 11 August 2022
ACCEPTED 30 January 2023
PUBLISHED 16 February 2023

CITATION
Al-Gburi G, Al-Shakarchi A, Al-Dabagh JD and Lami F (2023) Assessing knowledge, attitudes, and practices toward sexually transmitted infections among Baghdad undergraduate students for research-guided sexual health education. *Front. Public Health* 11:1017300. doi: 10.3389/fpubh.2023.1017300

Assessing knowledge, attitudes, and practices toward sexually transmitted infections among Baghdad undergraduate students for research-guided sexual health education

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Background: Sexually transmitted infections are common and tend to cause a lot of public misconceptions. This study was conducted to identify knowledge gaps and negative attitudes toward sexually transmitted infections and infected individuals among undergraduate students and give recommendations accordingly for the development of more objective research-guided health campaigns and school sex education programs.

Method: A cross-sectional study was conducted between May 17, 2022 and June 2, 2022 using a self-administrated questionnaire containing 84 items related to sexually transmitted infections distributed online to Baghdad-based university students.

Result: The sample consisted of 823 respondents; 332 men and 491 women. Overall knowledge was moderate to high, with 628 individuals (76.3%) answering more than half the questions correctly. There was no difference according to gender or previous sexual experience, but knowledge increased by an average of 2.73 points ($p < 0.001$) when a participant knew a previously infected individual. Less than half identified systemic symptoms of STIs, and their knowledge of other HIV items was also poor. Most respondents (85.5%) agreed to the need for sex education during middle or high school and cited traditional barriers as the most critical barrier (64.8%); in comparison, those who did not agree on its need cited the sensitivity of the subject (40.3%) or religious barriers (20.2%) as more important.

Conclusion: Specific knowledge gaps exist for HIV and non-HIV sexually transmitted infections; these should be addressed during sex education, focusing on specific high-risk groups. Negative attitudes and stigmatizing behavior should be addressed as well by increasing focused STI knowledge.

KEYWORDS

sexually transmitted infections, sex education, Middle East, Iraq, Baghdad

Introduction

Sexually transmitted infections (STIs) are a major public health concern worldwide. They refer to the multiplication of microbes in the genital tract after transmission through sexual routes. They can present with a broad spectrum of manifestations ranging from asymptomatic infections to diseases, which can end with infertility, cancers, and even death. According to the WHO, more than one million STIs are acquired every day globally (1). In developed countries, like the USA, nearly 27 million new STIs are estimated to be transmitted annually (2), half of which are among youth aged 15–24 years. While in the UK, the highest rate of more than 142,000 diagnosed cases was recorded among the same age group in 2020 (3). The estimated incidence for four curable STIs (chlamydia, gonorrhea, syphilis, and trichomoniasis) was 60.6 per 1,000 in the Middle East/North Africa region. Although this region is classified as low risk, the estimated death of 10.4 per million was more than regions with higher incidence (4). STIs Epidemiological data (in terms of incidence and prevalence) from Iraq was scarce and incomplete; with more focus on AIDS (5) or using a syndromic approach for estimation rather than laboratory tests (6).

Despite the incomplete profile of STIs in Iraq, the recent political, socioeconomic, and cultural situation of the country suggests that there are factors that may contribute to an increased spread of STIs and cause under-reporting. These factors may include war, displacement, poverty, unemployment, and the disruption of families and communities. Furthermore, increased access to the outside world through TV, cell phones, and the Internet may lead to the development of a more open mindset toward sex in a large proportion of the young Iraqi population (5), especially in urban regions including the capital city of Baghdad. University students might be especially vulnerable, as they are part of the youth group (15–24 years) designated by the United Nations; these individuals are usually disproportionately high in terms of their STI incidence (3). In Iraq, university also characterizes a period of return to mixed-gender education after 6 years of segregation during middle and high school. A sharp increase in high-risk sexual behavior is therefore expected.

According to Becker's health belief model, people's knowledge and attitude toward a health-related problem might correlate with their future behavior (7); this, in turn, means that studies which assess these indices can be useful during the development and implementation of public health campaigns and education programs in a way that is suitable to the needs of the local environment. Many studies of this nature have been performed in countries that are culturally similar to Iraq; like Iran (8, 9), Saudi Arabia (10, 11), and Turkey (12–14), while in Iraq only few articles have been published; mainly focusing on AIDS/HIV or a specific point related to STIs rather than the subject as a whole (15–18).

This study was done to identify knowledge gaps and negative attitudes toward sexually transmitted infections and infected individuals among undergraduate students. The goal is to give recommendations for the development of more objective research-guided health campaigns and school sex education programs.

Materials and methods

Study design and sampling

A cross-sectional study was conducted from May 17, 2022, to June 2, 2022, among undergraduate college students in Iraq using a self-administrated structured questionnaire (Appendix A). The questionnaire was distributed using a web-based Google form across social media websites and applications belonging to public and private universities based in Baghdad, as listed by the Ministry of Higher Education. An explanation of the targeted sample was provided at the top of the questionnaire and on the related website posts, and private social media forums were selected during questionnaire distribution. This was done to reduce the participation of individuals not meeting the sampling criteria—although complete elimination of this bias cannot be achieved with online data collection.

College students were selected as the target sample for two reasons. First, they form a part of the youth high-risk group which tends to have a disproportionally high STI incidence (3) and because they have group-specific risk factors as university, in Iraq, is a period of return to mixed-gender education after 6 years of segregation and therefore more chances for high-risk sexual behavior to occur. Knowledge gaps and attitudes need to be assessed for this group to design targeted public health campaigns and sex education programs.

To increase the validity of our data; First, the research team did not offer any incentives to the respondents to fill out the questionnaire. Second, all questions were mandatory to reduce the number of missing values during the following data analysis steps. Finally, to ensure that no initial data analysis would occur before the end of the data collection period, we made sure that the form would close automatically after 1,000 responses were collected. This was achieved using a Google workplace application, known as "form limiter." All this was conducted and reported according to the (CHERRIES) checklist for E-surveys (19).

To be included in the final sample, respondents had to fulfill 2 criteria; be enrolled as an undergraduate in a Baghdad-based university during the academic year of 2021/2022 (assigned as criteria 1) and be enrolled in a discipline not related to medicine or medical technology (assigned as criteria 2). This was judged as a necessary step, as previous studies have demonstrated an obvious difference between non-medical and medical college students (11, 18, 20).

Data collection tool

The questionnaire was developed after a literature review (9, 12, 21). Culture-specific items were then added, including polygamy (described as a man having more than one wife as it is legal in Iraq) and circumcision. The questionnaire was then translated into Arabic and pretested on a small sample of 25 medical students and was subjected to expert review by the department of dermatology at Baghdad Teaching Hospital. Candidiasis was initially included

as an item similar to a study from Kampala, Uganda (21). It was removed later as a review revealed that candidiasis is connected to sexual activity itself rather than high-risk behavior or sexual transmission (22, 23).

The questionnaire (Appendix A) was divided into demographics, knowledge, attitudes, and practices. Each section is further divided into blocks with items related to a single topic; for example, within the knowledge section, there were blocks pertaining to diseases, symptoms, transmission, outcomes, sources of information, risk, and protective factors.

In total, there were 84 items related to sexually transmitted infections. Most were presented as Yes/No questions. Knowledge-related items were each assigned 1 point for a total of 60 points from which respondents' overall knowledge could be extrapolated; with those who answered >50% of questions correctly, regarded as having good knowledge. Items related to attitudes and practices, on the other hand, had no similar scoring. This was due to their innate heterogeneity compared to knowledge-related items, it was therefore judged to be more beneficial and representative to discuss each item or block of items separately instead of calculating an overall score.

Measurements and analysis plan

Statistical Package for the Social Sciences (SPSS) version 24 was used to perform both descriptive measurements (means and proportions) and statistical analysis with an independent-samples *T*-test to assess the effect of gender, knowing someone with an STI, and previous sexual experience on the overall knowledge score. A Chi-square test was also performed to assess the effect of the three factors on each item. Spearman's correlation coefficient was also used to assess the congruency of knowledge self-evaluation with the measured knowledge score. D'Agostino-Pearson-Omnibus test was performed using an Excel statistics plugin as it could not be performed on SPSS.

Ethical approval and informed consent

A written description of the study's purpose was provided at the top of the questionnaire with information regarding the purpose of the study, the targeted population, and the attainment of study participants' full anonymity during the process of data collection, manuscript writing, and publication. Also, individuals were told on two instances (at the top of the questionnaire and again near the submit button) that by submitting their answers they consent to the usage of the provided information for research which might also include sharing of research data to a data repository to increase transparency. Initial ethical approval was obtained from University of Baghdad/College of Medicine followed by approval from the research committee of the National Center for Training and Human Development belonging to the Ministry of Health and Environment with decision number 8 on May 15, 2022 prior to data collection.

Results

Overview

A total of 1,000 responses were collected; 83 individuals did not meet Criteria 1 (not enrolled as undergraduates in a Baghdad-based college) and were therefore excluded from the final sample selection. A further 94 who met Criteria 1 were also excluded because they did not meet Criteria 2 (not enrolled in a medical or a medical technology-related field), providing 823 as the final sample size with a valid response rate of 82.3%.

TABLE 1 Sample socio-demographic characteristics.

Characteristics	$N = 823$ (%)
Age (Years)	
18–19	130 (15.8)
20–21	273 (33.2)
22–23	249 (30.2)
24–25	73 (8.9)
>25	98 (11.9)
Gender	
Male	332 (40.3)
Female	491 (59.7)
Residency	
Urban	747 (90.8)
Rural	76 (9.2)
Marital experience	
Married/Divorced/Widow	110 (13.4)
No marital experience	713 (86.6)
Field of study	
Engineering and technology	249 (30.3)
Education	203 (24.7)
Science studies	165 (20)
Law	64 (7.8)
Business and finances	45 (5.5)
Language	36 (4.4)
Social studies	31 (3.8)
Media and public affairs	18 (2.2)
Others (Arts, Sports, tourism, Etc.)	12 (1.3)
Do you know someone who has been diagnosed with an STI?	
Yes	195 (23.7)
No	628 (76.3)
Previous sexual experience (of any type)	
Yes	226 (27.5)
No	597 (72.5)

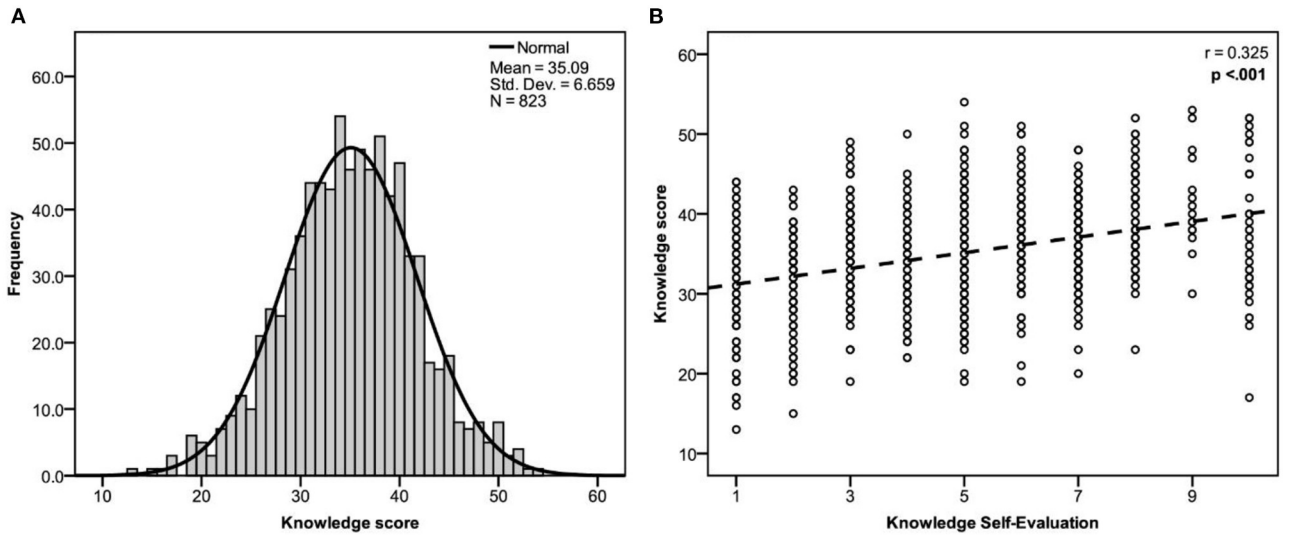

FIGURE 1
(A) Knowledge score distribution, **(B)** Correlation between measured knowledge score and knowledge self-evaluation using spearman's correlation coefficient (r) and a *p*-value of 0.05 as a cutoff point for significance.

687 (83.4%) of respondents were equal to or below the age of 24 years and are therefore part of the 15–24 youth group (Table 1). The number of individuals with previous sexual experience is 226 (27.5%), more than twice that of individuals with marital experience (110, 13.4%). The number of individuals with previous sexual but no marital experience is 150 (18.2% of the study sample).

Overall knowledge

As per the Agostino-Pearson-Omnibus test ($K^2 = 1.367$, $p = 0.504$), respondents' knowledge scores are normally distributed with a range from 13 to 54, a mean of 35.09 (SD = 6.65) and a median of 35 (IQR = 31–40) (Figure 1). 195 (23.7%) of respondents answered less than half the assigned questions correctly (have a score of < 31). The (B) portion of the figure also shows the relation between the measured (objective) knowledge score and knowledge self-evaluation. Spearman's coefficient (r) indicates a weak but statistically significant correlation measuring 0.325.

Appendix B shows the effect of three factors: gender, previous sexual experience, and knowing someone who has been diagnosed with a sexually transmitted infection; out of these, the latter had the strongest effect, with a mean difference of 2.73 ($P < 0.001$).

Knowledge of sexually transmitted infections

In our study, the awareness that STIs can be transmitted by sexual intercourse was the most correctly answered item across all categories with a correct response rate of 98.4% (Table 2), closely followed by the awareness of HIV as an STI at 98.2%, while the lowest was the common misconception that showering before and after sex is a protective factor with only 7.9% of the study respondents having the right answer as shown in Appendix B. There were also 21 additional items with > 50% incorrect response rates, these were regarded as "common misconceptions" (Appendix Table B2). Other items exist with < 50% incorrect response rate, but they relate to topics of high public health interest and should therefore be mentioned. These include: the availability of HIV vaccination (standing at 42% incorrect response rate), the non-curability of HIV infections (32.9%), the perception that hormonal contraceptives are useful against STIs (39.2%), and that condoms cause infertility (22.2%).

Attitudes toward sexually transmitted infections

82.6% of respondents agreed that sex education should be taught in middle or high school (Table 3). For these individuals, "traditional barriers" was selected as the most important barrier against the implementation of such programs (64.77%), followed by the sensitivity of the subject (24.57%) and religious barriers (10.65%) (Appendix C). This distribution was different for individuals who were against teaching sex education. On average, individuals who agreed to sex education scored 2.3 points higher on the knowledge scale ($P < 0.001$).

Practices related to sexually transmitted infections

Individuals who had a previous sexual experience were 2 years older on average and more likely to be men (41.3% of men had some sort of sexual experience compared to 18.1% of women) and

10.3389/fpubh.2023.1017300

TABLE 2 Knowledge about sexually transmitted infections among non-medical undergraduates in Baghdad, Iraq.

Category	Gender			Do you know someone who has been diagnosed with an STI?			Previous sexual experience		
	Male 332 (%)[a]	Female 491 (%)[a]	*P*-value[b]	Yes 195 (%)[a]	No 628 (%)[a]	*P*-value[b]	Yes 226 (%)[a]	No 597 (%)[a]	*P*-value[b]
Diseases									
HIV	326 (98.2)	482 (98.2)	0.978	189 (96.9)	619 (98.6)	0.134	220 (97.3)	588 (98.5)	0.272
Syphilis	124 (37.3)	156 (31.8)	0.098	89 (42.6)	197 (31.4)	**0.004**	91 (40.3)	189 (31.7)	**0.020**
Gonorrhea	224 (67.5)	254 (51.7)	**7*10^−6**	138 (70.8)	340 (54.1)	**5*10^−5**	160 (70.8)	318 (53.3)	**5*10^−6**
Genital warts	83 (25.0)	144 (29.3)	0.173	67 (34.3)	160 (25.5)	**0.015**	80 (35.4)	147 (24.6)	**0.002**
Genital herpes	154 (46.4)	243 (49.5)	0.382	106 (54.4)	291 (46.3)	0.050	110 (48.7)	287 (48.1)	0.878
Chlamydia	84 (25.3)	117 (23.8)	0.630	59 (30.3)	142 (22.6)	**0.030**	65 (28.8)	136 (22.8)	0.075
Trichomoniasis	65 (19.6)	106 (21.6)	0.486	51 (26.2)	120 (19.1)	**0.034**	52 (23.0)	119 (19.9)	0.332
Molluscum	97 (29.2)	136 (27.7)	0.635	77 (39.5)	156 (24.8)	**1*10^−4**	73 (32.3)	160 (26.8)	0.118
Scabies and pediculosis	144 (43.3)	229 (46.6)	0.356	108 (55.4)	265 (42.2)	**0.001**	101 (44.7)	272 (45.6)	0.823
Hepatitis B and C	160 (48.2)	243 (49.5)	0.715	108 (55.4)	295 (47.0)	**0.040**	108 (47.8)	295 (49.4)	0.677
Symptoms									
Groin swelling	168 (50.6)	258 (52.5)	0.584	119 (61.0)	307 (48.9)	**0.003**	127 (56.2)	299 (50.1)	0.117
Genital ulcers	247 (74.4)	414 (84.3)	**6*10^−4**	170 (87.2)	491 (78.2)	**0.006**	183 (81.0)	478 (80.1)	0.770
Genital itching	235 (70.8)	366 (74.5)	0.233	157 (80.5)	444 (70.7)	**0.007**	184 (81.4)	417 (69.8)	**0.001**
Genital rash	241 (72.6)	369 (75.2)	0.410	156 (80.0)	454 (72.3)	**0.032**	175 (77.4)	435 (72.9)	0.182
Groin pain	172 (51.8)	290 (59.1)	**0.040**	128 (65.6)	334 (53.2)	**0.012**	128 (56.6)	334 (55.9)	0.859
Painful urination	203 (61.1)	282 (57.4)	0.288	121 (62.1)	364 (58.0)	0.311	140 (61.9)	345 (57.8)	0.279
Menstrual issues	179 (53.9)	257 (52.3)	0.657	112 (57.4)	324 (51.6)	0.153	127 (56.2)	309 (51.8)	0.255
Vaginal discharge	214 (64.5)	335 (68.2)	0.260	142 (72.8)	407 (64.8)	**0.038**	159 (70.4)	390 (65.3)	0.172
Urethral discharge	195 (58.7)	303 (61.7)	0.392	133 (68.2)	365 (58.1)	**0.002**	140 (61.9)	358 (60.0)	0.604
Body rash	135 (40.7)	202 (41.1)	0.891	87 (44.6)	250 (39.8)	0.233	93 (41.2)	244 (40.9)	0.942
Fever	140 (42.2)	217 (44.2)	0.565	104 (53.3)	253 (40.3)	**0.001**	98 (43.4)	259 (43.4)	0.996
Frequent diarrhea	96 (28.9)	127 (25.9)	0.334	59 (30.3)	164 (26.1)	0.256	57 (25.2)	166 (27.8)	0.457
Frequent coughing	78 (23.5)	92 (18.7)	0.098	49 (25.1)	121 (19.3)	0.077	48 (21.2)	122 (20.4)	0.799
Frequent Sore throat	66 (19.9)	90 (18.3)	0.564	42 (21.5)	114 (18.2)	0.296	44 (19.6)	112 (18.8)	0.795
Weight loss	122 (36.7)	187 (38.1)	0.697	80 (41.0)	229 (36.5)	0.251	78 (34.5)	231 (38.7)	0.269
No symptoms	275 (82.8)	397 (80.9)	0.472	167 (85.6)	505 (80.4)	0.099	187 (82.7)	485 (81.2)	0.619
Transmission									
Sexual intercourse	325 (97.9)	485 (98.8)	0.317	191 (97.9)	619 (98.6)	0.545	222 (98.2)	588 (98.5)	0.788
Skin contact	125 (37.7)	198 (40.3)	0.441	96 (49.2)	227 (36.1)	**0.001**	98 (43.4)	225 (37.7)	0.137
Sharing objects	192 (57.8)	369 (75.2)	**1*10^−7**	144 (73.8)	417 (66.4)	0.051	153 (67.7)	408 (68.3)	0.860
Sharing food[c]	166 (50.0)	196 (39.9)	**0.004**	110 (56.4)	252 (40.1)	**8*10^−5**	103 (45.6)	259 (43.4)	0.572
Swimming pools[c]	230 (69.3)	415 (84.5)	**1*10^−7**	163 (83.6)	482 (76.8)	**0.043**	180 (79.6)	465 (77.9)	0.585
Blood and injections	304 (91.6)	430 (87.6)	0.071	181 (92.8)	553 (88.1)	0.061	203 (89.8)	531 (88.9)	0.717
Hairdressing	243 (73.2)	378 (77.0)	0.215	164 (84.1)	457 (72.8)	**0.001**	177 (78.3)	444 (74.4)	0.240
Pregnancy and childbirth	184 (55.4)	240 (48.9)	0.065	118 (60.5)	306 (48.7)	**0.004**	131 (58.0)	293 (49.1)	**0.023**
Breastfeeding	174 (52.4)	180 (36.7)	**7*10^−6**	101 (51.8)	253 (40.3)	**0.005**	110 (48.7)	244 (40.9)	**0.044**
Mosquito bite[c]	203 (61.1)	281 (57.2)	0.263	130 (66.7)	354 (56.4)	**0.011**	143 (63.3)	341 (57.1)	0.109

(Continued)

TABLE 2 (Continued)

Category	Gender			Do you know someone who has been diagnosed with an STI?			Previous sexual experience		
	Male 332 (%)[a]	Female 491 (%)[a]	*P*-value[b]	Yes 195 (%)[a]	No 628 (%)[a]	*P*-value[b]	Yes 226 (%)[a]	No 597 (%)[a]	*P*-value[b]
Risk factors									
Multiple partners	324 (97.6)	476 (96.9)	0.582	190 (97.4)	610 (97.1)	0.823	220 (97.3)	580 (97.2)	0.881
Unprotected sex	300 (90.4)	386 (78.6)	**9*10^−6**	169 (86.7)	517 (82.3)	0.155	190 (84.1)	496 (83.1)	0.734
Substance use	222 (66.9)	357 (72.7)	0.072	145 (74.4)	434 (69.1)	0.161	148 (65.5)	431 (72.2)	0.060
Prostitution	311 (93.7)	452 (92.1)	0.381	184 (94.4)	579 (92.2)	0.310	213 (94.2)	550 (92.1)	0.296
STI co-infection	309 (93.1)	452 (92.1)	0.588	187 (95.9)	574 (91.4)	**0.038**	211 (93.4)	550 (92.1)	0.549
Multiple marriages	180 (54.2)	396 (80.7)	**4*10^−16**	148 (75.9)	428 (68.2)	**0.039**	155 (68.6)	136 (22.8)	0.589
Prevention									
Abstinence[d]	155 (46.7)	230 (46.8)	0.965	95 (48.7)	290 (46.2)	0.535	93 (41.2)	292 (48.9)	**0.046**
Condoms	287 (86.4)	371 (75.6)	**1*10^−4**	165 (84.6)	493 (78.5)	0.063	192 (85.0)	466 (78.1)	**0.027**
Single partner	268 (80.7)	455 (92.7)	**2*10^−7**	168 (86.2)	555 (88.4)	0.407	190 (84.1)	533 (89.3)	**0.041**
Routine check-up	307 (92.5)	477 (97.1)	**0.002**	187 (95.9)	597 (95.1)	0.632	212 (93.8)	572 (95.8)	0.226
Vaccines (warts)	278 (83.7)	437 (89.0)	**0.028**	169 (86.7)	546 (86.9)	0.921	197 (87.2)	518 (86.8)	0.879
Vaccines (HIV)[c]	120 (36.1)	226 (46.0)	**0.005**	95 (48.7)	251 (40.0)	**0.031**	98 (43.4)	248 (41.5)	0.637
Showering before and after sex	301 (90.7)	457 (93.1)	0.208	181 (92.8)	577 (91.9)	0.670	208 (92.0)	550 (92.1)	0.965
Contraceptive pill	130 (39.2)	193 (39.3)	0.965	90 (46.2)	233 (37.1)	**0.024**	88 (38.9)	235 (39.4)	0.911
Circumcision	238 (71.7)	356 (72.5)	0.797	140 (71.8)	454 (72.3)	0.892	164 (72.6)	430 (72.0)	0.877
Outcome									
Resolution (HIV)[c]	83 (25.0)	114 (23.2)	0.557	58 (29.7)	139 (22.1)	**0.030**	70 (31.0)	127 (21.3)	**0.004**
Resolution (others)[c]	214 (64.5)	285 (58.0)	0.065	127 (65.1)	372 (59.2)	0.141	139 (61.5)	360 (60.3)	0.753
Infertility	178 (53.6)	262 (53.4)	0.943	107 (54.9)	333 (53.0)	0.652	125 (55.3)	315 (52.8)	0.513
Abortion	198 (59.6)	326 (66.4)	**0.048**	133 (68.2)	391 (62.3)	0.132	143 (63.3)	381 (63.8)	0.885
Premature birth	149 (44.9)	254 (51.7)	0.054	99 (50.8)	304 (48.4)	0.564	126 (55.8)	277 (46.4)	**0.017**
Birth defects	201 (60.5)	303 (61.7)	0.736	123 (63.1)	381 (60.7)	0.547	143 (63.3)	361 (60.5)	0.461
Kidney problems	260 (78.3)	361 (73.5)	0.117	163 (83.6)	458 (72.9)	**0.003**	177 (78.3)	444 (74.4)	0.240
Cancer	193 (58.1)	313 (63.7)	0.104	127 (65.1)	379 (60.4)	0.231	140 (61.9)	366 (61.3)	0.866
Death	219 (66.0)	318 (64.8)	0.723	137 (70.3)	400 (63.7)	0.093	143 (63.3)	394 (66.0)	0.464
Information source									
School	170 (51.2)	249 (50.7)	0.890	95 (48.7)	324 (51.6)	0.483	111 (49.1)	308 (51.6)	0.526
Healthcare providers	148 (44.6)	194 (39.5)	0.148	99 (50.8)	243 (38.7)	**0.003**	104 (46.0)	238 (39.9)	0.110
Parents	93 (28.0)	159 (32.4)	0.182	75 (38.5)	177 (28.2)	**0.007**	69 (30.5)	183 (30.7)	0.973
Friends	216 (65.1)	212 (43.2)	**7*10^−10**	121 (62.1)	307 (48.9)	**0.001**	146 (64.6)	282 (47.2)	**8*10^−6**
Books	207 (62.3)	279 (56.8)	0.114	124 (63.6)	362 (57.6)	0.140	154 (68.1)	332 (55.6)	**0.001**
TV	188 (56.6)	270 (55.0)	0.643	111 (56.9)	347 (55.3)	0.682	134 (59.3)	324 (54.3)	0.196
The internet	313 (94.6)	451 (91.9)	0.137	183 (93.8)	581 (92.7)	0.573	211 (93.8)	553 (92.6)	0.567

[a]Counts and column percent are described as individuals who have answered "Yes" during data collection.
[b]Chi-square for association with a cutoff point of 0.05 for p-value and significant results indicated with a bold text.
[c]For these questions, "No" was the correct answer.
[d]During data collection, abstinence was described as restraining from sexual experience before marriage.

10.3389/fpubh.2023.1017300

TABLE 3 Attitudes toward sexually transmitted infections, their prevention, and infected individuals among non-medical undergraduates in Baghdad, Iraq.

Categories	Gender			Do you know someone who has been diagnosed with an STI?		
	Male 332 (%)[a]	Female 491 (%)[a]	*P*-value[b]	Yes 195 (%)[a]	No 628 (%)[a]	*P*-value[b]
Sexually transmitted infections						
Can be effectively prevented	317 (95.5)	472 (96.1)	0.647	187 (95.9)	602 (95.9)	0.982
Public health campaigns						
Have made you reconsider sex	270 (81.3)	410 (83.5)	0.419	166 (85.1)	514 (81.8)	0.291
More campaigns are needed	319 (96.1)	474 (96.5)	0.734	189 (96.9)	604 (96.2)	0.628
Sex education						
Should be taught in middle/high school	280 (84.3)	424 (86.4)	0.420	173 (88.7)	531 (84.6)	0.291
Should be a part of science class	269 (81.0)	429 (87.4)	**0.013**	164 (84.1)	534 (85.0)	0.628
Condoms						
Can cause infertility	62 (18.7)	121 (24.6)	**0.043**	48 (24.6)	135 (21.5)	0.360
Can increase participation in casual sex	177 (53.3)	317 (64.6)	**0.001**	108 (55.4)	386 (61.5)	0.130
Can decrease sexual pleasure	280 (84.3)	310 (63.1)	**3*10^−11**	149 (76.4)	441 (70.2)	0.094
Can lead to partner mistrust	212 (63.9)	259 (52.7)	**0.002**	114 (58.5)	357 (56.8)	0.691
Are not effective when used as the only infection prevention method	188 (56.6)	351 (71.5)	**1*10^−5**	125 (64.1)	414 (65.9)	0.640
Individuals with STIs						
Should be socially isolated	211 (63.6)	288 (58.7)	0.158	120 (61.5)	379 (60.4)	0.767
Should suffer from violence	114 (34.3)	147 (29.9)	0.183	61 (31.3)	200 (31.8)	0.882
Should have fewer jobs	156 (47.0)	178 (36.3)	**0.002**	84 (43.1)	250 (39.8)	0.417
Should be stigmatized by doctors	171 (51.5)	222 (45.2)	0.076	95 (48.7)	298 (47.5)	0.757

Categories	Previous sexual experience		
	Yes 226 (%)[a]	No 597 (%)[a]	*P*-value[b]
Sexually transmitted infections			
Can be effectively prevented	219 (96.9)	570 (95.5)	0.359
Public health campaigns			
Have made you reconsider sex	186 (82.3)	494 (82.7)	0.880
More campaigns are needed	218 (96.5)	575 (96.3)	0.921
Sex education			
Should be taught in middle/high school	196 (86.7)	508 (85.1)	0.552
Should be a part of science class	191 (84.5)	507 (84.9)	0.883
Condoms			
Can cause infertility	45 (19.9)	138 (23.1)	0.324
Can increase participation in casual sex	111 (49.1)	383 (64.2)	**8*10^−5**
Can decrease sexual pleasure	175 (77.4)	415 (69.5)	**0.024**
Can lead to partner mistrust	117 (51.8)	354 (59.3)	0.051
Are not effective when used as the only infection prevention method	139 (61.5)	400 (67.0)	0.139

(Continued)

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TABLE 3 (Continued)

Categories	Previous sexual experience		
	Yes 226 (%)[a]	No 597 (%)[a]	*P*-value[b]
Individuals with STIs			
Should be socially isolated	137 (60.6)	562 (60.6)	0.996
Should suffer from violence	71 (31.4)	190 (31.8)	0.910
Should have fewer jobs	87 (38.5)	247 (41.4)	0.453
Should be stigmatized by doctors	105 (46.5)	288 (48.2)	0.648

[a]Counts and column percent are described as individuals who have answered "Yes" during data collection.
[b]Chi-square for association with a cutoff point of 0.05 for p-value and significant results indicated with a bold text.

TABLE 4 Practices upon suspicion or diagnosis with a sexually transmitted infection among non-medical undergraduates in Baghdad, Iraq.

Categories	Gender			Do you know someone who has been diagnosed with an STI?		
	Male 332 (%)[a]	Female 491 (%)[a]	*P*-value[b]	Yes 195 (%)[a]	No 628 (%)[a]	*P*-value[b]
Suspicion of having an STI due to symptoms or after high-risk behavior						
Ask your parent	129 (38.9)	198 (40.3)	0.672	77 (39.5)	250 (39.8)	0.936
Ask a friend	149 (44.9)	158 (32.2)	**8*10^−5**	76 (39.0)	231 (36.8)	0.581
Seek medical advice	317 (95.5)	449 (91.4)	**0.025**	181 (92.8)	585 (93.2)	0.873
Search the internet	295 (88.9)	447 (91.0)	0.302	176 (90.3)	566 (90.1)	0.958
Ignore this suspicion if no symptoms	111 (33.4)	145 (29.5)	0.235	59 (30.3)	197 (31.4)	0.769
Diagnosis with an STI						
Follow the doctor's advice	320 (96.4)	476 (96.9)	0.658	187 (95.9)	609 (97.0)	0.461
Self-medicate with OTC drugs[c]	55 (16.6)	91 (18.5)	0.469	45 (23.1)	101 (16.1)	**0.026**
Seek herbal and traditional medicine	105 (31.6)	133 (27.1)	0.159	63 (32.3)	175 (27.9)	0.232
Ignore the diagnosis if mild	48 (14.5)	82 (16.7)	0.387	38 (19.5)	92 (14.6)	0.106

Categories	Previous sexual experience		
	Yes 226 (%)[a]	No 597 (%)[a]	*p*-value[b]
Suspicion of having an STI due to symptoms or after high-risk behavior			
Ask your parent	72 (31.9)	255 (42.7)	**0.005**
Ask a friend	93 (41.2)	214 (35.8)	0.160
Seek medical advice	213 (94.2)	553 (92.6)	0.415
Search the internet	203 (89.8)	539 (90.3)	0.843
Ignore this suspicion if no symptoms	67 (29.6)	189 (31.7)	0.578
Diagnosis with an STI			
Follow the doctor's advice	217 (96.0)	579 (97.0)	0.487
Self-medicate with OTC drugs[c]	45 (19.9)	101 (16.9)	0.316
Seek herbal and traditional medicine	64 (28.3)	174 (29.1)	0.815
Ignore the diagnosis if mild	35 (15.5)	95 (15.9)	0.881

[a]Counts and column percent are described as individuals who have answered "Yes" during data collection.
[b]Chi-square for association with a cutoff point of 0.05 for p-value and significant results indicated with a bold text.
[c]OTC, over the counter.

as demonstrated in Appendix D, they were also more likely to know someone who has been diagnosed with an STI compared to those without sexual experience. Other practices related to suspicion or after a diagnosis with an STI are summarized in Table 4.

Discussion

The current study revealed that overall knowledge was moderate to high, with around three-quarters of respondents

answering more than half the questions correctly; this is higher than the overall knowledge reported in other studies from Kufa in south Iraq (18), Iran (9), and Saudi Arabia (11) and comparable to results from Malaysia (20, 24). In this study, knowledge about STIs was not affected by gender. This is similar to several studies (9, 20, 24, 25), but differs from two studies in which women had higher knowledge (11, 18). Knowing someone who has been infected with an STI was more critical to increase knowledge than having a previous sexual experience. This is a concerning finding, as knowledge is acquired after someone else has already been affected. It also shows that people who might be thinking about having a sexual relationship might not have access to better sources of information, making school-based sex education programs and targeted public health campaigns more essential.

Internet was the most common source of information, as with most studies (9, 10, 20). However, this was not the case in one Turkish study from 2014 in which written media like books, magazines, and newspapers took first place (13). Studies on the credibility of Arab health-related websites show that only a minority of the websites are credible and certified by the Health on the Net (HON) foundation (26, 27). Social media is probably more problematic but less investigated. This dependence on online information may stem from the void created by a lack of sufficient information from other sources which were less cited (9, 10, 13). Furthermore, almost all the respondents think that more public health campaigns are needed and more than 80% think that sex education should be taught in middle or high school. This propensity to know more about STIs must be met with credible sources under the supervision of Iraqi health and education authorities.

HIV was the most commonly recognized STI (98.2%). The same finding was obtained from other research (8, 10, 12–14, 20, 24). A study conducted on Iraqi females published in 2008 showed that only half the respondents had heard about HIV/AIDS and 88.5% recognized sex as a transmission route (17). Another study conducted on high school students in Erbil, north of Iraq, in 2015 showed a higher level of recognition for HIV sexual transmission (94.3%) (16). It should be noted that both of these studies did not mention systemic manifestations commonly associated with AIDS (frequent diarrhea, frequent cough, and frequent sore throat). In our study, less than half the respondents recognized these as symptoms of STIs. As for other HIV items, only 58% of respondents correctly identified the unavailability of a vaccine, and 67.1% correctly identified HIV as a non-curable infection. The vaccine misconception was less prominent in two other studies from Iraq focusing on knowledge of HIV in a sample of Erbil high school students and university students from two governorates (15, 16), in the latter those from Diyala were more likely to believe in the vaccine misconception. All of this indicates that although more people now recognize HIV as an STI, there are still gaps in knowledge that might lead to lower risk perception and delayed care-seeking.

In terms of non-HIV STIs, trichomoniasis and chlamydia have the highest incidence among all STIs both globally and in the Middle East/North Africa region (1, 4). Yet, they were the least recognized in this study and many other studies (8, 10, 13, 24). Men were more likely to recognize gonorrhea as an STI similar to another study conducted in Iran (9) since gonorrhea is more symptomatic in men (28). In contrast, women were more likely to recognize the presence of HPV vaccines, presumably because cervical cancer in women is given more public health attention than HPV outcomes in men. This gender difference was also found in other studies (29–31). Half the respondents did not recognize pregnancy and childbirth as modes of transmission, and an even higher portion did not recognize breastfeeding as such. These are important topics that should be focused on in future educational campaigns as they relate to a significant risk to the baby from severe forms of non-HIV sexually transmitted infections including chronic hepatitis B, gonococcal conjunctivitis, and HSV, along with HIV transmission (28).

An interesting trend is noted regarding gender differences in the recognition of preventive methods; men were more likely to recognize condoms as a protective method, even when used alone, and unprotected sex as a risk factor, making men favor protection over monogamy. Women, on the other hand, were more likely to recognize polygamy (which is permissible in the Muslim world) as a risk factor, and having a single partner as a protective factor, which indicates a propensity for monogamy as a preventive method. This notion was not found in a study from Iran (9) where females were more likely to cite condom non-use as a risk factor.

Although there was relatively high support for school sex education programs, individuals who did not support such measures reported sensitivity and religious barriers more frequently. This means that future programs need to be modified and modulated in a generally acceptable way to traverse these two barriers. Still, the most cited barrier overall was traditional barriers, exemplified by tribalism which constitutes a part of legal pluralism in Iraq (32). This is unlikely to be solved just by adjusting the content of sex education programs and might need a wider governmental approach outside the scope of sexual health education. The notion that higher overall knowledge correlated with higher acceptance of sex education programs points out that it might also be possible to increase acceptance by improving knowledge from other sources like the media, the internet, or by community-based public health campaigns, and not only by addressing the aforementioned barriers.

Despite the moderately good level of knowledge, attitudes toward infected individuals were still negative, especially social stigmatization. People in favor of the social isolation of infected individuals were more likely to recognize sharing food and swimming pools as possible transmission routes for STIs (Appendix C). Women were more empathetic in terms of institutional stigmatization. This might be explained by women having a more compassionate nature than men (33) or due to socio-demographic differences between the two genders locally (34).

A significant portion of respondents, especially men and individuals with previous sexual experience, had the attitude that condoms decrease sexual pleasure. While women and those without sexual experience were more likely to think that condoms can increase participation in casual sex. These concerns should be addressed in future educational programs if an attempt is to be made to encourage condom usage. A previous study done in north Iraq also showed that an increased individual's risk perception was associated with more condom use, which may indicate that increasing overall knowledge about STIs might also increase condom use (35).

College students were more likely to have sex as they got older. This can be explained by increased independence from parents and is supported by the lower likelihood of asking parents for advice when suspecting being infected. This means that if sex education was to be implemented in college, implementing it in early grades would be more beneficial. Women were less likely to have had sex, similar to another study (14), and less likely to ask friends for advice upon suspicion of having an STI, largely because females are more stigmatized in terms of sexual activity and even more in the context of STIs (36). This stigma may also delay or prevent test seeking (37). People who know someone with an STI are more likely to self-medicate with over-the-counter drugs on suspicion of having an STI. This might be explained by studies done on self-medication behavior in Iraq and the Middle East, in which family and friends were prominent sources for self-medication advice (38, 39).

Limitations

The main shortcoming of this study is that the sample was convenient and not random. This is due to the lack of an official body to facilitate the random allocation of university students. In addition, the heterogeneity of STIs, especially in terms of their transmission routes, might call for separate studies for each individual disease. Finally, although an explanation of the targeted sample was provided at the top of the questionnaire and on the related website posts, and the questionnaire was distributed to private social media forums, belonging to Baghdad-based universities, to decrease the participation of individuals who don't meet the sample criteria, online data collection methodically leads to an inability to verify the integrity of participants' answers or sample selection.

Conclusion and recommendations

Despite the good level of recognition for HIV and gonorrhea as sexually transmitted infections, certain knowledge gaps still persist for both HIV (recognizing systemic symptoms usually associated with AIDS, unavailability of a vaccine, and non-curability of HIV infections) and non-HIV infections (recognizing chlamydia and trichomoniasis as STIs and vertical transmission). Most students showed openness toward public health campaigns and school sex education, but negative attitudes were still found toward condom usage and STI-infected individuals with certain gender variations. All the aforementioned points should be addressed in any future sex education program or public health campaign. Such interventions should be started early before sexual debut and modified according to the needs of each demographic group.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://data.mendeley.com/datasets/2dmhrmt7n8/3.

Ethics statement

The studies involving human participants were reviewed and approved by the Research Committee of the National Center for Training and Human Development belonging to the Ministry of Health and Environment. The patients/participants provided their written informed consent to participate in this study.

Author contributions

JA-D and AA-S led the conception of the research idea. GA-G, AA-S, and JA-D designed the data collection tool and participated in data collection. FL reviewed the study design and reviewed the manuscript for intellectual content. JA-D applied for and provided ethical approvals for the implementation of the study. GA-G led the data analysis. AA-S and GA-G interpreted the data. All authors drafted the manuscript, attain full responsibility for the accuracy, integrity of the work, and have approved the final version of the manuscript.

Acknowledgments

The authors are grateful to Razan Al-yousif from the Department of Dermatology at Baghdad Teaching Hospital for their expert review during the development of the research questionnaire. We would also like to thank Hussaam Haider Akram, a medical student from Al-Kindy Medical College, for their help during data collection.

Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1017300/full#supplementary-material

References

1. World Health Organization. *Sexually Transmitted Infections (STIs). World Health Organization*. (2021). Available online at: https://www.who.int/news-room/fact-sheets/detail/sexually-transmitted-infections-(STIs) (accessed January 29, 2023).

2. Weinstock HS, Kreisel KM, Spicknall IH, Chesson HW, Miller WC. STI prevalence, incidence, and costs in the United States: new estimates, new approach. *Sex Transm Dis.* (2021) 48:207–207. doi: 10.1097/OLQ.0000000000001368

3. UK Health Security Agency. *Sexually transmitted infections (STIs): Annual Data Tables. Updated March 1*. (2022). Available online at: https://www.gov.uk/government/statistics/sexually-transmitted-infections-stis-annual-data-tables (accessed July 23, 2022).

4. Kenyon C, Buyze J, Colebunders R. Classification of incidence and prevalence of certain sexually transmitted infections by world regions. *Int J Infect Dis.* (2014) 18:73–80. doi: 10.1016/j.ijid.2013.09.014

5. Ministry of health. *Country Progress Report*. UNAIDS. (2012). p. 4–6. Available online at: https://www.unAIDS.org/en/dataanalysis/knowyourresponse/countryprogressreports/2012countries (accessed January 29, 2023).

6. Al Jumaily H. Prevalence of sexually transmitted Diseases (STDs) in Iraq for the years (1999–2001) based on syndromic approach. *IRAQI J Community Med.* (2022) 24:105–8.

7. Becker MH. The Health Belief Model and Sick Role Behavior. *Health Educ Monogr.* (1974) 2:409–19. doi: 10.1177/109019817400200407

8. Vakilian K. Investigating the knowledge of sexually transmitted diseases in university students of Iran. *Open Public Health J.* (2021) 14:277–81. doi: 10.2174/1874944502114010277

9. Karamouzian M, Shahesmaeili A, Khajehkazemi R, Hooshyar SH, Fallahi H, Haghdoost AA, et al. Awareness of and Knowledge About STIs Among Nonmedical Students in Iran. *Int Perspect Sex Reprod Health.* (2017) 43:21–8. doi: 10.1363/43e3217

10. El-Tholoth H, Alqahtani F, Aljabri A, Alfaryan K, Alharbi F, Alhowaimil A, et al. Knowledge and attitude about sexually transmitted diseases among youth in Saudi Arabia. *Urol Ann.* (2018) 10:198–202. doi: 10.4103/UA.UA_14_17

11. Albanghali MA, Othman BA. A cross-sectional study on the knowledge of sexually transmitted diseases among young adults living in Albaha, Saudi Arabia. *Int J Environ Res Public Health.* (2020) 17:1872. doi: 10.3390/ijerph17061872

12. Kaptanoglu AF, Süer K, Diktaş H, Hinçal E. Knowledge, attitudes and behaviour towards sexually transmitted diseases in turkish cypriot adolescents. *Cent Eur J Public Health.* (2013) 21:54–8. doi: 10.21101/cejph.a3808

13. Ekşi Z, Kömürcü N. Knowledge level of university students about sexually transmitted diseases. *Procedia Soc Behav Sci.* (2014) 122:465–72. doi: 10.1016/j.sbspro.2014.01.1374

14. Saraçoglu GV, Erdem I, Dogan S, Tokuç B. Gençlik Cinsel Sagligi: Türkiye'deki Bir Üniversitede Ögrenciler Arasinda Cinsel Bilgi, Tutumlar ve Davranişlar. *Nöro Psikiyatr Arşivi.* (2014) 51:222–8. doi: 10.4274/npa.y6768

15. Naif HM, Hwaid AH, Hasan A-RSH, Khalifa RM, Humadi AT. Knowledge and awareness about HIV and AIDS among Iraqi College Students. *Open AIDS J.* (2019) 13:17–24. doi: 10.2174/1874613601913010017

16. Othman SM. Knowledge about HIV/AIDS among high school students in Erbil City/Iraq. *Glob J Health Sci.* (2014) 7:16–23. doi: 10.5539/gjhs.v7n1p16

17. Siziya S, Muula AS, Rudatsikira E, HIV. and AIDS-related knowledge among women in Iraq. *BMC Res Notes.* (2008) 1:123. doi: 10.1186/1756-0500-1-123

18. Hasan SM, Khudair FW. Knowledge and attitudes of undergraduate university students about sexual transmitted diseases at university of Kufa. *Int J Sci Res Publ.* (2019) 9:893–901. doi: 10.29322/IJSRP.9.08.2019.p92122

19. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of internet e-surveys (CHERRIES). *J Med Internet Res.* (2004) 6:e34. doi: 10.2196/jmir.6.3.e34

20. Soleymani S, Abdul Rahman H, Lekhraj R, Mohd Zulkefli NA, Matinnia N. A cross-sectional study to explore postgraduate students' understanding of and beliefs about sexual and reproductive health in a public university, Malaysia. *Reprod Health.* (2015) 12:77. doi: 10.1186/s12978-015-0070-3

21. Sekirime WK, Tamale J, Lule JC, Wabwire-Mangen F. Knowledge, attitude and practice about sexually transmitted diseases among university students in Kampala. *Afr Health Sci.* (2001) 1:16–22.

22. Reed BD, Zazove P, Pierson CL, Gorenflo DW, Horrocks J. Candida transmission and sexual behaviors as risks for a repeat episode of Candida Vulvovaginitis. *J Women's Heal.* (2003) 12:979–89. doi: 10.1089/154099903322643901

23. Ginter G, Soyer HP, Rieger E. Vaginal yeast colonization and promiscuity. A study of 197 prostitutes. *Mycoses.* (2009) 35:177–80. doi: 10.1111/j.1439-0507.1992.tb00841.x

24. Mansor N, Ahmad N, Rahman HA. Determinants of knowledge on sexually transmitted infections among students in public higher education institutions in Melaka state, Malaysia. *PLoS ONE.* (2020) 15:e0240842. doi: 10.1371/journal.pone.0240842

25. Sham f, Yaakub S, Fawati fn, Fatinni SJ, Azamuddin AA. Knowledge, attitudes, risk behaviours and preventive practices on sexually transmitted diseases among students in a public university in Malaysia Malaysian. *J Public Heal Med.* (2020) 20:100–8. doi: 10.37268/mjphm/vol.20/no.3/art.610

26. Halboub E, Al-Ak'hali MS, Al-Mekhlafi HM, Alhajj MN. Quality and readability of web-based Arabic health information on COVID-19: an infodemiological study. *BMC Public Health.* (2021) 21:151–8. doi: 10.1186/s12889-021-10218-9

27. Weber AS, Verjee M, Rahman ZH, Ameerudeen F, Al Baz N. Typology and credibility of internet health websites originating from gulf cooperation council countries. *East Mediterr Heal J.* (2014) 20:804–11. doi: 10.26719/2014.20.12.804

28. Gross GE, Tyring SK. *Sexually Transmitted Infections and Sexually Transmitted Diseases.* 1st ed. Berlin, Heidelberg: Springer Berlin Heidelberg. (2011). p. 79.

29. Oz M, Cetinkaya N, Apaydin A, Korkmaz E, Bas S, Ozgu E, et al. Awareness and knowledge levels of turkish college students about human papilloma virus infection and vaccine acceptance. *J Cancer Educ.* (2018) 33:260–8. doi: 10.1007/s13187-016-1116-0

30. Cinar IO, Ozkan S, Aslan GK, Alatas E. Knowledge and behavior of university students toward human papillomavirus and vaccination. *Asia Pac J Oncol Nurs.* (2019) 6:300–7. doi: 10.4103/apjon.apjon_10_19

31. Kwang NB, Yee CM, Shan LP, Teik CK, Chandralega KN, Abdul Kadir AK. Knowledge perception and attitude towards human papillomavirus among pre-university students in Malaysia. *Asian Pacific J Cancer Prev.* (2014) 15:9117–23. doi: 10.7314/APJCP.2014.15.21.9117

32. Kao K. Legal pluralism and fragmented sovereignty in Iraq. *SSRN Electron J.* (2022).

33. Rueckert L, Branch B, Doan T. Are gender differences in empathy due to differences in emotional reactivity? *Psychology.* (2011) 2:574–8. doi: 10.4236/psych.2011.26088

34. World Bank. *Labor Force, Female (% of total labour force) – Iraq.* (2022). Available online at: https://data.worldbank.org/indicator/SL.TLF.TOTL.FE.ZS?locations=IQ (accessed July 22, 2022).

35. Ismael AS, Sabir Zangana JM. Knowledge attitudes and practice of condom use among males aged (15-49) Years in Erbil Governorate. *Glob J Health Sci.* (2012) 4:27–36. doi: 10.5539/gjhs.v4n4p27

36. Bruyn M. *Facing the Challenges of HIV, AIDS, STD.* Amsterdam: KIT Royal Tropical Institute. (1998).

37. Fortenberry JD, McFarlane M, Bleakley A, Bull S, Fishbein M, Grimley DM, et al. Relationships of Stigma and Shame to Gonorrhea and HIV Screening. *Am J Public Health.* (2002) 92:378–81. doi: 10.2105/AJPH.92.3.378

38. Khalifeh MM, Moore ND, Salameh PR. Self-medication misuse in the Middle East: a systematic literature review. *Pharmacol Res Perspect.* (2017) 5:e00323. doi: 10.1002/prp2.323

39. Jasim AL, Fadhil TA, Taher SS. Self medication practice among iraqi patients in Baghdad City. *Am J Pharmacol Sci.* (2014) 2:18–23. doi: 10.12691/ajps-2-1-4

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 20 February 2023
DOI 10.3389/fpubh.2023.1058029

OPEN ACCESS

EDITED BY
Ferdinando Petrazzuoli,
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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 30 September 2022
ACCEPTED 02 February 2023
PUBLISHED 20 February 2023

CITATION
Tao Z, Xu Q, Zhu Y, Mei Q, Feng H, Jin Q, Ding S and Dong Y (2023) Relationship between health literacy and COVID-19 knowledge: A cross-sectional study.
Front. Public Health 11:1058029.
doi: 10.3389/fpubh.2023.1058029

Relationship between health literacy and COVID-19 knowledge: A cross-sectional study

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Background: Health literacy (HL) is a protective factor for some chronic diseases. However, its role in the Coronavirus Disease 2019 (COVID-19) pandemic has not been clarified. This study aims to explore the association between HL and COVID-19 knowledge among residents in Ningbo.

Methods: A total of 6,336 residents aged 15–69 years in Ningbo were selected by multi-stage stratified random sampling method. The "Health Literacy Questionnaire of Chinese Citizens (2020)" was used to evaluate the relationship between COVID-19 knowledge and HL. Chi-square test, Mann-Whitney *U* test and logistic regression were used to analyze the data.

Results: The HL and COVID-19 knowledge levels of Ningbo residents were 24.8% and 15.7%, respectively. After adjusting for confounding factors, people with adequate HL were the more likely to have adequate COVID-19 knowledge compared with those with limited HL ($OR = 3.473$, 95% CI = 2.974–4.057, $P < 0.001$). Compared with the limited HL group, the adequate HL group had a higher rate of COVID-19 knowledge, a more positive attitude, and a more active behavior.

Conclusion: COVID-19 knowledge is significantly associated with HL. Improving HL may influence people's knowledge about COVID-19, thereby changing people's behaviors, and finally combating the pandemic.

KEYWORDS

health literacy, COVID-19, knowledge, attitude, behavior

Introduction

On December 31, 2019, the International Committee on Classification of Viruses isolated a novel coronavirus strain from patients with pneumonia of unknown cause in Wuhan and named it SARS-CoV-2 (1). On 11 March 2020, the World Health Organization (WHO) declared COVID-19 a "Public Health Emergency of International Concern" (2). In terms of geographical scope, number of infected persons, and world economic recession, the impact of COVID-19 is shocking. As of June 3, 2022, COVID-19 has infected at least 528 million people and killed 6 million (3). The current COVID-19 pandemic poses a huge threat to global public health, people's lives and the world economy.

In the face of an outbreak of a major infectious disease, no individual can be immune. It is crucial for residents to master relevant knowledge, have a positive attitude and take appropriate actions to prevent and control the epidemic. The rapid development of COVID-19 requires people to access and use health information to adjust their behavior at a fast pace (4). COVID-19 prevention measures, such as frequent hand washing and wearing

masks, have been clarified. But the effective implementation of these measures has been affected by perceptions (5). Public knowledge is essential to prevent the spread of COVID-19 due to the lack of effective treatment measures, and large-scale public knowledge campaigns have played a key role in the fight against COVID-19 (6).

A study has shown that race/ethnicity, education, and socioeconomic status are associated with COVID-19 knowledge (7). However, there are few studies on health literacy (HL) and COVID-19 knowledge. Health literacy is an individual's ability to obtain, understand, evaluate and use information to make decisions and take actions that have an impact on health status (8). Health literacy questionnaires are different in different countries. The Canadian HL questionnaire includes 191 questions about daily life, covering five dimensions: health promotion, health protection, disease prevention, systems orientation, health and disease management (9). HL in the United States was measured with a modified version of the Single-Item Health Literacy Screener, designed to measure limited reading ability, a principal component of HL (10). In China, the HL questionnaire includes three dimensions: knowledge and attitudes, behavior and lifestyle, and health-related skills. One study found that improving HL was effective in helping residents prevent and control disease (11).

As far as we know, the relationship between residents' HL and knowledge, attitude and behavior of COVID-19 prevention and control has not been reported. Understanding this relationship can not only improve the awareness of the importance of HL of the whole society, but also facilitate the prevention and control of major infectious diseases. Hence, based on the 2020 China Health Literacy Survey, this study collected relevant data from Ningbo residents, and explored the relationship between residents' HL and knowledge, attitude and behavior of COVID-19 prevention and control.

Methods

Study population

This study was a cross-sectional study of people aged 15–69 years who had lived continuously in Ningbo for more than 6 months. This study was reviewed and approved by the Research Ethics Committee of the Ningbo Municipal Center for Disease Control and Prevention (Approval No.: 202203). All potential participants had read and understood the consent information and agreed to the questionnaire.

Sampling methods

The minimum sample size for each county (district) was calculated using the formula $N = \frac{{\mu_\alpha}^2 * p * (1-p)}{\delta^2} * deff$. Based on the HL of Zhejiang Province in 2019, the level of HL was 29.49%, $p = 0.2949$, the allowable relative error was set to 15%, and the allowable absolute error $\delta = 0.2949 * 0.15 = 0.0442$, $\mu_\alpha = 1.96$, $deff = 1$. The minimum sample size for each layer was 408. The sample size was set at 640 per county (district) to account for invalid questionnaires and rejection rates. Stratified multistage probabilities proportional to population size sampling was used in this study. The whole sampling was divided into four stages: (1) Four townships were selected from each of the 10 counties (districts) in Ningbo City, (2) two segments were selected within each of the selected townships, (3) 100 households were randomly selected from each segment, (4) one participant from each household was selected using a Kish grid. Finally, 6,336 valid questionnaires were collected.

Tools used

We used the "Health Literacy Questionnaire of Chinese Citizens (2020)," which included three parts: personal characteristics, HL, and COVID-19 knowledge, published by the Chinese Center for Health Education. The first part aimed to collect personal characteristics such as gender, age, marital status, education, occupation, place of residence, annual household income, chronic conditions, and self-rated health (SRH).

The second part is the China Health Literacy Scale, which is used to evaluate HL (12). The 50-item scale includes three dimensions: knowledge and attitudes, behavior and lifestyle, and health-related skills. There are three types of questions on the scale: true or false (one point is awarded for correct response), single answer (one point is awarded for correct response), and multiple answers (two points are awarded for correct response). The overall Cronbach's α of the scale was 0.95 (13). Based on the data of this questionnaire survey, the Cronbach's α coefficient was calculated as 0.892. The maximum total score of the scale is 66 points. A total score of 53 (80% of 66) was considered adequate HL. A score of 0–52 was thought to indicate limited HL (14).

The third part is the COVID-19 knowledge Scale. The scale consisted of three dimensions, including (a) knowledge and, (b) and attitudes, and (c) behavior. For the three links of infectious diseases, the knowledge section has a total of 11 questions, covering the source of infection, route of transmission and susceptible people. It includes both single choice and multiple choice questions. The attitude part includes three aspects: the responsibility citizens should assume (6 questions, yes/no selection questions), the evaluation of COVID-19 related information reports (5 questions, five-level single-choice questions), and the evaluation of the government's prevention and control effectiveness (1 question, five-level single-choice questions). Seven questions in behavior section (yes/no choice questions), mainly including actively searching for relevant information or consulting medical staff. One point is awarded for a correct single-choice answer and two points are awarded for a correct multiple-choice answer. An overall score of 80% or more in the knowledge component indicates adequate COVID-19 knowledge.

The on-site survey was conducted by household survey, and the respondents were encouraged to complete the questionnaire by themselves. If the respondents could not complete the questionnaire independently, the investigators who had received unified training and passed the assessment completed the questionnaire by face-to-face inquiry. According to the above scheme, three stages of quality control methods are adopted: before, during and after the investigation. Before the survey, the Ningbo Center for Disease Control and Prevention

completed the household sampling, coding and investigator training. In the survey, all counties and districts used the uniformly printed questionnaire. The investigator did not use inductive or suggestive language, reviewed the completion of the questionnaire on the spot, and finally filled in the name of the investigator and other survey completion information. After the investigation, the quality control personnel of each county and district shall review the questionnaires of each township in time.

Statistical analysis

All data in this study were analyzed using SPSS 22.0 (SPSS Corp, Chicago, IL, USA). Two-tailed P value < 0.05 was considered statistically significant. COVID-19 knowledge and HL scores were dichotomized into two categories: adequate and limited. Pearson chi-square test was used to compare categorical variables between groups. The Mann-Whitney U test was used for comparison of ordinal data. Significant variables in chi-square test were included in multivariate logistic regression models. One model included HL and the other did not, the -2 log likelihood (-2LL) and Nagelkerke R^2 changes were compared. The R^2 mainly explains how much variation in COVID-19 knowledge can be attributed by the model. The -2LL can evaluate the model, and a smaller value indicates a better goodness of fit.

Results

COVID-19 knowledge level among different groups

As shown in Table 1, there were 6,336 subjects in this study, of which 24.8% had adequate HL. The male: female ratio was 1:1.05, and the average age was 49.55 ± 13.56 years. The Marital status was mainly married, accounting for 83.1% of the sample; The education level of the respondents was mainly Junior/Senior high school, accounting for 47.2% of the sample; With respect to occupation, the majority of participants (44.5%) were workers and farmers; 57.0% of the residents lived in rural areas; The number of people with household income (0–49,999) was the largest; The prevalence of chronic diseases was 25.9%; 70.1% of the residents thought that their health status was good.

Table 1 demonstrates that 15.7% of the participants had adequate COVID-19 knowledge. The univariate analysis showed significant differences in COVID-19 knowledge by gender, age, marital status, educational, occupation, annual household income, chronic conditions, and HL. COVID-19 knowledge in females was slightly higher than that in males. COVID-19 knowledge gradually decreased with age. Interestingly, married people had lower COVID-19 knowledge than single people; People with higher education level and annual income had higher knowledge rate of COVID-19 than other groups. However, workers, farmers and patients with chronic diseases had limited COVID-19 knowledge. People with adequate HL had higher COVID-19 knowledge, and the difference reached 23.2%.

Factors analysis using logistic regression model

Two logistic regression models were conducted to identify factors which might affect COVID-19 knowledge. Model 1 included significant variables (gender, age, marital status, educational level, occupation, annual household income, and chronic conditions) in univariate analysis, but did not include HL; and model 2 included HL. Changes in both models were evaluated by -2LL and R^2. In model 1, gender, educational level, occupation, and annual household income were significantly associated with COVID-19 knowledge. The variation explained by the logistic regression model was Nagelkerke $R^2 = 0.074$. In model 2, the Nagelkerke R^2 was nearly doubled to 0.137 after HL was added to the model. And its -2LL is also reduced, indicating a better goodness of fit. People with adequate HL were the more likely to have adequate COVID-19 knowledge compared with those with limited HL ($OR = 3.473$, 95%CI = 2.974–4.057, $P < 0.001$). HL is the most important factor likely to affect COVID-19 knowledge, compared to other factors.

Differences in knowledge of COVID-19 prevention and control among limited and adequate HL residents

As shown in Table 3, except for the choice of mask, there was no significant difference between the two groups, the awareness rate of COVID-19 knowledge in the adequate HL group was higher than that in the limited HL group ($P < 0.001$). The least correct question was the route of transmission of the COVID-19, and the most correct was the shortest quarantine period.

Differences in attitude of COVID-19 prevention and control among limited and adequate HL residents

Table 4 summarizes the survey results of the three aspects of prevention and control attitudes. In terms of each prevention and control attitude, the selection results of each question in the adequate HL group were more positive than those in the limited HL group ($P < 0.001$). Those who with adequate HL were more likely to recognize the responsibility of citizens for epidemic prevention and control of infectious diseases, more likely to agree the release and report of COVID-19 related information, and more likely to recognize the achievements made by the government in epidemic prevention and control of COVID-19.

Differences in behavior of COVID-19 prevention and control among limited and adequate HL residents

As shown in Table 5, the limited HL group was more likely to use the telephone, while the adequate HL group was more likely to

TABLE 1 Association between COVID-19 knowledge and basic characteristics.

Variables		N (%)	COVID-19 knowledge		χ^2	*P*
			Limited	Adequate		
	Total	6,336 (100.0)	5,344 (84.3)	992 (15.7)		
Gender	Male	3,092 (48.8)	2,638 (85.3)	454 (14.7)	4.334	**0.037**
	Female	3,244 (51.2)	2,706 (83.4)	538 (16.6)		
Age	15–34	1,074 (17.0)	808 (75.2)	266 (24.8)	115.671	**<0.001**
	35–54	2,492 (39.3)	2,071 (83.1)	421 (16.9)		
	55–69	2,770 (43.7)	2,465 (89.0)	305 (11.0)		
Marital status	Single/widow/ divorced	1,071 (16.9)	868 (81.0)	203 (19.0)	10.614	**0.001**
	Married	5,265 (83.1)	4,476 (85.0)	789 (15.0)		
Educational levels	Less than junior high school	1,867 (29.5)	1,710 (91.6)	157 (8.4)	254.551	**<0.001**
	Junior/senior high school	2,990 (47.2)	2,571 (86.0)	419 (14.0)		
	College or above	1,479 (23.3)	1,063 (71.9)	416 (28.1)		
Occupation	Service/commercial	666 (10.5)	503 (75.5)	163 (24.5)	136.058	**<0.001**
	Students	215 (3.4)	157 (73.0)	58 (27.0)		
	Workers/farmers	2,818 (44.5)	2,529 (89.7)	289 (10.3)		
	Others	2,637 (41.6)	2,155 (81.7)	482 (18.3)		
Place of residence	Rural areas	3,609 (57.0)	3,070 (85.1)	539 (14.9)	3.307	0.069
	Urban areas	2,727 (43.0)	2,274 (83.4)	453 (16.6)		
Annual household income	0–49,999	1,648 (26.1)	1,467 (89.0)	181 (11.0)	133.127	**<0.001**
	50,000–99,999	1,595 (25.3)	1,413 (88.6)	182 (11.4)		
	100,000–149,999	1,344 (21.3)	1,129 (84.0)	215 (16.0)		
	≥150,000	1,719 (27.3)	1,312 (76.3)	407 (23.7)		
Chronic conditions	No	4,692 (74.1)	3,895 (83.0)	797 (17.0)	24.215	**<0.001**
	Yes	1,644 (25.9)	1,449 (88.1)	195 (11.9)		
SRH	Good	4,441 (70.1)	3,724 (83.9)	717 (16.1)	2.990	0.224
	Fair	1,683 (26.6)	1,436 (85.3)	247 (14.7)		
	Poor	212 (3.3)	184 (86.8)	28 (13.2)		
Health literacy	Limited	4,762 (75.2)	4,291 (90.1)	471 (9.9)	482.576	**<0.001**
	Adequate	1,574 (24.8)	1,053 (66.9)	521 (33.1)		

Boldface indicates statistical significance.

use the internet for information query ($P < 0.05$). There was no significant difference between the two groups in using the Internet to consult doctors.

Analysis of correlation

We analyzed the relationship between the score of HL, the score of COVID-19 knowledge and other dimension, and found that the score of HL was positively correlated with each part, among which the correlation coefficient of knowledge was the largest, and behavior was the smallest ($P < 0.001$).

Discussion

Principal findings

The COVID-19 pandemic has stirred fear because its direct impact on the public has created unprecedented challenges for education and healthcare systems (15). As vaccination remains slow and specific treatments are lacking, non-pharmaceutical public health interventions have become important in the fight against COVID-19 (16).

HL has been shown to be associated with a variety of diseases (17, 18), but its relationship with COVID-19 knowledge is still poorly studied. We explored the relationship between them through a large sample cross-sectional study. As shown

TABLE 2 Logistic regression model of factors influencing adequate COVID-19 knowledge.

Variables	Model 1			Model 2		
	OR	95% CI	*P*	*OR*	95% CI	*P*
Gender (ref. = Male)	1.163	1.01–1.339	**0.036**	1.170	1.012–1.352	**0.034**
Age (ref. = 15–34)						
35–54	0.968	0.783–1.196	0.764	1.033	0.83–1.287	0.769
55–69	0.913	0.707–1.18	0.488	1.083	0.83–1.412	0.558
Marital status (ref. = single/widow/divorced)	0.967	0.783–1.195	0.755	0.913	0.735–1.134	0.410
Educational levels (ref. = Less than junior high school)						
Junior/senior high school	1.517	**1.222–1.884**	**<0.001**	1.353	1.085–1.687	**0.007**
College or above	2.812	**2.136–3.702**	**<0.001**	1.924	1.444–2.564	**<0.001**
Occupation (ref. = Service/Commercial)						
Students	1.368	0.902–2.074	0.140	1.332	0.866–2.048	0.192
Workers/Farmers	0.765	0.594–0.986	**0.038**	0.880	0.677–1.144	0.341
Others	0.946	0.764–1.171	0.610	1.046	0.839–1.305	0.689
Annual household income (ref. = 0–49,999)						
50,000–99,999	0.909	0.726–1.139	0.408	0.914	0.727–1.15	0.444
100,000–149,999	1.097	0.873–1.378	0.427	1.078	0.853–1.361	0.529
≥150,000	1.376	1.102–1.719	**0.005**	1.320	1.051–1.657	0.017
Chronic conditions (ref. = No)	1.012	0.837–1.223	0.903	1.030	0.85–1.25	0.761
Health literacy (ref. = limited)	–	–	–	3.473	2.974–4.057	**<0.001**
−2LL	5,186.791			4,942.475		
Nagelkerke R^2	0.074			0.137		

Boldface indicates statistical significance.

TABLE 3 Comparison of knowledge among people with and without HL.

Question	Health literacy		χ^2	*P*
	Limited	Adequate		
K1 correct *n* (%)	1,839 (38.3)	885 (56.2)	155.651	<0.001
K2 correct *n* (%)	4,117 (85.7)	1,515 (96.2)	126.574	<0.001
K3 correct *n* (%)	2,076 (43.2)	955 (60.6)	144.506	<0.001
K4 correct *n* (%)	1,382 (28.8)	684 (43.4)	116.536	<0.001
K5 correct *n* (%)	1,146 (23.9)	506 (32.1)	42.348	<0.001
K6 correct *n* (%)	1,835 (38.2)	994 (63.1)	298.516	<0.001
K7 correct *n* (%)	2,992 (62.3)	1,397 (88.7)	385.967	<0.001
K8 correct *n* (%)	3,012 (62.7)	965 (61.3)	1.011	0.315
K9 correct *n* (%)	1,751 (36.4)	999 (63.4)	352.270	<0.001
K10 correct *n* (%)	4,108 (83.6)	1,533 (97.3)	197.277	<0.001
K11 correct *n* (%)	3,242 (67.5)	1,470 (93.3)	410.881	<0.001

K1, Body temperature over how much need to go to the hospital; K2, What is the minimum number of days of isolation after close contact; K3, People susceptible to the COVID-19; K4, The source of infection of the COVID-19; K5, Route of transmission of the COVID-19; K6, Personal protective measures; K7, The proper way to wash hands; K8, Choice of mask; K9, Proper way to wear masks; K10, The correct way to eat in a group; K11, Protective measures in low-risk areas.

TABLE 4 Comparison of attitude among people with and without HL.

Attitude question		HL limited					HL adequate					Statistical tests	
		No *n* (%)		Yes *n* (%)			No *n* (%)		Yes *n* (%)			χ^2	*P*
Responsibility	AA1	547 (11.4)		4,258 (88.6)			18 (11.1)		1,557 (98.9)			154.131	<0.001
	AA2	614 (12.8)		4,191 (87.2)			19 (1.2)		1,556 (98.8)			177.733	<0.001
	AA3	572 (11.9)		4,233 (88.1)			16 (1.0)		1,559 (99.0)			168.080	<0.001
	AA4	788 (16.4)		4,017 (83.6)			27 (1.7)		1,548 (98.3)			229.582	<0.001
	AA5	1,008 (21.0)		3,797 (79.0)			41 (2.6)		1,534 (97.4)			291.517	<0.001
	AA6	1,262 (26.3)		3,543 (73.7)			44 (2.8)		1,531 (97.2)			401.376	<0.001
Evaluation of information		Complete agreement	Agree	General	Disagree	Complete disagreement	Complete agreement	Agree	General	Disagree	Complete disagreement	*Z*	*P*
	AB1	59.5%	36.2%	2.6%	0.4%	0.4%	73.5%	25.6%	0.8%	0.0%	0.1%	9.997	<0.001
	AB2	53.9%	39.8%	4.1%	0.6%	0.6%	70.4%	28.3%	1.1%	0.1%	0.1%	11.759	<0.001
	AB3	49.2%	42.2%	6.3%	0.8%	0.6%	65.3%	32.1%	2.2%	0.1%	0.2%	11.565	<0.001
	AB4	47.5%	42.4%	7.5%	0.9%	0.7%	65.4%	31.9%	2.3%	0.3%	0.1%	12.932	<0.001
	AB5	45.9%	42.7%	8.3%	1.2%	1.0%	65.1%	31.8%	2.7%	0.1%	0.2%	13.957	<0.001
Evaluation of policies		Very good	Good	General	Poor	Very poor	Very good	Good	General	Poor	Very poor	*Z*	*P*
	AC	69.3%	28.6%	1.8%	0.3%	0.0%	79.4%	19.8%	0.5%	0.3%	0.0%	7.843	<0.001

AA1, Timely report of patients found; AA2, Cooperate with the government's investigation work and report the situation truthfully; AA3, Cooperate with health institutions to implement quarantine observation, treatment and other measures; AA4, Do not touch, buy or eat wild animals; AA5, No rumor, no price gouging; AA6, No discrimination against infectious disease patients, suspected patients and pathogen carriers. AB1, Timely, open and transparent publication of information; AB2, Scientific and authoritative sources of information; AB3, Sufficient information reporting; AB4, The presentation of information is easy to understand; AB5, Informative guidance. AC, Evaluation of the effectiveness of government prevention and control.

10.3389/fpubh.2023.1058029

TABLE 5 Comparison of behavior among people with and without HL.

Question	Health literacy		χ^2	*P*
	Limited	Adequate		
B1 practice *n* (%)	568 (11.8)	137 (8.7)	11.767	0.001
B2 practice *n* (%)	387 (8.1)	96 (6.1)	6.505	0.011
B3 practice *n* (%)	1,833 (38.1)	503 (31.9)	19.718	<0.001
B4 practice *n* (%)	2,397 (49.9)	1,286 (81.7)	490.475	<0.001
B5 practice *n* (%)	1,918 (39.9)	1,133 (71.9)	487.388	<0.001
B6 practice *n* (%)	555 (11.6)	302 (19.2)	59.295	<0.001
B7 practice *n* (%)	468 (9.7)	178 (11.3)	3.179	0.075

B1, Call 12320 for information; B2, Call the psychological counseling hotline; B3, Telephone or on-site consultation with community doctors; B4, Use the internet to search disease prevention knowledge; B5, Use the internet to check the epidemic situation near your residence; B6, Use the internet to query the information of fellow passengers; B7, Use the internet to consult a doctor.

TABLE 6 Correlation analysis between HL score and COVID-19 score.

Variable	COVID-19 knowledge score	COVID-19 attitude score	COVID-19 behavior score
HL score	0.631*	0.503*	0.230*

*$P < 0.001$.

in Tables 1, 2, our study showed that people with adequate HL had higher COVID-19 knowledge, and the difference reached 23.2%. And after adjusting for a series of confounding factors, the *OR* value of HL still reached 3.473, and the Nagelkerke R^2 increased nearly doubled. HL is an important influencing factor of COVID-19 knowledge. In addition, gender, age, short marital status, educational level, occupation, annual household income, and chronic conditions also affected COVID-19 knowledge in our study. The elderly people, people with low education level, workers and farmers, and people with low income have more limited COVID-19 knowledge. This is consistent with the conclusion of the study by Jaber et al. (19). Another study found that COVID-19 was connected with lower HL in rural areas (20). The government should take different intervention measures for different groups. But there is no doubt that HL is the easiest and most rapid modifiable factor.

In addition, HL is closely related to the three dimensions of COVID-19. Compared with the limited HL group, the adequate HL group had a higher rate of COVID-19 knowledge (Table 3), a more positive attitude (Table 4), a more active behavior (Table 5). Interestingly, in terms of behavior, those in limited HL group were more likely to use the phone to get information, while those in adequate HL group were more likely to use the internet. Public intervention measures based on HL can help to promote COVID-19-related health behaviors and reduce the risk of COVID-19 infection among college students (21). The results of correlation analysis showed that HL had the strongest association with COVID-19 knowledge and the weakest association with COVID-19 behavior (Table 6). We must not only understand the knowledge, but also translate the knowledge gained into health-promoting behaviors to improve or maintain health (22, 23). With sufficient knowledge of COVID-19, change your emphasis on COVID-19 and act accordingly to protect yourself.

HL is a broad and important topic in public health, yet it is still underestimated globally and thus considered a silent epidemic (24). The COVID-19 pandemic has been accompanied by rapidly emerging evidence, changing guidelines, and misinformation, posing new challenges to HL (10). There are widespread misconceptions about COVID-19 transmission and protection. Most people are unaware that asymptomatic infected persons can transmit the virus. In this survey, the correct rate of questions about the source of infection was only 32.6%. People with limited HL had a poorer understanding of COVID-19 symptoms, were less able to identify behaviors to prevent infection, were more likely to endorse misinformed beliefs about COVID-19 and vaccinations, and experienced more difficult finding and understanding the government's message on COVID-19 (25). Another study also showed that acceptance of COVID-19 vaccines is associated with the ability to detect fake news and HL (26).

Therefore, in these uncertain and difficult times, good HL has never been more vital for survival. Factors such as age, sex, chronic disease, place of residence and economic status can affect health literacy (27, 28). Adherence to protective measures is an important component of controlling the COVID-19 pandemic, and HL is a major driver of this adherence (29). The results of this study not only provide new evidence for understanding the importance of residents' HL, but also point out the key points for carrying out health education targeted to cope with the threat of sudden major infectious diseases and make up for the shortcomings of residents' HL. Targeted interventions and strategies should be developed to strengthen the HL of the population and improve people's attitudes, so as to reduce the spread of COVID-19.

Limitations

This study has some limitations. The results of this study are only from the survey in Ningbo City, Zhejiang Province, and cannot represent the situation of the whole Zhejiang province, let alone the whole of China. At the same time, we were unable to compare knowledge rates of COVID-19 among countries, as the type and difficulty of questionnaires used varied across countries. Due to the cross-sectional design of this study, it cannot prove a causal relationship between HL and COVID-19 knowledge. Future studies should examine these relationships closely. And the process

of how HL affects COVID-19 knowledge needs to be further studied. In addition, logistic regression analysis only controlled for sociodemographic factors, and there were other factors that would affect the relationship between HL and COVID-19 knowledge.

Conclusions

This study showed that knowledge of COVID-19 was associated with HL. Furthermore, gender, age, marital status, educational, occupation, annual household income, and chronic conditions are associated with COVID-19 knowledge. Targeted health education and promotion strategies should be adopted for different populations to improve the HL of residents, so as to reduce the spread of COVID-19.

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 reviewed and approved by the Research Ethics Committee of the Ningbo Municipal Center for Disease Control and Prevention (Approval No.: 202203). Informed consent was obtained from all subjects involved in the study.

Author contributions

ZT and QX were responsible for conceptualization, data collection, methodology, resources, and software. YZ and SD were responsible for conceptualization, data collection, and methodology. QM was responsible for methodology and software. HF and QJ were responsible for data collection and investigation. YD was responsible for conceptualization, funding acquisition, resources, supervision, reviewing, and editing the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content, review, and approval of the final manuscript.

Funding

This work was supported by funding from the Major Special Project of Science and Technology Innovation 2025 in Ningbo, Ningbo Municipal Emergency Science and Technology Major Project and funded by Ningbo Medical and Health Brand Discipline (Grants 2021Z021, 2022Z034, and PPXK2018–10).

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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References

1. Phelan AL, Katz R, Gostin LO. The novel coronavirus originating in Wuhan, China: challenges for global health governance. *JAMA.* (2020) 323:709–10. doi: 10.1001/jama.2020.1097

2. Li X, Wang W, Zhao X, Zai J, Zhao Q, Li Y, et al. Transmission dynamics and evolutionary history of 2019-Ncov. *J Med Virol.* (2020) 92:501–11. doi: 10.1002/jmv.25701

3. Liu P, Zheng Y. Temporal and spatial evolution of the distribution related to the number of COVID-19 pandemic. *Physica A.* (2022) 603:127837. doi: 10.1016/j.physa.2022.127837

4. Paakkari L, Okan O. COVID-19: health literacy is an underestimated problem. *Lancet Public Health.* (2020) 5:e249–e50. doi: 10.1016/S2468-2667(20)30086-4

5. Spring H. Health literacy and COVID-19. *Health Info Libr J.* (2020) 37:171–2. doi: 10.1111/hir.12322

6. Khan S, Gilani US, Raza SMM, Hussain T. Knowledge, awareness and practices of Pakistani professionals amid-COVID-19 outbreak. *Sci Rep.* (2021) 11:17543. doi: 10.1038/s41598-021-96705-w

7. Khanijahani A, Iezadi S, Gholipour K, Azami-Aghdash S, Naghibi D, A. Systematic review of racial/ethnic and socioeconomic disparities in COVID-19. *Int J Equity Health.* (2021) 20:248. doi: 10.1186/s12939-021-01582-4

8. Nutbeam D, Lloyd JE. Understanding and responding to health literacy as a social determinant of health. *Annu Rev Public Health.* (2021) 42:159–73. doi: 10.1146/annurev-publhealth-090419-102529

9. Visscher KL, Hutnik CML. Health literacy in Canada and the ophthalmology patient. *Can J Ophthalmol.* (2012) 47:72–8. doi: 10.1016/j.jcjo.2011.12.016

10. Patil U, Kostareva U, Hadley M, Manganello JA, Okan O, Dadaczynski K, et al. Health literacy, digital health literacy, and COVID-19 pandemic attitudes and behaviors in U.S. college students: implications for interventions. *Int J Environ Res Public Health.* (2021) 18:3301. doi: 10.3390/ijerph18063301

11. Liu Y-B, Liu L, Li Y-F, Chen Y-L. Relationship between health literacy, health-related behaviors and health status: a survey of elderly Chinese. *Int J Environ Res Public Health.* (2015) 12:9714–25. doi: 10.3390/ijerph120809714

12. Nie X, Li Y, Li C, Wu J, Li L. The association between health literacy and self-rated health among residents of China aged 15–69 years. *Am J Prev Med.* (2021) 60:569–78. doi: 10.1016/j.amepre.2020.05.032

13. Li Z, Tian Y, Gong Z, Qian L. Health literacy and regional heterogeneities in China: a population-based study. *Front Public Health.* (2021) 9:603325. doi: 10.3389/fpubh.2021.603325

14. Rong H, Cheng X, Garcia JM, Zhang L, Lu L, Fang J, et al. Survey of health literacy level and related influencing factors in military college students in Chongqing, China: a cross-sectional analysis. *PLoS ONE.* (2017) 12:e0177776. doi: 10.1371/journal.pone.0177776

15. Nguyen HT, Do BN, Pham KM, Kim GB, Dam HTB, Nguyen TT, et al. Fear of COVID-19 scale-associations of its scores with health literacy and health-related behaviors among medical students. *Int J Environ Res Public Health.* (2020) 17:4164. doi: 10.3390/ijerph17114164

16. Iezadi S, Azami-Aghdash S, Ghiasi A, Rezapour A, Pourasghari H, Pashazadeh F, et al. Effectiveness of the non-pharmaceutical public health interventions against COVID-19; a protocol of a systematic review and realist review. *PLoS ONE.* (2020) 15:e0239554. doi: 10.1371/journal.pone.0239554

17. Taylor DM, Fraser S, Dudley C, Oniscu GC, Tomson C, Ravanan R, et al. Health literacy and patient outcomes in chronic kidney disease: a systematic review. *Nephrol Dial Transplant.* (2018) 33:1545–58. doi: 10.1093/ndt/gfx293

18. Magnani JW, Mujahid MS, Aronow HD, Cené CW, Dickson VV, Havranek E, et al. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American Heart Association. *Circulation.* (2018) 138:e48–74. doi: 10.1161/CIR.0000000000000579

19. Jaber RM, Mafrachi B, Al-Ani A, Shkara M. Awareness and perception of COVID-19 among the General Population: A Middle Eastern Survey. *PLoS ONE.* (2021) 16:e0250461. doi: 10.1371/journal.pone.0250461

20. Greer ML, Sample S, Jensen HK, McBain S, Lipschitz R, Sexton KW. COVID-19 Is connected with lower health literacy in rural areas. *Stud Health Technol Inform.* (2021) 281:804–8. doi: 10.3233/SHTI210286

21. Li S, Cui G, Kaminga AC, Cheng S, Xu H. Associations between health literacy, ehealth literacy, and COVID-19-related health behaviors among Chinese college students: cross-sectional online study. *J Med Internet Res.* (2021) 23:e25600. doi: 10.2196/25600

22. Kickbusch IS. Health literacy: addressing the health and education divide. *Health Promot Int.* (2001) 16:289–97.

23. Gautam VSD, Rustagi N, Mittal A, Patel M, Shafi S, et al. Health literacy, preventive COVID-19 behaviour and adherence to chronic disease treatment during lockdown among patients registered at Primary Health Facility in Urban Jodhpur, Rajasthan. *Diab Metab Synd.* (2021) 15:205–11. doi: 10.1016/j.dsx.2020.12.023

24. Cangussú LR, Barros IRPd, Botelho Filho CAdL, Sampaio Filho JDR, Lopes MR. COVID-19 and health literacy: the yell of a silent epidemic amidst the pandemic. *Rev Assoc Med Bras.* (2020) 66(Suppl 2):31–3. doi: 10.1590/1806-9282.66.S2.31

25. McCaffery KJ, Dodd RH, Cvejic E, Ayrek J, Batcup C, Isautier JM, et al. Health literacy and disparities in COVID-19-related knowledge, attitudes, beliefs and behaviours in Australia. *Public Health Res Pract.* (2020) 30:e30342012. doi: 10.17061/phrp30342012

26. Montagni I, Ouazzani-Touhami K, Mebarki A, Texier N, Schück S, Tzourio C. Acceptance of a COVID-19 vaccine is associated with ability to detect fake news and health literacy. *J Public Health (Oxford, England).* (2021) 43:695–702. doi: 10.1093/pubmed/fdab028

27. Uysal N, Ceylan E, Koç A. Health literacy level and influencing factors in university students. *Health Soc Care Commun.* (2020) 28:505–11. doi: 10.1111/hsc.12883

28. Yang P, Ou Y, Yang H, Pei X, Li J, Wang Y, et al. Research on influencing factors and dimensions of health literacy in different age groups: before and after the COVID-19 era in Chongqing, China. *Front Public Health.* (2021) 9:690525. doi: 10.3389/fpubh.2021.690525

29. Seytre B, Barros C, Bona P, Fall B, Konaté B, Rodrigues A, et al. Revisiting COVID-19 communication in Western Africa: a health literacy-based approach to health communication. *Am J Trop Med Hyg.* (2021) 105:708–12. doi: 10.4269/ajtmh.21-0013

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 20 February 2023
DOI 10.3389/fpubh.2023.1084667

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 30 October 2022
ACCEPTED 30 January 2023
PUBLISHED 20 February 2023

CITATION
Younas E, Fatima M, Alvina A, Nawaz HA, Anjum SM, Usman M, Pervaiz M, Shabbir A and Rasheed H (2023) Correct administration aid for oral liquid medicines: Is a household spoon the right choice? *Front. Public Health* 11:1084667. doi: 10.3389/fpubh.2023.1084667

Correct administration aid for oral liquid medicines: Is a household spoon the right choice?

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Background: Correct medicine dosing is an important component in the safe and effective delivery of medicines, particularly for the pediatric population. However, there is a scarcity of public campaigns on the correct administration and choice of dosing aids for oral liquid dosage form in many countries, leading to medicine safety issues and therapeutic failures.

Methods: The study targeted the assessment of the knowledge and practice of university students. It utilizes pre- and post-intervention surveys administered through google forms as a survey tool during online zoom and in-person sessions. The intervention included a short video presentation detailing the selection and use of medicine spoons and other aids for the administration of oral liquid dosage. The Fischer Exact test was used to assess the pre- and post-test shift of responses.

Results: Nine-degree programs were engaged in the activity, and 108 students attended this health awareness activity after obtaining formal consent. A significant decline (CI = 95%, ****p-value < 0.05) in the choice of selecting tablespoon and a shift to a low-volume spoon, as well as rejection of an entire variety of household spoons, were observed. A significant improvement in the correct naming of spoons, the meaning of the abbreviation "tsp," and the correct volume of a standard teaspoon were also observed with a p-value of <0.001.

Conclusion: A deficit in the knowledge of the proper use of measuring devices for oral liquid medicines in the educated population was observed, which can be enhanced through simple tools like short video presentations and awareness seminars.

KEYWORDS

oral liquid medication, pediatrics, medication safety, rational use of medicines, household spoon, administration aid

Public interest summary

One of the key responsibilities of the healthcare system is to ensure medication safety. Various factors contribute to ensuring this, including but not limited to packaging, labeling, dosing, consumption, and marketing. This study assesses the correctness of household spoons as dosing and administration aid for oral liquid dosage forms among university students using a short video presentation as an intervention tool. The message in the video focused on disseminating the risks involved with the use of a common household spoon. Assessments were made before and after video presentation and the data were analyzed for the knowledge of respondents and its shift with the use of intervention.

The revealed that the digitally enabled population of university students were receptive to short video presentation highlighting the avoidable risks in medication management.

Introduction

Oral liquid pharmaceutical dosage forms are widely accepted and used, especially in pediatric and geriatric care. Their safety and effectiveness depend on the right dosing measurement (1). Dose measurement is a common step prone to error with drug administration (2–4), especially with liquid formulations such as syrups, suspensions, elixirs, linctus, and solutions (3) unless the packaging is supplemented with the correct administration containers. These dosage forms include common therapeutic categories, for instance, antipyretics, analgesics, anti-cough, and flu remedies, antibiotics, laxatives, and multivitamins. Most people tend to use household spoons for oral dosing (5). Most commonly available household spoons include 5 ml teaspoons, 10 mL dessert-spoon, 15 mL soup spoons, and 15 mL tablespoons, which vary greatly in their design and volumes that they can accommodate (1).

The variation in shapes, sizes, forms, and make of these household spoons leads to dosing errors (6). The American Pharmaceutical Association in 1902 and American Medical Association in 1903 defined the "standard teaspoonful" as 5 mL (7). The American Academy of Pediatrics (AAP) Committee on Drugs reported that, when liquid medicine is not provided with a teaspoon, 75–80% of people use a household teaspoon as an alternative to standard teaspoons (8). One study from Israel reported that 80% of children are given medications by a household teaspoon (9). A similar report from Minnesota, United States, stated that a household teaspoon was the device most frequently used by 73% of the population for measuring liquid medications (5).

Dosing and administering medication for the pediatric population is even more difficult as compared to the adult population as they need to be adjusted according to age and body weight. As a result, children are more vulnerable to dosing errors (2, 10, 11). Calibrated devices such as dosing cups, oral droppers, and oral syringes have been recommended to measure and administer liquid medication to the pediatric population. However, the oral syringe is found to be the most convenient and accurate dosing device (12).

Various studies showed that the most commonly used medicinal aids for oral liquid dosing are cylindrical spoons, dosing cups, droppers, teaspoons, oral syringes, and spoons or syringes with bottle adapters (6, 12). Dosing cups, droppers, and household spoons are mostly used for the measurement of oral liquid dosing at home (12). Spoons and dosing cups are at a higher disadvantage for doses that are not multiples of 5, like 0.5 or 3.5 mL and are not measurable with a cup marked with 5, 10, 15, and 20 mL (13). Oral syringes account for the least percentage of imprecise dosing (12). A spoon or syringe with a bottle adapter and dispensing bottle also provided accurate results (14–16).

This study aimed to evaluate the pre- and post-intervention knowledge of university students about the choice of household spoons and oral liquid dosing aids in Pakistan.

Methods

Pre- and post-awareness surveys were conducted using predesigned questionnaires on undergraduate students of the University of Veterinary and Animal Sciences (UVASs), Lahore, who have undergone at least 1 year of university education.

A sample size of 108 (12% of 908) students was targeted using convenient sampling. Students from nine different degree programs were invited in person by meeting post-class for volunteer participation to attend the public health awareness session. Interested students were placed in a WhatsApp group for efficient communication. A convenient time was fixed for the session in which students were connected on zoom call. They were provided with a link to a Google form for a pre-intervention survey which was followed by the video presentation. Similarly, the post-intervention form was shared in a second zoom call after the video presentation. The questionnaires (Supplementary material 1) and video presentation included the following segments:

- Assessment of health literacy of university students regarding the use of medicine spoon.
- Educating students about problems associated with the use of household spoons for use and the choice of aids for administering oral liquid medicines (Figure 1).
- Raising awareness about different choices of tools for oral liquid medicines and the importance of correct dosing (Figure 2).
- Propose recommendations to avoid dosing errors.
- To develop skills in health promotion and health education among university students working under the core team of female students.

The key component of the study was two charts. The first chart displayed the photographs of five differently sized household spoons (Figure 1). The spoon included two different designs of tablespoon/dinner spoons (I and II), two teaspoons (III and IV), and a sugar spoon (V). The spoons were arranged in the order of decreasing sizes. They were calibrated using a 5-mL syringe and labeled with the exact volume in milliliters, and this information was shared in the awareness session. The respondents were also briefed on how they can do a small experiment at home to know the volume of the household teaspoon to calibrate it, in case it is inevitable to use. The other chart displayed the photographs of six different tools for oral liquid medication administration, including (1) a medicine spoon, (2) a medicine spoon with graduated tubing, (3) a graduated dropper, (4) an oral syringe, (5) a graduated cup/beaker, and (6) a household teaspoon (Figure 2).

Ethical approval was received from the Institutional Review Board of The University of Veterinary and Animal Sciences under the letter No. 174/IRC/BMR, dated: 03.03.2022, to carry out this study. Training of the trainers was conducted by the principal investigator on a team of four researchers who carried out surveys and awareness sessions with the students of different degree programs. A pilot was first performed by four lead trainers on the Doctor of Pharmacy (Pharm.D) student's batch through hybrid zoom and in-person sessions. After this session, necessary changes were made to the survey form and presentation. The survey was divided into two phases. In the first phase, a pre-intervention survey was conducted to analyze the knowledge of the students of Pharm.D about the use of household spoons and other medical aids for oral dosing. Subsequently, an awareness

	Type 1	Type 2	Type 3	Type 4	Type 5
Name	Table spoon	Table spoon	Dessert spoon	Dessert spoon	Tea spoon
Volume (ml)	8	7	4	3.5	2.5

FIGURE 1
Chart One: the selection of a spoon for the administration of medicine from household spoons, along with actual measurements.

FIGURE 2
Different oral liquid medicine administration aids.

training session was conducted using a video recording on zoom to inform the respondents about the right choices for oral dosing, the consequences of using the household spoon and wrong dosing, and the use of graduated dosing aids for accurate dosing. Then, a post-awareness survey was conducted to re-evaluate their choice of the right oral dosing aid and knowledge about dosing errors using household spoons. This assessment was made to evaluate the effectiveness of this health literacy activity so that it can be recorded if the key information was successfully understood by the respondents or not. The same methodology was repeated to conduct the survey and awareness training for the rest of the eight-degree programs, assisted by the volunteer trainers by conducting in-person surveys and awareness sessions.

Analysis was carried out on the collected data using MS Excel and Graph Pad Prism, Version 8.0.2. The Fischer exact test and the chi-square test were used for the comparison of pre- and post-test results. Recommendations were also designed based on the results and literature survey obtained to improve public health

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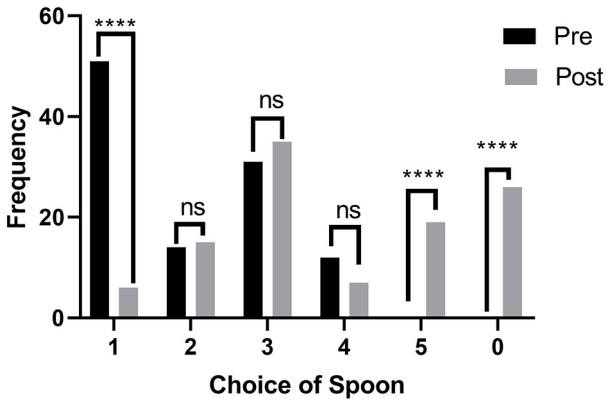

FIGURE 3
Pre- and post-intervention selection of spoons from household spoons by respondents for oral liquid medicine administration. ****means very highly significant.

literacy regarding the safe use of medication, especially oral liquid dosage form.

Results

Pre- and post-intervention surveys were conducted from 118 and 108 participants, respectively. The 10 mismatched respondents that did not appear in the post-test were excluded from the study.

Figure 3 shows the age distribution of the respondents, falling mainly between 18 and 23 years of age, with 75% of the respondents being women (Table 1). The majority (79) of students (73.15%) were in the age group of 21–24 and had passed their third professional (75%), whereas (28) 25.93% of them were 18–20 years and had passed their second professional exam (25%). Only one student was aged in between 24 and 26 years and was from the fifth semester (Table 1). Eight students did not share their passing years. Most respondents belonged to subjects related to medical sciences, including 30 from Human Nutrition and Dietetics (HND), 21 from Pharm.D., and 15 from Biotechnology and Food Science and Technology (FST). The other degree programs included Microbiology, Medical Laboratory Technology, Environmental Sciences, and Doctor of Veterinary Medicine. The participants were residents of Punjab Province, and 43% were inhabitants of Lahore, with 5.5% from Gujranwala and 4% from Faisalabad.

In question 1 of the surveys, the respondents were asked to select a household spoon from the set of five spoons (Types I–V) that should be used to administer one spoon of medicine, as shown in Figure 1, without mentioning the volume they can hold. Type I, the largest spoon was chosen by 51 (47.22%) respondents, whereas Type III was the second most popular choice with 31 (28.7%), followed by Type II [14 (12.96%)] and Type IV [12 (11.11%)]. On the contrary, no one chose Type V, the smallest spoon or the option of none in the pre-test. In the post-test, only 6 (5%) respondents chose the Type I spoon; there was an increase of four responses seen for Type III and 19 (17.59%) respondents opted for the smallest spoon, and 26 (24.07%) for the options none/blank (Figure 3). The chi-square test showed that there was a highly significant overall change in the pre- and post-test responses (****$p < 0.0001$). Similarly, the application of the Fischer exact test on individual options for pre- and post-values revealed that a highly significant (****$p < 0.05$) decrease was seen for the choice of type I spoon, whereas there was a highly significant (****$p < 0.05$) increase for choice of spoon type V and the introduction of the choice of none of the spoons (Figure 3). The shift in other options tested through the Fischer exact test was found to be not significant.

TABLE 1 Frequency distributions of participants.

Parameter	No. of students ($n = 108$)	Percentage (%)
Age (years)		
18–20	28	26
21–23	79	78
24–26	1	1
Gender		
Men	27	25
Women	81	75
Degree program		
Pharm.D	19	21%
HND	28	30%
FST	14	15%
Biotechnology	14	15%
Microbiology	7	8%
MLT	6	6%
Biological Sciences	5	5%
Environmental Sciences	5	5%
DVM	2	2%
Home city		
Lahore	46	43%
Gujranwala	27	25%
Faisalabad	4	4%
Burewala	3	3%
Sialkot	3	3%
Toba Tek Singh	3	3%
Ali Pur Chatta	2	2%
Bahawalnagar	2	2%
Bahawalpur	2	2%
Kasur	2	2%
Okara	2	2%
Sheikhupura	2	2%
Zafarwal	2	2%
Others	5	5%

Pharm.D, Doctor of Pharmacy; HND, Human Nutrition and Dietetics; FST, Food Science and Technology; MLT, Medical Lab Technology; DVM, Doctor of Veterinary Medicine.

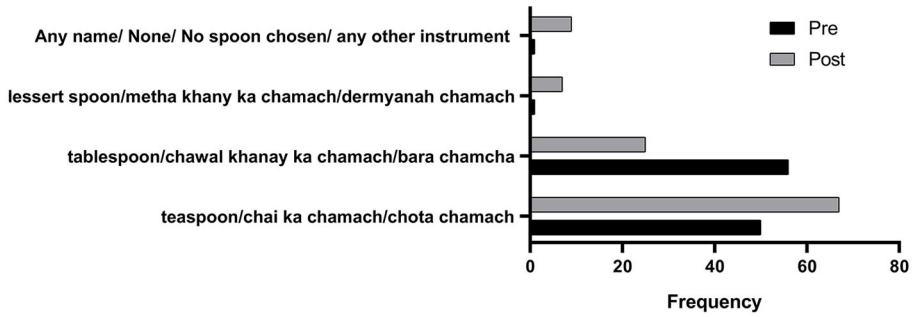

FIGURE 4
Pre- and post-intervention responses on the name of the spoon chosen for medicine administration. **** means very highly significant.

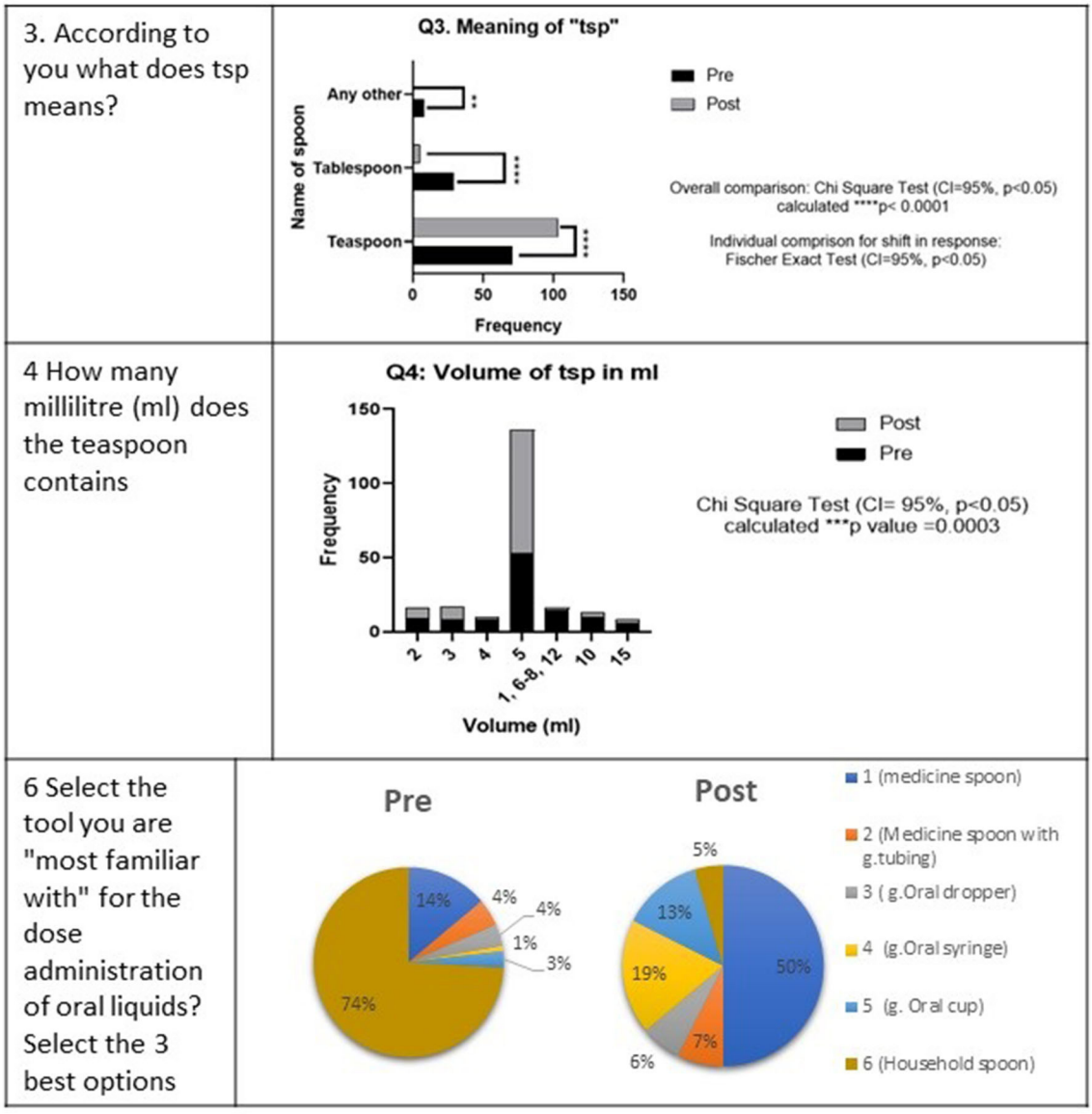

FIGURE 5
Comparison of pre- and post-intervention responses of the survey participants on the choice of a spoon for medicine administration. ** means very significant. *** means highly significant.

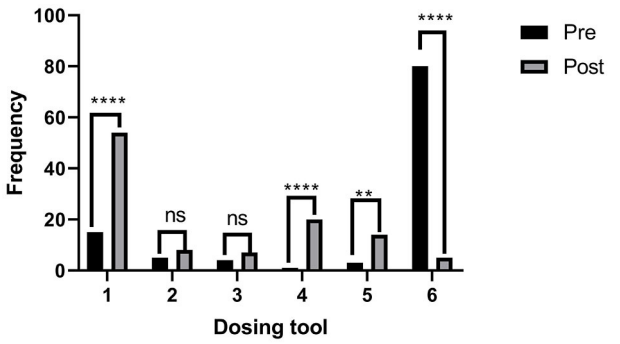

FIGURE 6
Comparison of pre- and post-intervention responses of the survey participants showing a shift of preference from household spoon to medicine spoon. **means very significant. ****means very highly significant.

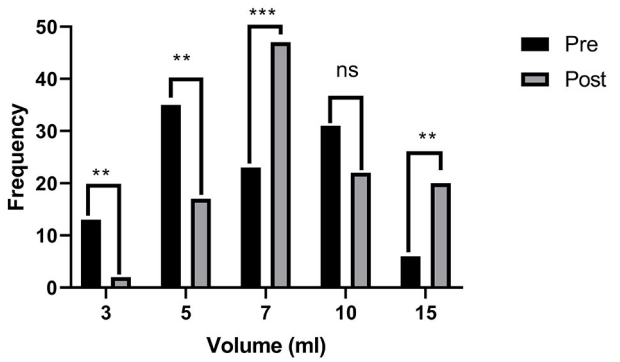

FIGURE 7
Respondent's answers to the volume of type II spoons are shown in Chart One, pre-, and post-intervention. ** means very significant. *** means highly significant. **** means very highly significant.

To confirm the choice of the type of spoon, a second question inquired the respondents about the household name of the spoon they chose in question 1. It was revealed that 56 (46%) respondents intended to choose the option *tablespoon/chawal khanay ka chamachs/bara chamcha* (rice eating spoon/big spoon), whereas 50 (42%) respondents opted for *teaspoon/chai ka chamach/Chota chamach* (Tea Spoon in Urdu/small spoon) as the name of the spoon they would choose for administering medicines. This explains that even the information on medicine spoons being based on teaspoon measures is also faulty in half of the population. In the post-test, the question was rephrased to ask what they would call their chosen spoon in their households after attending the session; the response of 62% of respondents was for the tablespoon option, which confirms that 65 out of 108 (55%) respondents chose the spoon Types I and II in the pre-test (Figure 4). Again, the application of the chi-square test showed a highly significant change in the responses in pre- and post-test results (*****$p < 0.00001$).

In response to question 3 where respondents were inquired about what they understood from the abbreviation "tsp," the options were grouped as "teaspoon," "tablespoon," and "any other." A 29.6% gain was observed in the respondents opting for teaspoons as the answer in the post-test. The pre-test result showed that 29 respondents out of 108 opted for the tablespoon option, which was reduced to five in the post-test (Figure 5). The highly significant change was demonstrated by the application of the Fischer exact test on individual change in response (****$p < 0.05$) and an overall change of high significance using the chi-square test (****$p < 0.0001$).

Similarly, the results were obtained in pre- and post-assessments on the volume in milliliters that a teaspoon holds. A 27.78% increase was observed in the initial number of 53–83 for respondents opting for 5 mL as the volume of a teaspoon (Figure 6). The other popular responses were 7, 10, 2, 3, 4, and 15 mL, with the frequency of 10, 10, 9, 8, 8, and 6, respectively (Figure 5). Whereas, in the post-test results, 2 and 7 mL were the only two other responses above 5% with a frequency of 7 and 9, respectively. The overall change was recorded as high significance using the chi-square test (***$p = 0.0003$).

Respondents were shown the chart carrying photographs of different devices used in the administration of the oral liquid medicines and were asked to pick up the three best options. The selection of household spoons was 74% in the pre-test, which dropped to 5% in the post-test (Figure 5). The order of choices was a household spoon, medicine spoon, oral cup or beaker, cylindrical medicine spoon, graduated dropper, and oral syringe in the pre-test, which changed to a medicine spoon, oral syringe, graduated oral cup/beaker, a medicine spoon with a graduated tube, and graduated oral dropper, followed by the household spoon at the end (Figure 5).

Figure 5 shows the pie chart presentation of pre- and post-responses of the survey participants showing a shift of preference from household spoon to medicine spoon, whereas Figure 6 shows the bar graph presentation with the statistical difference observed in each choice.

Inquiring respondents on the volume of Type II (desert) spoons, the correct responses were significantly increased from 21.3% (pre-test) to 43.5% (post-test) using the Fischer exact test (** to ***$p < 0.05$), except for those who responded it as 10 mL (Figure 7).

Another significant shift was observed as the strong contrast appeared in the pre- and post-test for the responses inquiring if they had used any methods other than the shared six methods for dosing oral liquid medicines (Figure 8). During the pre-test, a big proportion of respondents (57%) had used bottle caps, and 22% had admitted direct administration from the bottles. At the same time, this practice was reduced to 7 and 6% in the post-test, respectively. The response that no other method is to be used shifted from 20 to 78% in the post-test.

Respondents were asked their opinion about their choice of a spoon from chart one if they were to label it as "accurate," "inaccurate," "overdosing," or "under-dosing." All responses can be assumed as correct except the one given as "accurate," for which the response was reduced from 45% in the pre-test to 9% in the post-test, which is proof that a good proportion of respondents participating in the study learned about the risk attached to the use of household spoons for the administration of medicines (Figure 9).

In the final question of the survey, respondents were asked to state the information sources from which they learned about

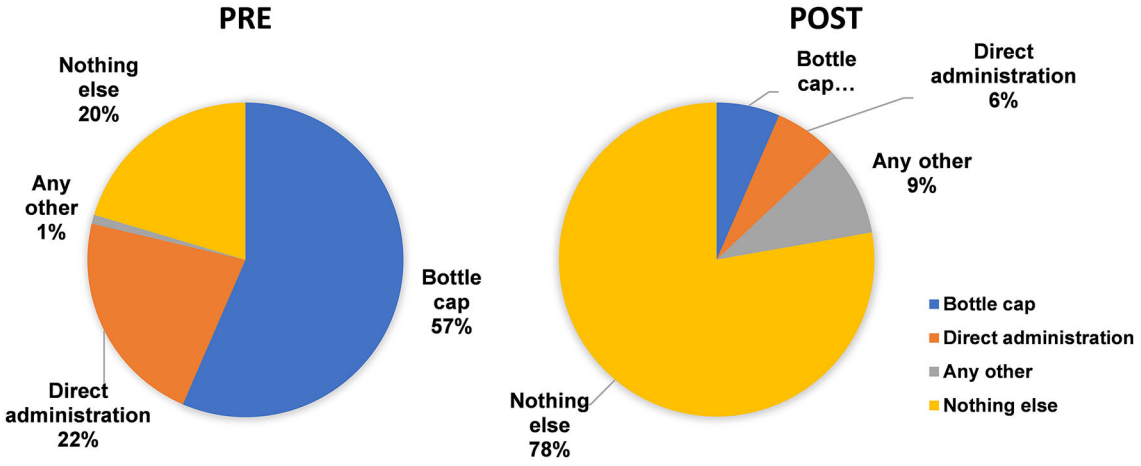

FIGURE 8
Three best choices for oral medicine administration aids (pre- and post-test).

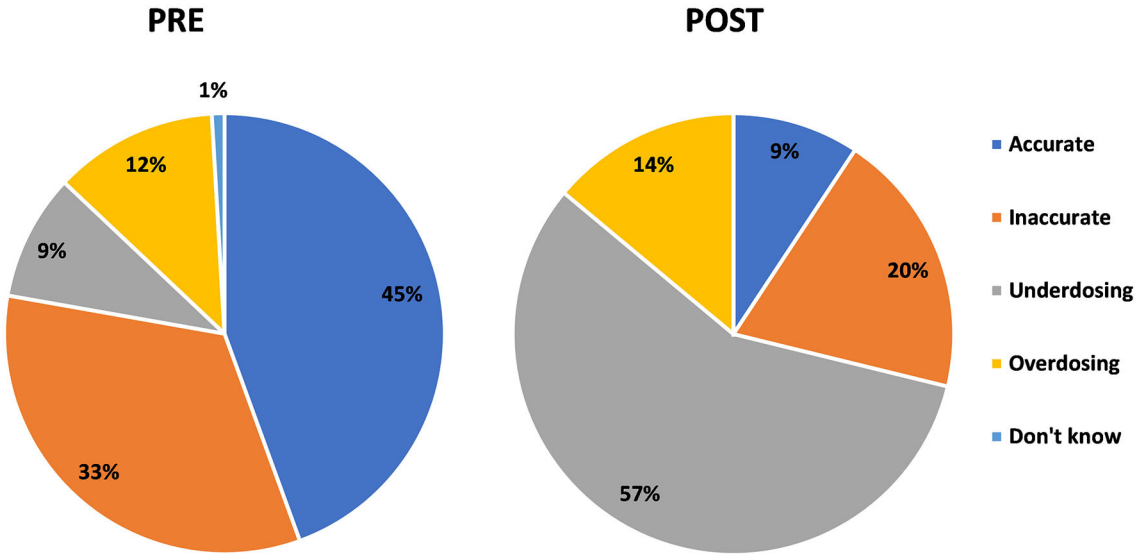

FIGURE 9
Pre- and post-intervention responses for any other method (than the six tools shared) that can be used for the administration of oral liquid medicines.

the tools for medicine administration. In the pre-intervention assessment, the order of sources from which the respondents obtained information about the selection of tools for medicine administrations was 39% from physicians, 34% from medical stores, 16% by self-understanding, and 7% from family or friends. In the post-intervention assessment, the results shifted to a pharmacist at 36%, an awareness session at 37%, a physician at 12%, and a medical store at 11% (Figure 10).

Discussion

In the current study, 108 students were successfully assessed for their knowledge and practice on the use of household spoons for administering oral liquid medicines. A household spoon stands universally as the most accessible and commonly used device (5) for the administration of oral liquids, yet it holds the risk of being the most unpredictable one, especially concerning accuracy (12), including mixing tablespoons and teaspoons (5) and handling. Household spoons vary in their design and shape and so may contain varied volumes in different cutlery sets. The same was shown to the respondent during the awareness video (Figure 1), and they were taught the short experiment on how they can measure the volume of the spoons in their household cutlery sets. The current study showed that there is also a mix-up in the understanding of the abbreviation of "tsp" by the respondents as evident from their response to question 3. This inaccuracy was recorded in a study on administering the desired dose of drugs with teaspoons and tablespoons. Teaspoons/tablespoons were collected from 25 households in Attica, Greece. A total of 71 teaspoons and

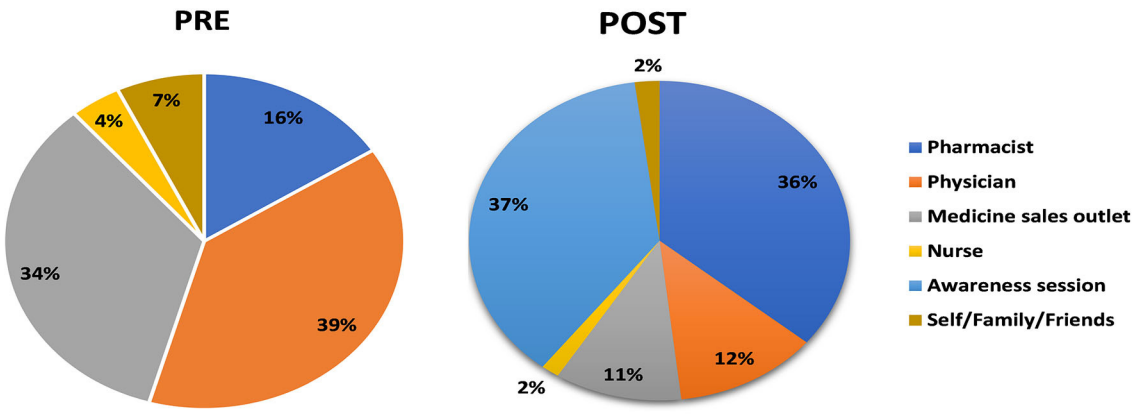

FIGURE 10
Pre- and post-intervention understanding of the consequence of the use of a household spoon.

49 tablespoons were filled with water to measure their capacity. A major portion consisting of 71 teaspoons was recorded to have a volume of 2.5–7.3 mL, making the household teaspoons and tablespoons unreliable as dosing devices, and should no longer be recommended (14).

In the post-test assessment of this study, a sense of consciousness and care was established among the respondents, and they raised a strong opinion of rejecting the use of a household spoon altogether. The awareness session informed the participants on the volume of each spoon. They were informed that none of the spoon is fit for the volume of 5 mL. However, the type III spoon being the closest with 1 mL less than 5 mL and type II being 2 mL in excess of 5 mL. The latter is approximately 0.3 times more than the volume of a medicine spoon (Figure 1). It is interesting to note that the choice of spoon shifted from overdosing (65/108 responses to 21/108 responses) in the post-test, i.e., to under-dosing and recorded the introduction of rejection of the use of a household spoon altogether by choosing none of the spoons (26/108, i.e., 24.07%). The spoons II and I of under-dose choice shifted from a total of 43 (39.81%) to 61 (56.48%). This information brings a caveat for the design of such training activities to simultaneously make an effort to counter the tendency of the respondents to make under-dosing choices. A tendency for under-dosing using a household teaspoon was observed for the acetaminophen (paracetamol) dosing in an Israeli study carried out in 1989 (9). In previous studies, under-dosing has been associated with the ineffectiveness of some therapeutic agents used in emergencies, like paracetamol (9) and ipecac syrup (17), because of the household teaspoons.

In response to question 3, the options were discretely divided into these two choices in the post-test, showing that the respondent got clarity in their opinion; however, there was a small number responding for "tsp" to be interpreted as a tablespoon.

Pre- and post-test assessments on the volume in milliliters that a teaspoon holds showed that only 53 students on the pre-test and 83 students on the post-test opted for the correct choice of 5 mL out of the total 108 students. The incorrect response to the volume of a teaspoon in the 12 and 13th year of education is a serious concern, showing the failure of the education system in imparting basic knowledge to the students. Such a fundamental concept should be a mandatory set of information that any child going through a learning process must receive. Especially, the introduction of the volume units and measures in primary classes can be linked to a practical exercise of calibrating a household teaspoon or cutlery set to make education aimed at improving the understanding of life and its needful skills.

The response regarding the volume of Type II spoons from Chart One also showed (Figure 7) that even the educated population has not been involved in knowing the volume of their household spoons though they have been using them for sensitive tasks like for provision of medicines to the sick ones.

Information on the different oral medicine administration aids showed that respondents were familiar with these aids only to some extent, and the awareness session increased their information. In a previous study, patient caregivers perceived oral beakers/cups as more convenient than oral syringes, which were found to be more accurate in their results. However, the results of the study showed that a big proportion of the caregivers were unable to use both accurately. It also showed that droppers, dosing cups, and household spoons as the most familiar devices for the patients in their settings (12). Another Korean study showed that etched dosing cups, dosing spoons, and printed dosing cups were not so preferred by the public for oral liquid medicine dosing (16). In the current study, the most significant impact was, however, the moving of household spoons from the first place to the last one.

Unsafe practices like using a bottle cap and direct administration from the bottle in the pre-test are suggestive of the lack of proper information on the consequence of wrong doses by the public, even in the educated community. However, little effort led by young professionals through this study changed this negligence into the adoption of awareness and responsibility toward the medication use process. Studies have shown that the correct use of dosing devices was not linked to education, age, or ethnicity (16). Awareness and training sessions are suggested to be essential factors in developing skills regarding these basics in health practices.

The household spoons are not reliable for delivering accurate, safe, and efficacious doses of oral liquid medications. Their

reliability is significantly reduced due to improper identification of the spoon type, unavailability, wide variations, spillage, and handling inability. The U.S. Food and Drug Administration (FDA) and National Council for Prescription Drugs in the United States have issued a white paper in which they have also warned that patients should not use their household spoons and choose a more accurate dosing device when taking liquid medications (18, 19). The medicine cups, wells, and cylinders are the most common (80%) dosing devices enclosed with the medicine packs. These devices are comparatively valid and can be relied upon to deliver specific doses of oral liquid medications effectively and efficiently, with correct use. They also possess other benefits, including ease of handling and use, and are less susceptible to spillage (18, 19). The current study also noted that the choice of the household spoon can never be accurate in the respondents' minds.

In addition, efforts should be made to standardize the dosing labeling and instructions (18, 19). To administer most oral liquid prescription medications, a patient or caregiver depends on the prescription container label dosing designations to guide the measurement of the correct dose with a dosing device. The use of multiple volumetric units (e.g., teaspoons, tablespoons, and droppers) and multiple abbreviations (e.g., mL, cc, MLS; tsp, TSP, and t) increases the likelihood of dosing errors by healthcare professionals, patients, and caregivers, which may result in patient harm (20). Milliliters should be the standard unit of measure used on prescription container labels for oral liquid medications (21, 22).

In this study, the response for dose accuracy using a household spoon was reduced from 45% in the pre-test to 9% in the post-test, which is proof that a good proportion of respondents participating in the study learned about the risk attached to the use of household spoons for the administration of medicines and considered it inaccurate, overdosing, or under-dosing. The study was able to register the importance of pharmacists and the use of awareness sessions as a medium for receiving information on the safe and proper use of medicines.

Conclusion

Knowledge of correct liquid dose measurement tools and volumes of household spoons were assessed successfully, and it was found that there is a deficit in the knowledge of proper use of measuring devices for oral liquid medicines in the educated population, which can be enhanced through simple tools like short video presentations and awareness seminars.

Recommendations

Based on the results of this study, it is recommended that comprehensive information on the choice of the spoon should be included in the academic and professional curriculum using practical exercises, videos, and graphical presentations to improve the safe administration of oral liquid medicines. Similarly, the regulatory authority should make it a mandatory requirement for the manufacturers to include necessary graphical instructions in the patient information leaflets. It is also recommended that more studies on medicine administration should be conducted in other populations to identify the gaps and propose strategies for the safe use of medicines.

Limitations

The data were collected only from one country, and all respondents were students from a public sector university. Because of the limited period of the study, reinforcement through multiple interventions and their evaluation of information retention could not be included in the study design.

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 human participants were reviewed and approved by Institutional Review Board of the University of Veterinary and Animal Sciences. The patients/participants provided their written informed consent to participate in this study.

Author contributions

EY, MF, and AA collected data and made initial draft of manuscript. HN designed figures and illustrations. SA performed statistical analysis of data. MU and HR edited and finalized the manuscript. HR, MP, and AS conceived the idea and designed the study. HR supervised the study. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors wish to acknowledge the volunteer pharmacy students (Abdul Haq, Muhammad Mustaqeem, and Syeda Rabia Jillani) for assistance in holding the awareness sessions. The authors are also thankful to Awais Siraj for his unconditional assistance in improving the English language of the manuscript.

Conflict of interest

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

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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.2023.1084667/full#supplementary-material

References

1. Bayor M, Kipo S, Rikwakye K. The accuracy and quality of household spoons and enclosed dosing devices used in the administration of oral liquid medications in Ghana. *Int J Pharm Pharm Sci.* (2010) 2:150–3.

2. Wong IC, Ghaleb MA, Franklin BD, Barber N. Incidence and nature of dosing errors in pediatric medications. *Drug Saf.* (2004) 27:661–70. doi: 10.2165/00002018-200427090-00004

3. Neves I, Proença L, Auxtero MD. Reproducibility and accuracy of measurement of oral liquid pharmaceutical forms, using a dosing spoon. *Ann Med.* (2019) 51(Sup.1):86. doi: 10.1080/07853890.2018.1561800

4. Yin HS, Parker RM, Sanders LM, Dreyer BP, Mendelsohn AL, Bailey S, et al. Liquid medication errors and dosing tools: A randomized controlled experiment. *Pediatrics.* (2016) 138:357. doi: 10.1542/peds.2016-0357

5. Madlon-Kay DJ, Mosch FS. Liquid medication dosing errors. *J Fam Pract.* (2000) 49:741–4.

6. Yin HS, Mendelsohn AL, Wolf MS, Parker RM, Fierman A, Van Schaick L, et al. Parents' medication administration errors: Role of dosing instruments and health literacy. *Arch Pediatr Adolesc Med.* (2010) 164:181–6. doi: 10.1001/archpediatrics.2009.269

7. Whelpley HM. State phamaceutical association proceedings. *J Am Pharm Assoc.* (1912) 1:146–8.

8. Yaffe SJ, Bierman CW, Cann HM, Cohen SN, Freeman J, Segal S, et al. Inaccuracies in administering liquid medication. *Pediatrics.* (1975) 56:327–8. doi: 10.1542/peds.56.2.327

9. Hyam E, Brawer M, Herman J, Zvieli S. What's in a teaspoon? Underdosing with acetaminophen in family practice. *Fam Practice.* (1989) 6:221–3. doi: 10.1093/fampra/6.3.221

10. Kaushal R, Barker KN, Bates DW. How can information technology improve patient safety and reduce medication errors in children's health care? *Arch Pediatr Adolesc Med.* (2001) 155:1002–7. doi: 10.1001/archpedi.155.9.1002

11. Aseeri MA. The impact of a pediatric antibiotic standard dosing table on dosing errors. *J Pediatr Pharmacol Therapeut.* (2013) 18:220–6. doi: 10.5863/1551-6776-18.3.220

12. Sobhani P, Christopherson J, Ambrose PJ, Corelli RL. Accuracy of oral liquid measuring devices: comparison of dosing cup and oral dosing syringe. *Ann Pharmacother.* (2008) 42:46–52. doi: 10.1345/aph.1K420

13. Joshi P, Bavdekar SB. Liquid drug dosage measurement errors with different dosing devices. *Ind J Pediatr.* (2019) 86:382–5. doi: 10.1007/s12098-019-02894-8

14. Falagas ME, Vouloumanou E, Please E, Peppas G, Rafailidis P. Inaccuracies in dosing drugs with teaspoons and tablespoons. *Int J Clin Pract.* (2010) 64:1185–9. doi: 10.1111/j.1742-1241.2010.02402.x

15. Ravikiran S, Shivarajashankara Y. Dosing ability of Indian parents for liquid medication. *Indian Pediatr.* (2011) 48:153–4. doi: 10.1007/s13312-011-0040-y

16. Ryu GS, Lee YJ. Analysis of liquid medication dose errors made by patients and caregivers using alternative measuring devices. *J Manag Care Pharm.* (2012) 18:439–45. doi: 10.18553/jmcp.2012.18.6.439

17. Dean BS, Krenzelok EP. Syrup of ipecac dosing. How much is a tablespoonful? *Vet Hum Toxicol.* (1986) 28:155–6.

18. NCPDP. NCPDP recommendations for standardizing dosing in metric units (mL) on prescription container labels of oral liquid medications, version 2.0. *Am J Health Syst Pharm.* (2021) 78:578–605. doi: 10.1093/ajhp/zxab023

19. US Food and Drug Administration. *Standardize the Dosing Designations on Prescription Container Labels for Oral Liquid Medications.* (2021). Available online at: https://www.fda.gov/media/88498/download (accessed October 30, 2022).

20. Shah R, Blustein L, Kuffner E, Davis L. Communicating doses of pediatric liquid medicines to parents/caregivers: A comparison of written dosing directions on prescriptions with labels applied by dispensed pharmacy. *J Pediatr.* (2014) 164:596–601.e1. doi: 10.1016/j.jpeds.2013.11.007

21. Yin HS, Dreyer BP, Ugboaja DC, Sanchez DC, Paul IM, Moreira HA, et al. Unit of measurement used and parent medication dosing errors. *Pediatrics.* (2014) 134:e354–61. doi: 10.1542/peds.2014-0395

22. Yin HS, Neuspiel DR, Paul IM, Franklin W, Tieder JS, Adirim T, et al. Preventing home medication administration errors. *Pediatrics.* (2021) 148:54666. doi: 10.1542/peds.2021-054666

frontiers | Frontiers in Public Health

TYPE Study Protocol
PUBLISHED 21 February 2023
DOI 10.3389/fpubh.2023.1112538

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to
Public Health Education and Promotion,
a section of the journal
Frontiers in Public Health

RECEIVED 30 November 2022
ACCEPTED 03 February 2023
PUBLISHED 21 February 2023

CITATION
Jawahar Z, Elmer S, Hawkins M and
Osborne RH (2023) Application of the
optimizing health literacy and access (Ophelia)
process in partnership with a refugee
community in Australia: Study protocol.
Front. Public Health 11:1112538.
doi: 10.3389/fpubh.2023.1112538

Application of the optimizing health literacy and access (Ophelia) process in partnership with a refugee community in Australia: Study protocol

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Refugees experience health inequities resulting from multiple barriers and difficulties in accessing and engaging with services. A health literacy development approach can be used to understand health literacy strengths, needs, and preferences to build equitable access to services and information. This protocol details an adaptation of the Ophelia (Optimizing Health Literacy and Access) process to ensure authentic engagement of all stakeholders to generate culturally appropriate, needed, wanted and implementable multisectoral solutions among a former refugee community in Melbourne, Australia. The Health Literacy Questionnaire (HLQ), widely applied around the world in different population groups, including refugees, is usually the quantitative needs assessment tool of the Ophelia process. This protocol outlines an approach tailored to the context, literacy, and health literacy needs of former refugees. This project will engage a refugee settlement agency and a former refugee community (Karen people origin from Myanmar also formerly knowns as Burma) in codesign from inception. A needs assessment will identify health literacy strengths, needs, and preferences, basic demographic data and service engagement of the Karen community. This community will be engaged and interviewed using a semi-structured interview based on the Conversational Health Literacy and Assessment Tool (CHAT) will cover supportive professional and personal relationships, health behaviors, access to health information, use of health services, and health promotion barriers and support. Using the needs assessment data, vignettes portraying typical individuals from this community will be developed. Stakeholders will be invited to participate in ideas generation and prioritization workshops for in-depth discussion on what works well and not well for the community. Contextually and culturally appropriate and meaningful action ideas will be co-designed to respond to identified health literacy strengths, needs, and preferences of the community. This protocol will develop and test new and improved methods that are likely to be useful for community-based organizations and health services to systematically understand and improve communication, services and outcomes among disadvantaged groups, particularly migrants and refugees.

KEYWORDS

health literacy development, co-design, former refugee community, Ophelia process, Conversational Health Literacy Assessment Tool (CHAT)

1. Introduction

The complexity of health issues arising from the movement of refugees around the world poses challenges for health systems. Former refugee groups often experience challenges in accessing and using healthcare services because of economic and legal limitations, language barriers, lack of knowledge about their health rights, and other socio-cultural, administrative, and institutional barriers (1–3). Consequently, former refugee communities often tend to be overlooked by mainstream health programs and so do not receive fit-for-purpose health education and information. These systemic barriers result in delayed or no access to health services (4). Each year, ∼4,000 refugees settle in the Australian State of Victoria through the humanitarian program (5). In Victoria, as with many regions around the world, the size of refugee populations is increasing, leading to the need for improved processes for health services to understand and respond to their health issues.

Globally, there is a limited research on the health issues faced by refugees after they have resettled in a destination country, including Australia (6–10). Refugees have relatively poor health and encounter barriers to accessing healthcare services. These barriers include the lack of culturally and linguistically sensitive health services and information, which cause difficulties in navigating the health system and for understanding or interpreting health information (11–13). The pre-migration, migration and resettlement experiences of refugees have multiple impacts on their health and wellbeing. These impacts vary across individuals, families, and communities depending on country of origin, duration of the migration experience, and their pre-existing health behaviors and ailments (14). Previous traumatic experiences of refugees have a persistent impact on their health and wellbeing after arrival in host countries (15, 16). Refugees may have experienced interruptions in access to healthcare services in their country of origin due to war and conflict (17). Consequently, they may have inadequately managed diseases, injuries, as well as have ongoing mental health issues due to trauma (18–20). In addition to experiencing conflict, poverty and variable access to health services, the settlement process in the host countries may aggravate health inequities and increase exposure to various health risks. The factors leading to the poor health of refugees in destination countries are well documented (21–23). However, a deeper understanding is required to inform health and community services about ways to better respond to these identified needs (24).

Researchers, public health practitioners and service providers across the health system attempt to identify and eliminate disparities in the health and wellbeing of former refugees. However, it is challenging to design approaches that examine underlying causes and worldviews that influence cultural beliefs, norms, values, health behaviors, and expectations (25). While a focus on these has raised awareness of the needs of these communities, much of the work to date has focused on deficits that refugees might have (e.g., what they can't do or are lacking in) (26). This has led to stereotyping such refugees as "hard to reach" (27, 28). A deficit approach, with a predilection for identifying weaknesses and problems limits research processes to capture potential strengths such as community values, resilience, tacit knowledge, skills and competencies that may be used to build a more comprehensive understanding of a population and inform the development of wholistic solutions.

Health literacy is a multidimensional concept that has recently evolved to be a valuable problem-solving tool to assess and understand both the strengths and challenges of individuals and communities including those who do not access services (26, 29–31). According to the WHO, health literacy represents "the personal knowledge and competencies that accumulate through daily activities and social interactions and across generations. Personal knowledge and competencies are mediated by the organizational structures and availability of resources that enable people to access, understand, appraise and use information and services in ways that promote and maintain good health and wellbeing for themselves and those around them" (31, 32). Different groups of people may have different sets of health literacy strengths, needs and preferences. This has important implications for understanding what is really required to determine how to build services and initiatives that may help different communities, especially those who come from diverse cultures, including refugees (26, 33, 34).

Health literacy initiatives are particularly important for refugees to facilitate uptake of available health services and information (35). Few studies provide insights into health literacy initiatives suitable for refugee populations (36–39). The limited research suggests that needs assessments, using community participatory approaches and plain language are useful (40). However, there are very few studies about methods for identifying and addressing the health literacy needs in the refugee setting. A systematic review of randomized control trials was conducted to identify methods and outcomes that aimed to improve health literacy and behaviors of refugee communities (41). Overall, the studies in the field of refugees' health literacy were highly heterogenous in terms of study groups (e.g., immigrants, refugees, and asylum seekers) (see Table 1 for migration terminology), research design, metrics, methods, and overall methodologies and did not critically assess the health literacy needs and local knowledge of refugee groups (41).

Robust research methods that recognize and address health literacy diversity, and consider the contexts of communities, are necessary to develop fit-for-purpose and sustainable solutions to health disparities (46). The Ophelia (Optimizing Health Literacy and Access) process engages community members to help identify and respond to their health literacy strengths and needs. The Ophelia process was developed in Australia (29) and further tested and refined in different contexts and several countries (2, 33, 47–51). It has three phases (Figure 1): Phase 1: needs assessment; Phase 2: co-design and testing of health literacy actions; Phase 3: implementation, evaluation and continuous quality improvement. Typically, the needs assessment in Ophelia Phase 1 uses a multi-dimensional health literacy assessment tool – the Health Literacy Questionnaire (HLQ) – to investigate the diverse health literacy strengths, needs and preferences of groups and communities. Collaboration is undertaken across stakeholder groups, such as community leaders and members, health professionals, managers, and service users to select, test and implement health literacy actions in Phases 2 and 3.

This study protocol describes a health literacy development project that aims to collaboratively identify the health literacy

TABLE 1 Migration terminology.

Terminology	Definition
Pre-Migration	"Pre-migration is the stage in the relocation process when the refugees are in their home countries and are deciding and preparing to move to a safe country" (42).
Migration	"Migration is the process of social change whereby an individual moves from one cultural setting to another for the purposes of settling down either permanently or for a prolonged period" (43).
Resettlement	"Resettlement is the transfer of refugees from an asylum country to another State, that has agreed to admit them and ultimately grant them permanent residence" (44).
Immigrants	"From the perspective of the country of arrival, a person who moves into a country other than that of his or her nationality or usual residence, so that the country of destination effectively becomes his or her new country of usual residence" (45).
Refugee	"A person who qualifies for the protection of the United Nations provided by the High Commissioner for Refugees (UNHCR), in accordance with UNHCR's Statute and, notably, subsequent General Assembly's resolutions clarifying the scope of UNHCR's competency, regardless of whether or not he or she is in a country that is a party to the 1951 Convention or the 1967 Protocol – or a relevant regional refugee instrument – or whether or not he or she has been recognized by his or her host country as a refugee under either of these instruments" (45).
Asylum Seeker	"An individual who is seeking international protection. In countries with individualized procedures, an asylum seeker is someone whose claim has not yet been finally decided on by the country in which he or she has submitted it. Not every asylum seeker will ultimately be recognized as a refugee, but every recognized refugee is initially an asylum seeker" (45).
Former Refugee	A former refugee means an individual who was a refugee.

strengths, needs and preferences of a former refugee community living in Melbourne, Australia, and co-design health literacy actions that are culturally and linguistically relevant, meaningful and useful to the community. The Ophelia process will be applied in accordance with the eight Ophelia principles that have been operationalised for this research (Table 2). Health literacy actions will have a strong focus on building the responsiveness of health and community services to support and develop the health literacy of the community. It is expected that the project outcomes will increase the capacity of community members to access, understand, appraise, and use health information and services and enhance their confidence to make informed decisions about their health.

The setting for this study is a Karen community (i.e., refugees from the country of Myanmar formerly known as Burma) who were identified by AMES Australia, a refugee settlement agency that agreed to form a partnership with the Center for Global Health and Equity, Swinburne University of Technology, including to engage with the Ophelia guiding principles (see Table 2). Consultation then began with the Karen community leaders and members to explore their willingness to participate in a health project. Following endorsement by the Karen community leaders and members and AMES Australia, the project aim was discussed and culturally and linguistically appropriate processes were explored.

2. Methods and analysis

2.1. Project governance

An Advisory Group was established with community leaders to advise on the aims, purpose and community engagement processes, including recruitment. This group provides advice about relevant tribal and ethnic affiliations and ensures diverse groups will be encouraged to take part.

2.2. Setting and participants

The Karen community groups residing in Melbourne mainly originate from rural areas in Burma/ Myanmar. The participants will be recruited by invitation through the Advisory Group, and community and professional networks. Informed consent will be obtained from all participants.

Community members will be invited to participate in semi-structured interviews and/or attend ideas generation and prioritization workshops. The inclusion criteria include people who are:

- A former refugee from Burma/Myanmar;
- Aged 18 years and above; and
- Cognitively able to provide informed consent.

Service providers such as health and social care workers, health practitioners, language support providers, members from the partner organization (AMES Australia), community leaders and clinicians, community nurses, and people who provide direct or indirect services (e.g., policymakers) will be invited to participate in ideas generation and prioritization workshops.

2.3. Study design

The study design will be informed by the Ophelia process (see below). The general timeline below provides an approximate schedule for the project.

- July 2021 to 2022 – data collection and analysis (includes interviews, ideas generation workshops, and corresponding analyses)
- July 2022 to 2023 – intervention development, implementation, and evaluation (includes intervention co-design and implementation, and establishing meaningful ongoing monitoring and evaluation strategies).

2.3.1. Phase 1: Identifying the local health literacy strengths, needs and preferences

The Ophelia process is usually conducted using a quantitative data collection method – the Health Literacy Questionnaire (HLQ), which has 44 items in nine scales (four to six items per scale) (30, 33). Cluster analysis is used to analyze the HLQ data, which can be useful to uncover the mechanisms that enable or inhibit groups of people within a population from engaging with

health information and services (52). However, quantitative data collection is not appropriate or relevant for every community or culture (26). For example, studies in Aboriginal and Torres Strait Islander communities in Australia identified that yarning methodology (First Nations cultural form of conversation) is an effective and respectful data gathering tool for the Australian First Nations cultures. Yarning nurtures the sharing of knowledge and stories through in-depth discussions (53). This interview technique is a culturally appropriate method of communication transfer to help the Aboriginal and Torres Strait Islander community with chronic disease education and self-management (54). The Karen community in Melbourne has limited English language, as well as limited reading ability in their own language, and there is risk of epistemic injustice if a health literacy measurement instrument that is not meaningful or relevant to their culture is used (26). To minimize the potential for biased data, an open interview technique will be used in this study instead of the HLQ.

To ensure the interview guide captures health literacy dimensions, the Conversational Health Literacy Assessment Tool (CHAT) will be used. The CHAT uses a series of open-ended-questions to facilitate conversations about the ways in which people access, understand, appraise and use health information and services (55, 56). The CHAT consists of five topics, each with 2 questions (total of 10 questions):

1) Supportive professional relationships
2) Supportive personal relationships
3) Health information access and comprehension
4) Current health behaviors
5) Health promotion barriers and support

The CHAT interview guide will be translated into the Karen language by the AMES Karen community liaison officer. The translated CHAT interview guide will be pilot tested with up to 5 community members to check understanding of the questions, issues with the translation, and relevance to the community needs and experiences. Feedback from the community members will be used to inform revisions to the translated questions. Semi-structured interviews will take about 30 min and will be undertaken with the assistance of bilingual workers. Up to 30 community members will be invited to participate in interviews.

Using the needs assessment data, vignettes (evidence-based case studies derived from study data) that portray typical individuals from the target community will be developed. Vignettes are realistic descriptions of profiles of health literacy strengths, needs, and preferences that influence the abilities of groups of people in the community to understand, access, appraise and use health information and services (2). The vignettes will be extensively revised and vetted by participants to ensure they portray the daily lived experiences of the target community members (57, 58).

2.3.1.1. Vignettes development

The health literacy needs assessment data from the interviews and participant demographic data will be used to construct vignettes about community members' experiences and health literacy strengths, needs, and preferences. It is expected that the thematic analysis will yield between 5 and 10 different profiles. Vignettes will be developed for the different health literacy profiles. The social and demographic data will provide narrative information about the contexts in which these experiences may take place. In this way, the vignettes are built to represent the characteristics and challenges of each health literacy profile without representing or revealing specific details about any one individual.

2.3.1.2. Ideas generation workshop

The vignettes will be presented to stakeholders in each workshop with 6 to 10 participants over 2 h. Separate workshops will be held for community members and direct service providers. Language interpretation support will be provided by bilingual workers. In each workshop, participants will be asked 4 key questions based on the vignettes:

1. Do you know people who have had, or have you had, experiences similar to the person in this story [participant is a community member] or Do you see people like this in your community or services? [participant is a service provider]
2. What sorts of problems is this person experiencing in relation to their health?
3. What strategies could be used to help this person?
4. If there were many people like this in your community, what could health services and community organizations do to help?

The Ideas Generation Workshops bring together researchers, community leaders and members, and other stakeholders to participate in discussions about issues facing the community, and to identify what works well and what does not work well for the community. This technique, with a focus on lived experiences embodied in the vignettes, emotes genuine engagement as workshop participants relate to the vignettes (32, 59, 60). Additionally, engaging various stakeholders in the discussion will increase the potential for collaborative efforts to respond to the identified needs using existing resources according to the health literacy strengths, needs and preferences of the community.

2.3.2. Phase 2: Select, plan, develop, and test selected health literacy actions

An action-oriented program logic model and theory will be developed based on the workshop outputs with categorization of short- term, intermediate and long-term outcomes where appropriate (32). This logic model will be co-designed with the key stakeholders to describe the mechanisms for how the generated action ideas are intended to work (61).

2.3.3. Phase 3: Implementation, evaluation and ongoing monitoring of health literacy actions

This phase involves implementation of the chosen health literacy actions from Phase 2, which include improving the local uptake, effectiveness, and sustainability of health actions using quality improvement cycles. AMES Australia will evaluate and examine the intended outcomes (short-term, intermediate, and long-term) of the chosen health actions, and refine the processes to enhance responsiveness and effectiveness, capacity building, and sustainability of the health actions. A post-implementation

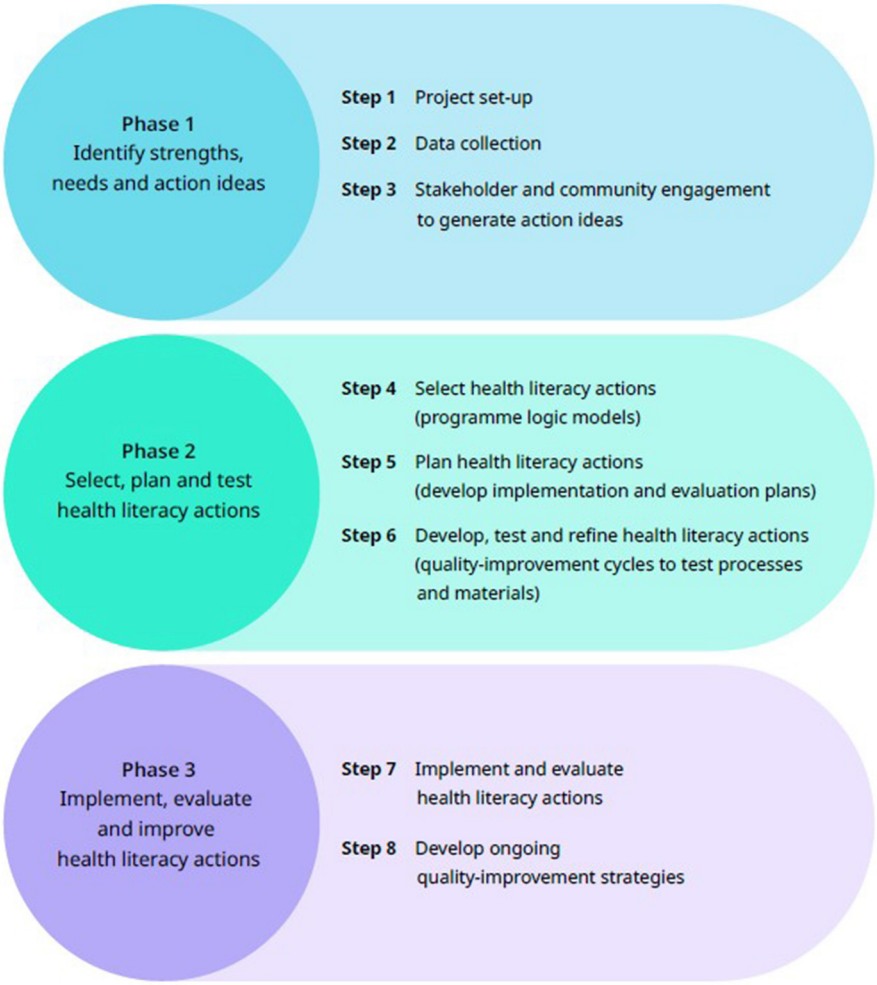

FIGURE 1
The three phases of the Ophelia process.

evaluation tool will be identified and used to evaluate the outcomes (32).

2.4. Data analysis

The data will be synthesized in two stages: analysis of the semi-structured interviews and analysis of the data generated from the workshops.

2.4.1. Semi- structured interviews

The narratives from the semi-structured interviews, guided by the CHAT questions, will be coded, themed and analyzed deductively (62–65), whilst also allowing for inductive generation of codes identified in the data. The codes will be categorized and themes will be developed from the categories.

The themes will be used to generate groups of similar health literacy profiles across the interviewed participants. The coded data, within the themes, will be scored according to challenges experienced by participants. A score 3 of 3 means the person experienced fewer challenges; a score of 2 means the person experienced a moderate number of challenges; and a score of 1 means the person had many challenging experiences. The scoring of the challenges will be based on the number and severity of challenges. The severity of the challenges will be determined based on participants' expressions, communication styles, tone of voice and behaviors while responding to the interview questions. Some participants may not give any responses that are relevant to the identified theme, and these will be categorized as "no response". Scores for each theme will be summed. The total scores will be grouped from the highest scores to the lowest scores. Higher scores suggest potential strengths, and lower scores indicate potential challenges. The demographic data will be linked to each individual to identify demographic differences in terms of education, age, and gender. The health literacy profile of the interviewed community members will be used to develop vignettes.

TABLE 2 Principles of the Ophelia process and the application in this study [Adapted from Osborne et al. (32)].

Principles	Description	Application in the study
Focus on outcomes	Focus on improving health and wellbeing outcomes	• We will listen to and respect community voices. • We will give priority to issues of concern to improve the health and wellbeing of former refugee communities. • We aim to equip and empower former refugee communities with the necessary health literacy competencies to increase their capacity to make good health decisions.
Driven by equity	Focus on increasing equity in health outcomes and access to services for people with varying health literacy needs	• The study is designed in a way to ensure the full participation of community leaders and members in all discussions. • The community leaders and members, and other stakeholders will be involved in the decision-making process to ensure ownership and transparency of the study process. • We will emphasize the community values in the development of health actions and interventions that build on their health literacy strengths.
Driven by local wisdom	Prioritize local wisdom, culture, and systems	• We will respect and listen to the lived experience of former refugees. • We will identify and respond to the communities' diverse health literacy needs and preferences to improve their engagement with healthcare services. • We will value their lived experience of migration and settlement.
Diagnosis of local needs	Respond to locally identified health literacy needs	• We will value the lived experiences of community members and other stakeholders. • The study is designed by taking into consideration the context, cultural background, health beliefs and available resources.
Co-design approach	Engage all relevant stakeholders in the co-design and implementation of actions	• In each stage of the Ophelia process, all the stakeholders will be included in the process of developing the study design, suitable data collection tool, action plan, and interventions.
Responsive-ness	Respond to the varying and changing health literacy needs of individuals and communities	• We will recognize the cultural diversity of former refugees and, and their migration history. • We will prioritize their voices and ideas to inform the development of locally and culturally appropriate solutions. • Interventions will be co-designed to increase the community's capacity to understand, access and use health care services and information and enhance their ability to make informed decisions about their health.
Applied across systems	Focus on improvements at and across all levels of the health systems	• The sequence of the study process (e.g., health literacy assessments and workshops) will capture meaningful and evidence-based knowledge over time through the full participation of and engagement with the relevant stakeholders, which will promote changes in different socio-ecological levels.
Sustainable	Focus on achieving sustained improvements through changes to environments, practices, cultures, and policies	• We will work collaboratively with former refugee communities, settlement services, and other community organizations to reinforce sustainable and meaningful interventions through the individual- and community-centered approach. • The collaborative effort is anticipated to advocate for communities needs and preferences. • This study will use culturally and linguistically informed methods, which can be applied in different former refugee population groups.

2.4.2. Ideas generation workshop

In each workshop participants will discuss up to 4 vignettes. The ideas will be grouped into 3 categories of health literacy actions: (1) actions related to what community members can do (e.g., increasing confidence of individuals in using their knowledge and skills of local culture, beliefs, resources, and environment); (2) actions related to what community or local health organizations can do (e.g., understanding local wisdom of the community, providing culturally sensitive services); and (3) policy level actions (e.g., actions that influence organizational policy and decision making processes) (29). Data analysis will be led by one researcher with iterative review and checking of congruency of codes by other members from the team including the community leaders and AMES Australia staff.

Following the thematic analysis of the health literacy actions, a prioritization workshop will be conducted with key stakeholders, including community members and leaders and AMES Australia staff. A health literacy development and implementation plan will be developed.

3. Discussion

Health service organizations and settlement agencies who work closely with former refugees experience challenges in identifying, understanding, and responding in culturally responsive ways to the diverse health literacy needs of this cohort. Given that substantial health disparities in former refugee communities are frequently

observed (23), new ways to support communities and health authorities to understand the health needs and to take action are warranted. Simply providing health information in different languages for these communities is not sufficient to enhance their engagement with the health services, reduce health inequities, and improve their health outcomes (66–68).

This protocol details an adaptation of the Ophelia process such that it can accelerate a settlement agency's engagement with their community and develop an in depth understanding about how to best generate and implement health literacy development actions and programs that are locally relevant and implementable. Importantly, Ophelia provides an authentic process for engagement and co-design with diverse stakeholders. The Ophelia process has been successfully adapted to fit many projects in different countries around the world (32) and previous Ophelia protocols for studies in different contexts have been published (29, 69, 70) including a study about refugees in Portugal (2). This study will be conducted in accordance with the eight principles of the Ophelia process (Table 2) which may mean that during the co-design phases of the project, some protocol changes may be necessary to suit the cultural and linguistic needs of the community, available resources, and other contextual circumstances.

Potential limitations to this study protocol include inadequate time for consultation and code sign with the agency and community members, limited reach into the full range of refugee groups, and reluctance of refugee groups to express any concerns they may have in their new host country. The governance of the Advisory Group and adherence to the Ophelia principles are, however, likely to mitigate these potential limitations.

The Ophelia process recommends application of a formal multidimensional questionnaire [i.e., the Health Literacy Questionnaire (30)]. However, this type of tool, whether administered in written or oral form, may miss key health literacy elements of the refugee settlement experience, and may be an unacceptable burden to people who are illiterate in the own language, or come from an oral language tradition (26). Consequently, this protocol includes a semi-structured qualitative interview using the CHAT. If successful, this protocol will increase the reach and impact of Ophelia into wider settings, including among groups often not authentically included in research and program development activities. The development and continuous improvement of equitable healthcare services require responsiveness to the local nuances of a community, development of bespoke or tailored health literacy actions, and careful evaluation of the acceptability, uptake and impact of public health responses (32).

4. Conclusion

This study will support an organization to understand and respond to the factors that affect a community's ability to understand, access, appraise, and use health information and services to make informed decisions about their health. This protocol applies authentic co-design to develop locally appropriate interventions based on diverse stakeholders' experiences and identified needs. The outcomes of this study are anticipated to be useful for various community-based organizations and policy makers to reduce health disparities in former refugee and other communities that experience vulnerability and marginalization and to create enabling environments that enhance meaningful engagement with and equitable access to health information and services.

Ethics statement

The studies involving human participants were reviewed and approved by the Swinburne University of Technology Human Research Ethics Committee (Ref: 20214120-5868). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

ZJ, SE, MH, and RHO contributed to the conceptualization and development of this research design. ZJ drafted the manuscript. All the listed authors reviewed and provided constructive feedback to all manuscript sections and approved the final manuscript.

Funding

ZJ was funded by a Swinburne University Postgraduate Research Award (SUPRA) (102943987). RHO was funded in part through an Australian National Health and Medical Research Council (NHMRC) Principal Research Fellowship (APP115125).

Acknowledgments

The authors acknowledge the members of AMES Australia Tess Demediuk, Maria Tsopanis, Angelica Svensson and Melika Yassin Sheik-Eldin for their continued support and contribution in this study. Importantly, the authors gratefully acknowledge Nanthu Kunoo for her steadfast assistance in supporting the researchers to engage with the community leaders and members and for providing cultural and linguistic guidance and advice in all aspects of the study.

Conflict of interest

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

Publisher's note

References

1. Dias S, Gama A, Cortes M, de Sousa B. Healthcare-seeking patterns among immigrants in Portugal. *Health Soc Care Commun.* (2011) 19:514–21. doi: 10.1111/j.1365-2524.2011.00996.x

2. Dias S, Gama A, Maia AC, Marques MJ, Campos Fernandes A, Goes AR, et al. Migrant communities at the center in co-design of health literacy-based innovative solutions for non-communicable diseases prevention and risk reduction: application of the optimising health literacy and access (ophelia) process. *Front Public Health.* (2021) 9:639405. doi: 10.3389/fpubh.2021.639405

3. Dias S, Gama A, Rocha C. Immigrant women's perceptions and experiences of health care services: Insights from a focus group study. *J Public Health.* (2010) 18:489–96. doi: 10.1007/s10389-010-0326-x

4. Ahmadinia H, Eriksson-Backa K, Nikou S. Health-seeking behaviours of immigrants, asylum seekers and refugees in Europe: a systematic review of peer-reviewed articles. *J Document.* (2021) 78:18–41. doi: 10.1108/JD-10-2020-0168

5. Department of Health and Human Services. *Refugee and asylum seeker health and wellbeing* State Government of Victoria, Australia. (2020). Available online at: https://www2.health.vic.gov.au/about/populations/refugee-asylum-seeker-health#:$\sim$:text=Victoria%20currently%20receives%20around%20one,settle%20in%20Victoria%20each%20year (accessed July 7, 2020).

6. Mårtensson L, Lytsy P, Westerling R, Wångdahl J. Experiences and needs concerning health related information for newly arrived refugees in Sweden. *BMC Public Health.* (2020) 20:1–1044. doi: 10.1186/s12889-020-09163-w

7. Bogic M, Njoku A, Priebe S. Long-term mental health of war-refugees: a systematic literature review. *BMC Int Health Hum Rights.* (2015) 15:1–41. doi: 10.1186/s12914-015-0064-9

8. Hahn K, Steinhäuser J, Goetz K. Equity in health care: A qualitative study with refugees, health care professionals, and administrators in one region in Germany. *BioMed Res Int.* (2020) 8:1–15. doi: 10.1155/2020/4647389

9. Lloyd A. Building information resilience: how do resettling refugees connect with health information in regional landscapes–implications for health literacy. *Australian Acad Res Libraries.* (2014) 45:48–66. doi: 10.1080/00048623.2014.884916

10. Russell G, Harris M, Cheng I-H, Kay M, Vasi S, Joshi C, Chan B, Lo W, Wahidi S, Advocat J. *Coordinated primary health care for refugees: a best practice framework for Australia*. (2013). Available online at: http://files.aphcri.anu.edu.au/reports/Grant%20RUSSELLFinal%20Report.pdf (accessed August 28, 2022).

11. Murray SB, Skull SA. Hurdles to health: immigrant and refugee health care in Australia. *Australian Health Review.* (2005) 29:25–9. doi: 10.1071/AH050025

12. Sheikh M, Nugus PI, Gao Z, Holdgate A, Short AE, Al Haboub A, et al. Equity and access: understanding emergency health service use by newly arrived refugees. *Med J Australia.* (2011) 195:74–6. doi: 10.5694/j.1326-5377.2011.tb03210.x

13. Simich L. *Health Literacy and Immigrant Populations. Public Health Agency of Canada and Metropolis Canada, Ottawa, Canada.* (2009). Available online at: http://www.metropolis.net/pdfs/health_literacy_policy_brief_jun15_e.pdf (accessed July 20, 2022).

14. Dowling A, Enticott J, Kunin M, Russell G. The association of migration experiences on the self-rated health status among adult humanitarian refugees to Australia: An analysis of a longitudinal cohort study. *Int J Equity Health.* (2019) 18:1–10. doi: 10.1186/s12939-019-1033-z

15. George M, A. theoretical understanding of refugee trauma. *Clin Soc Work J.* (2010) 38:379–87. doi: 10.1007/s10615-009-0252-y

16. Kartal D, Alkemade N, Kiropoulos L. Trauma and mental health in resettled refugees: mediating effect of host language acquisition on posttraumatic stress disorder, depressive and anxiety symptoms. *Transcult Psychiatry.* (2019) 56:3–23. doi: 10.1177/1363461518789538

17. Sheikh-Mohammed M, MacIntyre CR, Wood NJ, Leask J, Isaacs D. Barriers to access to health care for newly resettled sub-Saharan refugees in Australia. *Medical J Austr.* (2006) 185:594–7. doi: 10.5694/j.1326-5377.2006.tb00721.x

18. Sigvardsdotter E, Vaez M, Hedman A-M, Saboonchi F. Prevalence of torture and other war-related traumatic events in forced migrants: a systematic review. *J Rehab Torture Victims Prev Torture.* (2016) 26:41–73.

19. Masters PJ, Lanfranco PJ, Sneath E, Wade AJ, Huffam S, Pollard J, et al. Health issues of refugees attending an infectious disease refugee health clinic in a regional Australian hospital. *Austr J Gen Practice.* (2018) 47:305–10. doi: 10.31128/AFP-10-17-4355

20. Chaves NJ, Paxton GA, Biggs BA, Thambiran A, Gardiner J, Williams J, et al. The australasian society for infectious diseases and refugee health network of australia recommendations for health assessment for people from refugee-like backgrounds: an abridged outline. *Med J Austr.* (2017) 206:310–5. doi: 10.5694/mja16.00826

21. Chiarenza A, Dauvrin M, Chiesa V, Baatout S, Verrept H. Supporting access to healthcare for refugees and migrants in European countries under particular migratory pressure. *BMC Health Serv Res.* (2019) 19:1–14. doi: 10.1186/s12913-019-4353-1

22. World Health Organization (WHO). *Report on the Health of Refugees and Migrants in the WHO European Region: No Public Health Without Refugee and Migrant Health. World Health Organization Regional Office.* (2018). Available online at: https://apps.who.int/iris/bitstream/handle/10665/311347/9789289053846-eng.pdf (accessed September 20, 2022).

23. Matlin SA, Depoux A, Schütte S, Flahault A, Saso L. Migrants' and refugees' health: towards an agenda of solutions. *Public Health Rev.* (2018) 39:1–55. doi: 10.1186/s40985-018-0104-9

24. Greenhalgh T. *Speaking of Medicine and Health: Less Research is Needed. PLOS BLOG*. Available online at: https://speakingofmedicine.plos.org/2012/06/25/less-research-is-needed/ (accessed November 28, 2022).

25. Rikard R, Hall JK, Bullock K. Health literacy and cultural competence: a model for addressing diversity and unequal access to trauma-related health care. *Traumatology.* (2015) 21:227. doi: 10.1037/trm0000044

26. Osborne RH, Cheng CC, Nolte S, Elmer S, Besancon S, Budhathoki SS, et al. Health literacy measurement: embracing diversity in a strengths-based approach to promote health and equity, and avoid epistemic injustice. *BMJ Global Health.* (2022) 7:e009623. doi: 10.1136/bmjgh-2022-009623

27. Bonevski B, Randell M, Paul C, Chapman K, Twyman L, Bryant J, et al. Reaching the hard-to-reach: a systematic review of strategies for improving health and medical research with socially disadvantaged groups. *BMC Med Res Methodol.* (2014) 14:1–29. doi: 10.1186/1471-2288-14-42

28. O'Reilly-de Brún M, de Brún T, Okonkwo E, Bonsenge-Bokanga J-S, Silva MMDA, Ogbebor F, et al. Using participatory learning and action research to access and engage with 'hard to reach'migrants in primary healthcare research. *BMC Health Serv Res.* (2015) 16:1–16. doi: 10.1186/s12913-015-1247-8

29. Batterham RW, Buchbinder R, Beauchamp A, Dodson S, Elsworth GR, Osborne RH. The optimising health literacy (ophelia) process: study protocol for using health literacy profiling and community engagement to create and implement health reform. *BMC Public Health.* (2014) 14:694. doi: 10.1186/1471-2458-14-694

30. Osborne RH, Batterham RW, Elsworth GR, Hawkins M, Buchbinder R. The grounded psychometric development and initial validation of the health literacy questionnaire (HLQ). *BMC Public Health.* (2013) 13:658. doi: 10.1186/1471-2458-13-658

31. Osborne RH, Elmer S, Hawkins M, Cheng CC, Batterham RW, Dias S, et al. Health literacy development is central to the prevention and control of non-communicable diseases. *BMJ Global Health.* (2022) 7:e010362. doi: 10.1136/bmjgh-2022-010362

32. Osborne RH, Elmer S, Hawkins M, Cheng C. *The Ophelia Manual. The Optimising Health Literacy and Access (Ophelia) process to plan and implement National Health Literacy Demonstration Projects*. Centre for Global Health and Equity, School of Health Sciences, Swinburne University of Technology, Melbourne, Australia (2021).

33. Cheng C, Elsworth GR, Osborne RH. co-designing ehealth and equity solutions: application of the ophelia (optimizing health literacy and access) process. *Front Public Health.* (2020) 8: 604401. doi: 10.3389/fpubh.2020.604401

34. Jordan JE, Buchbinder R, Osborne RH. Conceptualising health literacy from the patient perspective. *Patient Educ Couns.* (2010) 79:36–42. doi: 10.1016/j.pec.2009.10.001

35. Bouclaous C, Haddad I, Alrazim A, Kolanjian H, El Safadi A. Health literacy levels and correlates among refugees in Mount Lebanon. *Public Health.* (2021) 199:25–31. doi: 10.1016/j.puhe.2021.08.006

36. Berkman ND, Davis TC, McCormack L. Health literacy: what is it? *J Health Commun.* (2010) 15:9–19. doi: 10.1080/10810730.2010.499985

37. Fernández-Gutiérrez M, Bas-Sarmiento P, Albar-Marín M, Paloma-Castro O, Romero-Sánchez J. Health literacy interventions for immigrant populations: a systematic review. *Int Nurs Rev.* (2018) 65:54–64. doi: 10.1111/inr.12373

38. Shohet L, Renaud L. Critical analysis on best practices in health literacy. *Canadian J Pub Health.* (2006):S10–13. doi: 10.1007/BF03405366

39. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med.* (2011) 155:97–107. doi: 10.7326/0003-4819-155-2-201107190-00005

40. Williams ME, Thompson SC. The use of community-based interventions in reducing morbidity from the psychological impact of conflict-related trauma among refugee populations: a systematic review of the literature. *J Immigrant Minority Health.* (2011) 13:780–94. doi: 10.1007/s10903-010-9417-6

41. Fox S, Kramer E, Agrawal P, Aniyizhai A. Refugee and migrant health literacy interventions in high-income countries: a systematic review. *J Immigrant Minority Health.* (2021) 25:1–30. doi: 10.1007/s10903-021-01152-4

42. Wessels WK. *The Refugee Experience: Involving Pre-Migration, in Transit, and Post Migration Issues in Social Services*. (2014). Available online at: https://sophia.stkate.edu/msw_papers/280 (accessed September 20, 2022).

43. Bhugra D, Jones P. Migration and mental illness. *Adv Psychiatr Treatment.* (2001) 7:216–22. doi: 10.1192/apt.7.3.216

44. The United Nations High Commissioner for Refugees (UNHCR). *Resettlement: How We do Resettlement. The United Nations High Commissioner for Refugees*. (2022). Available online at: https://www.unhcr.org/en-au/resettlement.html (accessed December 12, 2022).

45. International Organization for Migration (IOM). *International Migration Law: Glossary on Migration. International Organization for Migration*. (2019). Available online at: https://publications.iom.int/books/international-migration-law-ndeg34-glossary-migration (accessed December 12, 2022).

46. World Health Organisation (WHO). *Health Literacy Toolkit for Low and Middle-Income Countries: A Series of Information Sheets to Empower Communities and Strengthen Health Systems. WHO Regional Office for South-East Asia*. (2015). Available online at: https://apps.who.int/iris/handle/10665/205244 (accessed September 20, 2022).

47. Aaby A, Simonsen CB, Ryom K, Maindal HT. Improving organizational health literacy responsiveness in cardiac rehabilitation using a co-design methodology: results from the heart skills study. *Int J Environ Res Public Health.* (2020) 17:1015. doi: 10.3390/ijerph17031015

48. Bakker MM, Putrik P, Aaby ASE, Debussche X, Morrissey J, Borge CR, et al. Acting together–WHO national health literacy demonstration projects (nhldps) address health literacy needs in the european region. *Public Health Panorama.* (2019) 5:233–43.

49. Kolarcik P, Belak A, Osborne RH. The Ophelia (OPtimise HEalth LIteracy and Access) Process. Using health literacy alongside grounded and participatory approaches to develop interventions in partnership with marginalised populations. *Eur Health Psychologist.* (2015) 17:297–304.

50. Stubbs T. Exploring the design and introduction of the ophelia (optimising health literacy and access) process in the philippines: a qualitative case study. *Health Promotion J Austr.* (2022) 33:829–37. doi: 10.1002/hpja.546

51. Anwar WA, Mostafa NS, Hakim SA, Sos DG, Cheng C, Osborne RH. Health literacy co-design in a low resource setting: harnessing local wisdom to inform interventions across fishing villages in egypt to improve health and equity. *Int J Environ Res Public Health.* (2021) 18:4518. doi: 10.3390/ijerph18094518

52. Bakker M, Putrik P, Rademakers J, Van de Laar M, Vonkeman H, Kok M, et al. OP0257-PARE using patient health literacy profiles to identify solutions to challenges faced in rheumatology care. *Ann Rheum Dis.* (2020) 79:162. doi: 10.1136/annrheumdis-2020-eular.877

53. Bessarab D. Ng'Andu B. Yarning about yarning as a legitimate method in Indigenous research. *Int J Criti Indig Studies.* (2010) 3:37–50. doi: 10.5204/ijcis.v3i1.57

54. Rheault H, Coyer F, Bonner A. Chronic disease health literacy in first nations people: a mixed methods study. *J Clin Nurs.* (2021) 30:2683–95. doi: 10.1111/jocn.15757

55. O'Hara J, Hawkins M, Batterham R, Dodson S, Osborne RH, Beauchamp A. Conceptualisation and development of the conversational health literacy assessment tool (CHAT). *BMC Health Serv Res.* (2018) 18:199. doi: 10.1186/s12913-018-3037-6

56. Jensen NH, Aaby A, Ryom K, Maindal HT, A CHAT. about health literacy–a qualitative feasibility study of the conversational health literacy assessment tool (CHAT) in a danish municipal healthcare centre. *Scand J Caring Sci.* (2021) 35:1250–8. doi: 10.1111/scs.12943

57. Choi J, Kushner KE, Mill J, Lai DW. Understanding the language, the culture, and the experience: translation in cross-cultural research. *Int J Q Methods.* (2012) 11:652–65. doi: 10.1177/160940691201100508

58. Hawkins M, Cheng C, Elsworth GR, Osborne RH. Translation method is validity evidence for construct equivalence: analysis of secondary data routinely collected during translations of the health literacy questionnaire (HLQ). *BMC Med Res Methodol.* (2020) 20:1–13. doi: 10.1186/s12874-020-00962-8

59. Wilkinson S. Focus group methodology: a review. *Int J Soc Res Methodol.* (1998) 1:181–203. doi: 10.1080/13645579.1998.10846874

60. Liamputtong P. Focus group methodology: introduction and history. *Focus Group Methodol Principle Practice.* (2011) 224:1–14. doi: 10.4135/9781473957657.n1

61. Funnell SC, Rogers PJ. *Purposeful Program Theory: Effective Use of Theories of Change and Logic Models*. New York, NY: John Wiley & Sons (2011) 46–7 p.

62. Creswell JW, Plano Clark VL, Gutmann ML, Hanson WE. Advanced mixed methods research designs. *Handb Mixed Methods Soc Behav Res.* (2003) 209:209–40.

63. Edmondson AC, McManus SE. Methodological fit in management field research. *Acad Manage Rev.* (2007) 32:1246–64. doi: 10.5465/amr.2007.26586086

64. Creswell JW, Creswell JD. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. London: Sage Publications (2017), 160–90 p.

65. Braun V, Clarke V. Using thematic analysis in psychology. *Q Res Psychol.* (2006) 3:77–101. doi: 10.1191/1478088706qp063oa

66. Gele AA, Pettersen KS, Torheim LE, Kumar B. Health literacy: the missing link in improving the health of Somali immigrant women in Oslo. *BMC Public Health.* (2016) 16:1134. doi: 10.1186/s12889-016-3790-6

67. Renzaho A, Polonsky M, Mellor D, Cyril S. Addressing migration-related social and health inequalities in Australia: call for research funding priorities to recognise the needs of migrant populations. *Australian Health Review.* (2016) 40:3–10. doi: 10.1071/AH14132

68. Svensson P, Carlzén K, Agardh A. Exposure to culturally sensitive sexual health information and impact on health literacy: a qualitative study among newly arrived refugee women in Sweden. *Cult Health Sexuality.* (2017) 19:752–66. doi: 10.1080/13691058.2016.1259503

69. Hawkins M, Massuger W, Cheng C, Batterham R, Moore GT, Knowles S, et al. Codesign and implementation of an equity-promoting national health literacy programme for people living with inflammatory bowel disease (IBD): a protocol for the application of the Optimising Health Literacy and Access (Ophelia) process. *BMJ Open.* (2021) 11:e045059. doi: 10.1136/bmjopen-2020-045059

70. Meldgaard M, Maimburg RD, Damm MF, Aaby A, Peeters A, Maindal HT. The health literacy in pregnancy (HeLP) program study protocol: development of an antenatal care intervention using the ophelia process. *Int J Environ Res Public Health.* (2022) 19:4449. doi: 10.3390/ijerph19084449

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 24 February 2023
DOI 10.3389/fpubh.2023.1109158

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 27 November 2022
ACCEPTED 07 February 2023
PUBLISHED 24 February 2023

CITATION
Dai Z, Jing S, Liu X, Zhang H, Wu Y, Wang H, Xiao W, Huang Y, Fu J, Chen X, Gao L and Su X (2023) Development and validation of the diabetic self-management scale based on information-motivation-behavioral skills theory. *Front. Public Health* 11:1109158. doi: 10.3389/fpubh.2023.1109158

Development and validation of the diabetic self-management scale based on information-motivation-behavioral skills theory

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Background: Self-management is important for the blood sugar control of middle-aged and elderly Type 2 diabetes mellitus (T2DM) patients, of which diet, exercise, and drug compliance are the most common components. The Information-Motivation-Behavioral Skills Model (IMB) has been widely used in health behavior management and intervention.

Objective: The purpose of this study is to develop and validate the Diabetic Self-Management Scale (DSMS) based on the IMB model.

Methods: Self-report survey data was collected from middle-aged and elderly T2DM patients in Zhongmu City, Henan Province, China in November 2021 using convenience sampling. The original DSMS was developed through a literature review and summary of previous similar scales using an inductive approach. Item modification was finished by a panel of specialists. Exploratory factor analysis and confirmatory factor analysis were used to evaluate the reliability, convergent validity, discriminant validity, and criterion validity of DSMS.

Results: Four hundred and sixty nine T2DM patients completed the questionnaire survey. The final DSMS consists of 22 items with three dimensions, including information (five items), motivation (eight items), and behavior skills (nine items). The results of simple factor analysis showed that the KMO value was 0.839, Bartlett spherical test 2 = 3254.872, $P < 0.001$. The results of confirmatory factor analysis showed that 2/df = 2.261, RMSEA = 0.073, CFI = 0.937, TLI = 0.930, and SRMR = 0.096. The standardized factor loadings of 22 DSMS items were all above 0.6, and the CR values of 3 dimensions were all higher than 0.9. In addition, DSMS also showed good discriminant and criterion validity.

Conclusion: The 22-item DSMS has good reliability and validity, and can be used to make diabetic self-management assessment regarding diet, physical activity, and medication among middle-aged and elderly Chinese T2DM patients. DSMS is of moderate length and easy to understand. It can be promoted in China in the future to understand the self-management status of middle-aged and elderly T2DM patients in China.

KEYWORDS

type 2 diabetes mellitus, self-management, psychometric properties, validation, Information-Motivation-Behavioral Skills Model (IMB)

1. Introduction

With the increasing rates of aging and obesity worldwide, diabetes has become one of the most serious and common chronic diseases currently (1). According to International Diabetes Federation (IDF), there were about 537 million people suffering from diabetes in 2021 worldwide, with a global prevalence estimated to be more than 10%, and the number is expected to reach 783 million by 2045 (2). Due to the large aging population, China has now become the country with the highest prevalence of diabetes in the world and has the largest number of diabetic patients (3). According to the 2021 Global Diabetes Atlas released by International Diabetes Federation (IDF), the total number of diabetic patients in mainland China was estimated to be 140.9 million in 2021 (2). The incidence of diabetes continues to increase with age, especially after the age of 50, and among the middle-aged and elderly populations in China, the prevalence of diabetes and pre-diabetes was more than 10 and 40% respectively in 2018 (4–6). Worse still, the high incidence of diabetes in middle-and low-income countries has brought huge costs and burdens to the global health economy (7). Empirical data showed that in 2021, the direct health expenditure caused by diabetes has reached nearly 1 trillion dollars, which has increased about 316% over the past 15 years globally (2). Moreover, the socio-economic inequities in diabetes are also not conducive to the prevention and control of diabetes worldwide, especially in developing countries (8). Type 2 diabetes mellitus (T2DM) is the most common type of diabetes mellitus, accounting for 90% of all diabetic patients (9). T2DM patients may develop microvascular and macrovascular complications such as cardiovascular disease, diabetes nephropathy, and diabetes ophthalmopathy without effective control of blood sugar (10). In addition, T2DM patients have a 15% increased risk of all-cause death compared with healthy people (11). This will lead to both the compromise of life quality of T2DM patients and huge financial burden to their families (12).

The main contributing factors for T2DM were obesity and unhealthy lifestyles like sedentariness (13). Early control of T2DM and patient-centered self-management can reduce blood glucose levels and minimize complications (9). A series of randomized controlled trials indicated that lifestyle interventions, such as increasing physical activity and having a healthy diet, are simple and effective ways to control the progression of T2DM (14–18). Apart from the lifestyle changes recommended by their family, friends or doctors, most of the T2DM patients are benefiting from the diabetes medication, typically given to the control of the blood glucose and further occurrence of complications of T2DM. Hence, adhering to a doctor's prescription for hypoglycemic medications and suggestions is crucial for managing the condition and preventing the emergence of T2DM complications (4, 19, 20). However, the self-management practice of T2DM patients need further optimization and refinement, since it involves multiple aspects, such as eating habits, physical activities, and medication adherence, and might be complicated for T2DM patients to follow it strictly (21). Recent studies have found that most T2DM patients only adhere to their treatment to a moderate degree (22–24). In this case, an instrument to systematically assess eating habits, physical activities, and medication adherence is necessary for T2DM patients to evaluate their capacity for self-management. Currently, most self-management scales employed among Chinese T2DM patients were introduced from other countries, such as the Diabetes Self-Care Scale (DSCS) which evaluates the self-management ability from the perspective of diet, blood sugar detection, feet care, physical activity, and medication; Summary of Diabetes Self-Care Activities Scale (SDSCA) that contains the assessment of diet, physical activity, blood sugar detection, feet care, and smoking; The Personal Diabetes Questionnaire (PDQ) that was developed under the structure of knowledge, self-decision, self-management, and psychology; and Diabetes Care Profiles (DCP) that evaluate the mental and social health of diabetic patients from multiple dimensions (25–28). However, few studies focused on the development and validation of a self-management scale for T2DM patients in China considering the culture of the Chinese context. Additionally, the existing self-management evaluation tools for diabetes often involve multiple dimensions such as diet, physical activity, blood glucose monitoring, feet care, and drug compliance. Among them, diet, physical activity and drug treatment are of utmost concerns by majority of the diabetes and prediabetes patients, and it is also the focus of medical staff (6). Therefore, developing a tool focusing on the above mentioned three aspects to evaluate the self-management status of diabetes patients might be expected to provide a measurement applicable to a broader T2DM population.

The Information-Motivation-Behavioral Skills Model (IMB) developed by Fisher et al. in the 1990's was originally used to evaluate the risk of HIV infection and promote the prevention of HIV/AIDS (29). According to the IMB theory, the performance of behavior requires behavior-specific information, motivation, and behavior skills. Individuals with higher levels of information, motivation and behavioral skills are more likely to adopt healthy behaviors. Therefore, measuring the level of the above three dimensions can well-predict and reflect individual's behavior. Information is a factor directly related to health-related behavior, and motivation is an additional determinant of health-related behavior. Adequate information and motivation can promote individuals to develop appropriate behavioral skills and ultimately lead to health-promoting behaviors (Figure 1) (30, 31). At present, the IMB model has demonstrated a satisfactory predictive ability to improve the compliance of self-management behavior and ameliorate the health outcome of T2DM patients, showing good practicability and maturity (32). For example, Qin compiled the IMB-SMBG questionnaire based on the IMB model to investigate the self-monitoring of blood glucose in adult type I diabetes patients (33). However, the diabetic self-management scales employed in these studies were mostly self-designed without strict validation, and few studies focused on middle-aged and elderly T2DM patients in China (34). Therefore, the purpose of the current study is to develop a diabetic self-management scale (DSMS) in Chinese middle-aged and elderly T2DM patients based on IMB theory. And it is intended to evaluate the self-management of T2DM patients from the perspective of diet, physical activity, and medication, respectively, and to provide a tool for systematically understanding of their relevant health-related behaviors.

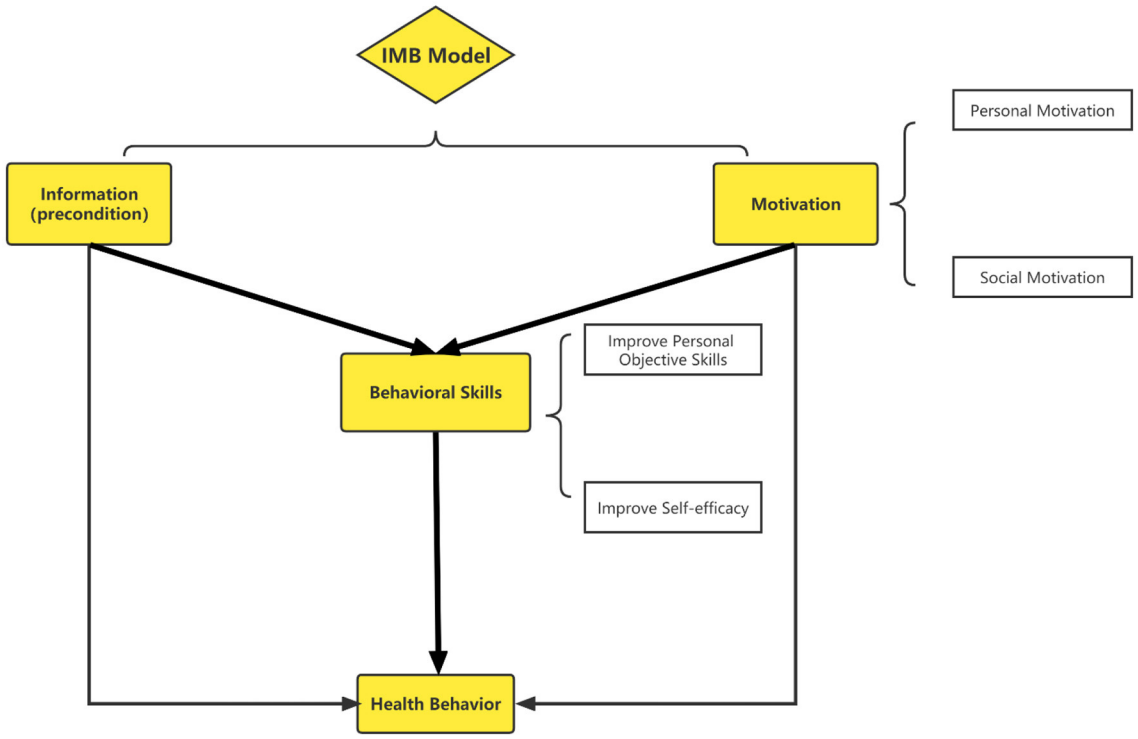

FIGURE 1
Conceptual framework of the role of IMB model on health behavior.

2. Materials and methods

2.1. Scale development

The Diabetic Self-Management Scale (DSMS) developed in this study was based on the three dimensions of IMB theory, namely information, motivation, and behavioral skills. And each dimension covered items on physical activity, diet, and medication of T2DM. The information dimension was developed based on the items from the diabetes knowledge questionnaires of the Diabetes Education Project in China of Project Hope, while items of motivation and behavioral skill dimensions were developed based on comprehensive literature reading and other scales that our research team had previously developed and employed based on IMB or similar models (35, 36). Initially, a 55-item pool (15 items of information, 20 items of motivation, and 20 items of behavioral skill) was generated *via* literature review and group discussion. Then, similar items were collapsed into 1 item to avoid redundancy. For example, "Appropriate physical activities can lower my blood sugar level," "Physical activities can make my blood sugar well controlled", and "Blood sugar level is difficult to control if I do not exercise." were collapsed into "Appropriate physical activities can lower my blood sugar level." Meanwhile, some items were also removed by considering the practicability and applicability in the study population by investigators and field workers who were familiar with the study population and the local culture of the study site, such as "Do you know what your ideal weight is?." After this phase, the 55-item pool was reduced to 43 items (13 items of information, 15 items of motivation, and 15 items of behavioral skill). Later, a panel of specialists in epidemiology, psychology, and behavioral science were invited to further review the 43-item pool, evaluating the face validity of the items, and to make the final modification suggestion. According to the suggestions of specialists, some unnecessary items were removed, such as "High-fat food will increase the risk of complications of diabetes," and "I will feel anxious if my blood sugar level cannot be well-controlled," and a few items were slightly reworded to improve their linguistic clarity. Finally, a total of 25 items (eight items of information, eight items of motivation, and nine items of behavioral skill) remained for subsequent analyses.

2.2. Study design and participants

The sample size was planned to be at least 120 in this study, with the set of $\alpha = 0.05$; $\beta = 0.2$; degree of freedom (df) = 120; RMSEA = 0.05 in the null hypothesis; RMSEA = 0.08 in the test of close fit, and RMSEA = 0.01 in the test of non-close fit (37). The calculation was completed in R 4.2.2.

A descriptive cross-sectional questionnaire survey was conducted in the present study. Participants were recruited from Zhongmu, Henan province, China, and they were invited to fill out a questionnaire including demographics and DSMS by convenience sampling from November 2nd, 2021 to November 12nd, 2021. The inclusion criteria were: (1) Registered clinically diagnosed diabetic patients aged from 45 to 65 years old; (2) Fasting

TABLE 1 Demographic characteristics of participants ($n = 469$).

Variables	*N* (%)
Age (years)	
45–60	336 (71.6)
>60	133 (28.4)
Gender	
Male	188 (40.1)
Female	281 (59.9)
Educational level	
Primary school or below	265 (56.5)
Above primary school	204 (43.5)
Marital status	
unmarried/divorced/widowed	32 (6.8)
Married	437 (93.2)
Annual household income in 2020 (RMB)	
≤30,000	294 (62.7)
>30,000	175 (37.3)
Drink in the past year	
No	363 (77.4)
Yes	106 (22.6)
Smoke in the last 6 months	
No	395 (84.2)
Yes	74 (15.8)
High blood pressure	
No	100 (21.3)
Yes	369 (78.7)
GLU (mmol/L)	9.93 ± 4.36
GHB (%)	10.27 ± 2.62

blood glucose level is not lower than 7.0 mmol/L or HbA1c is not lower than 6.5%; (3) Can independently finish questionnaires; (4) Can sign the informed consent form and cooperate to complete all the research contents. The exclusion criteria were: (1) Patients with serious diseases (such as malignant tumors), immunodeficiency or immunosuppressants, or those with severe neurological or mental disorders; (2) Patients who are deaf-mute, unable to move, etc. Investigators who are familiar with the local dialect were recruited and trained. Unified instructions were set for each item in the questionnaire for the investigators to ask questions, and they would fill out the questionnaire according to the answers of the participants. After the investigators and proofreaders sign at the end of each questionnaire, it is deemed that the investigation of this sample is completed. Epidata software was used for data entry and double check to ensure the accuracy of the data. In this study, 484 participants completed the questionnaires, and 469 out of them met the eligibility criteria of the study, which were employed for subsequent analysis, with an effective recovery rate of 97%. The study protocol was approved by the Ethics Committee of the Institute of Pathogen Biology, Chinese Academy of Medical Sciences (Beijing, China) (IPB-2021-09).

2.3. Measurement

2.3.1. Demographic information

Demographic information included age, gender, educational level, marital status, annual household income in 2020, whether drank in the past year, whether smoked in the last 6 months, whether have high blood pressure, blood glucose (GLU), and glycosylated hemoglobin or glycated hemoglobin (GHB). (GLU and GHB are the current diagnostic criteria for diabetes in China) (38). GLU and GHB were measured by researchers during investigation.

2.3.2. Preliminary version of diabetic self-management scale

The DSMS developed in this study was based on IMB theory, which included three dimensions: information, motivation, and behavioral skill. The information dimension consisted of eight items on knowledge of diet, physical activity, and medication of T2DM. Each item was of dichotomous response on "Yes" and "No" ("Yes" equals 1 while "No" equals 0), participants would receive 1-point for each correct response, and the higher total score of this dimension indicated a higher level of knowledge on T2DM. The Cronbach's α of this dimension was 0.630 in this study. The motivation dimension consisted of eight items and each item was 5-point Likert scaled from 1–5, and higher total scores indicated a higher level of motivation on diabetic self-management. The Cronbach's α of this dimension was 0.938 in this study. The behavioral skill dimension consisted of nine items and each item was a question that need an answer from "Yes," "No," or "Not clear." Participants would receive 1-point for each correct response and get the total score after finishing all items. Higher total scores indicated a higher level of behavioral skill. The Cronbach's α of this dimension was 0.898 in this study.

2.4. Statistical analysis

Descriptive analysis was used to describe the demographic characteristics. Pearson correlation analysis was employed to examine the correlation among the 3 dimensions of DSMS. When assessing the psychometric properties of DSMS, the sample was randomly divided into two parts *via* a random number generator, to perform exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), respectively. The final sample size of the EFA sample (sample 1) was 234 and the CFA sample (sample 2) was 235. Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity was used to test whether our data were suitable for factor analysis. In EFA, principal component factor analysis with varimax rotation was conducted to assess the underlying structure for the 25 items of the DSMS. Items that had a factor loading of more than 0.50 and did not load on multiple factors were obtained for further CFA (39). After EFA, three-factor CFA with oblique rotation was employed to evaluate the reliability and validity of

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TABLE 2 Factor loadings of 25 items in the preliminary DSMS ($n = 234$).

Items and expected dimensions	Dimension		
	Information	Motivation	Behavioral skill
Information			
Eating too much sugar or sweet food is a cause of diabetes.	**0.279**	−0.148	0.277
People with diabetes cannot eat fruits and vegetables.	**0.122**	−0.139	−0.077
Appropriate physical activities can lower my blood sugar level	**0.546**	0.198	0.046
Diabetic patients should start exercising 1/2 to 1 h after a meal	**0.703**	0.157	0.167
Diabetic patients should take sweets with them when exercising	**0.696**	−0.068	0.148
If I forget to take the hypoglycemic drugs in the morning, then I can take the two drugs together at noon to make up for the morning's vacancy	**0.411**	0.127	−0.253
All hypoglycemic agents may cause hypoglycemia	**0.563**	0.051	0.082
Paying attention to diet and strengthening physical activities are as important as taking hypoglycemic agents	**0.591**	0.294	−0.061
Motivation			
I attach great importance to my health	0.177	**0.616**	−0.198
It will be difficult to control my blood sugar if I do not control my diet	−0.038	**0.741**	0.119
Poor control of blood sugar can easily lead to diabetic complications (such as nephropathy, etc.)	0.168	**0.784**	−0.098
My relatives and friends around me think I should stick to the diabetes diet	0.081	**0.826**	0.161
Moderate physical activities can control my blood sugar well	0.078	**0.817**	0.128
My relatives and friends around me think I should keep moderate physical activity to control my blood sugar	0.079	**0.849**	0.184
Medication according to the doctor's advice can control my blood sugar well	0.149	**0.824**	−0.062
My relatives and friends around me think that I should stick to the doctor's advice	0.160	**0.845**	0.157
Behavioral skill			
When you are busy, can you still follow the dietary principles suggested by your doctor?	0.020	0.039	**0.756**
If you make up your mind, can you stick to the diabetes diet?	0.021	−0.011	**0.800**
Do you know how to eat and drink to help control blood sugar?	0.117	0.159	**0.667**
When you are busy, can you still keep exercising?	0.059	0.090	**0.820**
If you make up your mind, can you keep exercising?	0.108	0.105	**0.795**
Do you know how to exercise to help control blood sugar?	0.163	0.110	**0.755**
Can you take the medicine according to the doctor's advice during the period of taking the medicine recommended by the doctor?	−0.135	−0.043	**0.659**
If you make up your mind, can you follow the doctor's advice?	−0.075	0.048	**0.588**
Do you know how you should take medicine to control blood sugar?	0.085	0.047	**0.796**

The bold values indicate factor loadings of expected dimensions.

the DSMS. Since the scales of indicators of "information" and "behavioral skill" were binary, mean and variance-adjust weight least squares (WLSMV) was used to estimate the parameters of the CFA model (40). The structural validity of the DSMS was evaluated by model fit indices, which include $\chi 2$, df, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). The reliability and convergent validity of the DSMS were assessed by standardized factor loadings, composite reliability (CR), and average variance extracted (AVE) (41). The discriminant validity of the DSMS was assessed by the AVE method (41). The criterion validity was assessed by the correlation among the three dimensions of DSMS and GLU and GHB (42). All the analyses were completed with SAS 9.4 and Mplus 8.3.

3. Results

3.1. Participant characteristics

A total of 469 T2DM patients were recruited in this study. 28.4% of the participants were above 60 years old, 59.9% were female, and 78.7% had high blood pressure (see Table 1).

TABLE 3 Model fit indices of the proposed model ($n = 235$).

	χ^2	df	χ^2/df	CFI	TLI	RMSEA	SRMR
Model	465.681	206	2.261	0.937	0.930	0.073	0.096

3.2. Exploratory factor analysis

The KMO measure of the 25-item original DSMS was 0.839, indicating enough items are predicted by each factor in the current study. The result of Bartlett's test of sphericity was statistically significant ($\chi 2 = 3254.872$, $P < 0.001$), suggesting that the items are correlated highly enough to provide a reasonable basis for factor analysis. In EFA, 3 major factors were expected, based on the fact that the items were designed to index 3 constructs: information, motivation, and behavioral skill. Table 2 displays the items and factor loadings for the rotated factors, with loadings <0.50 omitted in the further analysis (39). Three items in the information dimension were deleted: "Eating too much sugar or sweet food is a cause of diabetes," "People with diabetes cannot eat fruits and vegetables," "If I forget to take the hypoglycemic drugs in the morning, then I can take the two drugs together at noon to make up for the morning's vacancy."

3.3. Confirmatory factor analysis

3.3.1. Structural validity

The CFA model with 22 items extracted from the EFA showed $\chi 2/df = 2.261$, RMSEA = 0.073, CFI = 0.937, TLI = 0.930, and SRMR = 0.096, suggesting an acceptable model fit and structural validity of the DSMS. The model fit indices of the CFA are illustrated in Table 3.

3.3.2. Reliability and convergent validity

The standardized factor loadings of 22-item DSMS were all above 0.6 and statistically significant. The values of CRs for the three dimensions were all above 0.9. The AVEs of the dimensions were above 0.6, suggesting good reliability and convergent validity of the DSMS (see Table 4, Figure 2).

3.3.3. Discriminant and criterion validity

To evaluate discriminant and criterion validity, the correlations of 3 dimensions were examined. When the square root of each factor's AVE is greater than the absolute value of the correlation between this dimension and the other two dimensions, the model demonstrates discriminant validity. As is shown in Table 5, the diagonal elements in the correlation matrix of DSMS factors were the square root of AVE. All the diagonal elements were greater than corresponding off-diagonal elements, indicating the DSMS showed good discriminant validity. Additionally, criterion validity was evaluated by the correlation between 3 dimensions of DSMS and GLU, and GHB. As shown in Table 5, three dimensions of DSMS were all negatively associated with GLU and GHB, except the correlation between behavioral skill and GHB, but this correlation was not statistically significant. Additionally, despite the non-significant correlation between motivation and GLU, the correlation between motivation and GHB were statistically significant, indicating that DSMS developed in this study had good criterion validity.

3.4. Characteristics of dimensions in DSMS

The average scores of information, motivation, and behavioral skill for all participants were (2.697 ± 1.607), (4.073 ± 0.517), and (6.058 ± 3.033) (see Table 6).

4. Discussion

T2DM is a chronic disease requiring patients' lifelong self-management to avoid the occurrence of complications and to ensure the achievement of the best clinical outcomes (43, 44). Recognizing the weak links and misconceptions of self-management of T2DM patients in China is of positive significance for the health authorities and medical care workers to implement targeted intervention among this population. Therefore, it is necessary to develop a scale to comprehensively assess the self-management status of T2DM patients. The primary aim of this study was to develop a scale to evaluate the self-management ability, including diet, physical activity, and medication, of middle-aged and elderly T2DM patients in China based on IMB theory. The final DSMS is a 22-item scale with a systematic yet simple 3-factor structure encapsulating information, motivation, and behavioral skill, which is consistent with the established theoretical perspectives of IMB (34). The standardized factor loadings of 22 items in CFA were all above the recommended value of 0.5 and statistically significant, indicating good communalities of items (39). The value of Cronbach's α and CR for the three dimensions were all above 0.7, indicating good reliability and convergent validity of the CFA model (41, 45). In addition, the discriminant validity of the CFA model was acceptable according to the comparison between correlation coefficients and AVEs. These findings provide reasonable evidence that DSMS has satisfied psychometric properties to meet the requirement for a self-report measure of self-management ability among Chinese middle-aged and elderly T2DM patients.

Blood sugar is an important indicator to evaluate the self-management of T2DM patients (46, 47). The three dimensions of DSMS were all negatively associated with hyperglycemia markers, such as higher levels of GHB and GLU. The first dimension is information, which is the precondition for healthy behavior in the IMB model. Researchers have pointed out that information can directly affect diabetes patients' self-management behavior, and a high level of diabetes-related knowledge is beneficial for patients' glycemic control (34, 48). In addition, sufficient diabetes-related information can improve drug compliance and regular glycemic monitoring of T2DM patients, which will also help to avoid the deterioration of the disease (32, 49). The second dimension is motivation, including personal motivation and social motivation, which are independent and direct predictors of T2DM self-management behavior (50). Researches indicated

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TABLE 4 Reliability and convergent validity of 22-item DSMS ($n = 235$).

Construct	Indicator	STD	S.E.	Z	P	CR	AVE
Information	Appropriate physical activities can lower my blood sugar level	0.820	0.067	12.194	<0.001	0.908	0.664
	Diabetic patients should start exercising half an hour to 1 h after a meal	0.752	0.061	12.406	<0.001		
	Diabetic patients should take sweets with them when exercising	0.737	0.064	11.527	<0.001		
	All hypoglycemic agents may cause hypoglycemia	0.809	0.063	12.789	<0.001		
	Paying attention to diet and strengthening physical activities are as important as taking hypoglycemic agents	0.942	0.055	17.029	<0.001		
Motivation	I attach great importance to my health	0.695	0.020	34.477	<0.001	0.949	0.702
	It will be difficult to control my blood sugar if I do not control my diet	0.767	0.017	46.418	<0.001		
	Poor control of blood sugar can easily lead to diabetic complications (such as nephropathy, etc.)	0.828	0.013	66.076	<0.001		
	My relatives and friends around me think I should stick to the diabetes diet	0.884	0.010	84.458	<0.001		
	Moderate physical activities can control my blood sugar well	0.906	0.007	127.555	<0.001		
	My relatives and friends around me think I should keep moderate physical activity to control my blood sugar	0.886	0.010	85.441	<0.001		
	Medication according to the doctor's advice can control my blood sugar well	0.854	0.009	96.811	<0.001		
	My relatives and friends around me think that I should stick to the doctor's advice	0.862	0.012	70.752	<0.001		
Behavioral skill	When you are busy, can you still follow the dietary principles suggested by your doctor?	0.927	0.022	42.545	<0.001	0.977	0.826
	If you make up your mind, can you stick to the diabetes diet?	0.947	0.025	38.425	<0.001		
	Do you know how to eat and drink to help control blood sugar?	0.861	0.030	28.944	<0.001		
	When you are busy, can you still keep exercising?	0.934	0.021	45.399	<0.001		
	If you make up your mind, can you keep exercising?	0.916	0.023	40.319	<0.001		
	Do you know how to exercise to help control blood sugar?	0.919	0.023	39.335	<0.001		
	Can you take the medicine according to the doctor's advice during the period of taking the medicine recommended by the doctor?	0.895	0.030	29.867	<0.001		
	If you make up your mind, can you follow the doctor's advice?	0.925	0.028	33.400	<0.001		
	Do you know how you should take medicine to control blood sugar?	0.853	0.031	27.200	<0.001		

STD, Standardized factor loading; S.E., Standard error; CR, Composite reliability; AVE, Average variance extracted.

that positive motivation can promote physical activity and a healthy diet in T2DM patients (49, 51). However, the relationship between motivation and blood glucose monitoring and drug compliance has not been identified, since these behaviors may be more strictly limited by information such as doctor's advice, while the diet and physical activity are more flexible and can be easily adjusted according to the patient's motivation (52). The last part of the IMB model is behavior skills. Behavior skills are composed of personal objective skills and self-efficacy, which are also positively associated with diabetes self-management behavior (53). Previous studies have shown that information and motivation are positively associated with behavioral skills, and behavioral skills are also positively associated with T2DM self-care behaviors (54). Although information and motivation are essential for self-management behaviors in T2DM patients, it might be difficult to adopt correct healthy behaviors without solid practical skills (50). In addition, HIV-related intervention studies suggested that behavioral skills mediate the relationship among information, motivation, and health behaviors (55, 56). Therefore, DSMS developed in this study might give a direct evaluation of the health outcome of T2DM self-management. Based on the DSMS, health authorities and medical care workers can understand the factors of poor self-management behavior of T2DM patients and then take targeted health education and intervention.

In this study, all the items in the dimensions of motivation and behavioral skill of the preliminary DSMS have been completed and retained, indicating that the items of these two dimensions could well-assess the self-management of T2DM patients. However, in EFA, we found three redundant items and deleted them in the "Information" dimension from the original version of DSMS due to their low factor loadings and poor interpretability to the whole DSMS. Since the launch of the new round of health system reform in China in 2009, community-based diabetes management and care has become one of the key contents of the country's basic public health services, including regular blood glucose testing, the guidance of medication, diet control, and physical activity, which has helped to improve the knowledge and self-care awareness level of T2DM patients (57–59). In this case, the deleted three items in "Information" dimension were more like common sense for T2DM

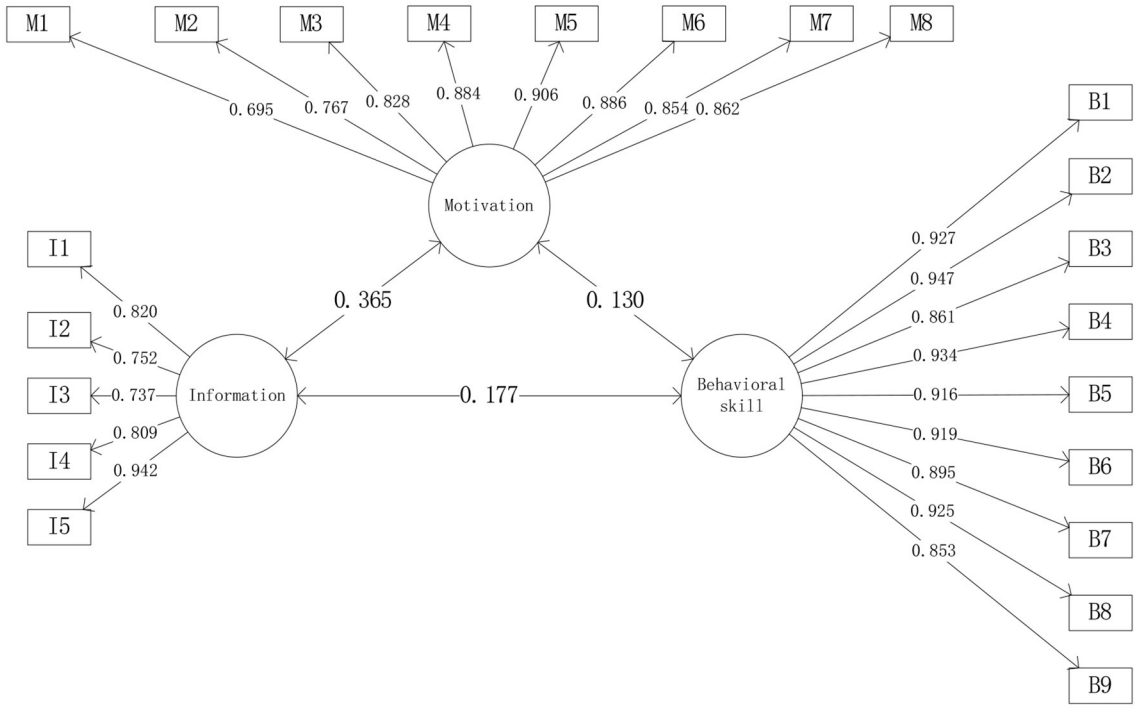

FIGURE 2
Confirmatory factor analysis of DSMS. I1–I5 are items of information; M1–M8 are items of motivation; B1–B9 are items of behavioral skill.

TABLE 5 Discriminant and criterion validity of 22-item DSMS.

	Information	Motivation	Behavioral skill
Information	**0.815**		
Motivation	0.365*	**0.838**	
Behavioral skill	0.177*	0.130*	**0.909**
GLU	−0.196*	−0.068	−0.148*
GHB	−0.091*	−0.171*	0.015

*$P < 0.05$. The diagonal bold values indicate the correlation matrix of DSMS factors were the square root of AVE.

TABLE 6 Average scores of 3 dimensions in 22-item DSMS.

	Min	Max	Mean	SD
Information	0.00	5.00	2.6972	1.60728
Motivation	1.00	5.00	4.0728	0.51720
Behavioral skill	0.00	9.00	6.0576	3.03310

Min, minimum; Max, maximum; SD, standard deviation.

patients, which might be too simple for them, thus demonstrating low consistency with other items.

This study has several strengths. First, the 22-item scale is relatively appropriate for the middle-aged and elderly and is comparable in length to other widely used measures, such as DSCS which has 26 items (26). Second, researchers in this study had background in diabetic epidemiology and were familiar with psychology and behavioral science, which could ensure the face and content validity of the scale. Third, during the scale-development process, we employed the IMB model as our theoretical framework and considered the items from aspects of diet, physical activity, and medication, which provided a systematic and comprehensive assessment for the T2DM. Moreover, all 469 T2DM patients fully completed the questionnaires, indicating the acceptability of the scale, and the sample size was large enough for the psychometric testing.

This study also has several limitations. First, this study is limited by the convenience sampling method and the fact that it consisted only of middle-aged and elderly T2DM patients in Zhongmu, Henan, China. Further studies including T2DM patients of different ages and regions are necessary to examine the validity of DSMS in the Chinese context. Second, the CR values of the three subscales were all above 0.9, despite displaying good reliability of the scale, it suggested that further scale reduction might be applicable, however, further deletion may reduce the face and content validity of the scale. Third, this study may also be limited by the fact that the DSMS is a self-report instrument. Participants may give a subjective or socially appropriate answer that does not reflect their true thoughts. Further comprehensive investigation with the additional use of qualitative methods may be valuable.

5. Conclusion

Currently, no instrument can be used to systematically assess the self-management readiness of middle-aged and elderly T2DM patients in China. The 22-item DSMS developed in our study is an important step toward closing this gap, and can be used to make

comprehensive assessment of diabetic self-management regarding diet, physical activity, and medication, based on IMB theory. The DSMS is validated with good reliability and validity, with moderate length and understandable content for middle-aged and elderly T2DM patients in China. Thus, the DSMS can be applied in China to identify levels of self-management among middle-aged and elderly T2DM patients in China.

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 human participants were reviewed and approved by the Ethics Committee of the Institute of Pathogen Biology, Chinese Academy of Medical Sciences (Beijing, China) (IPB-2021-09). The patients/participants provided their written informed consent to participate in this study.

Author contributions

XS, ZD, SJ, and XL prepared the first draft. XS provided overall guidance and managed the overall project. ZD, SJ, XL, HZ, YW, HW, WX, YH, JF, XC, and LG were responsible for the questionnaire survey, intervention implementation, and data analysis. All authors contributed to the article and approved the submitted version.

Funding

This study was funded by the Innovative Engineering Program sponsored by Chinese Academy of Medical Sciences (2020-I2M-2-015).

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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References

1. Tinajero MG, Malik VS. An update on the epidemiology of type 2 diabetes: a global perspective. *Endocrinol Metab Clin North Am.* (2021) 50:337–55. doi: 10.1016/j.ecl.2021.05.013

2. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: global, regional, and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract.* (2022) 183:109119. doi: 10.1016/j.diabres.2021.109119

3. Tu WJ, Xue Y, Nie D. The prevalence and treatment of diabetes in China from 2013 to 2018. *JAMA.* (2022) 327:1706. doi: 10.1001/jama.2022.3014

4. Wang L, Peng W, Zhao Z, Zhang M, Shi Z, Song Z, et al. Prevalence and treatment of diabetes in China, 2013–2018. *JAMA.* (2021) 326:2498–506. doi: 10.1001/jama.2021.22208

5. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the international diabetes federation diabetes atlas, 9(th) edition. *Diabetes Res Clin Pract.* (2019) 157:107843. doi: 10.1016/j.diabres.2019.107843

6. Li YZ, Teng D, Shi XG, Qin GJ, Qin YF, Quan HB, et al. Prevalence of diabetes recorded in mainland China using 2018 diagnostic criteria from the American diabetes association: national cross sectional study. *Bmj-Brit Med J.* (2020) 369:997. doi: 10.1136/bmj.m997

7. Liu C, Wang B, Liu S, Li S, Zhang K, Luo B, et al. Type 2 diabetes attributable to PM2.5: a global burden study from 1990 to 2019. *Environ Int.* (2021) 156:106725. doi: 10.1016/j.envint.2021.106725

8. Cao G, Cui Z, Ma Q, Wang C, Xu Y, Sun H, et al. Changes in health inequalities for patients with diabetes among middle-aged and elderly in China from 2011 to 2015. *BMC Health Serv Res.* (2020) 20:719. doi: 10.1186/s12913-020-05609-4

9. Wu Y, Ding Y, Tanaka Y, Zhang W. Risk factors contributing to type 2 diabetes and recent advances in the treatment and prevention. *Int J Med Sci.* (2014) 11:1185–200. doi: 10.7150/ijms.10001

10. Kautzky-Willer A, Harreiter J, Pacini G. Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocr Rev.* (2016) 37:278–316. doi: 10.1210/er.2015-1137

11. Tancredi M, Rosengren A, Svensson AM, Kosiborod M, Pivodic A, Gudbjornsdottir S, et al. Excess mortality among persons with type 2 diabetes. *N Engl J Med.* (2015) 373:1720–32. doi: 10.1056/NEJMoa1504347

12. Chatterjee S, Khunti K, Davies MJ. Type 2 diabetes. *Lancet.* (2017) 389:2239–51. doi: 10.1016/S0140-6736(17)30058-2

13. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. *Nat Rev Endocrinol.* (2018) 14:88–98. doi: 10.1038/nrendo.2017.151

14. Li G, Zhang P, Wang J, Gregg EW, Yang W, Gong Q, et al. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing diabetes prevention study: a 20-year follow-up study. *Lancet.* (2008) 371:1783–9. doi: 10.1016/S0140-6736(08)60766-7

15. Gong Q, Gregg EW, Wang J, An Y, Zhang P, Yang W, et al. Long-term effects of a randomised trial of a 6-year lifestyle intervention in impaired glucose tolerance on diabetes-related microvascular complications: the China Da Qing diabetes prevention outcome study. *Diabetologia.* (2011) 54:300–7. doi: 10.1007/s00125-010-1948-9

16. Gong Q, Zhang P, Wang J, Ma J, An Y, Chen Y, et al. Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the Da Qing diabetes prevention outcome study. *Lancet Diabetes Endocrinol.* (2019) 7:452–61. doi: 10.1016/S2213-8587(19)30093-2

17. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med.* (2002) 346:393–403. doi: 10.1056/NEJMoa012512

18. Ojo O. Dietary intake and type 2 diabetes. *Nutrients.* (2019) 11:2177. doi: 10.3390/nu11092177

19. Yu CG, Fu Y, Fang Y, Zhang N, Sun RX, Zhao D, et al. Fighting type-2 diabetes: present and future perspectives. *Curr Med Chem.* (2019) 26:1891–907. doi: 10.2174/0929867324666171009115356

20. Gloyn AL, Drucker DJ. Precision medicine in the management of type 2 diabetes. *Lancet Diabetes Endocrinol.* (2018) 6:891–900. doi: 10.1016/S2213-8587(18)30052-4

21. Yuksel M, Bektas H. Compliance with treatment and fear of hypoglycaemia in patients with type 2 diabetes. *J Clin Nurs.* (2021) 30:1773–86. doi: 10.1111/jocn.15736

22. Zkaptan BB, Kapucu S, Demirci N. Relationship between adherence to treatment and acceptance of illness in patients with type 2 diabetes. *Cukurova Med J.* (2019) 3:25–8.

23. American Diabetes A. Standards of medical care in diabetes-2018 abridged for primary care providers. *Clin Diabetes.* (2018) 36:14–37. doi: 10.2337/cd17-0119

24. Bussell JK, Cha E, Grant YE, Schwartz DD, Young LA. Ways health care providers can promote better medication adherence. *Clin Diabetes.* (2017) 35:171–7. doi: 10.2337/cd016-0029

25. Fitzgerald JT, Davis WK, Connell CM, Hess GE, Funnell MM, Hiss RG. Development and validation of the diabetes care profile. *Eval Health Prof.* (1996) 19:208–30. doi: 10.1177/016327879601900205

26. Lee NP, Fisher WP Jr. Evaluation of the diabetes self-care scale. *J Appl Meas.* (2005) 6:366–81.

27. Stetson B, Schlundt D, Rothschild C, Floyd JE, Rogers W, Mokshagundam SP. Development and validation of the personal diabetes questionnaire (PDQ): a measure of diabetes self-care behaviors, perceptions and barriers. *Diabetes Res Clin Pract.* (2011) 91:321–32. doi: 10.1016/j.diabres.2010.12.002

28. Toobert DJ, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measure: results from seven studies and a revised scale. *Diabetes Care.* (2000) 23:943–50. doi: 10.2337/diacare.23.7.943

29. Fisher WA, Fisher JD, Harman J. The information-motivation-behavioral skills model: A general social psychological approach to understanding and promoting health behavior. In: Suls J, Wallston KA, editors. *Social Psychological Foundations of Health and Illness*. Hoboken, NJ: John Wiley and Sons (2003). p. 82–106. doi: 10.1002/9780470753552.ch4

30. Jeon E, Park HA. Development of the IMB model and an evidence-based diabetes self-management mobile application. *Healthc Inform Res.* (2018) 24:125–38. doi: 10.4258/hir.2018.24.2.125

31. Motahari-Tabari NS, Nasiri-Amiri F, Faramarzi M, Shirvani MA, Bakhtiari A, Omidvar S. The effectiveness of information-motivation-behavioral skills model on self-care practices in early pregnancy to prevent gestational diabetes mellitus in iranian overweight and obese women: a randomized controlled trial. *Int Q Community Health Educ.* (2021) 3:272684X211020300. doi: 10.21203/rs.2.24420/v2

32. Nelson LA, Wallston KA, Kripalani S, LeStourgeon LM, Williamson SE, Mayberry LS. Assessing barriers to diabetes medication adherence using the information-motivation-behavioral skills model. *Diabetes Res Clin Pract.* (2018) 142:374–84. doi: 10.1016/j.diabres.2018.05.046

33. Qin ZY, Yan JH, Yang DZ, Deng HR, Yao B, Weng JP, et al. Behavioral analysis of chinese adult patients with type 1 diabetes on self-monitoring of blood glucose. *Chinese Med J-Peking.* (2017) 130:39–44. doi: 10.4103/0366-6999.196574

34. Chen Q, Wang H, Wang Y, Wang Z, Zhao D, Cai Y. Exploring effects of self-management on glycemic control using a modified information-motivation-behavioral skills model in type 2 diabetes mellitus patients in Shanghai, China: A cross-sectional study. *J Diabetes.* (2018) 10:734–43. doi: 10.1111/1753-0407.12655

35. Si M, Jiang Y, Su X, Wang W, Zhang X, Gu X, et al. Willingness to accept human papillomavirus vaccination and its influencing factors using information-motivation-behavior skills model: a cross-sectional study of female college freshmen in mainland China. *Cancer Control.* (2021) 28:10732748211032899. doi: 10.1177/10732748211032899

36. Wang H, Huang YM, Su XY, Xiao WJ, Si MY, Wang WJ, et al. Acceptance of the COVID-19 vaccine based on the health belief model: a multicenter national survey among medical care workers in China. *Hum Vaccin Immunother.* (2022) 5:2076523. doi: 10.1080/21645515.2022.2076523

37. MacCallum RC, Browne MW, Sugawara HM. *Power Analysis and Determination of Sample Size for Covariance Structure Modeling*. US: American Psychological Association (1996). doi: 10.1037/1082-989X.1.2.130

38. Chinese Elderly Type 2 Diabetes P, Treatment of Clinical Guidelines Writing G, Geriatric E, Metabolism Branch of Chinese Geriatric S, Geriatric E, Metabolism Branch of Chinese Geriatric Health Care S. Clinical guidelines for prevention and treatment of type 2 diabetes mellitus in the elderly in China (2022 edition). *Zhonghua Nei Ke Za Zhi.* (2022) 61:12–50. doi: 10.3760/cma.j.cn112138-20211027-00751

39. Hair JF, Black WC, Babin BJ, Anderson RE. *Multivariate Data Analysis*. Cengage Learning (2019).

40. Flora DB, Curran PJ. An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychol Methods.* (2004) 9:466–91. doi: 10.1037/1082-989X.9.4.466

41. Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. *J Mark Res.* (1981) 18:39–50. doi: 10.1177/002224378101800104

42. Li C. Yu-ning W, Xiao-mei L. The reliability and validity of Chinese version of the personal diabetes questionnaire. *Chin J Nurs.* (2014) 49:734–8. doi: 10.3761/j.issn.0254-1769.2014.06.024

43. Ausili D, Bulgheroni M, Ballatore P, Specchia C, Ajdini A, Bezze S, et al. Self-care, quality of life and clinical outcomes of type 2 diabetes patients: an observational cross-sectional study. *Acta Diabetol.* (2017) 54:1001–8. doi: 10.1007/s00592-017-1035-5

44. Weisman A, Fazli GS, Johns A, Booth GL. Evolving trends in the epidemiology, risk factors, and prevention of type 2 diabetes: a review. *Can J Cardiol.* (2018) 34:552–64. doi: 10.1016/j.cjca.2018.03.002

45. Kline RB. *Principles and Practice of Structural Equation Modeling*. New York: Guilford Press (2016).

46. Peng X, Guo X, Li H, Wang D, Liu C, Du Y, et al. Qualitative exploration of self-management behaviors and influencing factors in patients with type 2 diabetes. *Front Endocrinol.* (2022) 13:771293. doi: 10.3389/fendo.2022.771293

47. Chen L, Chuang LM, Chang CH, Wang CS, Wang IC, Chung Y, et al. Evaluating self-management behaviors of diabetic patients in a telehealthcare program: longitudinal study over 18 months. *J Med Internet Res.* (2013) 15:e266. doi: 10.2196/jmir.2699

48. Al-Qazaz HK, Sulaiman SA, Hassali MA, Shafie AA, Sundram S, Al-Nuri R, et al. Diabetes knowledge, medication adherence and glycemic control among patients with type 2 diabetes. *Int J Clin Pharm-Net.* (2011) 33:1028–35. doi: 10.1007/s11096-011-9582-2

49. Meunier S, Coulombe S, Beaulieu MD, Cote J, Lesperance F, Chiasson JL, et al. Longitudinal testing of the information-motivation-behavioral skills model of self-care among adults with type 2 diabetes. *Patient Educ Couns.* (2016) 99:1830–6. doi: 10.1016/j.pec.2016.06.011

50. Gao JL, Wang JL, Zhu YC, Yu JM. Validation of an information-motivation-behavioral skills model of self-care among Chinese adults with type 2 diabetes. *Bmc Public Health.* (2013) 13:100. doi: 10.1186/1471-2458-13-100

51. Austin S, Guay F, Senecal C, Fernet C, Nouwen A. Longitudinal testing of a dietary self-care motivational model in adolescents with diabetes. *J Psychosom Res.* (2013) 75:153–9. doi: 10.1016/j.jpsychores.2013.04.013

52. Ferrari M, Speight J, Beath A, Browne JL, Mosely K. The information-motivation-behavioral skills model explains physical activity levels for adults with type 2 diabetes across all weight classes. *Psychol Health Med.* (2021) 26:381–94. doi: 10.1080/13548506.2020.1749292

53. Osborn CY, Egede LE. Validation of an Information-Motivation-Behavioral Skills model of diabetes self-care (IMB-DSC). *Patient Educ Couns.* (2010) 79:49–54. doi: 10.1016/j.pec.2009.07.016

54. Yao JJ, Wang HP, Yin X, Yin J, Guo XL, Sun Q. The association between self-efficacy and self-management behaviors among Chinese patients with type 2 diabetes. *PLoS ONE.* (2019) 14:4869. doi: 10.1371/journal.pone.0224869

55. Fisher JD, Fisher WA, Amico KR, Harman JJ. An information-motivation-behavioral skills model of adherence to antiretroviral therapy. *Health Psychol.* (2006) 25:462–73. doi: 10.1037/0278-6133.25.4.462

56. Qiu TY, Huang J, Wang WX. Association between Diabetes knowledge and self-efficacy in patients with type 2 diabetes mellitus in china: a cross-sectional study. *Int J Endocrinol.* (2020) 3:2020. doi: 10.1155/2020/2393150

57. Jia H, Wang X, Cheng J. Knowledge, attitudes, and practices associated with diabetic foot prevention among rural adults with diabetes in North China. *Front Public Health.* (2022) 10:876105. doi: 10.3389/fpubh.2022.876105

58. Wang Q, Zhang X, Fang L, Guan Q, Guan L, Li Q. Prevalence, awareness, treatment and control of diabetes mellitus among middle-aged and elderly people in a rural Chinese population: a cross-sectional study. *PLoS ONE.* (2018) 13:e0198343. doi: 10.1371/journal.pone.0198343

59. Yao J, Wang H, Yin J, Shao D, Guo X, Sun Q, et al. Factors associated with the utilization of community-based diabetes management care: a cross-sectional study in Shandong Province, China. *BMC Health Serv Res.* (2020) 20:407. doi: 10.1186/s12913-020-05292-5

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 24 February 2023
DOI 10.3389/fpubh.2023.1092892

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 08 November 2022
ACCEPTED 31 January 2023
PUBLISHED 24 February 2023

CITATION
Mei X, Chen G, Zuo Y, Wu Q, Li J and Li Y (2023) Changes in the health literacy of residents aged 15–69 years in central China: A three-round cross-sectional study. *Front. Public Health* 11:1092892. doi: 10.3389/fpubh.2023.1092892

Changes in the health literacy of residents aged 15–69 years in central China: A three-round cross-sectional study

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Introduction: Health literacy is an effective strategy to promote more cost-effective use of health care services and a crucial tool for preventing the spread of infectious diseases. The main objective of this study was to analyze changes in health literacy from 2019 to 2021.

Methods: Data were from the latest three-round cross-sectional studies with the same study design.

Results: Although the prevalence of adequate health literacy rose significantly over time, increasing from 26.9% (95% CI 20.1–33.7) in 2019 to 34.1% (32.9–35.3) in 2021, it was still at a relatively low level. The most significant decrease was observed for health skills among the three aspects and health information literacy among the six dimensions. Working as medical staff was a protective factor for adequate health literacy, health skills literacy, and health information literacy. Risk factors for adequate health literacy and health information literacy were older age and lower education level. Furthermore, adequate health information literacy was positively related to annual family income.

Discussion: More practical and effective policies targeting health literacy for critical aspects and groups in Central China, are urgently needed, especially during the epidemic.

KEYWORDS

health literacy, changing trend, prevalence, healthcare, COVID-19

Introduction

As defined by the U.S. National Library of Medicine and the World Health Organization (WHO), health literacy refers to the ability to obtain, understand, and process basic health information and services and use them to make sound health-related decisions to maintain and promote health (1, 2). Health literacy is an essential factor affecting health and a strong predictor of the population's health status (3). Studies have shown that limited health literacy is not only related to adverse health behaviors such as smoking, alcoholism, low physical activity, difficulty communicating with doctors, and poor adherence to medicines prescribed by doctors but also closely related to adverse health outcomes such as hypertension, diabetes, stroke, and high mortality (4–8). Limited health literacy will also lead to increased medical expenses and waste of healthcare services (9). Thus, improving health literacy can be an effective strategy to promote more cost-effective use of healthcare services, contributing to the ultimate goal of primary healthcare and improving the population's health (10–14).

Therefore, the international emphasis on health literacy is increasing (15–17). Health literacy has become a research hotspot in clinical medicine, health education, and health promotion (18, 19). Research on health literacy is mainly based on two perspectives: the clinical perspective (20) and the public health perspective (21).

Research on health literacy in North American and European countries mainly focuses on the clinical perspective (20, 21). With the development of the health literacy evaluation system, many countries have successively launched health literacy surveys. The setting for these studies has been expanded from patients to the general public, and the measurement content has expanded from the clinical context to disease prevention, healthcare, and health promotion (22).

From the perspective of public health, the impact of health literacy on disease prevention, healthy lifestyle and behavior, and maintenance and promotion of health was studied in China (23). The National Health Commission of China released the educational book "Health Literacy of Chinese Citizens-Basic Knowledge and Skills (Trial)" and organized the first national health literacy survey in 2008 (24). In 2010, the China Health Education Center studied the evaluation system of health literacy, with the educational book as the evaluation content, and compiled the Chinese Health Literacy Survey Questionnaire (CHLSQ) (25). Since 2012, China has carried out scientific and continuous health literacy monitoring. Focusing on basic knowledge and concepts, healthy lifestyle and behavior, and health skills, a health literacy monitoring system for permanent residents aged 15–69 has gradually been established in China (23).

Although the definitions, measurement instruments, evaluation perspectives, and survey methods of health literacy are different in different countries or regions, many surveys have come to the same conclusion: Globally, health literacy needs to be improved (26, 27). The National Assessment of Adult Literacy (NAAL) found that 88% of adults do not have sufficient health literacy in the USA (26). A systematic review indicated that the prevalence of low health literacy ranged from 27 to 48% in Europe (27). The Chinese national health literacy survey showed that the prevalence of adequate health literacy among residents aged 15–69 was only 19% (28).

On 31 January 2020, the WHO declared the COVID-19 outbreak a Public Health Emergency of International Concern (17). The pandemic posed a considerable threat to human health (29, 30). Health literacy is a crucial determinant of health at both the social and individual levels, in healthy populations and with diverse infectious diseases (31), which is also a crucial tool for preventing the spread of infectious diseases (32).

Previous studies have highlighted the significance of health literacy for the outcomes of infectious diseases and the role that health literacy plays regarding infectious diseases (33, 34). People with low health literacy may not obtain adequate health knowledge on time and cannot implement protective behaviors, such as the adoption of immunization, to prevent infectious diseases (33). Therefore, it is significant to study the changes in the health literacy level and its determinants during this time. However, we found few studies describing the changes in health literacy during the pandemic.

Wuhan is located in central China, with a permanent population of 13.6 million (35). The main objective of this study was to analyze, based on three-wave city-level representative data among 15- to 69-year-old permanent residents in Wuhan, China, levels and changes in health literacy from 2019 to 2021 and the relationship between health literacy and related factors.

Materials and methods

Study population

The China Health Literacy Survey (CHLS) is a nationally representative household survey of the permanent population aged 15–69 (36). In conjunction with the CHLS, the Wuhan Health Literacy Survey (WHLS) aimed to provide data necessary to estimate health literacy since 2016 at the 1-year interval. The WHLS is a cross-sectional survey using the CHLS standardized protocol and questionnaire. We based our study on the latest three rounds (conducted from August to November 2019, 2020, and 2021) of the WHLS. The processes and sampling design of the survey were reviewed and approved by the Institutional Review Board (IRB) of Wuhan CDC (WHCDCIRB-K-2019016). All study participants provided electronic informed consent. All collected data were anonymous and self-administered.

Sampling method

The sample size was calculated by the formula $N = \frac{\mu_\alpha^2 \times p(1-p)}{\delta^2} \times deff$, where α was the significance level, μ_α was the α-quantile of the standard normal distribution, p was the health literacy level, δ was the maximum permissible error, and $deff$ was the design effect of complex sampling. Considering the rate of invalid questionnaires and rejections, the final sample size is expected to be calculated. The sampling procedure involved five stages to ensure the representativeness of the selected study population. First, the simple random sampling (SRS) method was used to select several administrative districts (six in 2019 and 2020 and five in 2021) from the 15 districts in Wuhan. Second, the SRS method was used in each administrative district to select several streets (four in 2019 and 2021 three in 2020). Third, the SRS method was used in each street to select several neighborhood committees (three in 2019 and 2021 and two in 2020). Fourth, the SRS method was used in each neighborhood committee to select several households (55 in 2019, 85 in 2020, and 80 in 2021). Fifth, one resident was selected from each household using the KISH method, and a certain number of questionnaires were completed in each neighborhood committee (40 in 2019, 70 in 2020, and 52 in 2021).

Measurement instrument

The CHLSQ, as compiled by the China Health Education Center (36), was used to measure health literacy. The questionnaire has strong internal consistency and split-half reliability (23),

which consists of two parts: sociodemographic characteristics and health literacy content (a total of 50 items). The 50 items include eight true-or-false questions, 23 single-choice questions, 15 multiple-choice questions, and four situational questions (including three single and one multiple-choice questions). The 50-item health literacy is further categorized into three aspects and six dimensions. Based on the knowledge, attitude, practice (KAP) theory, the three aspects of literacy are basic knowledge and concept literacy, healthy lifestyles and behavior literacy, and health skill literacy (25). Guided by public health problems, the six dimensions of literacy are scientific views of health, infectious disease literacy, chronic disease literacy, safety and first aid literacy, medical care literacy, and health information literacy (24).

The total score of 50 items ranged from 0 to 66 points, with one point for every true-or-false and every single-choice question and two points for every multiple-choice question. Moreover, every wrong or missing choice received 0 points. The total scores of the three aspects were 28 (basic knowledge and concepts literacy, 22 items), 22 (healthy lifestyles and behavior literacy, 16 items), and 16 (health skill literacy, 12 items) points. The maximum total scores for the six dimensions of literacy were 11 points (scientific views of health, eight items), seven points (infectious disease literacy, six items), 12 points (chronic disease literacy, nine items), 14 points (safety and first aid literacy, ten items), 14 points (medical care literacy, 11 items), and eight points (health information literacy, six items).

Adequate health literacy is defined as when participants achieve more than 80% of the total score (53–66 points), and limited health literacy is defined as when participants score $<80\%$ of the total score (0–52 points) (24, 25). The judgment criterion for adequate health literacy in each aspect or dimension was $\geq 80\%$ of the total score for the aspect or dimension. Health literacy level was defined as the proportion of participants who had adequate health literacy out of the total number of participants, as was the health literacy level of the three aspects and six dimensions (37).

Survey method

Before the fieldwork, the neighborhood committee issued an investigation announcement about the purpose of the study to encourage residents to participate. In the investigation, face-to-face interviews were conducted at each participant's home or in other public places at their convenience. A portable tablet was used to complete electronic questionnaires. If participants could not complete the questionnaire, the investigators would neutrally interview them as an alternative to completing the questionnaire on behalf of the participants. In addition, participants were sent small gifts as an incentive for participating. If the individuals were already participants, they could withdraw at any time without penalty or loss of benefits. Strict quality control was applied to the whole investigative process. Two training sessions were held, and all staff participated and passed the on-site exams. The investigator complied with the investigation guidelines during all processes.

Statistical analysis

We used the following independent variables drawn from the literature in our analysis: (21, 24, 25, 38) sociodemographic characteristics (i.e., gender, age, marital status, education level, occupation, and annual family income) and self-reported health status (Supplementary Table 1).

Data cleansing rules were created to ensure accuracy and eliminate internal inconsistencies. The sampling weight was considered since the survey adopted a multi-stage sampling procedure. The three waves of data were weighted: calculation of the sampling weight, non-response adjustment, and poststratification calibration adjustment of the sample totals to the known population totals. All of the analyses were based on a complex survey design. Rao-Scott chi-square tests were used to compare the differences in health literacy among subgroups in bivariate analyses. Cochran–Armitage trend tests were used to measure trends in health literacy over time. Multivariable logistic regression analysis was conducted to identify the risk factors related to adequate health literacy. A two-sided 5% significance level assessed statistical inferences. Data cleaning, weighting, and analysis were conducted using SAS software version 9.4 (SAS Institute Inc. Cary, NC).

Results

Participant characteristics

Table 1 shows descriptive statistics of the study population over time. A total of 2,880 individuals in 2019, 2,520 individuals in 2020, and 3,120 individuals in 2021 were invited to participate in the survey, with effective response rates of 94.7% in 2019 (2,544 individuals), 95.3% in 2020 (2,295 individuals), and 99.0% in 2021 (3,088 individuals).

The unweighted average ages in 2019, 2020, and 2021 were 46.9 ± 13.4, 49.5 ± 13.7, and 47.8 ± 13.9, respectively. The male:female ratios in 2019, 2020, and 2021 were 0.95:1, 0.94:1, and 0.93:1, respectively. No statistically significant difference was found in the gender or age composition of the participants among the different years.

Bivariate analysis of health literacy level with variables of sociodemographic characteristics

As shown in Table 2, there were significant differences in health literacy level by age, education level, and occupation but not by gender or self-reported health status in 2019, 2020, and 2021.

Trend analysis of health literacy, three aspects, and six dimensions of literacy over time

Table 2 shows the level and trend in health literacy for subgroups of sociodemographic characteristics. The prevalence of adequate health literacy in most subgroups showed a

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TABLE 1 Descriptive statistics of the study population over time ($n = 7,927$).

Characteristic	Survey year 2019 ($n = 2,544$)		Survey year 2020 ($n = 2,295$)		Survey year 2021 ($n = 3,088$)		P[c]
	n[a]	% (95%CI)[b]	n[a]	% (95%CI)[b]	n[a]	% (95%CI)[b]	
Gender							
Male	1,238	51.3 (45.5–57.1)	1,110	51.3 (44.3–58.3)	1,492	51.3 (47.2–55.4)	
Female	1,306	48.7 (42.9–54.5)	1,185	48.7 (41.7–55.7)	1,596	48.7 (44.6–52.8)	
Age, years							
15–29	281	38.0 (32.7–43.4)	202	38.0 (28.8–47.2)	352	38.0 (30.6–45.4)	
30–44	830	28.2 (21.9–34.5)	629	28.2 (21.6–34.8)	889	28.2 (24.8–31.6)	
45–59	841	25.1 (19.2–31.1)	794	25.1 (16.8–33.4)	1,082	25.1 (20.8–29.5)	
60–69	592	8.7 (5.4–11.9)	670	8.7 (4.5–12.8)	765	8.7 (4.8–12.6)	
Marital status							<0.001
Unmarried	249	26.2 (18.2–34.3)	203	24.3 (14.5–34.0)	401	30.1 (22.8–37.5)	
Married	2,160	70.8 (61.7–80.0)	1,953	73.3 (63.6–83.0)	2,479	66.4 (59.4–73.5)	
Divorced/Widowed	135	2.9 (1.0–4.9)	139	2.5 (1.0–3.9)	208	3.4 (2.8–4.1)	
Education level							<0.001
College or above	790	43.5 (22.2–64.9)	688	48.0 (29.5–66.5)	1,011	46.8 (24.7–68.8)	
Senior high school and below	1,754	56.5 (35.1–77.8)	1,607	52.0 (33.5–70.5)	2,077	53.2 (31.2–75.3)	
Occupation							<0.001
Medical staff	47	2.3 (0.8–3.8)	53	3.0 (0.4–5.5)	69	2.7 (0.8–4.6)	
Civil servant/teacher	136	4.7 (1.4–7.9)	62	2.9 (1.1–4.7)	61	2.2 (1.2–3.1)	
Farmer/worker	788	18.5 (4.9–32.0)	829	23.4 (0.0–47.4)	943	24.1 (0.0–50.5)	
Others	1,573	74.6 (63.5–85.6)	1,351	70.7 (46.4–95.0)	2,015	71.0 (46.3–95.8)	
Annual family income (CNY)[d]							<0.001
≥100,000	1,084	48.6 (25.4–71.8)	779	49.5 (26.2–72.8)	1,184	45.0 (24.8–65.2)	
<100,000	1,460	51.4 (28.2–74.6)	1,516	50.5 (27.2–73.8)	1,904	55.0 (34.8–75.2)	
Self-reported health status							<0.001
Good	1,816	76.5 (67.6–85.3)	1,798	86.0 (81.0–91.0)	2,478	86.2 (81.8–90.7)	
Medium	658	21.4 (13.7–29.1)	450	12.7 (8.3–17.2)	518	11.7 (8.6–14.8)	
Poor	70	2.2 (0.8–3.5)	47	1.3 (0.2–2.4)	92	2.0 (0.3–3.7)	
Health literacy							<0.001
Limited (40–52 points)	1,948	73.1 (66.3–79.9)	1,648	66.4 (59.5–73.3)	2,175	65.9 (64.7–67.1)	
Adequate (53–66 points)	596	26.9 (20.1–33.7)	647	33.6 (26.7–40.5)	913	34.1 (32.9–35.3)	

[a]Unweight frequency. [b]Weighted percentage. 95% CI, 95% confidence interval. [c]On the basis of chi-square tests. [d]CNY, Chinese Yuan; 1 US dollars, 6.7 Chinese yuan.

significant upward trend, but the subgroup of poor self-reported health status showed a significant downward trend from 2019 to 2021.

The level and trend of health literacy, the three aspects, and the six dimensions of literacy over time are presented in Table 3. The prevalence of adequate health literacy rose significantly over time, increasing from 26.9% (95% CI 20.1–33.7) in 2019 to 34.1% (32.9–35.3) in 2021.

In 2021, the lowest prevalence of adequate health literacy of the three aspects was for health skills; the lowest prevalence of the six dimensions was for medical care literacy.

In the trend analysis, the most significant increase was observed for healthy lifestyles and behavior (increased 39% in 2020 and 48% in 2021) among the three aspects and infectious disease literacy (increased 101% in 2020 and 99% in 2021) among the six dimensions; the most significant decrease was observed for health skills (decreased 15% in 2021) among the three aspects and health information literacy (decreased 13% in 2021) among the six dimensions.

TABLE 2 Factors related to adequate health literacy (AHL) over time—results of bivariate analyses and trend analysis (weighted).

Characteristic	AHL (Survey year 2019)		AHL (Survey year2020)		AHL (Survey year 2021)		Z	P^b for Trend
	%(95%CI)	P^a	%(95%CI)	P^a	%(95%CI)	P^a		
Gender		0.914		0.225		0.725		
Male	26.8 (19.3–34.3)		35.3 (26.0–44.6)		33.6 (28.7–38.5)		212.172	<0.001
Female	27.0 (20.1–34.0)		31.8 (25.7–37.8)		34.7 (30.6–38.7)		235.174	<0.001
Age, years		<0.001		<0.001		<0.001		
15–29	31.8 (18.5–45.0)		36.7 (26.4–47.0)		38.4 (34.0–42.7)		172.675	<0.001
30–44	29.6 (25.1–34.1)		41.5 (30.5–52.6)		36.9 (30.2–43.5)		164.221	<0.001
45–59	21.3 (15.7–27.0)		23.7 (16.6–30.9)		30.8 (23.1–38.4)		221.557	<0.001
60–69	13.2 (7.8–18.6)		22.7 (13.3–32.2)		16.4 (11.9–21.0)		51.455	<0.001
Marital status		0.625		0.022		0.041		
Unmarried	28.5 (16.4–40.7)		32.0 (22.0–42.0)		38.7 (32.2–45.2)		233.494	<0.001
Married	26.5 (21.4–31.6)		34.6 (28.3–40.9)		32.5 (28.1–37.0)		223.990	<0.001
Divorced/Widowed	23.2 (7.6–38.8)		18.8 (6.1–31.5)		25.6 (20.3–30.9)		22.414	<0.001
Education level		<0.001		0.042		0.001		
College or above	37.2 (24.4–50.0)		40.3 (35.8–44.8)		44.5 (38.6–50.5)		204.254	<0.001
Senior high school and below	19.0 (12.3–25.7)		27.4 (14.0–40.8)		25.0 (15.8–34.2)		216.982	<0.001
Occupation		<0.001		<0.001		<0.001		
Medical staff	63.0 (34.7–91.2)		63.5 (54.5–72.4)		72.0 (46.8–97.2)		63.337	<0.001
Civil servant/teacher	39.4 (20.2–58.5)		60.2 (27.0–93.4)		40.4 (11.4–69.4)		42.213	<0.001
Farmer/worker	19.1 (12.8–25.4)		22.9 (13.3–32.5)		29.1 (23.7–34.5)		220.361	<0.001
Others	26.9 (21.0–32.9)		34.8 (26.6–43.0)		34.2 (30.9–37.5)		272.719	<0.001
Annual family income (CNY)[c]		0.003		0.001		0.178		
≥100,000	32.7 (30.3–35.1)		42.2 (31.3–53.1)		36.8 (33.4–40.1)		123.490	<0.001
<100,000	21.5 (10.8–32.1)		25.2 (17.0–33.3)		32.0 (25.9–38.0)		354.688	<0.001
Self-reported health status		0.699		0.636		0.067		
Good	27.6 (19.9–35.4)		33.3 (26.0–40.6)		35.3 (34.9–35.7)		297.991	<0.001
Medium	24.4 (17.2–31.6)		36.5 (21.8–51.2)		27.5 (17.5–37.6)		88.458	<0.001
Poor	27.0 (0.0–58.7)		24.8 (5.8–43.8)		22.6 (0.0–45.5)		−29.843	<0.001

AHL, adequate health literacy. [a]Based on chi-square tests for comparing the proportion of adequate health literacy across groups. [b]Based on Cochran–Armitage tests for comparing the changing trend of adequate health literacy across subgroups. [c]CNY, Chinese Yuan; 1 US dollars, 6.7 Chinese yuan.

Multivariable logistic regression analysis of health literacy, health skill literacy, and health information literacy

As the most significant decrease was observed for health skills among the three aspects and health information literacy of the six dimensions, they were also included in the multivariable logistic regression analysis along with health literacy (Table 4).

Compared to 2021, the odds of adequate health literacy were significantly lower in 2019. Working as medical staff was a protective factor for adequate health literacy, health skill literacy, and health information literacy compared with other occupations. Risk factors for adequate health literacy and health information literacy were older age (45–69) and lower education level (senior high school and below). Risk factors for adequate health skill literacy were older age (60–69). Furthermore, adequate health information literacy was positively related to annual family income.

Discussion

This is the first study describing the changes over time in health literacy in Wuhan, central China, based on representative three-time-series survey data. We observed that the prevalence of adequate health literacy rose significantly over time, increasing from 26.9% (95% CI 20.1–33.7) in 2019 to 34.1% (32.9–35.3) in 2021. Although the prevalence showed the same upward trend as a previous study (37) and is slightly higher than that of the Chinese national level (25.4%) (39), it is still at a relatively low level, similar

TABLE 3 Adequate health literacy, three aspects, and six dimensions of literacy in total and subgroup population over time—results of trend analysis (weighted) (95% CI).

	Survey year 2021	Survey year 2020	Survey year 2019	Z	P[a] for Trend
Health literacy	34.1 (32.9–35.3)	33.6 (26.7–40.5)	26.9 (20.1–33.7)	316.001	<0.001
Three aspects					
Basic knowledge and concepts	46.3 (42.1–50.5)	39.6 (27.2–52.0)	45.8 (32.4–59.1)	23.539	<0.001
Healthy lifestyles and behavior	41.1 (36.4–45.7)	38.7 (30.5–46.8)	27.8 (19.7–36.0)	561.653	<0.001
Health skills	26.5 (23.4–29.6)	29.6 (21.5–37.7)	31.1 (20.1–42.1)	−207.328	<0.001
Six dimensions					
Scientific views of health	57.3 (48.5–66.1)	55.9 (44.0–67.9)	59.7 (49.8–69.6)	−97.339	<0.001
Infectious disease literacy	39.4 (28.1–50.7)	39.9 (31.6–48.2)	19.8 (12.9–26.7)	848.035	<0.001
Chronic disease literacy	37.5 (32.5–42.5)	32.7 (25.1–40.2)	37.2 (26.8–47.5)	13.836	<0.001
Safety and first aid literacy	61.4 (50.2–72.7)	61.3 (50.2–72.4)	64.6 (53.1–76.2)	−134.418	<0.001
Medical care literacy	34.2 (26.3–42.1)	34.4 (24.6–44.3)	27.8 (17.1–38.5)	277.968	<0.001
Health information literacy	39.8 (29.5–50.2)	44.2 (35.5–53.0)	45.9 (30.5–61.3)	−249.012	<0.001

[a]Based on Cochran–Armitage tests, comparing changing trend of adequate health literacy in the total population and age subgroups.

to American and European countries (26, 27). The significant rise may be mainly related to economic and social development, the in-depth development of health education and health promotion, and the people's close attention to and urgency regarding health during the COVID-19 epidemic (24, 37, 40, 41).

In 2021, the highest prevalence of adequate health literacy among the three aspects was for basic knowledge and concepts, and the lowest was for health skills. The prevalence of adequate health literacy for healthy lifestyles and behaviors has risen rapidly, and health skills have shown a significant downward trend. In recent years, healthy lifestyle actions have been vigorously carried out, and knowledge of infectious diseases has been spread, effectively promoting healthy behavior (42). Health education should focus on behavioral intervention and health skill training in the future.

In 2021, the lowest prevalence among the six dimensions was medical care literacy. Residents who lack medical care literacy may not be able to access and understand basic health information and services and cannot effectively utilize the complex healthcare system when they seek treatment (2, 10). From the perspective of trend changes, the most significant increase was observed for infectious disease literacy among the six dimensions. It may be that the government and health departments paid more attention to educating the public about infectious disease prevention and control due to the COVID-19 epidemic (30). Against this background, people not only knew about virus transmission routes but also knew how to engage in effective preventive behaviors such as hand washing, mask-wearing, household ventilation and disinfection, and reduced interpersonal contact by avoiding visiting crowded spaces (42, 43). In addition, the prevalence of adequate literacy of the six dimensions for scientific views of health, safety and first aid, and health information showed a downward trend from 2019 to 2021, and health information literacy declined the most. Therefore, health education in Wuhan should focus on the aforementioned dimensions of literacy.

In multivariable logistic regression analysis, working as the medical staff was a protective factor for adequate health literacy, health skill literacy, and health information literacy compared with other occupations, which is in line with the characteristics of an occupation engaged in the medical and healthcare industries (23, 24, 44). The education level, knowledge reserve, and information acquisition channels of medical staff are better than those of other occupations. This study also showed that the prevalence of health literacy of residents who reported poor health status showed a significant downward trend from 2019 to 2021, indicating that medical staff can be used to carry out health education of residents with poor health status seeking treatment, to improve their health literacy in a targeted manner.

Risk factors for adequate health literacy and health information literacy were older age and lower education level, consistent with previous studies (24, 25, 37, 45). This may be due to the following reasons: the cognitive ability, learning ability, and memory of elderly people decline, and their ability to accept new knowledge is relatively poor, directly leading to the poor acquisition of health knowledge and skills and limited health literacy; well-educated individuals are more likely to seek beneficial information and medical care and can communicate effectively with healthcare workers (46). In addition, adequate health information literacy was positively related to annual family income, consistent with previous studies (21, 38, 47). This may be because a good economic situation positively affects the acquisition of health information and the utilization of healthcare resources. This indicates that targeted health education and health promotion should be strengthened, focusing on residents with older ages, lower education levels, and lower annual family incomes.

Our study has several limitations that can be improved in further research. First, the study design was cross-sectional, and no causal relationships could be made. Second, some factors, such as health behaviors, and health service quality were not assessed. Third, we obtained data from self-reported items, which are prone to bias. Finally, our research population consisted of permanent residents aged 15–69, and some groups were not included, which should be further studied.

10.3389/fpubh.2023.1092892

TABLE 4 Multivariable logistic regression analysis of factors related to health literacy, health skill literacy, and health information literacy (weighted).

Variables	Health literacy		Health skills literacy		Health information literacy	
	OR (95% CI)[a]	*P*	OR (95% CI)[a]	*P*	OR (95% CI)[a]	*P*
Year						
2021	Ref		ref		ref	
2020	0.9 (0.7–1.3)	0.691	1.1 (0.8–1.7)	0.528	1.2 (0.7–1.9)	0.510
2019	0.7 (0.5–0.9)	0.005	1.3 (0.9–1.9)	0.242	1.3 (0.8–2.1)	0.285
Gender						
Male	Ref		ref		ref	
Female	0.9 (0.8–1.1)	0.245	0.9 (0.7–1.1)	0.309	1.0 (0.9–1.1)	0.930
Age, years						
15–29	Ref		ref		ref	
30–44	0.9 (0.7–1.2)	0.575	1.0 (0.8–1.3)	0.905	0.9 (0.7–1.0)	0.131
45–59	0.7 (0.5–1.0)	0.024	0.7 (0.5–1.0)	0.083	0.7 (0.6–0.8)	<0.001
60–69	0.5 (0.3–0.7)	<0.001	0.5 (0.3–0.8)	0.003	0.5 (0.4–0.7)	<0.001
Marital status						
Unmarried	Ref		ref		ref	
Married	1.2 (0.9–1.7)	0.158	1.1 (0.8–1.5)	0.724	1.2 (0.9–1.5)	0.146
Divorced/Widowed	1.1 (0.7–1.8)	0.704	0.8 (0.6–1.2)	0.344	1.1 (0.8–1.5)	0.546
Education level						
College or above	Ref		ref		ref	
Senior high school and below	0.6 (0.4–0.9)	0.011	0.7 (0.5–1.1)	0.099	0.6 (0.5–0.8)	<0.001
Occupation						
Medical staff	Ref		ref		ref	
Civil servant/teacher	0.4 (0.2–0.7)	0.001	0.4 (0.2–0.6)	<0.001	0.5 (0.3–0.7)	<0.001
Farmer/worker	0.3 (0.2–0.4)	<0.001	0.3 (0.2–0.4)	<0.001	0.4 (0.2–0.6)	<0.001
Others	0.3 (0.2–0.4)	<0.001	0.3 (0.2–0.4)	<0.001	0.4 (0.2–0.6)	<0.001
Annual family income (CNY)[b]						
≥100,000	Ref		ref		ref	
<100,000	0.8 (0.5–1.0)	0.078	0.8 (0.6–1.2)	0.308	0.8 (0.6–1.0)	0.021
Self-reported health status						
Good	Ref		ref		ref	
Medium	1.1 (0.9–1.4)	0.297	1.0 (0.8–1.2)	0.991	1.0 (0.8–1.1)	0.582
Poor	1.0 (0.6–1.7)	0.984	1.1 (0.7–1.7)	0.705	0.7 (0.4–1.3)	0.295

[a]OR, odds ratio; 95% CI, 95% confidence interval; [b]CNY, Chinese Yuan; 1 US dollars, 6.7 Chinese yuan.

This is the first study to characterize the levels, changes, and factors related to health literacy among residents aged 15–69 from 2019 to 2021 in central China. Overall, although the prevalence of adequate health literacy rose significantly, increasing from 26.9% (95% CI 20.1–33.7) in 2019 to 34.1% (32.9–35.3) in 2021, it was still at a relatively low level. In the context of the COVID-19 epidemic, the prevalence of adequate infectious disease literacy rose rapidly, but health skills and health information literacy declined. The protective factor for adequate health literacy, health skill literacy, and health information literacy was working as medical staff, and the risk factors were older age, lower education level, and lower annual family income. Tailored health education and promotion strategies are needed for different subgroups of residents to improve health literacy, especially for health skills and health information literacy. At the same time, medical staff with adequate health literacy can effectively be used by providing health education for people who seek treatment with a poor health status to improve the health literacy of this population.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The datasets generated during and/or analyzed during the current study are not publicly available due to restrictions applied to the availability of these data but are available from the corresponding author on reasonable request. Requests to access these datasets should be directed to liyilin@whcdc.org.

Ethics statement

The processes and sampling design of the survey were reviewed and approved by the Institutional Review Board (IRB) of Wuhan CDC (WHCDCIRB-K-2019016). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

XM: conceptualization, formal analysis, investigation, data curation, and writing—reviewing and editing. GC, YZ, and QW: formal analysis, investigation, and writing—reviewing and editing. JL: conceptualization, methodology, writing—reviewing and editing, supervision, and project administration. YL: conceptualization, methodology, investigation, writing—reviewing and editing, supervision, and project administration. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors acknowledge and thank all the participants involved in the survey. The authors express their special thanks to the Center for Disease Prevention and Control involved in the survey in Wuhan, China. The research presented in this article is that of the authors and does not reflect the official policy of the Wuhan CDC.

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.2023.1092892/full#supplementary-material

References

1. National Library of Medicine. *An Introduction to Health Literacy*. (2022). https://nnlm.gov/guides/intro-health-literacy (accessed August 1, 2022).

2. World Health Organization. *Health Literacy Toolkit for Low- and Middle-Income Countries*. (2014). Available online at: https://www.who.int/publications/i/item/9789290224754 (accessed August 1, 2022).

3. U.S. National Library of Medicine. *Health Literacy*. (2022). Available online at: https://medlineplus.gov/healthliteracy.html#summary (accessed August 1, 2022).

4. Schaffler J, Leung K, Tremblay S, Belzile E, Lambrou A, Lambert SD, et al. The effectiveness of self-management interventions for individuals with low health literacy and/or low income: a descriptive systematic review. *J Gen Intern Med.* (2018) 33:510–23. doi: 10.1007/s11606-017-4265-x

5. Marciano L, Camerini AL, Schulz PJ. The role of health literacy in diabetes knowledge, self-care, and glycemic control: a meta-analysis. *J Gen Intern Med.* (2019) 34:1007–17. doi: 10.1007/s11606-019-04832-y

6. Waters EA, Biddle C, Kaphingst KA, Schofield E, Kiviniemi MT, Orom H, et al. Examining the interrelations among objective and subjective health literacy and numeracy and their associations with health knowledge. *J Gen Intern Med.* (2018) 33:1945–53. doi: 10.1007/s11606-018-4624-2

7. Muscat DM, Shepherd HL, Nutbeam D, Trevena L, Mccaffery KJ. Health literacy and shared decision-making: exploring the relationship to enable meaningful patient engagement in healthcare. *J Gen Intern Med.* (2021) 36:521–4. doi: 10.1007/s11606-020-05912-0

8. Chin J, Wang HP, Awwad AW, Graumlich JF, Wolf MS, Morrow DG. Health literacy, processing capacity, illness knowledge, and actionable memory for medication taking in type 2 diabetes: cross-sectional analysis. *J Gen Intern Med.* (2021) 36:1921–7. doi: 10.1007/s11606-020-06472-z

9. Liu LF, Huang J, Li GX, Chen Z, He TF. The economic costs of limited health literacy in China: evidence from China's national health literacy surveillance data. *BMC Health Serv Res.* (2022) 22:521. doi: 10.1186/s12913-022-07795-9

10. Vandenbosch J, Van den Broucke S, Vancorenland S, Avalosse H, Verniest R, Callens M. Health literacy and the use of healthcare services in Belgium. *J Epidemiol Commun H.* (2016) 70:1032–8. doi: 10.1136/jech-2015-206910

11. Dewalt DA, Broucksou KA, Broucksou KA, Hawk V, Baker DW, Schillinger D, et al. Relationship between literacy, knowledge, self-care behaviors, and heart failure-related quality of life among patients with heart failure. *J Gen Intern Med.* (2011) 26:979–86. doi: 10.1007/s11606-011-1668-y

12. Lindquist LA, Go L, Fleisher J, Jain N, Friesema E, Baker DW. Relationship of health literacy to intentional and unintentional non-adherence of hospital discharge medications. *J Gen Intern Med.* (2012) 27:173–8. doi: 10.1007/s11606-011-1886-3

13. Wu JR, Holmes GM, Dewalt DA, Macabasco-O'Connell A, Bibbins-Domingo K, Ruo B, et al. Low literacy is associated with increased risk of hospitalization and death among individuals with heart failure. *J Gen Intern Med.* (2013) 28:1174–80. doi: 10.1007/s11606-013-2394-4

14. Sanders K, Schnepel L, Smotherman C, Livingood WC, Dodani S, Antonios N, et al. Assessing the impact of health literacy on education retention of stroke patients. *Prev Chronic Dis.* (2014) 11:E55. doi: 10.5888/pcd11.130259

15. World Health Organization. *New Bangkok Charter for Health Promotion Adopted to Address Rapidly Changing Global Health Issues*. (2005). Available online at: https://www.who.int/news/item/11-08-2005-new-bangkok-charter-for-health-promotion-adopted-to-address-rapidly-changing-global-health-issues (accessed August 1, 2022).

16. World Health Organization. *9th Global Conference on Health Promotion: Global Leaders Agree to Promote Health in Order to Achieve Sustainable Development*

Goals. (2016). Available online at: https://www.who.int/news/item/21-11-2016-9th-global-conference-on-health-promotion-global-leaders-agree-to-promote-health-in-order-to-achieve-sustainable-development-goals (accessed August 1, 2022).

17. World Health Organization. *WHO Director-General's Statement on IHR Emergency Committee on Novel Coronavirus (2019-nCoV)*. (2020). Available online at: https://www.who.int/director-general/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-(2019-ncov) (accessed August 1, 2022).

18. Brach C, Harris LM. Healthy people 2030 health literacy definition tells organizations: make information and services easy to find, understand, and use. *J Gen Intern Med*. (2021) 36:1084–5. doi: 10.1007/s11606-020-06384-y

19. Curtis LM, Kwasny MJ, Opsasnick L, O'Conor RM, Yoshino-Benavente J, Eifler M, et al. Change in health literacy over a decade in a prospective cohort of community-dwelling older adults. *J Gen Intern Med*. (2021) 36:916–22. doi: 10.1007/s11606-020-06423-8

20. Visscher BB, Steunenberg B, Heijmans M, Hofstede JM, Devillé W, van der Heide I, et al. Evidence on the effectiveness of health literacy interventions in the EU: a systematic review. *BMC Public Health*. (2018) 18:1414. doi: 10.1186/s12889-018-6331-7

21. Huang YQ, Qi F, Wang R, Jia X, Wang Y, Lin P, et al. The effect of health literacy on health status among residents in Qingdao, China: a path analysis. *Environ Health Prev*. (2021) 26:78. doi: 10.1186/s12199-021-01001-8

22. Rui L, Shan H. Foreign studies on the assessment tools for health literacy: a systematic review. *J Modern Inform*. (2020) 40:154–66, 77. doi: 10.3969/j.issn.1008-0821.2020.11.016

23. Nie XQ, Li YH, Li CN, Wu J, Li L. The association between health literacy and self-rated health among residents of china aged 15-69 years. *Am J Prev Med*. (2021) 60:569–78. doi: 10.1016/j.amepre.2020.05.032

24. Mei X, Zhong Q, Chen G, Huang YX, Li JL. Exploring health literacy in Wuhan, China: a cross-sectional analysis. *BMC Public Health*. (2020) 20:1417. doi: 10.1186/s12889-020-09520-9

25. Li ZH, Tian YQ, Gong ZC, Qian L. Health literacy and regional heterogeneities in china: a population-based study. *Front Public Health*. (2021) 9:603325. doi: 10.3389/fpubh.2021.603325

26. Kutner M, Greenberg E, Jin Y, Paulsen C. *The Health Literacy of America's Adults: Results from the 2003 National Assessment of Adult Literacy*. (2006). Available online at: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006483 (accessed July 29, 2022).

27. Baccolini V, Rosso A, Di Paolo C, Isonne C, Salerno C, Migliara G, et al. What is the prevalence of low health literacy in European Union member states? a systematic review and meta-analysis. *J Gen Intern Med*. (2021) 36:753–61. doi: 10.1007/s11606-020-06407-8

28. Publicity Department of the National Health Commission of the People's Republic of China. *In 2019, the Health Literacy Level of Chinese Residents Rose to 19.17%*. (2020). Available online at: http://www.nhc.gov.cn/xcs/s3582/202004/df8d7c746e664ad783d1c1cf5ce849d5.shtml (accessed July 29, 2022).

29. Jia YH, Ma SL, Bai LJ, Xiao Q, Wu Y, Gao Y, et al. Health literacy and disparities in knowledge, attitude and practice regarding COVID-19 among college students during the COVID-19 outbreak in China: a cross-sectional study. *Risk Manag Healthc Policy*. (2021) 14:4477–88. doi: 10.2147/RMHP.S319331

30. Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): the epidemic and the challenges. *Int J Antimicrob Ag*. (2020) 55:105924. doi: 10.1016/j.ijantimicag.2020.105924

31. Albus C. Health literacy: do we have effective interventions to enhance it in socially disadvantaged people? *Eur J Prev Cardiol*. (2019) 26:1760–1. doi: 10.1177/2047487319861221

32. Paakkari L, Okan O. COVID-19: health literacy is an underestimated problem. *Lancet Public Health*. (2020) 5:E249–50. doi: 10.1016/S2468-2667(20)30086-4

33. Castro-Sanchez E, Chang P, Vila-Candel R, Escobedo AA, Holmes AH. Health literacy and infectious diseases: why does it matter? *Int J Infect Dis*. (2016) 43:103–10. doi: 10.1016/j.ijid.2015.12.019

34. Yang P, Dunzhu C, Widdowson MA, Wu S, Ciren P, Duoji D, et al. Infectious disease-specific health literacy in Tibet, China. *Health Promot Int*. (2018) 33:84–91. doi: 10.1093/heapro/daw054

35. Statistical Bulletin of Wuhan's National Economic and Social Development. *Population Distribution*. (2022). Available online at: http://www.wuhan.gov.cn/zjwh/whgk/202003/t20200316_976479.shtml (accessed July 29, 2022).

36. Liu Z, Li YH, Cui ZY, et al. Prevalence of tobacco dependence and associated factors in China: findings from nationwide China Health Literacy Survey during 2018-19. *Lancet Reg Health West Pac*. (2022) 24:100464. doi: 10.1016/j.lanwpc.2022.100464

37. Yang PY, Ou YR, Yang HL, Pei X, Li J, Wang Y, et al. Research on influencing factors and dimensions of health literacy in different age groups: before and after the COVID-19 era in Chongqing, China. *Front Public Health*. (2021) 9:690525. doi: 10.3389/fpubh.2021.690525

38. Wu Y, Wang L, Cai ZY, Bao LQ, Ai P, Ai ZS. Prevalence and risk factors of low health literacy: a community-based study in Shanghai, China. *Int J Env Res Pub Health*. (2017) 14:628. doi: 10.3390/ijerph14060628

39. Publicity Department of the National Health Commission of the People's Republic of China. *In 2021, the National Health Literacy Level of Residents Will Reach 25.40% in China*. (2022). Available online at: http://www.nhc.gov.cn/xcs/s3582/202206/5dc1de46b9a04e52951b21690d74cdb9.shtml (accessed August 1, 2022).

40. Li SJ, Cui GH, Kaminga AC, Cheng SX, Xu HL. Associations between health literacy, eHealth literacy, and COVID-19-related health behaviors among Chinese college students: cross-sectional online study. *J Med Internet Res*. (2021) 23:e25600. doi: 10.2196/25600

41. Naveed MA, Shaukat R. Health literacy predicts Covid-19 awareness and protective behaviours of university students. *Health Info Libr J*. (2022) 39:46–58. doi: 10.1111/hir.12404

42. Zhong B-L, Luo W, Li H-M, Zhang Q-Q, Liu X-G, Li W-T, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci*. (2020) 16:1745–52. doi: 10.7150/ijbs.45221

43. Chen Y, Zhou R, Chen BY, Chen H, Li Y, Chen Z, et al. Knowledge, perceived beliefs, and preventive behaviors related to COVID-19 among chinese older adults: cross-sectional web-based survey. *J Med Internet Res*. (2020) 22:e23729. doi: 10.2196/23729

44. Wallington S, Cummings C, Greaney ML, Rampa S, Lees FD. Exploring healthcare. employees' perceptions of health literacy to increase health literacy among underserved populations. *Ann Behav Med*. (2020) 54:S317.

45. Mcclintock H, Schrauben S, Andrews A, Wiebe D. Measurement of health literacy to advance global health research: a study based on demographic and health surveys in 14 sub-Saharan countries. *Lancet Glob Health*. (2017) 5:18–18. doi: 10.1016/S2214-109X(17)30125-0

46. Nutbeam D, Lloyd JE. *Understanding and Responding to Health Literacy as a Social Determinant of Health*. In: Fielding JE, editor. (2021). p. 159–73. doi: 10.1146/annurev-publhealth-090419-102529

47. Tang CX, Wu XJ, Chen XF, Pan BY, Yang XC. Examining income-related inequality in health literacy and health-information seeking among urban population in China. *BMC Public Health*. (2019) 19:221. doi: 10.1186/s12889-019-6538-2

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 May 2023
DOI 10.3389/fpubh.2023.1091015

OPEN ACCESS

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RECEIVED 06 November 2022
ACCEPTED 11 April 2023
PUBLISHED 16 May 2023

CITATION
Marzo RR, Chakraborty R, Soh SY, Thew HZ, Chong C, Siau CS, Abdul Wahab KB, Binti Ariffin IA, Chauhan S, Brackstone K, Padhi BK and Heidler P (2023) Factors influencing parents' hesitancy to vaccinate their children aged 5–11 years old against COVID-19: results from a cross-sectional study in Malaysia. *Front. Public Health* 11:1091015. doi: 10.3389/fpubh.2023.1091015

Factors influencing parents' hesitancy to vaccinate their children aged 5–11 years old against COVID-19: results from a cross-sectional study in Malaysia

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Introduction: Vaccination programs have been rolled out across the globe to contain and mitigate the spread of the COVID-19 infection. Until recently, such programs were limited to adults and the older population, thereby limiting children from getting vaccinated. Recently, the Malaysian government rolled out vaccination for children aged 5–11 years. However, there are certain factors that might affect vaccination uptake among children. This study explores factors influencing parents' hesitancy to vaccinate children in Malaysia.

Method: A nationwide online cross-sectional convenience sampling survey from April 21, 2022 to June 3, 2022 was conducted. The study used descriptive statistics to inform about vaccine hesitancy among parents. Cross-tabulation was performed to calculate the frequency and percentage of vaccine hesitancy, quality of life, e-health literacy, and the 5C psychological antecedents of vaccination among parents with children 5-11 years in Malaysia. Graphical methods were used to portray the levels of e-health literacy and levels of 5C psychological antecedents of vaccination. The study used both bi-variate and multivariate analysis to understand the relationship between vaccine hesitancy and the socio-demo-economic factors, quality of life, e-health literacy and 5C psychological antecedents.

Results: Of 382 participants, almost one-third (33%) of participants reported vaccine hesitancy for their children. For 5C's psychological antecedents of vaccination, around one quarter (26.96%) reported disagreement for confidence in vaccination, almost half (52.36%) reported disagreement for vaccination complacency, three-fifths (60.99%) reported vaccination constraint, one quarter

(25.92%) reported calculation antecedent, and almost one-third reported disagreement over collective responsibility antecedent (25.92%). Chi-square test revealed that gender, employment status, and parents' COVID-19 vaccination status were significantly associated ($p<0.05$) with vaccine hesitancy among parents. Assessing the influence of transactional e-health literacy, only the communication component contained a significant association ($p<0.05$). Among the 5C psychological antecedents, confidence, calculation, and collective responsibility were significantly associated ($p<0.05$) with vaccine hesitancy. Parents with secondary [OR: 8.80; CI: 2.44–31.79, ($p<0.05$)], post-secondary [OR: 5.21; CI: 2.10-13.41, ($p<0.05$)], and tertiary education [OR: 6.77; CI: 2.25–20.35, ($p<0.05$)] had significantly higher likelihood of vaccine hesitancy than those with primary education.

Conclusion: Highly educated parents are more skeptical and are more likely to perceive the vaccine as unsafe and ineffective for their children. It is critical to disseminate the required information about the vaccine safety to the educated group.

KEYWORDS

vaccine hesitancy, COVID-19, children, Malaysia, health education and awareness

Introduction

The novel coronavirus disease (COVID-19) was first isolated from the Chinese city of Wuhan in December 2019, and has been the source of the most recent global health crisis (1–3). Malaysia detected its first three cases of COVID-19 before the declaration of pandemic status on 25 January 2020 (4–7). Since then, Malaysia has undergone multiple waves of COVID-19 infections. As of 5 October 2022, there were 4.85 million of confirmed COVID-19 cases in Malaysia, while there were 619 million cases globally at the same time (1, 2). Vaccination programs have been since rolled out across the globe to contain and mitigate the spread of the COVID-19 infection. The Malaysian government pledged its commitment toward the COVID-19 Vaccine Global Access (COVAX) partnership, which the World Health Organization (WHO) spearheaded (5). The administration of COVID-19 vaccines in Malaysia was administered via the National COVID-19 Vaccine Immunization Program (Program Imunisasi COVID-19 Kebangsaan – PICK), which began on 24 February 2021 (8)– (9). There were three vaccines first introduced to the country vaccination program, namely AZD1222 (AstraZeneca), BNT162b2 (Pfizer-BioNTech), and CoronaVac (Sinovac) (8, 9). On 23 September 2021, Malaysia began offering COVID-19 vaccines to adolescents in the country, primarily employing the BNT162b2 vaccine (10, 11). It was not until February 2022, however, that the same BNT162b2 vaccine was offered to children aged 5–11, while CoronaVac was too provided to this group in March 2022 (12).

Clinical evidence has shown the efficacies of these vaccines against COVID-19-related mortality, hospitalization, and symptomatic illness (8). Despite this, a small number of people may be unsure about the acceptance of certain vaccines. Vaccine hesitancy was defined by the Strategic Advisory Group of Experts on Immunization (SAGE) as "the delay in acceptance or refusal of vaccination despite the availability of vaccine services" (13, 14), and is regarded a certain hindrance for a country to achieve herd immunity against COVID-19.

A recent systematic review explored vaccine acceptance rates across the globe and found that Malaysia had the highest acceptance rate (94.3%) for COVID-19 (13, 15). Various studies have also explored the attitude of the Malaysian population toward COVID-19 vaccines and the phenomenon of vaccine hesitancy among adults (16, 17). However, these studies primarily focused on vaccine hesitancy rates among adults. A recently published study investigated parents' willingness to vaccinate their children under 12 years old against COVID-19, and 73.6% of their participants were willing to vaccinate their children (18). Parental levels of vaccine hesitancy, together with parental knowledge and attitudes about the disease and vaccine, has been shown to predict willingness to vaccinate their children (3, 4).

Examining coronavirus-related issues has remained elusive in the Malaysian context as far as vaccine hesitancy for children is concerned, especially from the parents' perspective. To our knowledge, there is no published study investigating the willingness of parents to vaccinate their adolescent children at the time of writing. However, authors found some studies pertaining to health literacy related to COVID-19 vaccination, although these studies did not examine health literacy from parent's perspective as we intend to examine in this study (19, 20). Some countries have conducted surveys to investigate COVID-19 vaccine hesitancy among parents with children aged 5–11 years old. In the United States, 40.75% of Malaysian parents were willing to vaccinate their children (21). In research involving multiple Middle Eastern countries, 32% of children were vaccinated against COVID-19 (22). A quarter of mothers participating in a survey in Saudi Arabia expressed hesitancy about their children's vaccination (23). There were also varying degrees of parental vaccine hesitancy among the Asian regions. Only 11.7–19.4% of parents expressed hesitancy in the Chinese cities of Shandong and Zhejiang (24), whereas 35.3% of Japanese parents were hesitant to vaccinate their children (25). In contrast, more than 70% of the parents in Hong Kong were hesitant to

vaccinate their children (26). Some studies have applied health beliefs and planned behavior theoretical models (27–29) to examine the relationship between vaccine hesitancy and parental attitudes and beliefs.

The most consistent predictors of parents' COVID-19 vaccine resistance for children 5–11 years are a lack of confidence in the safety and effectiveness of the vaccine, followed by lack of trust in government, perceptions that children are not susceptible to the disease, and a lack of community and family support for vaccinating children against COVID-19 (29–42). Positive attitudes toward vaccination experiences or outcomes may also play a role in predicting parental willingness to vaccinate their children (29). Demographic variables have also been associated with parental COVID-19 vaccine acceptance. These include higher parental income and education, and whether the parent has received the COVID-19 vaccination themselves (30, 32, 35). Racial and ethnic differences have also been reported. For example, Asian-American parents were most likely to vaccinate their 5–11-year-old and 12–17-year-old children, whereas non-Hispanic White parents were least likely (43, 44). These differences in parental intentions appear to coincide with the race and ethnicity of older children who have been vaccinated based on their share of the population (45).

The advancement of technology has a major influence on how health information is disseminated and received by the general public. The Transactional Model of eHealth Literacy was first proposed to define a hierarchy of skillsets that may have an impact on an individual's healthcare engagement experience (46). For example, functional eHealth literacy is defined as basic skills in writing and reading about health on the internet; communicative eHealth literacy involves skills that allowed communication about health with other users on the online environment; and critical eHealth literacy refers to the ability to evaluate the information obtained and understand the risk in the sharing of such information. The ability to apply health knowledge obtained via the internet across different setting forms the highest cognitive level of eHealth literacy and this is termed translational eHealth literacy (46). Health literacy has been proposed as an important element in the fight against COVID-19 and higher health literacy has been associated with higher likelihood of intention to be immunized (47–49).

Further, the 5C model of psychological antecedents, which include confidence, complacency, constraint, calculation, and collective responsibility, is often used to predict vaccination hesitancy in a population (50, 51). Generally, people with greater confidence trust the safety and efficacy of COVID-19 vaccines, and also believe in the competence and reliability of their local healthcare service providers in delivering the vaccination program (32). On the contrary, people lacking confidence may adopt a conspiracy mentality with regards to vaccines, and worry about the harmful effects of vaccine (50). Complacency in the 5C model of psychological antecedents was defined as having low perceived risk of the vaccine-preventable disease and eventually deeming vaccination as unnecessary (50). In view of this, complacent people may express lower intention to receive vaccination. Constraints may be seen as barriers that impede the vaccination process. These barriers may include the accessibility, availability, and affordability of vaccines and the willingness-to-pay of the population (50). Calculation in the 5C model refers to people who would undergo extensive information gathering. Depending on the sources of information search, calculation may influence vaccination attitudes in diverse ways. For example, if anti-vaccination or vaccine - critical information was found, calculation would potentially lead to higher hesitancy (50).

Herd immunity is an important public health concept that can be used to mitigate the spread of an infectious disease. Consequently, some may be willing to receive vaccination in order to protect others within the community. This is termed collective responsibility (50).

Our study aimed to investigate Malaysian parents' hesitancy, health literacy, and behaviors surrounding COVID-19 vaccinations of their children aged 5–11 years old, and to examine the psychological barriers that may prevent parents in Malaysia from getting their children vaccinated against the COVID-19 virus.

Method

Study design, respondents, and sample size

We conducted a nationwide online cross-sectional study in Malaysia from April 21, 2022 to June 3, 2022. The inclusion criteria of the study were as follows: parents with children 5–11 years, and currently a resident in Malaysia. Participants who were unable to read English, those not given consent, and non-citizens of Malaysia were excluded from the study. To calculate the required sample size for a single proportion, we used Pocock's formula: $n = Z\alpha\ 2\ p(1\text{-}p)/d2$, where n = minimum required sample size, $(Z\alpha) = 1.96$, d (precision) = 5%, and P = expected prevalence. Based on our extensive literature search, the prevalence of vaccine hesitancy was found to be within the range of 10 to 30%. Using these percentages, an estimated sample size of between 138 and 318 was required. The average provided a required minimum sample size of 227. Considering potential dropouts and incomplete forms (227 + [20%]), 275 was our target sample size. A total of 1,000 questionnaires were distributed with 38.2% response rate.

Procedure

A pilot study was conducted prior to the actual data collection to test the survey questions, assess the feasibility of the study design, and identify any potential issues. An online survey was used for data collection because of the ongoing COVID-19 pandemic in the country. Participants were recruited using convenience sampling method. Questionnaires were disseminated via various social media platforms such as Instagram, Twitter, Facebook, WhatsApp, and Telegram. Participants completed an online consent form after confirming that they understood the purpose, risks, and benefits of the study. Time for completion of questionnaire was approximately 10–15 min. No incentive was offered for completing the questionnaire. We conducted a follow-up and reminder to ensure a higher response rate. Specifically, we sent a reminder email to all participants who had not completed the survey after 1 week. Face and content validity were considered satisfying by the multidisciplinary panel of five experts including a psychiatrist, clinical psychologist, physician, pharmacist, and public health expert for critical review, content, and face validity. All items were evaluated for necessity, clarity, and relevance. The content validity and face validity were 88 and 92%, respectively.

10.3389/fpubh.2023.1091015

Measures

Demographics

Malaysian participants indicated their age, gender (male, female), residential area (rural, urban), educational level (no formal education, primary, secondary, tertiary), marital status (single, married, divorced, widowed), employment (unemployed, part-time, full-time), religion (Christian, Buddhism, Muslim, Hinduism, Other, None), ethnicity, and household income.

Quality of life

Next, participants were asked about their perceived quality of life ("How would you rate your quality of life?"), which was rated on a 5-point Likert scale (1 = *very poor*; 5 = *very good*; $M = 4.57$, $SD = 1.48$). The higher score indicates better quality of life.

Parents' hesitancy to vaccinate their children

This was measured by a single item asking the participants to rate the extent they felt likely to vaccinate their children with the COVID-19 vaccine on a 6-point Likert scale (1 = *very likely*; 6 *very unlikely*; $M = 4.57$, $SD = 1.48$). Higher scores indicate greater hesitancy. A point greater than or equal to 4 was considered overall likely to vaccinate the child, whereas a point of less than 4 suggested that the parents were overall unlikely to vaccinate their child. So, a score of <4 was coded as 1 and was labelled as "Unlikely," and a score of 4 and above was coded as 0 and labelled as "Likely" and thus converted into a binary variable.

5C's psychological antecedents of vaccination

The 5Cs were assessed using the previously validated 5C scale (32). The scale consisted of 15 items. Each of the Cs — Confidence, Constraints, Calculation, Complacency and Collective responsibility — were captured using three items. Responses were provided on a six-point Likert scale (1 = *strongly disagree*; 6 = *strongly agree*). The scale was adapted to focus on COVID-19 vaccinations.

All items were scored in a way such that a higher score indicates a higher degree of the C assessed. Internal consistency, as reflected by Cronbach's alpha, were acceptable in our sample: Confidence $\alpha = 0.87$, $M = 4.57$, $SD = 1.48$; Complacency $\alpha = 0.75$, $M = 4.57$, $SD = 1.48$; Constraints $\alpha = 0.88$ $M = 4.57$, $SD = 1.48$; Calculation $\alpha = 0.76$, $M = 4.57$, $SD = 1.48$; Collective responsibility $\alpha = 0.77$, $M = 4.57$, $SD = 1.48$.

The 5C psychological antecedents of vaccination consisted of 5 domains. Each of the domains had 3 questions which were measured using a 6-point Likert Scale (1 = *strongly disagree*; 6 = *strongly agree*). So, the total possible score of each domain was 18. A cumulative score of greater than 9 was taken as overall agreement to that domain, whereas a score of less than or equal to 9 was taken as overall disagreement to that domain. It was then recoded as 1 "Disagree" and 2 "Agree" and converted to a binary variable. Thus 5 binary variables were created for each domain of the 5C psychological antecedent of vaccination.

e-Health Literacy

Participants' vaccine literacy was captured by the COVID-19 vaccine literacy scale (45). The scale was comprised of four components, including functional, communication, critical, and translational skills. Each component was measured using four items on a 6-point Likert scale (1 = *strongly disagree*; 6 = *strongly agree*; $\alpha = 0.86$, $M = 4.57$, $SD = 1.48$). The total score ranged from 16 to 48. The higher the score, the higher the COVID-19 vaccine literacy.

Ethical considerations

The anonymous survey data were confidentially stored with password-protected security standards. We utilized an online informed consent process that required participants to read and agree to the terms of participation before beginning the study. The online consent form provided participants with a clear explanation of the study's purpose, procedures, risks, benefits, confidentiality, and the participant's rights as a research subject, including information on the use and anonymization of the data and how survey responses guarantee the anonymity of each participant. Participants were also informed that their participation was voluntary, and they could withdraw at any time without consequence. We ensured that participants could only access the survey once to prevent multiple responses. This study was conducted according to the Declaration of Helsinki. Online informed written consent was obtained from all participants before the commencement of the study. Ethics approval was obtained from the Medical Research and Ethics Committee of the Management and Science University.

Data analysis

Vaccine hesitancy was taken as the primary outcome variable for this study. The variable was recoded as a binary variable (Yes = 1/ No = 0) for the primary analysis. Socio-economic and demographic categorical predictors included gender, marital status, highest qualification level, household monthly income, ethnicity, religion, employment status, residential area, insurance status of the child, parents' comorbidity status, comorbidity status of child, parents' COVID-19 vaccination status, oldest child's (5–11 years) COVID-19 vaccination status, side effects experienced by respondent after getting the COVID-19 vaccination, side effects experienced by the oldest child (5–11 years) after getting the COVID-19 vaccination, and risk perceptions about COVID-19. Quality of life, transactional e-health literacy, and 5C psychological antecedents to vaccination were also categorized based on scores from the Likert scale and included in the regression analysis.

Statistical analysis

The study used descriptive statistics to assess vaccine hesitancy among parents with children under 18 years old in Malaysia based on each socio-economic and demographic characteristics. Cross-tabulation was performed to calculate the frequency and percentage of vaccine hesitancy, quality of life, e-health literacy and 5C psychological antecedents of vaccination among parents with children 5–11 years in Malaysia. Graphical methods were used to portray the levels of e-health literacy and levels of 5C psychological antecedents of vaccination among the study subjects.

Next, the study used bi-variate and multivariate analysis to understand the relationship between vaccine hesitancy and the socio-demo-economic factors, quality of life, e-health literacy, and 5C

10.3389/fpubh.2023.1091015

psychological antecedents. Chi-square tests were performed to examine the association between vaccine hesitancy and the different predictor variables. *p*-values were reported to understand the significance of the association. Multivariate analysis included both unadjusted and adjusted binary logistic regressions with vaccine hesitancy as the binary outcome variable and the predictors as categorical variables.

The adjusted regression was performed taking into account all the predictor variables in a single model. This was used to understand the effect of a predictor variable on the outcome variable after adjusting for the effect of other predictor variables. Odds Ratios (OR) with 95% Confidence Intervals and *p*-values were reported to understand the significance of the relationship between the outcome variable and the predictor variables. ORs greater than 1 indicated a greater chance of vaccine hesitancy while ORs of less than 1 indicated a lesser risk of vaccine hesitancy.

Results

Table 1 shows percentages of vaccine hesitancy among parents with children 5–11 years old for socio-economic and demographic characteristics. Of the 382 participants, 33% of respondents expressed hesitation in vaccinating their children. In Table 2, among those hesitant to vaccinate their children, the majority were married couples (68.3%). People with lower household income expressed lower hesitation in vaccinating their children, as were people with post-secondary and tertiary education. Among those who were unlikely to vaccinate their children, a majority (62%) were full-time employees and residing in rural areas (78.6%). Further, 73.0% of the hesitant parents had insurance for their children. Among the 126 respondents who expressed hesitancy in vaccinating their children, 108 (85.7%) were without any chronic illness.

Table 3 presents levels of quality of life among parents with children 5–11 years old in Malaysia. Almost 30% of the respondents were satisfied with their lives, and 24% were very satisfied with their lives. 24 and 11% of the parents were very dissatisfied and dissatisfied with their lives, respectively. The remaining 11% were neither satisfied nor dissatisfied.

Tables 4, 5 provides the levels of e-health literacy among parents with children 5–11 years old in Malaysia. Above 90% of the respondents agreed to the functional, communicative, critical, and translational criterions of e-health literacy. The mean scores obtained from the respondents' answers was 4.13 for the functional criteria, 3.87 for the communication criteria, 3.95 and 4.15 for the critical and translational criterions, respectively, which indicated that most of the respondents agreed to the items asked to them.

TABLE 1 Percentage of COVID-19 vaccine hesitancy among parents with children 5–11 years old.

Vaccine hesitancy	Frequency	Percentage
No	256	67.02
Yes	126	32.98
Total	382	100

TABLE 2 Vaccine hesitancy among parents with children 5–11 years old.

Vaccine hesitancy →	No (*n*, %)	Yes (*n*, %)
Socio-economic and demographic variables ↓		
Age (Mean = 39.5)		
Gender		
Male	88 (34.0)	58 (46.0)
Female	168 (66.0)	68 (54.0)
Marital Status		
Single	83 (32.4)	25 (19.8)
Married	142 (55.5)	86 (68.3)
Divorced	10 (3.9)	8 (6.4)
Widowed	2 (0.8)	1 (0.8)
Single parent	19 (7.4)	6 (4.8)
Highest qualification level		
Primary	57 (22.3)	16 (12.7)
Secondary	23 (9.0)	13 (10.3)
Post-secondary	99 (38.7)	54 (42.9)
Tertiary education	77 (30.0)	43 (34.1)
Household Income		
Equals/less than RM 4,850	125 (49.0)	61 (48.4)
RM 4,850 to RM 10, 959	102 (40.0)	46 (36.5)
More than RM 10, 960	28 (11.0)	19 (15.1)
Ethnicity		
Malay	92 (36.1)	34 (27.0)
Chinese	46 (18.0)	28 (22.2)
Indian	97 (38.0)	59 (46.8)
Others	20 (7.9)	5 (4.0)
Religion		
Islam	98 (38.3)	39 (31.0)
Christianity	30 (11.7)	17 (13.5)
Buddhism	30 (11.7)	17 (13.5)
Hinduism	88 (34.4)	49 (38.9)
Others	10 (3.9)	4 (3.2)
Employment status		
Employed: full time	140 (54.7)	78 (61.9)
Employed: part time	9 (3.5)	9 (7.1)
Self-employed	19 (7.4)	12 (9.5)
Retired/Pensioners	2 (0.8)	3 (2.38)
Housewife/Househusband	17 (6.6)	10 (7.9)
Unemployed	69 (27.0)	14 (11.1)
Residential area		
Urban	53 (20.7)	27 (21.4)
Rural	203 (79.3)	99 (78.6)
Insurance status of child		
Insured	178 (69.5)	92 (73.0)

(Continued)

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TABLE 2 (Continued)

Vaccine hesitancy →	No (*n*, %)	Yes (*n*, %)
Not insured	78 (30.5)	34 (27.0)
Parent's comorbidity status		
With chronic illness	36 (14.1)	18 (14.3)
Without chronic illness	220 (85.1)	108 (85.7)
Comorbidity status of child		
With chronic illness	19 (7.4)	6 (4.8)
Without chronic illness	237 (92.6)	120 (95.2)
Parent's COVID 19 vaccination status		
Not vaccinated	3 (1.2)	0 (0.00)
Completed 1 dose	0 (0.0)	2 (1.6)
Completed 2 doses	23 (9.0)	35 (27.8)
Completed more than 2 doses	230 (89.8)	89 (70.6)
Oldest child's COVID 19 vaccination status		
Not vaccinated	85 (33.3)	54 (42.9)
Completed 1 dose	48 (18.8)	23 (18.2)
Completed 2 doses	122 (47.8)	49 (38.9)
Side effects experienced after getting COVID 19 vaccination		
Yes	90 (35.3)	44 (34.9)
No	165 (64.7)	82 (65.1)
Side effects experienced by oldest child after getting COVID 19 vaccination		
Yes	44 (17.2)	25 (19.8)
No	211 (82.8)	101 (80.2)
Risk perception about COVID 19		
Concerns over getting infected with COVID-19	64 (25.0)	34 (27.0)
Concerns over the continuous spread of COVID-19	96 (37.5)	53 (42.1)
Concerns over the new COVID-19 variants	96 (37.5)	39 (30.9)

TABLE 3 Level of quality of life among parents with children 5–11 years old.

Overall quality of life ↓	Frequency	Percentage
Very dissatisfied	91	23.82
Dissatisfied	42	10.99
Neither satisfied nor dissatisfied	41	10.73
Satisfied	116	30.37
Very satisfied	92	24.08
Total	382	100

TABLE 4 e-health literacy among parents with children 5–11 years old.

	Frequency	Percentage
Functional		
Agree	348	91.1
Disagree	34	8.9
Communicative		
Agree	368	96.34
Disagree	14	3.66
Critical		
Agree	366	95.81
Disagree	16	4.19
Translational		
Agree	345	90.31
Disagree	37	9.69

Tables 6, 7 shows the levels of 5C psychological antecedents of vaccination among parents with children 5–11 years old in Malaysia. The percentages of agreement and disagreement varied across the 5C areas. 73% agreed in the confidence area, while 52% disagreed in the complacency area. 39% of the respondents agreed in the constraints area, while 71 and 74% agreed in the calculation and collective responsibility areas, respectively. As observed in Table 7, the mean score for the set of questions was above 4 for the confidence, calculation and collective responsibility areas.

Table 8 provides the relationship between socio-economic and demographic variables, quality of life, transactional e-health literacy, 5C psychological antecedents to vaccine hesitancy. The left part of the table gives us the association between vaccine hesitancy and the different independent variables using Pearson's Chi-Square test. The right part of the table shows the univariate and multivariate logistic regression with vaccine hesitancy as the binary outcome variable. The unadjusted model (univariate regression) shows the effect of each independent variable on the dependent variable separately. The adjusted model (multivariate regression) shows the overall effects of all the independent variables when acting together on the dependent variable. From the *p*-values obtained from the Chi-Square tests, gender, employment status, and parent's COVID-19 vaccination status are significantly associated with vaccine hesitancy among parents ($p < 0.05$). Among transactional e-health literacy, only the communication component had a significant association ($p < 0.05$). Among the 5C psychological antecedents, confidence, calculation and collective responsibility were significantly associated ($p < 0.05$) with vaccine hesitancy.

Results from the univariate logistic regression suggest that parents who were married were 2 times [OR: 2.01; CI: 1.19–3.39] more likely to hesitate in vaccinating their children than those who were single. Parents with post-secondary and tertiary education also had significant higher risks of hesitancy than those with primary education ($p < 0.05$). Unemployed parents were 36% less likely to report hesitancy [OR: 0.36, CI: 0.19–0.69, $p = 0.002$] than those who were full-time employed. Parents who expressed lower confidence, calculation, and collective responsibility were also less likely to report vaccine hesitancy from the unadjusted regression.

After including all the independent variables together in the adjusted model, we found that parents with secondary [OR: 8.80; CI: 2.44–31.79, $p = 0.001$], post-secondary [OR: 5.21; CI: 2.10–13.41, $p = 0.000$] and tertiary education [OR: 6.77; CI: 2.25–20.35, $p = 0.001$] were significantly more likely to express vaccine hesitancy than those with primary education. Parents of Chinese and Indian ethnicity were 23 times and 18 times more likely to report hesitation than

TABLE 5 Levels of e-health literacy among parents with children 5–11 years old in Malaysia.

Transactional e-Health literacy	Score	Mean Score	Description
Functional	4.07	4.13	Can summarize basic health information from the Internet in my own words.
	4.32		Know how to access basic health information on the Internet
	4.08		Can use my computer to create messages that describe my health needs
	4.04		Have the skills I need to tell someone how to find basic health information on the Internet
Communicative	4.14	3.87	Can achieve my health information goals on the Internet while helping other users achieve theirs
	3.76		Have the skills I need to talk about health topics on the Internet with multiple users at the same time
	3.95		Can identify the emotional tone of a health conversation on the Internet
	3.75		Have the skills I need to contribute to health conversations on the Internet
	3.77		Have the skills I need to build personal connections with other Internet users who share health information
Critical	3.96	3.95	Can tell when an Internet user is a credible source of health information
	3.88		Can tell when health information on the Internet is fake
	3.84		Can tell when a health website is safe for sharing my personal health information
	4.06		Can tell when information on the Internet is relevant to my health needs
	3.99		Know how to evaluate the credibility of Internet users who share health information
Translational	4.17	4.15	Can use the Internet to learn how to manage my health in a positive way
	4.15		Can use the Internet as a tool to improve my health
	4		Can use information on the Internet to make an informed decision about my health
	4.27		Can use the Internet to learn about topics that are relevant to me

TABLE 6 5C Psychological antecedents of vaccination.

	Frequency	Percentage
Confidence		
Agree	279	73.04
Disagree	103	26.96
Complacency		
Agree	182	47.64
Disagree	200	52.36
Constraint		
Agree	149	39.01
Disagree	233	60.99
Calculation		
Agree	283	74.08
Disagree	99	25.92
Collective responsibility		
Agree	270	70.68
Disagree	112	29.32

Malay people, respectively. Unemployed parents were 28% less likely to express hesitancy [OR: 0.36, CI: 0.19–0.69, $p = 0.012$] than those who were full-time employed. Parents who expressed low confidence and collective responsibility were significantly less likely to report vaccine hesitancy than those who express high agreement. However, people low in complacency and calculation criteria had significantly higher likelihood of vaccine hesitancy (3 and 7 times, respectively) than those who agreed. Other independent variables did not have any significant association with vaccine hesitancy as per the multivariate analysis.

Discussion

The core aims of this study were to explore Malaysian parents' hesitancy, health literacy, and behaviors surrounding COVID-19 vaccinations of their children 5–11 years old, and to examine the psychological barriers that may prevent parents in Malaysia from getting their children vaccinated against the COVID-19 virus. We found that 32.98% of participants expressed hesitancy in allowing their children 5–11 years old to receive COVID-19 vaccines. This finding was similar to the study investigating the willingness of parents to vaccinate their children under 12 years old in Malaysia, where 26.4% of the participants were either unwilling or hesitant (18). Multiple studies investigating attitudes toward vaccinations among the Malaysian adult population reported varied acceptance rates (i.e., between 27.7 and 96%) (52–55). Parents' experiences and attitudes toward vaccination may play a role in their decision to vaccinate their children. Compared to other countries, parents from Italy and China showed a similar acceptance rate to vaccinate their children. In contrast, parents expressed greater vaccine hesitancy in countries such as Germany, Turkey, and Saudi Arabia (56–60).

Malaysia is a multiracial, multicultural country. Malays and the aborigine people of the country formed the largest ethnic group (61). Higher hesitancy to vaccinate their children was expressed among Chinese and Indian races. This finding was in line with studies investigating the willingness of the country's adult population in COVID-19 vaccination (53, 62). According to the SAGE working group report, culture and religion were the determinants of vaccine

TABLE 7 Levels of 5C psychological antecedents of vaccination among parents with children 5–11 years old in Malaysia.

5C area	Score	Mean score	Description
Confidence	4.15	4.15	Completely confident that COVID-19 vaccines are safe
	4.17		Completely confident that COVID-19 vaccines are effective
	4.14		Confident that public authorities decide in the best interest of the community
Complacency	3.09	3.31	Vaccination against COVID-19 for children is unnecessary
	3.5		The immune system of children is so strong; it also protects them against COVID-19
	3.33		COVID-19 disease in children is not severe; vaccinate them is superfluous
Constraint	2.84	2.92	Everyday stress prevents me from having my child vaccinated against COVID-19
	3.12		Inconvenient to have my child vaccinated against COVID-19
	2.79		Healthcare facility visits makes me uncomfortable
Calculation	4.09	4.21	I weigh its benefits and risks to make the best decision possible
	4.1		I closely consider whether COVID-19 vaccine is useful for my child
	4.43		It is important for me to fully understand the topic of vaccination before I get my child vaccinated
Collective responsibility	3.92	4.11	Like everyone else, I must get my child vaccinated
	4.15		Having my child vaccinated against COVID-19 can protect people with a weaker immune system
	4.27		Vaccination against COVID-19 is a collective action to prevent the spread of the disease

hesitancy via contextual influences (63). This may explain our finding on the differences in vaccine hesitancy among the ethnic groups. Nevertheless, our study found no significant association between most major religions (Islam, Christianity, Buddhism, and Hinduism) and vaccine hesitancy. This finding opposes results of previous studies in Malaysia in which religion was a significant predictor of vaccine hesitancy (62, 64, 65). Islam is the religion with most adherents in the country as 61.3% of Malaysians are Muslims, followed by Buddhism, Christianity, and Hinduism (66). Larger sample sizes are needed to obtain participants with religions proportionate to the country's population.

Further, higher educational levels was associated with a higher levels of vaccine hesitancy. This result echoed a previous study conducted in Malaysia, in which parents with higher education were more unwilling to vaccinate their children (18). Similar results were obtained in studies conducted in Saudi Arabia and Turkey (59, 67). It is possible that more educated parents may be more skeptical and perceive that the vaccine is unsafe and ineffective for their children. On the contrary, studies reported that higher parental education was associated with higher acceptance vaccinating children in other regions of the world, including China, Thailand, Italy, and the United States (56–59). The SAGE Working Group observed such diverse educational levels' effects on vaccine hesitancy. The working group reported that higher education may result in higher or lower vaccine hesitancy, despite better education often resulting in better overall health (63).

We found that only communicative eHealth literacy significantly reduced the risk of vaccine hesitancy, whereas the other dimensions of eHealth literacy were not significantly correlated with parental vaccine hesitancy. Studies in Asian countries show significant associations between eHealth literacy and hesitancy toward COVID-19 vaccination (68–70). However, studies on the impact of eHealth literacy on various health related behaviors and attitude are relatively scarce in Malaysia. Therefore, more research is needed in this area to better understand the detrimental effects of misinformation on important health-related issues such as vaccination (71).

We found that higher confidence from the 5C model reduced the risk of vaccine hesitancy among parents. This finding was similar to the studies in Switzerland and Israel, where confidence predicted intentions to vaccinate children against COVID-19 (51, 72). A Malaysian study conducted among the adult population found significant correlation between confidence and vaccine hesitancy (73). The population from our study supported this and showed significant vaccine hesitancy when expressing complacency. However, two studies conducted in Switzerland and Malaysian did not obtain significant correlation between complacency with vaccine hesitancy (72, 73). Parents expressed high calculation – referring to people undergoing extensive information gathering – were 7 times more likely to be vaccine-hesitant as compared to who were low. Various studies have shown that calculation may predict lower vaccine intention (72–75). Depending on the sources of information search, calculation may influence vaccination attitudes in diverse ways. For example, if anti-vaccination or vaccine-critical information was found, calculation may potentially lead to higher hesitancy (50). Healthcare providers may play an important role in providing correct and valuable information regarding vaccines to parents, which may influence their willingness to vaccinate their children. This has been supported in Italy and China (5, 6).

Parents with higher collective responsibility were found to have lower vaccine hesitancy as people would be willing to receive vaccination for the benefits of others. Collective responsibility was found to be a strong predictor of vaccine acceptance in many studies across the globe (72–74, 76). In our study, the only psychological antecedent in the 5C model that was not associated with negative vaccination attitudes was constraint.

Studies from Switzerland and Bangladesh yielded similar results in the aspect of constraint (72, 75). As opposed to our finding, previous research has found that constraint was a significant predictor of vaccine attitudes (73). All in all, the 5C model of psychological antecedents were important predictors of vaccine attitude in our study population.

This study uses eHealth literacy and the 5C model of psychological antecedents to explore Malaysian parents' hesitancy,

TABLE 8 Relationship between sociodemographic factors, quality of life, e-health literacy, psychological antecedents to vaccine hesitancy.

Parameters	Hesitancy *n* (%)	*p*-value	Univariate analysis		Multivariate analysis	
			OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Total = 382	126 (33.0)					
Age (mean ± SD)	37.6 ± 11.4	0.076	1.01 (0.99–1.02)	0.54	1.00 (0.97–1.03)	0.984
Gender		0.027				
Male	58 (46.0)		Ref.		Ref.	
Female	68 (54.0)		0.61** (0.4–0.95)	0.028	0.60* (0.34–1.06)	0.077
Marital status		0.061				
Single	25 (19.8)		Ref.		Ref.	
Married	86 (68.3)		2.01*** (1.19–3.39)	0.009	1.45 (0.63–3.32)	0.38
Divorced	8 (6.4)		2.66* (0.95–7.45)	0.063	2.03 (0.53–7.86)	0.303
Widowed	1 (0.8)		1.66 (0.14–19.08)	0.684	0.74 (0.05–1.31)	0.821
Single Parent	6 (4.8)		1.05 (0.38–2.91)	0.928	0.65 (0.19–2.26)	0.498
Highest qualification level		0.171				
Primary	16 (12.7)		Ref.		Ref.	
Secondary	13 (10.3)		2.01 (0.84–4.84)	0.118	8.80*** (2.44–31.79)	0.001
Post-Secondary (Pre University/ Diploma)	54 (42.9)		1.94** (1.02–3.71)	0.044	5.21*** (2.10–13.41)	0.000
Tertiary education (Degree/Master)	43 (34.1)		1.99** (1.02–3.88)	0.044	6.77*** (2.25–20.35)	0.001
Household income (Monthly)		0.492				
B40 (equals/less than RM 4,850)	61 (48.4)		Ref.		Ref.	
M40 (RM4,850 to RM10,959)	46 (36.5)		0.92 (0.58–1.47)	0.739	0.77 (0.42–1.42)	0.406
T20 (more than RM10,960)	19 (15.1)		1.39 (0.72–2.69)	0.326	1.55 (0.66–3.59)	0.313
Ethnicity		0.094				
Malay	34 (27)		Ref.		Ref.	
Chinese	28 (22.2)		1.65 (0.89–3.04)	0.11	23.33** (2.07–42.31)	0.011
Indian	59 (46.8)		1.65* (0.99–2.74)	0.055	18.18** (1.85–38.37)	0.013
Others	5 (4.0)		0.68 (0.24–1.95)	0.468	1.94 (0.31–12.16)	0.479
Religion		0.681				
Islam	39 (31.0)		Ref.		Ref.	
Christianity	17 (13.5)		1.42 (0.71–2.87)	0.323	0.11** (0.01–1.00)	0.05
Buddhism	17 (13.5)		1.42 (0.71–2.87)	0.323	0.09* (0.01–1.06)	0.056
Hinduism	49 (38.9)		1.4 (0.84–2.33)	0.196	0.11* (0.01–1.03)	0.053
Others	4 (3.2)		1.01 (0.3–3.4)	0.993	0.06** (0.004–0.93)	0.044
Employment status		0.01				
Employed; full-time	78 (61.9)		Ref.		Ref.	
Employed; part-time	9 (7.1)		1.8 (0.68–4.71)	0.235	1.32 (0.37–4.72)	0.659
Self-employed	12 (9.5)		1.13 (0.52–2.46)	0.751	0.64 (0.24–1.68)	0.366
Retired/Pensioners	3 (2.4)		2.69 (0.44–16.46)	0.284	0.83 (0.09–7.23)	0.864
Housewife/Househusband	10 (7.9)		1.06 (0.46–2.42)	0.898	1.39 (0.49–3.97)	0.533
Unemployed	14 (11.1)		0.36*** (0.19–0.69)	0.002	0.28** (0.10–0.0.75)	0.012
Residential area		0.87				
Rural	27 (21.4)		Ref.		Ref.	
Urban	99 (78.6)		0.96 (0.57–1.61)	0.87	0.80 (0.39–1.65)	0.552

(Continued)

TABLE 8 (Continued)

Parameters	Hesitancy *n* (%)	*p*-value	Univariate analysis		Multivariate analysis	
			OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Insurance status of the child		0.482				
Insured	92 (73.0)		Ref.		Ref.	
Not insured	34 (27.0)		0.84 (0.53–1.36)	0.482	0.73 (0.37–1.43)	0.357
Parent's comorbidity status		0.953				
With chronic illnesses; e.g.: asthma, autoimmune disease, heart disease etc.	18 (14.3)		Ref.		Ref.	
Without chronic illnesses	108 (85.7)		0.98 (0.53–1.81)	0.953	0.70 (0.30–1.64)	0.416
Comorbidity status of your child		0.323				
With chronic illnesses; e.g.: asthma, autoimmune disease, heart disease, etc.	6 (4.8)		Ref.		Ref.	
Without chronic illnesses	120 (95.2)		1.6 (0.62–4.12)	0.327	3.52* (0.84–14.67)	0.084
Parent's COVID-19 vaccination status		0				
Not vaccinated	0 (0)		Ref.		Ref.	
Completed 1 dose	2 (1.6)		-	-	-	-
Completed 2 doses	35 (27.8)		3.93*** (2.2–7.03)	0	7.26*** (3.23–16.29)	0.000
Completed more than 2 doses	89 (70.6)		-	-	-	-
Oldest child's (5–11 years) COVID-19 vaccination status		0.164				
Not vaccinated	54 (42.9)		Ref.		Ref.	
Completed 1 dose	23 (18.3)		0.75 (0.41–1.38)	0.359	0.68 (0.32–1.46)	0.326
Completed 2 doses	49 (38.9)		0.63* (0.39–1.02)	0.059	0.28*** (0.13–0.59)	0.001
Side effects experienced by respondent after getting the COVID-19 vaccination		0.943				
Yes	44 (34.9)		Ref.		Ref.	
No	82 (65.1)		1.02 (0.65–1.59)	0.943	0.98 (0.48–1.97)	0.945
Side effects experienced by the oldest child (5–11 years) after getting any vaccination before		0.537				
Yes	25 (19.8)		Ref.		Ref.	
No	101 (80.2)		0.84 (0.49–1.45)	0.538	0.42** (0.18–0.99)	0.049
Risk perception about COVID-19		0.448				
Concerns over getting infected with COVID-19	34 (27.0)		Ref.		Ref.	
Concerns over the continuous spread of COVID-19	53 (42.0)		1.04 (0.61–1.77)	0.888	1.10 (0.55–2.18)	0.795
Concerns over the new COVID-19 variants	39 (31.0)		0.77 (0.44–1.34)	0.346	0.69 (0.33–1.39)	0.3
Overall quality of life: how would you rate your quality of life?		0.635				
Very dissatisfied	30 (23.8)		Ref.		Ref.	
Dissatisfied	13 (10.3)		0.91 (0.42–2)	0.817	0.62 (0.23–1.730)	0.365
Neither satisfied nor dissatisfied	11 (8.7)		0.75 (0.33–1.69)	0.481	0.69 (0.20–2.39)	0.557
Satisfied	36 (28.6)		0.92 (0.51–1.65)	0.767	0.42 (0.15–1.21)	0.11
Very satisfied	36 (28.6)		1.31 (0.71–2.39)	0.386	1.01 (0.32–3.17)	0.98
Transactional e-Health literacy						
Functional		0.067				
Disagree	16 (12.7)		Ref.		Ref.	

(Continued)

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TABLE 8 (Continued)

Parameters	Hesitancy *n* (%)	*p*-value	Univariate analysis		Multivariate analysis	
			OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Agree	110 (87.3)		0.52 * (0.26–1.06)	0.071	1.07 (0.29–3.87)	0.922
Communicative		0.002				
Disagree	10 (7.9)		Ref.		Ref.	
Agree	116 (92.1)		0.18 ** (0.06–0.6)	0.005	0.30 (0.05–1.86)	0.196
Critical		0.043				
Disagree	9 (7.1)		Ref.		Ref.	
Agree	117 (92.9)		0.37 * (0.13–1.01)	0.051	0.43 (0.09–2.08)	0.297
Translational		0.509				
Disagree	14 (11.1)		Ref.		Ref.	
Agree	112 (88.9)		0.79 (0.39–1.59)	0.51	2.40 (0.67–8.63)	0.18
5C psychological antecedents						
Confidence		0.000				
Disagree	61 (48.4)		Ref.		Ref.	
Agree	65 (51.6)		0.21*** (0.13–0.34)	0.000	0.20*** (0.08–0.46)	0.000
Complacency		0.279				
Disagree	61 (48.4)		Ref.		Ref.	
Agree	65 (51.6)		1.27 (0.83–1.94)	0.279	2.69** (1.20–6.00)	0.02
Constraint		0.632				
Disagree	79 (62.7)		Ref.		Ref.	
Agree	47 (37.3)		0.89 (0.58–1.39)	0.632	1.19 (0.55–2.56)	0.663
Calculation		0.005				
Disagree	44 (34.9)		Ref.		Ref.	
Agree	82 (65.1)		0.51*** (0.32–0.82)	0.005	6.99*** (1.92–25.49)	0.003
Collective responsibility		0.000				
Disagree	67 (53.2)		Ref.		Ref.	
Agree	59 (46.8)		0.19*** (0.12–0.30)	0.000	0.06*** (0.02–0.21)	0.000

*means *p*-value < 0.1, **means *p*-value < 0.05 and ***means *p*-value < 0.01.

health literacy, and behaviors surrounding COVID-19 vaccinations of their children 5–11 years old. It has been found that parents who are in agreement with confidence and collective responsibility are at a lower risk of vaccine hesitancy in their children, as well as complacent parents, who may express a lower intention to receive the vaccination. The results of this study suggest the need for specific interventions in the future to reduce vaccine hesitancy in our practice as a whole.

A limitation of the TeHLI is that it is a self-reported measure. As such, this assessment was not objective as only the respondent's perceptions toward their own eHealth literacy competencies are measured. Even so, the TeHLI is an instrument built on a robust theoretical foundation and serves as a useful tool for the quick assessment of eHealth literacy levels. Further, the cross sectional design of the study is another important limitation as parental willingness to vaccinate their children is a dynamic process and the picture captured in the current study might have difficulty to reflect the changes over time. Selection bias as a result from convenience sampling method employed in this study may potentially affect the findings. The survey was conducted via online platform and this could also lead to selection bias as eHealth literacy of the people who commonly use the internet and social media may differ from those who are not. This could affect the generalizability of the result from this study. Social desirability bias may be present in the study as all the instruments used were of a self-reporting nature, therefore participants may underreport behaviors or ideas that might be deemed as unfavorable by others.

In conclusion, nearly a third of the participants in the study were hesitant to vaccinate their children. This study also suggests that highly educated parents are more skeptical and more likely to perceive the vaccine as unsafe and ineffective for their children. It is therefore critical to disseminate the required information about the vaccine safety to educated groups. Further, the 5C model of psychological antecedents explained probable reasons behind parental vaccine hesitancy in Malaysia. This is the first study that has examined vaccine hesitancy for children from their parents' perspective in Malaysia, and the findings could be used by policymakers to understand the ways through which they can improve the vaccination for children. In

addition, the study should be replicated, and the results contrasted with countries from Europe (e.g., Italy, Austria and Germany), who faced long lockdowns and conducted studies regarding vaccine hesitancy.

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.

Ethical statement

The studies involving human participants were reviewed and approved by Ethics approval was obtained from the Medical Research and Ethics Committee of the Management and Science University Shah Alam, Selangor, Malaysia. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors have made a substantial, direct, and intellectual contribution to the work, and each author has reviewed and approved the final manuscript for publication.

Conflict of interest

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

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References

1. Ministry of Health Malaysia (2022). COVID now in Malaysia. Available at: https://covidnow.moh.gov.my/?refresh=1679751760482 [Accessed March 25, 2023]

2. Organization WH (2023). WHO coronavirus (COVID-19) dashboard. Available at: https://covid19.who.int/ (Accessed March 25, 2023)

3. Della Polla G, Pelullo CP, Napolitano F, Angelillo IF. HPV vaccine hesitancy among parents in Italy: a cross-sectional study. *Hum Vaccin Immunother*. (2020) 16:2744–51. doi: 10.1080/21645515.2020.1744367

4. Dubé È, Farrands A, Lemaitre T, Boulianne N, Sauvageau C, Boucher FD, et al. Overview of knowledge, attitudes, beliefs, vaccine hesitancy and vaccine acceptance among mothers of infants in Quebec, Canada. *Hum Vaccin Immunother*. (2019) 15:113–20. doi: 10.1080/21645515.2018.1509647

5. Miraglia del Giudice G, Napoli A, Corea F, Folcarelli L, Angelillo IF. Evaluating COVID-19 vaccine willingness and hesitancy among parents of children aged 5–11 years with chronic conditions in Italy. *Vaccine*. (2022) 10:396. doi: 10.3390/vaccines10030396

6. Wang J, Lu X, Lai X, Lyu Y, Zhang H, Fenghuang Y, et al. The changing acceptance of COVID-19 vaccination in different epidemic phases in China: a longitudinal study. *Vaccine*. (2021) 9:191. doi: 10.3390/vaccines9030191

7. Che Mat NF, Edinur HA, Abdul Razab MKA, Safuan S. A single mass gathering resulted in massive transmission of COVID-19 infections in Malaysia with further international spread. *J Travel Med*. (2020) 27:taaa059. doi: 10.1093/jtm/taaa059

8. Suah JL, Tok PSK, Ong SM, Husin M, Tng BH, Sivasampu S, et al. PICK-ing Malaysia’s epidemic apart: effectiveness of a diverse COVID-19 vaccine portfolio. *Vaccine*. (2021) 9, 1–22. doi: 10.3390/vaccines9121381

9. Dollah R, Jafar A, Prayitno Joko E, Sakke N, Tahir Mapa M, Atang C, et al. Perception of youth in East Malaysia (Sabah) towards the Malaysia national covid-19 immunisation programme (PICK). *J Public Health Dev*. (2022) 20, 203–217. doi: 10.55131/jphd/2022/200116

10. Jamaluddin K.. (2021). PEMBERIAN VAKSINASI REMAJA SECARA BERJADUAL BAGI MENGELAKKAN KESESAKAN DI PPV. Ministry of Health Press Statement. Available at: https://covid-19.moh.gov.my/semasa-kkm/2021/09/pick-remaja-vaksinasi-berjadual-elak-ppv-sesak [Accessed August 10, 2022].

11. Husin M, Tok PSK, Suah JL, Thevananthan T, Tng BH, Peariasamy KM, et al. Real-world effectiveness of BNT162b2 vaccine against SARS-CoV-2 infection among adolescents (12 to 17-year-olds) in Malaysia. *Int J Infect Dis*. (2022) 121:55–7. doi: 10.1016/j.ijid.2022.04.053

12. Ministry of Health Malaysia (2022). PICKids Vaksinasi COVID-19 untuk Kanak-kanak. Available at: https://covid-19.moh.gov.my/vaksin-covid-19/pickids [Accessed August 10, 2022].

13. Sallam M. COVID-19 vaccine hesitancy worldwide: a concise systematic review of vaccine acceptance rates. *Vaccine*. (2021) 9, 1–14. doi: 10.3390/vaccines9020160

14. MacDonald NE. Vaccine hesitancy: definition, scope and determinants. *Vaccine*. (2015) 33:4161–4. doi: 10.1016/j.vaccine.2015.04.036

15. Shakeel CS, Mujeeb AA, Mirza MS, Chaudhry B, Khan SJ. Global COVID-19 vaccine acceptance: a systematic review of associated social and behavioral factors. *Vaccine*. (2022) 10, 1–38. doi: 10.3390/vaccines10010110

16. Jafar A, Dambul R, Dollah R, Sakke N, Mapa MT, Joko EP. COVID-19 vaccine hesitancy in Malaysia: exploring factors and identifying highly vulnerable groups. *PLoS One*. (2022) 17:e0270868. doi: 10.1371/journal.pone.0270868

17. Chan NN, Ong KW, Siau CS, Lee KW, Peh SC, Yacob S, et al. The lived experiences of a COVID-19 immunization programme: vaccine hesitancy and vaccine refusal. *BMC Public Health*. (2022) 22:296. doi: 10.1186/s12889-022-12632-z

18. Ng D-L-C, Gan GG, Chai CS, Anuar NAB, Sindeh W, Chua WJ, et al. The willingness of parents to vaccinate their children younger than 12 years against COVID-19: a cross-sectional study in Malaysia. *BMC Public Health*. (2022) 22:1265. doi: 10.1186/s12889-022-13682-z

19. Dalawi I, Chen XW, Isa MR, Azhar ZI, Mohd Nor F. Assessment of knowledge, attitude, practise and health literacy (KAPH) towards COVID-19 in post-COVID-19 new reality: the need and its challenges in Malaysia. *Front Public Health*. (2021) 9:704115. doi: 10.3389/fpubh.2021.704115

20. Marzo RR, Chen HWJ, Abid K, Chauhan S, Kaggwa MM, Essar MY, et al. Adapted digital health literacy and health information seeking behavior among lower income groups in Malaysia during the COVID-19 pandemic. *Front Public Health*. (2022) 10:998272. doi: 10.3389/fpubh.2022.998272

21. Fisher CB, Gray A, Sheck I. COVID-19 pediatric vaccine hesitancy among racially diverse parents in the United States. *Vaccine*. (2021) 10, 1–14. doi: 10.3390/vaccines10010031

22. Khatatbeh M, Albalas S, Khatatbeh H, Momani W, Melhem O, al Omari O, et al. Children's rates of COVID-19 vaccination as reported by parents, vaccine hesitancy, and determinants of COVID-19 vaccine uptake among children: a multi-country study from the eastern Mediterranean region. *BMC Public Health*. (2022) 22. Available from::1375. doi: 10.1186/s12889-022-13798-2

23. Aldakhil H, Albedah N, Alturaiki N, Alajlan R, Abusalih H. Vaccine hesitancy towards childhood immunizations as a predictor of mothers' intention to vaccinate their children against COVID-19 in Saudi Arabia. *J Infect Public Health*. (2021) 14:1497–504. doi: 10.1016/j.jiph.2021.08.028

24. Xu Y, Xu D, Luo L, Ma F, Wang P, Li H, et al. A cross-sectional survey on COVID-19 vaccine hesitancy among parents from Shandong vs. Zhejiang. *Front Public Health*. (2021) 9:779720. doi: 10.3389/fpubh.2021.779720

25. Horiuchi S, Sakamoto H, Abe SK, Shinohara R, Kushima M, Otawa S, et al. Factors of parental COVID-19 vaccine hesitancy: a cross sectional study in Japan. BK Padhi, editor. *PLoS One* (2021). 16:e0261121. doi: 10.1371/journal.pone.0261121

26. Lau EYH, Li J-B, King Chung Chan D. Intention to vaccinate young children against COVID-19: a large-scale survey of Hong Kong parents. *Hum Vaccin Immunother*. (2022) 18, 1–5. doi: 10.1080/21645515.2022.2065838

27. Shmueli L. Predicting intention to receive COVID-19 vaccine among the general population using the health belief model and the theory of planned behavior model. *BMC Public Health*. (2021) 21:804. doi: 10.1186/s12889-021-10816-7

28. Limbu YB, Gautam RK, Pham L. The health belief model applied to COVID-19 vaccine hesitancy: a systematic review. *Vaccine*. (2022) 10:973. doi: 10.3390/vaccines 10060973

29. Li J-B, Lau EYH, Chan DKC. Why do Hong Kong parents have low intention to vaccinate their children against COVID-19? Testing health belief model and theory of planned behavior in a large-scale survey. *Vaccine*. (2022) 40:2772–80. doi: 10.1016/j.vaccine.2022.03.040

30. Szilagyi PG, Shah MD, Delgado JR, Thomas K, Vizueta N, Cui Y, et al. Parents' intentions and perceptions about COVID-19 vaccination for their children: results from a National Survey. *Pediatrics*. (2021) 148:e2021052335. doi: 10.1542/peds.2021-052335

31. Alfieri NL, Kusma JD, Heard-Garris N, Davis MM, Golbeck E, Barrera L, et al. Parental COVID-19 vaccine hesitancy for children: vulnerability in an urban hotspot. *BMC Public Health*. (2021) 21:1662. doi: 10.1186/s12889-021-11725-5

32. Pippert C.H., Trujillo K.L., Lazer D., Baum M., Simonson M.D., Ognyanova K., et al. (2021). The COVID states project #68: heightened parental concerns about COVID-19 vaccinations for children; OSFPREPRINT Available at: https://osf.io/4u6hb (Accessed October 20, 2022).

33. Ruggiero KM, Wong J, Sweeney CF, Avola A, Auger A, Macaluso M, et al. Parents' intentions to vaccinate their children against COVID-19. *J Pediatr Health Care*. (2021) 35:509–17. doi: 10.1016/j.pedhc.2021.04.005

34. Shacham E, Little G, Scroggins S, Fredman A, Wray R, Charney R. Intent to vaccinate children against COVID-19: low levels of Trust in Public Health Agencies Trust across rural communities. *SocArXiv Papers*. (2021)

35. Teasdale CA, Borrell LN, Shen Y, Kimball S, Rinke ML, Fleary SA, et al. Parental plans to vaccinate children for COVID-19 in new York City. *Vaccine*. (2021) 39:5082–6. doi: 10.1016/j.vaccine.2021.07.058

36. Teherani M, Banskota S, Camacho-Gonzalez A, Smith AGC, Anderson EJ, Kao CM, et al. Intent to vaccinate SARS-CoV-2 infected children in US households: a survey. *Vaccine*. (2021) 9:1049. doi: 10.3390/vaccines9091049

37. Temsah M-H, Alhuzaimi AN, Aljamaan F, Bahkali F, al-Eyadhy A, Alrabiaah A, et al. Parental attitudes and hesitancy about COVID-19 vs. routine childhood vaccinations: a National Survey. *Front Public Health*. (2021) 9:752323. doi: 10.3389/fpubh.2021.752323

38. Zhang X, Guo Y, Zhou Q, Tan Z, Cao J. The mediating roles of medical mistrust, knowledge, confidence and complacency of vaccines in the pathways from conspiracy beliefs to vaccine hesitancy. *Vaccine*. (2021) 9:1342. doi: 10.3390/vaccines9111342

39. Brackstone K, Marzo RR, Bahari R, Head MG, Patalinghug ME, Su TT. COVID-19 vaccine hesitancy and confidence in the Philippines and Malaysia: a cross-sectional study of sociodemographic factors and digital health literacy. *PLOS Glob Public Health*. (2022) 2:e0000742. doi: 10.1371/journal.pgph.0000742

40. Marzo RR, Shrestha R, Sapkota B, Acharya S, Shrestha N, Pokharel M, et al. Perception towards vaccine effectiveness in controlling COVID-19 spread in rural and urban communities: a global survey. *Front Public Health*. (2022) 10:958668. doi: 10.3389/fpubh.2022.958668

41. Marzo RR, Su TT, Ismail R, Htay MN, Essar MY, Chauhan S, et al. Digital health literacy for COVID-19 vaccination and intention to be immunized: a cross sectional multi-country study among the general adult population. *Front Public Health*. (2022) 10:998234. doi: 10.3389/fpubh.2022.998234

42. Marzo RR, Chen HW, Abid K, Chauhan S, Kaggwa MM, Essar MY, et al. Adapted digital health literacy and health information seeking behavior among lower income groups in Malaysia during the COVID-19 pandemic. *Front Public Health*. (2022) 10:998272. doi: 10.3389/fpubh.2022.998272

43. Fisher CB, Gray A, Sheck I. COVID-19 pediatric vaccine hesitancy among racially diverse parents in the United States. *Vaccine*. (2022) 10:31. doi: 10.3390/vaccines10010031

44. Gray A, Fisher CB. Determinants of COVID-19 vaccine uptake in adolescents 12–17 years old: examining pediatric vaccine hesitancy among racially diverse parents in the United States. *Front Public Health*. (2022) 10:844310. doi: 10.3389/fpubh.2022.844310

45. Kaiser Family Foundation (2022). Latest data on COVID-19 vaccinations by race/ethnicity; USA. Available at: https://www.kff.org/coronavirus-covid-19/issue-brief/latest-data-on-covid-19-vaccinations-by-race-ethnicity/ (Accessed October 26, 2022).

46. Paige SR, Stellefson M, Krieger JL, Anderson-Lewis C, Cheong J, Stopka C. Proposing a transactional model of eHealth literacy: concept analysis. *J Med Internet Res*. (2018) 20:e10175. doi: 10.2196/10175

47. Dodd RH, Cvejic E, Bonner C, Pickles K, McCaffery KJ, Ayre J, et al. Willingness to vaccinate against COVID-19 in Australia. *Lancet Infect Dis*. (2021) 21:318–9. doi: 10.1016/S1473-3099(20)30559-4

48. Montagni I, Ouazzani-Touhami K, Mebarki A, Texier N, Schück S, Tzourio C, et al. Acceptance of a Covid-19 vaccine is associated with ability to detect fake news and health literacy. *J Public Health*. (2021) 43:695–702. doi: 10.1093/pubmed/fdab028

49. Marzo RR, Su TT, Ismail R, Htay MNN, Essar MY, Chauhan S, et al. Digital health literacy for COVID-19 vaccination and intention to be immunized: a cross sectional multi-country study among the general adult population. *Front Public Health*. (2022) 10:998234. doi: 10.3389/fpubh.2022.998234

50. Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C, Böhm R. Beyond confidence: development of a measure assessing the 5C psychological antecedents of vaccination. *PLoS One*. (2018) 13:e0208601. doi: 10.1371/journal.pone.0208601

51. Abdou MS, Kheirallah KA, Aly MO, Ramadan A, Elhadi YAM, Elbaraz I, et al. Psychological antecedents towards COVID-19 vaccination using the Arabic 5C validated tool: an online study in 13 Arab countries. *medRxiv*. (2021):2021.08.31.21262917. doi: 10.1101/2021.08.31.21262917

52. Shakeel CS, Mujeeb AA, Mirza MS, Chaudhry B, Khan SJ. Global COVID-19 vaccine acceptance: a systematic review of associated social and behavioral factors. *Vaccine*. (2022) 10:110. doi: 10.3390/vaccines10010110

53. Marzo RR, Ahmad A, Abid K, Khatiwada AP, Ahmed A, Kyaw TM, et al. Factors influencing the acceptability of COVID-19 vaccination: a cross-sectional study from Malaysia. *Vacunas*. (2022) 23:S33–40. doi: 10.1016/j.vacun.2021.07.007

54. Sallam M, Al-Sanafi M, Sallam M. A global map of COVID-19 vaccine acceptance rates per country: an updated concise narrative review. *J Multidiscip Healthc*. (2022) 15:21–45. doi: 10.2147/JMDH.S347669

55. Marzo RR, Sami W, Alam MZ, Acharya S, Jermsittiparsert K, Songwathana K, et al. Hesitancy in COVID-19 vaccine uptake and its associated factors among the general adult population: a cross-sectional study in six southeast Asian countries. *Trop Med Health*. (2022) 50:4. doi: 10.1186/s41182-021-00393-1

56. Wang L, Wen W, Chen C, Tang J, Wang C, Zhou M, et al. Explore the attitudes of children and adolescent parents towards the vaccination of COVID-19 in China. *Ital J Pediatr*. (2022) 48:122. doi: 10.1186/s13052-022-01321-7

57. Montalti M, Rallo F, Guaraldi F, Bartoli L, Po G, Stillo M, et al. Would parents get their children vaccinated against SARS- CoV-2? Rate and predictors of vaccine hesitancy according to a survey over 5000 families from Bologna, Italy. *Vaccine*. (2021) 9:366. doi: 10.3390/vaccines9040366

58. Yılmaz M, Sahin MK. Parents' willingness and attitudes concerning the COVID-19 vaccine: a cross-sectional study. *Int J Clin Pract*. (2021) 75:e14364. doi: 10.1111/ijcp.14364

59. Temsah M-H, Alhuzaimi AN, Aljamaan F, Bahkali F, al-Eyadhy A, Alrabiaah A, et al. Parental attitudes and hesitancy about COVID-19 vs. routine childhood vaccinations: a National Survey. *Front Public Health*. (2021) 9:752323. doi: 10.3389/fpubh.2021.752323

60. Brandstetter S, Böhmer MM, Pawellek M, Seelbach-Göbel B, Melter M, Kabesch M, et al. Parents' intention to get vaccinated and to have their child vaccinated against COVID-19: cross-sectional analyses using data from the KUNO- kids health study. *Eur J Pediatr*. (2021) 180:3405–10. doi: 10.1007/s00431-021-04094-z

61. Department of Statistics Malaysia (2020). Current population estimates, Malaysia, 2020. Available at: https://ophrp.org/journal/view.php?doi=10.24171/j.phrp.2021.0085#b62-j-phrp- [Accessed August 14, 2022].

62. Lau JFW, Woon YL, Leong CT, Teh HS. Factors influencing acceptance of the COVID-19 vaccine in Malaysia: a web-based survey. *Osong Public Health Res Perspect*. (2021) 12:361–73. doi: 10.24171/j.phrp.2021.0085

63. SAGE Working Group (2014). Report of the SAGE working group on vaccine hesitancy. Available at: https://www.asset-scienceinsociety.eu/sites/default/files/sage_working_group_revised_report_vaccine_hesitancy.pdf [Accessed August 14, 2022].

64. Ng JWJ, Vaithilingam S, Nair M, Hwang L-A, Musa KI. Key predictors of COVID-19 vaccine hesitancy in Malaysia: an integrated framework. *PLoS One*. (2022) 17:e0268926. doi: 10.1371/journal.pone.0268926

65. Syed Alwi SAR, Rafidah E, Zurraini A, Juslina O, Brohi IB, Lukas S. A survey on COVID-19 vaccine acceptance and concern among Malaysians. *BMC Public Health*. (2021) 21:1129. doi: 10.1186/s12889-021-11071-6

66. Nordin MZF. The identity in religious language in Malaysia. *Am J humanit soc sci*. (2018) 2:74–78.

67. Yigit M, Ozkaya-Parlakay A, Senel E. Evaluation of COVID-19 vaccine refusal in parents. *Pediatr Infect Dis J*. (2021) 40:e134–6. doi: 10.1097/INF.0000000000003042

68. Kim GY, Shin T, Son Y, Choi J. Psycho-behavioural factors influencing COVID-19 vaccine hesitancy among Korean adults: the moderating role of age. *J Adv Nurs*. (2022) 78:2904–15. doi: 10.1111/jan.15273

69. Nath R, Imtiaz A, Nath SD, Hasan E. Role of vaccine hesitancy, eHealth literacy, and vaccine literacy in young adults' COVID-19 vaccine uptake intention in a lower-middle-income country. *Vaccine*. (2021) 9:1405. doi: 10.3390/vaccines9121405

70. Liu H, Zhou Z, Tao X, Huang L, Zhu E, Yu L, et al. COVID-19 vaccine hesitancy among Chinese residents under the free vaccination policy. *Rev Assoc Med Bras*. (2021) 67:1317–21. doi: 10.1590/1806-9282.20210633

71. Dib F, Mayaud P, Chauvin P, Launay O. Online mis/disinformation and vaccine hesitancy in the era of COVID-19: why we need an eHealth literacy revolution. *Hum Vaccin Immunother*. (2022) 18:1–3. doi: 10.1080/21645515.2021.1874218

72. Aylin Wagnera JD, Liberatoreb F, Schmelzerb S. Confident and altruistic – parents' motives to vaccinate their children against COVID-19: a cross- sectional online survey in a Swiss vaccination Centre. *Swiss Med Wkly*. (2022) 152:1–10. doi: 10.4414/smw.2022.w30156

73. Azizan AH, Subramaniam G, Sivasamugham LA, Gopinathan S, Raman M, Wong LS. Vaccine hesitancy toward the COVID-19 vaccine among the Malaysian population. *J Exp Biol Agric Sci*. (2022) 10:544–53. doi: 10.18006/2022.10(3).544.553

74. Wismans A, Thurik R, Baptista R, Dejardin M, Janssen F, Franken I. Psychological characteristics and the mediating role of the 5C model in explaining students' COVID-19 vaccination intention. *PLoS One*. (2021) 16:e0255382. doi: 10.1371/journal.pone.0255382

75. Hossain MB, Alam MZ, Islam MS, Sultan S, Faysal MM, Rima S, et al. Health belief model, theory of planned behavior, or psychological antecedents: what predicts COVID-19 vaccine hesitancy better among the Bangladeshi adults? *Front Public Health*. (2021) 9:711066. doi: 10.3389/fpubh.2021.711066

76. Gendler Y, Ofri L. Investigating the influence of vaccine literacy, vaccine perception and vaccine hesitancy on Israeli parents' acceptance of the COVID-19 vaccine for their children: a cross-sectional study. *Vaccine*. (2021) 9:1391. doi: 10.3390/vaccines9121391

frontiers | Frontiers in Public Health

TYPE Systematic Review
PUBLISHED 16 August 2023
DOI 10.3389/fpubh.2023.1022803

OPEN ACCESS

EDITED BY
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RECEIVED 19 August 2022
ACCEPTED 10 April 2023
PUBLISHED 16 August 2023

CITATION
Wilandika A, Pandin MGR and Yusuf A (2023) The roles of nurses in supporting health literacy: a scoping review.
Front. Public Health 11:1022803.
doi: 10.3389/fpubh.2023.1022803

The roles of nurses in supporting health literacy: a scoping review

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Introduction: The importance of health literacy in achieving optimum health is highly significant, particularly in the nursing profession where it is an integral part of the roles and functions of nurses. Therefore, this scoping review aims to describe the roles of nurses in promoting patient health literacy and identify the determinant factors of health literacy in nursing practices.

Methods: An integrative search was conducted through four databases, namely, ScienceDirect, ProQuest, SAGE Journal, and PubMed, using various keyword combinations such as "health literacy," "health information," "patient health literacy," "patient literacy," and "nurses." Furthermore, the inclusion criteria employed were peer-reviewed articles focused on the nursing profession, explicitly discussing health literacy related to nursing, and including original studies, such as cross-sectional, quasi-experimental, and qualitative studies. The selected review articles were all published between 2017 and 2022.

Results: In total, 13 articles met the criteria and were applied in this scoping review. Most of these discuss health literacy related to nursing practice in clinical and community settings, as well as educational institutions. Health literacy is an essential aspect of professional nursing practice. Consequently, the supportive roles of nurses include acting as caregivers, facilitators, and educators to help patients overcome their literacy limitations and attain improved wellbeing.

Conclusion: Nurses can improve the health literacy skills of patients by making health information related to their illnesses easier to access, understand, evaluate, and use. They must also recognize various factors influencing health literacy and use the factors as opportunities to optimize health literacy improvement. A health literacy approach can be applied by nurses to solve health problems and improve the quality of care for patients.

KEYWORDS

health literacy, health information, patient health condition, nursing, nurse

Introduction

Health literacy is a concept that has been in existence for a long time but is relatively new in professional nursing practice. It is interpreted as health promotion (1), which is one of the goals of nursing science. This activity aims to maintain or improve individuals, groups, and communities (2). According to the American Nurses Association (ANA) (3), nurses must participate in ensuring and promoting the health of individuals, groups, communities, and society in general. Therefore, nurses should be well-equipped to protect, promote, and optimize the health and ability of everyone.

Nurses must understand health literacy as a concept that contributes to the health attitudes and behavior of individuals (4) in order to reduce health information gaps for patients (5). Limited health literacy can lead to health disparities and poor quality of care (6). Therefore, nurses and other healthcare providers need to be mindful of supporting health literacy to reduce existing disparities (7, 8). Patients with adequate health literacy are competent in paying attention to their health, families, and communities (9, 10). Good health literacy will improve healthy lifestyle behaviors and increase individual capacity to manage disease conditions (11–13). Meanwhile, limited health literacy will affect behaviors related to self-management of diseases, as well as health outcomes and costs (14, 15).

Based on the perspective of healthcare workers, health literacy can be described as a skill involving knowledge, motivation, and the ability to process information (16). This term is seen as a means of enabling individuals to access, understand, evaluate, and use health information to improve their wellbeing (17). Similarly, Guzys et al. (18) defined health literacy from the perspective of healthcare providers by emphasizing the knowledge and skills needed to prevent diseases and improve health in everyday life.

Health literacy skills in professional nursing facilitate effective communication between professional care providers and the public or clients. Carrying out this effective communication based on appropriate health information will enable patients to make the best decisions concerning their health problems (19, 20). Patients who make decisions based on health literacy are highly valued as they tend to be well-informed. Due to this, health literacy is defined as the process of obtaining and using correct information in making decisions related to health. It can be seen as a complex concept and requires a greater understanding of the nursing profession (21). Nurses need to understand that no one is entirely health literate. Therefore, they should have the necessary skills to help patients utilize information and correct misconceptions about diseases resulting from misinformation obtained from other sources (22). The general understanding of health literacy in nursing is of utmost importance, and more exploration is necessary in this area (23).

The enhancement of health literacy through health optimization is an integral aspect of professional nursing practice. Nurses, as healthcare professionals, play a vital role in addressing the issue of health literacy by comprehending the various forms of health literacy and providing quality care for patients. However, nurses understanding of health literacy and their associated supportive roles are still limited (23). The nature of health literacy in nursing practice needs to be explained to provide nurses with a clear understanding of how to utilize this concept. Therefore, this review aims to describe the roles of nurses in improving patient health literacy and identify the determinant factors that influence health literacy.

Methods

Protocols

Scoping reviews have been used to identify knowledge gaps, determine the scope of a body of literature, or clarify concepts (24). In this study, a scoping review approach was employed to collate articles focused on health literacy in nursing. An integrative search was conducted, and the results were presented following the guidelines of the Preferred Reporting Item for Systematic Reviews and Meta-Analysis (PRISMA) Extension (25). Therefore, the review question was formulated as "What are the role of nurses and the factors influencing it to increase health literacy within the scope of nursing?" Sub-questions explored to address the primary study question included the following:

- "What is the role of nurses in strengthening health literacy?"
- "What are the determinant factors influencing health literacy in nursing practice?"

Information sources and search strategy

In consultation with the study team, an expert information specialist conducted comprehensive literature searches through ScienceDirect, ProQuest, SAGE Journal, and PubMed to identify potentially relevant documents. These four databases were searched to fulfill the aims outlined above, using search terms specific to the context of health literacy in nursing. The searches were performed using various keyword combinations and Boolean operators, incorporating synonyms of "health literacy" or "health information," along with "patient health literacy," "patient literacy," and "nurses." Furthermore, the article search menu in all databases was enabled based on the nursing subject. The entire search terms were based on Medical Subject Headings (MeSH). The articles included in this review were limited to those peer-reviewed in the English language.

Eligibility criteria

Due to the vast literature obtained, the analysis conducted was restricted to the articles published in the last 6 years, from 2017 to 2022. The study team initially screened articles by reading the title and abstract and then reviewed the full text of relevant articles to determine their eligibility for inclusion. The inclusion criteria consisted of articles that (1) focused on individuals in the nursing field, with study subjects including nurses, nurse educators, and nursing students; (2) explicitly discussed health literacy related to nursing; and (3) included original studies, such as cross-sectional, quasi-experimental, qualitative, and mixed-method studies. Meanwhile, the exclusion criteria applied were as follows: (1) articles focused on health literacy involving various healthcare workers except for nurses; (2) articles that do not discuss health literacy about nursing; and (3) literature reviews, dissertations, editorials, commentaries, and other expert opinions.

Study selection process

Articles were selected based on inclusion criteria through predetermined data-based searches. Those found during the search were added to the bibliography manager software (Mendeley). Duplicates were excluded through the automatic duplication removal process in Mendeley's tool. Articles not identified by the software were further examined and manually removed.

During the review process, two reviewers independently filtered and assessed each article using two stages based on the eligibility criteria. The first stage involved reviewing the title and abstract, while the second stage included a thorough examination of the full-text articles selected from the first stage. Any article deemed relevant by at least one reviewer progressed further in the review process. Subsequently, two independent blind readers checked and scored the Materials and Methods as well as Results sections, and only articles they both considered relevant were included in this study. To ensure consistency and accuracy in the selection process, Cohen's Kappa and percent agreement were used to calculate inter-rater reliability for both titles/abstract and full-text articles (26, 27). The Altman benchmark scale was employed to interpret the agreement degree of the Kappa value: <0.20 (poor), 0.21–0.40 (fair), 0.41–0.60 (moderate), 0.61–0.80 (good), and 0.81–1.00 (very good) (26). A Kappa value >0.41 was considered acceptable (27). All disagreements between the two reviewers were discussed and resolved until a consensus was reached, and a third opinion was sought from a senior reviewer when unanimity was required.

Data extraction and analysis

After selecting the articles, their data were entered into a spreadsheet for extraction and charting. For those in form of scoping reviews, data on study characteristics, such as years of conduct, aims, design, and subjects, were abstracted and are presented in Table 1. The years of publication were limited to 2017–2022 according to the eligibility criteria. The design selected was primarily cross-sectional, and only one appeared quasi-experimental. To align with the study aims and formulated questions, the data were also extracted based on the aims and subjects related to the role of nurses and determinant factors of health literacy in nursing. In the next stage of analysis, all publications were screened for a second time to verify whether these issues were being addressed in the included articles.

The team read and assessed the entire results, which were then summarized descriptively and compared in the data extraction sheet to identify common themes. Two reviewers independently identified themes for synthesis using thematic analysis that matched the study aims, and all discrepancies were resolved through discussion. Data descriptions indicating statements related to the role of nurses in literacy were grouped, and all results that showed factors related to health literacy in nursing were reviewed. These were organized into two main categories based on the sub-review questions: (1) the role of nurses in promoting health literacy and (2) factors influencing health literacy in nursing.

Results

Search result

The PRISMA-ScR flow diagram (25) presented in Figure 1 depicts each step of the article selection process, including the specific rationale for the exclusion of full-text articles. An initial search through four electronic databases and review article references yielded 1,674 results, which were reduced to 1,315 after removing duplicates. Two independent reviewers evaluated 925 articles in a two-step screening process. First, title and abstract screening for key terms, including health literacy, health literacy in nursing, nurses' roles, and factors related to patient health literacy, led to the exclusion of 794 records. Second, the remaining 131 articles were further assessed to determine their eligibility. From this, 117 articles were eliminated for the following reasons: 55 were not original studies, 39 did not align with the nursing scope, and 23 did not explicitly address health literacy in nursing; then, the 14 articles left were included in the final examination.

The inter-rater reliability analysis conducted produced the Kappa values of 0.742 and 0.815 for title/abstract and full-text screening, respectively. The Kappa values of $0.61 \leq 0.80$ and $0.81 \leq 1.00$ indicated good to very good agreement between independent reviewers, respectively (26). Reviewing the references list of the last 14 full-text articles led to their inclusion in the final analysis. In total, 14 articles met the eligibility criteria for the current scoping review.

Characteristics of studies

Characteristics of the included studies, such as author, publication year, aims, design, and subjects, are presented in Table 1. The articles reviewed comprised both quantitative and qualitative studies ($n = 13$) focused on health literacy within nursing, with subjects including nurses ($n = 6$), nurse educators ($n = 1$), and nursing students ($n = 7$). Their designs were cross-sectional ($n = 11$), quasi-experimental ($n = 1$), and qualitative ($n = 1$). Each report provided information on health literacy in nursing scopes.

Synthesis of results

Based on the data synthesis pertaining to the review question shown in Table 2, the synthesis of the results was grouped into two categories. These categories included the role of nurses in health literacy and the factors influencing it.

Roles of nurses in health literacy

Nurses play a crucial role in health literacy as caregivers who offer support to enhance patients' health status. As professionals, they need to improve patient health and patient-centered care by providing nursing care that facilitates literacy support. Seven studies stated that nurses have a responsibility of providing health promotion to increase patient health literacy (11, 12, 30, 33–36). Health literacy is an essential factor in the scope of professional nursing practice. According to four studies, it has an impact on health behaviors and promotion that influence patients' health status (11, 28, 31, 32). The impact of health literacy is broad and covers the physical, psychological, social, and spiritual aspects of nursing care practice.

TABLE 1 Characteristics of the reviewed studies.

Author, year	Aims	Study Design	Subjects
Coşkun and Bebiş (11)	To determine the impact of health promotion on developing healthy lifestyle behaviors and health literacy in nursing students.	Quasi-experimental study	133 nursing students
Kim and Oh (28)	To identify the relationship between e-health literacy and health promotion behavior through social media related to health information, health information-seeking behavior, and self-care agency.	Cross-sectional study	558 nursing students
Mosley and Taylor (12)	To identify health literacy-based patient learning curricula and strategies.	Cross-sectional study	15 nursing educators and 53 nursing students
Shiferaw et al. (29)	To examine internet use and electronic health literacy skills among university students	Cross-sectional study	236 nursing students
Wittenberg et al. (20)	To assess nurse communication and health literacy in patients	Cross-sectional study	74 nurses
Ayaz-Alkaya and Terzi (30)	To determine health literacy and the factors influencing it in nursing students.	Cross-sectional study	303 nursing students
Nesari et al. (19)	To assess the knowledge and experience of registered nurses with health literacy practices.	Cross-sectional study	190 nurses
Turan et al. (31)	To examine the effect of e-health literacy on students' healthy lifestyle behavior.	Cross-sectional study	232 nursing students
Koduah et al. (32)	To assess the knowledge of health literacy and the factors influencing nurses.	Cross-sectional study	876 nurses
Munangatire et al. (33)	To explore nursing students' understanding of health literacy concepts and health practice.	Cross-sectional study	205 nursing students
Yusefi et al. (34)	To assess health literacy status and its relationship with quality of life among hospital nurses.	Cross-sectional study	185 nurses
Kim and Oh (35)	To identify nurses' perspectives on health literacy and education in elderly patients.	Qualitative study	16 nurses
Yang (36)	To identify the relationship between health literacy competencies and patient-centered care by clinical nurses.	Cross-sectional study	180 nurses

In addition to promoting patient health, providing information and knowledge about the disease is essential. In this case, nurses assist patients in understanding limited information about the disease and treatment procedure. The support of nurses in health literacy has a significant impact on patients' ability to obtain and comprehend disease information and apply it to improve their health behavior (11, 12, 30, 33, 35). With assistance from nurses, patients can interpret the disease process and manage their health effectively (12). The quality of patient care is optimized when nurses provide care that meets their health needs, such as the need for information about the disease being suffered. Three studies found that health literacy affects healthy lifestyle behaviors, as well as improves the quality of life and care (11, 31, 36). Health literacy is a strategy employed by nurses to meet this need.

According to three studies, nurses play an educational role in helping patients understand the value of practicing good health habits and promoting health literacy (30, 33, 35). All nurse educators should emphasize the importance of health literacy skills for themselves and their patients. Another three studies showed that health literacy skills impact the ability of nurses to deal with problems, such as stress management, positive thinking, spiritual wellbeing, and quality of life (11, 31, 34). Therefore, educating patients on health literacy skills becomes crucial to enhance their quality of life and health outcomes. Furthermore, four studies stated that health literacy is one of the core skills of nursing practice (11, 19, 20, 33). Even during the educational process, students must be imparted with health literacy knowledge to be used all through their nursing careers (12, 30, 33).

Determinant factors of health literacy

Many determinant factors influence health literacy in nursing practice. These include age, gender, education, ethnicity, religiosity, language, income, and marital status, which affect health literacy in both nurses and patients (11–13, 19, 20, 28, 30, 32, 33, 35). Additionally, work experience, work status, information media, and internet usage affect the health literacy of nurses in providing care for patients (19, 20, 28–32, 34). Two studies stated that communication, patient attitudes, and perceptions about their health impact the effectiveness of health literacy in addressing the health problems suffered (11, 35).

Two studies showed the impact of health literacy on health behavior through intermediary mediating factors, such as information-seeking motivation, information-seeking behavior, self-care agency, self-efficacy, and self-care management (13, 28). Another study suggested that health literacy does not directly increase health promotion behavior but directly impacts the use of social media in seeking information, thereby increasing information-seeking behavior and self-care agency (28, 35).

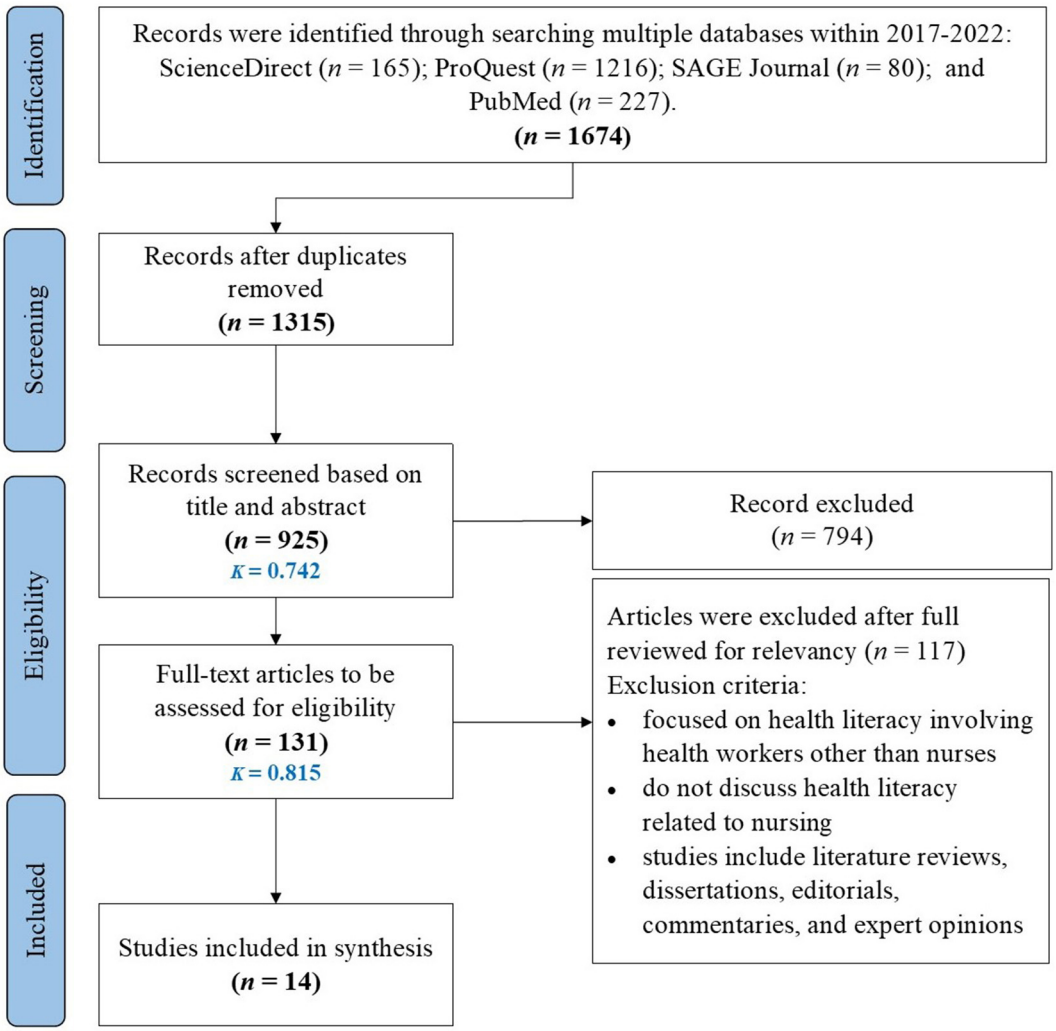

FIGURE 1
PRISMA scoping review flow diagram. Selection of sources of evidence.

Five studies reported that health literacy in nursing practice is influenced by educational factors and professional training, including nursing specialization or scope of the work area, work experience, employment status, length of study, and educational attainment (19, 29, 32, 34, 37). These factors have an impact on the understanding of health literacy among nurses and their performance in providing care to patients (29, 34, 36).

Discussion

This scoping review showed the roles of nurses in patient health literacy as caregivers, facilitators, and educators. As caregivers, they carry out comprehensive care by paying attention to patient health literacy as one of the factors to support the success of treatment goals. To support the success of treatment programs, nurses play a crucial role in enhancing patients' limited knowledge about their disease and treatment options. As educators, nurses provide information, knowledge, and health literacy skills essential for achieving optimal health outcomes. Health literacy is a complex concept and skill in nursing practice influenced by various factors, which nurses and patients should understand to effectively improve the quality of health. This study described the roles of nurses in patient health literacy and the factors influencing the concept within the framework are shown in Figure 2.

A nurse who plays a role in improving health literacy should understand the extent of health literacy skills and patients' level of understanding about a disease or problem. Applying health literacy at any time and in all patient care settings will promote achieving client empowerment, engagement, activation, and optimal health outcomes (38). Nurses have a significant role in educating patients on health information and promotion (12, 35). Their core skill also includes providing support for patient health literacy, which should be understood broadly (37).

Optimizing health outcomes is a fundamental goal of nursing, which involves efforts to prevent and promote health through individual awareness and active engagement in staying. To achieve this, individuals need to possess adequate health literacy skills

10.3389/fpubh.2023.1022803

TABLE 2 Summarized results of the reviewed studies.

Reference	Summarized Results		
	Roles of nurses in health literacy	Determinant factors	Outcomes
Coşkun and Bebiş (11)	Nurses play a role in facilitating health promotion to increase health literacy and positive health-related lifestyle behaviors	Gender, BMI, family structure, parental knowledge status, income, smoking habit, alcohol drinking habit, history of chronic disease, drug use, and perception of health status	• Health literacy has an impact on increasing the achievement of positive health behaviors. • The ability to find information and media sources related to health increases patient health literacy
Kim and Oh (28)	Nurses facilitate health literacy to carry out health promotion by encouraging the use of social media in seeking information and then increasing information-seeking behavior and self-care agency	Age, gender, education, religion, duration of internet use, and health status	• Electronic health literacy has a significant relationship with health promotion behavior in students. The higher the health literacy, the better the health promotion behavior
Mosley and Taylor (12)	Nurses must have the ability to provide care to patients with low health literacy. Therefore, health literacy education in the nursing process is essential	Age, language, language ability, and risk groups	• Health literacy increases the ability to use social media, online health information-seeking behavior, self-care agency, and health behavior. • Health literacy improves the patient's ability to interpret the disease process, manage their disease, and make decisions regarding health issues.
Shiferaw et al. (29)	The nursing profession must strengthen health literacy skills by increasing access to technology. In the clinical setting, the role of nurses is to improve patients' literacy skills	Gender, domicile, and students' registration years	• Health literacy impacts students' academic abilities or grade point averages. • Meanwhile, the ability to access the internet used to obtain information determines health literacy in college students
Wittenberg et al. (20)	Providing health literacy support to patients is one of the core skills of nursing. Nurses must have good communication skills, specifically in assessing the level of health literacy. This is a strategy to support health literacy	Age, ethnicity, education, income, language, job position, demographic situation, and work experience	Health literacy impacts patient health support and health quality
Ayaz-Alkaya and Terzi (30)	Nurses act as care providers by paying attention to health literacy needs based on knowledge and experience. Every nurse educator must emphasize the importance of health literacy and patient empowerment	Age, gender, family income, social insurance, domicile, history of chronic disease, drug consumption, visual and hearing impairment, and internet use	Health literacy has an impact on increasing patient empowerment. Nurses must have optimal health literacy skills to deal with rapid changes in the health care system
Nesari et al. (19)	Nurses play a role in improving public health literacy practices, such as understanding health information and making decisions about patients' health	Age, work experience, gender, and scope of the work area	• Efforts to increase equity in health literacy are significant in supporting the quality of patient care. • Health literacy practices facilitate effective communication between healthcare professionals and the public
Turan et al. (31)	Nurses can use electronic health literacy and healthy lifestyle behaviors to improve the quality of care by supporting teaching methods and nursing role models. Health literacies are essential to support patients and families in accessing and using health information to improve patient safety and quality of care	Age, health insurance, expenses, health status, and internet usage	• Health literacy is essential in promoting students' healthy lifestyle behavior. • Health literacy positively affects interpersonal relationships, stress management, positive life perspective, spiritual health, and lifestyle.
Koduah et al. (32)	Nursing practice must integrate health literacy knowledge professionally by considering characteristics, social and cultural values, nursing education, and experience	Educational and professional practice factors: nursing specialization, work experience, employment status, length of study, and higher education	Factors of personal characteristics, social and cultural values, nursing education, and experience have a relationship or connection with health literacy knowledge in nursing professional practice
Munangatire et al. (33)	Nurses play an educator role in ensuring patients understand the importance of health literacy and practice to increase their health quality. In the educational setting, the educators ensure that every nurse student understands the health literacy that will impact patients	Age, marital status, gender, and medical history	• Health literacy skills can transfer to students' professional careers as nurses • Nursing students understand health literacy concepts well, but they must all try to translate this understanding into health literacy skills
Yusefi et al. (34)	Nurses play a role in increasing patient health literacy, which affects their quality of life. Health literacy possessed by nurses has an impact on their professional ability to work and decide on a problem	Age, work experience, and employment status	Health literacy's dimensions closely related to the quality of life include access to information, and the ability to read, understand, and use health information
Kim and Oh (35)	Nurses act as health literacy educators for patients by helping to improve their literacy skills that support self-care practices	Age, knowledge, education, communication, patient attitude, and family support	Patient health literacy will increase with the support of effective communication and health education
Yang (36)	Nurses play a role in developing health literacy competencies to improve patient-centered care. Education programs should emphasize the integration of health literacy into the nursing school curriculum	Education level, prior health literacy knowledge, and health literacy competencies	Health literacy skills significantly affect the caring aspect of patients

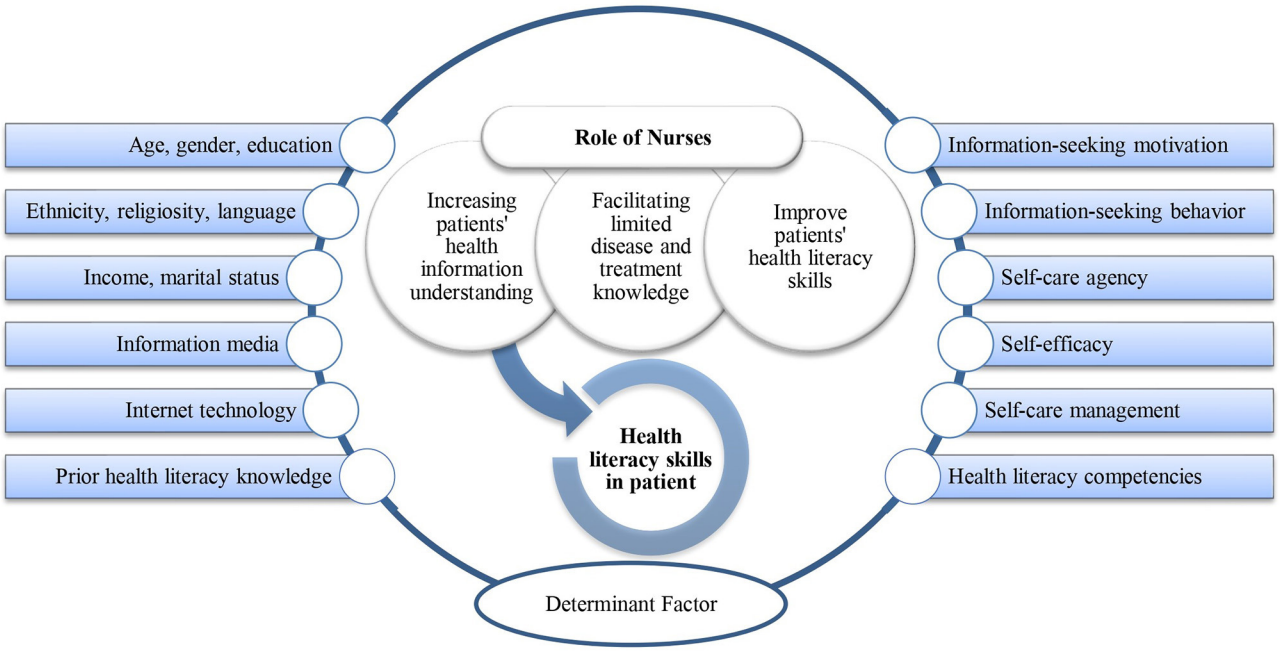

FIGURE 2
The framework for the role of the nurse and the factors that determine healthy literacy.

that ensure the making of good decisions on healthcare, disease prevention, and health promotion, ultimately leading to improved health outcomes (39, 40). Mosley and Taylor described health literacy as an ability required by nurses in adapting care to patients (12). Health literacy in the nursing process requires knowledge, motivation, and competence to access, understand, assess, and apply health information. Nurses play a critical role in facilitating patients' efforts to access and understand health information by developing interventions focused on improving their ability to manage illnesses through comprehensive reading and interpretation of health information (23).

Health literacy in nursing practice has been widely recognized as a mediator between individual and social health status and health outcomes. It is the initial component of obtaining a permanent health culture and optimal health status (41). Health literacy skills are a process to access, understand, evaluate, and use health information, to improve health quality and prevent disease emergence (11). According to the Healthy People 2030 framework, health literacy is the extent to which individuals can find, understand, and use a piece of information to make decisions about their health and that of other individuals (42).

Individuals with good health literacy will be able to participate in public and private discussions about health, medicine, scientific knowledge, and cultural beliefs (43). Ancker's definition places the responsibility of health literacy solely on the individual, leaving the healthcare provider not accountable for providing information in a health-literate manner (44). This situation makes the increase in health literacy not to be optimal. Therefore, strengthening health literacy with the assistance of nurses can enhance primary health conditions at the individual and community levels by using appropriate health information to increase health literacy and meet patient needs (12, 20).

Health literacy is how individuals can use the information studied effectively to determine the most appropriate nursing intervention offered to patients. Nurses are expected to assess the level of health literacy of patients (20). Decisions made based on health literacy are highlighted discoveries because being "well-informed" is not just the right decision. Therefore, health literacy is a process of obtaining and using appropriate information in deciding about personal health and the health of others. Nurses can utilize health literacy strategies in informing individuals to make the best possible health-related decision.

In nursing, health literacy is essential in communication strategies for all clients (35). Clients cannot fully participate in their healthcare choices or make appropriate decisions without accurate information for their health literacy needs (45). Nurses as healthcare workers who have a closer relationship with patients can become facilitators to meet these health literacy needs through health education or promotion activities. Sometimes nurses overestimate patients' level of health literacy, by creating reports based on their feelings and relying only on external indicators such as education or socioeconomic status. This approach is problematic because health literacy cannot be determined solely with the aforementioned factors. While providing information to the patients, nurses should be careful in interpreting their observable body language movements, such as nodding of the head as an indication that the information received was understood (46).

As previously explained, health literacy is a complex concept that requires careful, thorough, and persistent assessment. Inadequate assessment of health literacy can pose a significant barrier to clients' health literacy. As stated by Cohen et al. (47), to ensure understanding and overcome health literacy barriers, nurses must conduct adequate assessments to determine patients' level

of knowledge, emotional reactions to information, and external support from other healthcare teams.

Wittenberg et al. (37) provided several recommendations for assessing health literacy in individuals, groups, or communities experiencing barriers. This includes the following: (1) Nurses must understand the beliefs and cultural norms of their clients. (2) Information explanations should be repeated or provided in a way that is more technically adapted to clients' cultural approach. (3) Nurses should be attentive to verbal and non-verbal cues, and use simple language during communication, avoiding medical terms that may be unfamiliar to clients. (4) In case of a language barrier, a translator should be involved to ensure effective communication.

Assessing patient understanding and addressing challenges related to health literacy are essential for providing quality nursing care and improving health literacy. Therefore, nurses should possess good health literacy knowledge and experience to empower patients with the best information for their health. They need to emphasize the importance of health literacy and patient empowerment to achieve effective care.

Various determinant factors influence health literacy skills, which is the basis for professional nursing practice in supporting patient care. These should be considered by interventions meant to improve health status through good health literacy in individuals, communities, and society. Personal factors, specifically age, gender, income, education, and employment status, are associated with the determination of health literacy (11, 13, 20, 28, 30, 32, 33, 35). Among all, age has the closest relationship with health literacy as they are both inversely proportional (48–50). Similarly, Sántha (14) discovered that health literacy has a significant correlation with age and education.

According to Yang et al. (50), personal factors and access to information or its sources, such as the internet, play a crucial role in determining an individual's health literacy. Health literacy is a concept based on information existence, hence inadequate access to information may hinder health literacy development, despite possessing literacy skills. Various studies found that using multiple sources of information significantly impacts an individual's level of health literacy (28, 30, 31). Motivational factors and the ability to access information can influence health literacy (51).

In contrast to some previous studies, Guo et al. (39) found that sociodemographic factors, including gender, education, income, and access to information, are not directly related to health literacy. Personal characteristics, such as self-efficacy, social support, and health status, were observed to have a significant impact on health literacy. Furthermore, health status has been identified as a key predictor of health literacy. This along with factors such as disease history, disease severity, presence of other disorders, and the use of drugs can affect patients' ability to improve or decrease their health literacy (11, 13, 28, 30, 31, 33).

Health literacy is also affected by spiritual and environmental factors, as well as an individual's ecological aspects, education, place of work, and religious beliefs (8). The study conducted by Koduah et al. (32) discovered that religiosity can impact health literacy. Nurses with strong religious beliefs view health as necessary and make health literacy essential to their lives. Home and work environments can impact health literacy (19, 20, 32, 34). Therefore, nurses play a crucial role in improving and determining the health literacy levels of individuals, groups, or communities by considering these factors (20, 30, 32).

Strengths and limitations

This review systematically outlines the peer-reviewed literature related to health literacy within the scope of nursing science. Although health literacy skills are essential for nurses at all levels, specifically those providing direct care to patients, this study does not explicitly focus on any particular level. The literature analyzed was various study types, and the evidence level obtained was not the highest. Books, gray literature, or other sources that can provide more in-depth information on the subject of health literacy were not included in this scoping review.

Conclusion

The results showed that nurses play an essential role in supporting health literacy through the dissemination of relevant information. Health literacy is one of the critical skills that nurses and patients must master to make informed decisions capable of impacting health outcomes. Nurses act as caregivers, facilitators, and educators in meeting the limited health literacy needs of patients to improve their health status. They help to optimize patients' health literacy skills by facilitating the ability to find, understand, assess, and use health information related to their diseases. It is important to note that health literacy is influenced by various factors, and nurses should utilize these factors as opportunities to promote health literacy improvement. By fully understanding health literacy from a nursing perspective, nurses can use this approach to solve health problems and ultimately improve the quality of care for patients.

Author contributions

AW and MP created the presented idea and then revised the manuscript written. AW wrote the draft of the manuscript, directed the study, served as the guarantor responsible for the study's conduct and finished work, and had access to the data collected. MP and AY performed the review. All authors discussed the results and provided feedback on the manuscript.

Acknowledgments

The authors are grateful to all entities that contributed to this study, as well as Universitas Aisyiyah Bandung for the support provided.

Conflict of interest

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

Publisher's note

References

1. Alkorashy HAE, Villagracia HN. Nursing perspectives on health literacy challenges and strategies: a systematic review. *Middle-East J Sci Res.* (2015) 23:2645–56. doi: 10.5829/idosi.mejsr.2015.23.11.10160

2. Kim HS. *The Essence of Nursing Practice: Philosophy and Perspective*. New York: Springer Publishing Company (2015).

3. Association American Nurses. *Nursing: Scope and Standards of Practice. 3rd ed*. Silver Spring: American Nurses Association. (2015).

4. Silva MJ, Santos P. The impact of health literacy on knowledge and attitudes towards preventive strategies against COVID-19: a cross-sectional study. *Int J Environ Res Public Health.* (2021) 18:5421. doi: 10.3390/ijerph18105421

5. Sharma S, Oli N, Thapa B. Electronic health–literacy skills among nursing students. *Adv Med Educ Pract.* (2019) 10:527–32. doi: 10.2147/AMEP.S207353

6. Magnani JW, Mujahid MS, Aronow HD, Cené CW, Dickson VV, Havranek E, et al. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American heart association. *Circulation.* (2018) 138:e48–74. doi: 10.1161/CIR.0000000000000579

7. Gómez CA, Kleinman D V, Pronk N, Gordon GLW, Ochiai E, Blakey C, et al. Practice full report: addressing health equity and social determinants of health through healthy people 2030. *J Public Heal Manag Pract.* (2021) 27:S249. doi: 10.1097/phh.0000000000001297

8. Pronk N, Kleinman D V, Goekler SF, Ochiai E, Blakey C, Brewer KH. Practice full report: promoting health and wellbeing in healthy people 2030. *J Public Heal Manag Pract.* (2021) 27:S242. doi: 10.1097/phh.0000000000001254

9. Zhang F, Or PPL, Chung JWY. How different health literacy dimensions influences health and well-being among men and women: the mediating role of health behaviours. *Heal Expect.* (2021) 24:617–27. doi: 10.1111/hex.13208

10. Pitts PJ, Freeman E. Health literacy: the common denominator of healthcare progress. *Patient-Patient-Centered Outcomes Res.* (2021) 14:455–8. doi: 10.1007/s40271-021-00537-9

11. Coşkun S, Bebiş H. Effects of health promotion courses on development of healthy lifestyle behaviors and e-health literacy in nursing. *Gülhane Tip Derg.* (2019) 61:52. doi: 10.26657/gulhane.00054

12. Mosley CM, Taylor BJ. Integration of health literacy content into nursing curriculum utilizing the health literacy expanded model. *Teach Learn Nurs.* (2017) 12:109–16. doi: 10.1016/j.teln.2016.12.005

13. Kim MT, Kim KB, Ko J, Murry N, Xie B, Radhakrishnan K, et al. Health literacy and outcomes of a community-based self-help intervention: a case of Korean Americans with type 2 diabetes. *Nurs Res.* (2020) 69:210. doi: 10.1097/nnr.0000000000000409

14. Sántha Á. The sociodemographic determinants of health literacy in the ethnic hungarian mothers of young children in Eastern Europe. *Int J Environ Res Public Health.* (2021) 18:5517. doi: 10.3390/ijerph18115517

15. Dehghani A. Health literacy in multiple sclerosis patients: a concept analysis using the evolutionary method. *J Caring Sci.* (2021) 10:49. doi: 10.34172/jcs.2021.010

16. Smith GD. Health literacy: a nursing perspective. *Rev Enferm Ref.* (2021) 3:18. doi: 10.12707/RV21ED8

17. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health.* (2012) 12:1–13. doi: 10.1186/1471-2458-12-80

18. Guzys D, Kenny A, Dickson-Swift V, Threlkeld G. A critical review of population health literacy assessment. *BMC Public Health.* (2015) 15:1–7. doi: 10.1186/s12889-015-1551-6

19. Nesari M, Olson JK, Nasrabadi AN, Norris C. Registered nurses' knowledge of and experience with health literacy. *HLRP Heal Lit Res Pract.* (2019) 3:e268–79. doi: 10.3928/24748307-20191021-01

20. Wittenberg E, Ferrell B, Kanter E, Buller H. Health literacy: exploring nursing challenges to providing support and understanding. *Clin J Oncol Nurs.* (2018) 22:53–61. doi: 10.1188/18.cjon.53-61

21. Smith GD, Lai V, Poon S. Building the case for health literacy in gastroenterology. *Gastrointest Nurs.* (2021) 19:26–30. doi: 10.12968/gasn.2021.19.7.26

22. Tubaishat A, Habiballah L. eHealth literacy among undergraduate nursing students. *Nurse Educ Today.* (2016) 42:47–52. doi: 10.1016/j.nedt.2016.04.003

23. Macabasco-O'Connell A, Fry-Bowers EK. Knowledge and perceptions of health literacy among nursing professionals. *J Health Commun.* (2011) 16:295–307. doi: 10.1080/10810730.2011.60438

24. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol.* (2018) 18:143. doi: 10.1186/s12874-018-0611-x

25. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* (2018) 169:467–73. doi: 10.7326/m18-0850

26. Gwet KL. *Handbook of Inter-Rater Reliability: The Definitive Guide to Measuring the Extent of Agreement Among Raters*. Gaithersburg: Advanced Analytics, LLC (2014).

27. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Medica.* (2012) 22:276–82. doi: 10.11613/bm.2012.031

28. Kim S, Oh J. The relationship between e-health literacy and health-promoting behaviors in nursing students: a multiple mediation model. *Int J Environ Res Public Health.* (2021) 18:5804. doi: 10.3390/ijerph18115804

29. Shiferaw KB, Mehari EA, Eshete T. eHealth literacy and internet use among undergraduate nursing students in a resource limited country: a cross-sectional study. *Informatics Med Unlocked.* (2020) 18:100273. doi: 10.1016/j.imu.2019.100273

30. Ayaz-Alkaya S, Terzi H. Investigation of health literacy and affecting factors of nursing students. *Nurse Educ Pract.* (2019) 34:31–5. doi: 10.1016/j.nepr.2018.10.009

31. Turan N, Güven Özdemir N, Çulha Y, Özdemir Aydin G, Kaya H, Aşti T. The effect of undergraduate nursing students' e-Health literacy on healthy lifestyle behavior. *Glob Health Promot.* (2021) 28:6–13. doi: 10.1177/1757975920960442

32. Koduah AO, Amoah PA, Nkansah JO, Leung AYM, A. Comparative analysis of student and practicing nurses' health literacy knowledge in Ghana. *Healthcare Multidiscip Digital Pub Inst.* (2021) 38:3. doi: 10.3390/healthcare901003

33. Munangatire T, Tomas N, Mareka V. Nursing students' understanding of health literacy and health practices: a cross-sectional study at a university in Namibia. *BMC Nurs.* (2022) 21:1–8. doi: 10.1186/s12912-021-00776-z

34. Yusefi A, Ebrahim Z, Bastani P, Najibi M, Radinmanesh M, Mehrtak M. Health literacy status and its relationship with quality of life among nurses in teaching hospitals of shiraz university of medical sciences. *Iran J Nurs Midwifery Res.* (2019) 24:73–9. doi: 10.4103/ijnmr.IJNMR_205_17

35. Kim MY, Oh S. Nurses' perspectives on health education and health literacy of older patients. *Int J Environ Res Public Health.* (2020) 17:6455. doi: 10.3390/ijerph17186455

36. Yang Y. Effects of health literacy competencies on patient-centered care among nurses. *BMC Health Serv Res.* (2022) 22:1–9. doi: 10.1186/s12913-022-08550-w

37. WittenbergE, Ferrell B, Kanter E, Buller H. Nurse communication challenges with health literacy support. *Clin J Oncol Nurs.* (2018) 22:53. doi: 10.1188/18.CJON.53-61

38. Loan LA, Parnell TA, Stichler JF, Boyle DK, Allen P, VanFosson CA, et al. Call for action: nurses must play a critical role to enhance health literacy. *Nurs Outlook.* (2018) 66:97–100. doi: 10.1016/j.outlook.2017.11.003

39. Guo S, Yu X, Davis E, Armstrong R, Naccarella L. Health literacy: an interactive outcome among secondary students in Beijing. *HLRP Heal Lit Res Pract.* (2021) 5:e1–14. doi: 10.3928/24748307-20201117-01

40. Alsubaie MS, Salem OA. Nursesâ perception of health literacy. *Ann Med Health Sci Res.* (2019) 3:18.

41. Barton AJ, Allen PE, Boyle DK, Loan LA, Stichler JF, Parnell TA. Health literacy: essential for a culture of health. *J Contin Educ Nurs.* (2018) 49:73–8. doi: 10.3928/00220124-20180116-06

42. US Department of Health & Human Services. Healthy People 2030. *US Dep Heal Hum Serv Off Dis Prev Heal Promot.* (2020). Available online at: https://health.gov/our-work/healthy-people-2030/about-healthy-people-2030/health-literacy-healthy-people (accessed March 13, 2022).

43. Zarcadoolas C, Pleasant A, Greer DS. Understanding health literacy: an expanded model. *Health Promot Int.* (2005) 20:195–203. doi: 10.1093/heapro/dah609

44. Ancker JS, Grossman L V, Benda NC. Health literacy 2030: is it time to redefine the term? *J Gen Intern Med.* (2020) 35:2427–30. doi: 10.1007/s11606-019-05472-y

45. Ballard D, Hill JMF. The nurse's role in health literacy of patients with cancer. *Clin J Oncol Nurs.* (2016) 20:234. doi: 10.1188/16.cjon.232-234

46. Parnell TA. *Health Literacy in Nursing: Providing Person-Centered Care*. New York: Springer Publishing Company (2014).

47. Cohen MZ, Jenkins D, Holston EC, Carlson ED. Understanding health literacy in patients receiving hematopoietic stem cell transplantation. *Oncol. Nurs. Forum*. (2013) 40:151. doi: 10.1188/13.onf.508-515

48. Do BN, Nguyen P-A, Pham KM, Nguyen HC, Nguyen MH, Tran CQ, et al. Determinants of health literacy and its associations with health-related behaviors, depression among the older people with and without suspected COVID-19 symptoms: a multi-institutional study. *Front Public Heal.* (2020) 8:694. doi: 10.3389/fpubh.2020.581746

49. Liu YB, Liu L, Li YF, Chen YL. Relationship between health literacy, health-related behaviors and health status: a survey of elderly Chinese. *Int J Environ Res Public Health.* (2015) 12:9714–25. doi: 10.3390/ijerph120809714

50. Yang Q, Yu S, Wang C, Gu G, Yang Z, Liu H. Health literacy and its socio-demographic risk factors in Hebei: a cross-sectional survey. *Medicine.* (2021) 100:975. doi: 10.1097/md.0000000000025975

51. Izadirad H, Zareban I. The relationship of health literacy with health status, preventive behaviors and health services utilization in Baluchistan, Iran. *J Educ Community Heal.* (2022) 2:43–50. doi: 10.20286/jech-02036

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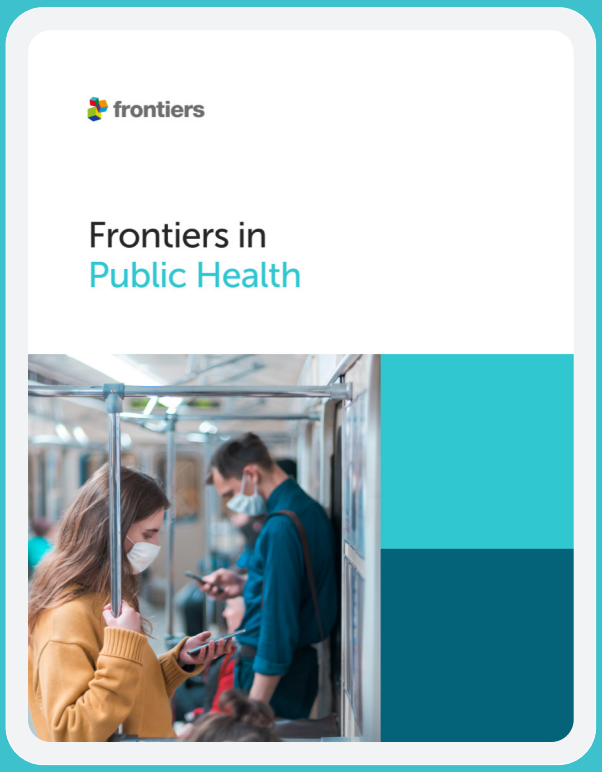

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