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Healthy aging, mental health, and sexuality

Edited by
Alex Siu-Wing Chan, Elsie Yan and Steve Wai Hee Chan

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Healthy aging, mental health, and sexuality

Topic editors

Alex Siu-Wing Chan — Hong Kong Polytechnic University, Hong Kong, SAR China
Elsie Yan — Hong Kong Polytechnic University, Hong Kong, SAR China
Steve Wai Hee Chan — Hong Kong Sanatorium and Hospital, Hong Kong, SAR China

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EDITED AND REVIEWED BY
Giorgio Ivan Russo,
University of Catania, Italy

*CORRESPONDENCE
Alex Siu Wing Chan
chansw.alex@gmail.com
Elsie Yan
elsie.yan@polyu.edu.hk

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Editorial: Healthy aging, mental health, and sexuality

Alex Siu Wing Chan [1]*, Steve Wai Hee Chan [2] and Elsie Yan [1]*

[1]Department of Applied Social Sciences, Faculty of Health and Social Sciences, The Hong Kong Polytechnic University, Hong Kong, Hong Kong SAR, China, [2]Urology Centre, Hong Kong Sanatorium and Hospital, Hong Kong, Hong Kong SAR, China

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Editorial on the Research Topic
Healthy aging, mental health, and sexuality

Background

The global demographic landscape is currently undergoing a significant transformation, marked by an increasingly aging population. This shift serves to amplify the importance of addressing the challenges faced by older adults (1, 2). Healthy aging, a complex and multifaceted phenomenon, intricately weaves together diverse dimensions spanning physical, mental, and social well-being, as well as the often-overlooked aspect of sexuality (3). Aging-related physical changes do not inherently precipitate a decline in sexual functioning. In fact, a substantial portion of older adults maintain a desire for and actively engage in a satisfying sexual life. Research demonstrates that a significant number of men and women continue to participate in sexual activities well into their later years, with regular sexual expression correlating with sound physical and mental health. The sustenance of robust physical and mental health, a constructive attitude towards sexuality in later stages of life, and access to a compatible partner collectively contribute to the perpetuation of sexual activity (4, 5). This avenue of research serves as a poignant reminder of the intricate and interconnected factors that influence the comprehensive well-being of older adults. It underscores the profound interplay between healthy aging, mental health, and sexuality, all of which fundamentally contribute to shaping the overall quality of life for older adults. Among the contributing factors that heighten the vulnerability of older adults to mental health concerns are compromised physical health, a history of mental health disorders, significant life transitions, the onset of medical ailments, personal losses, experiences of social isolation, and adverse life events (6). These elements collectively emphasize the need for a comprehensive understanding of the challenges that older adults face, spanning multiple domains of their lives.

The intersection of healthy aging, mental health, and sexuality

Obsa et al. delved into the risk factors of pelvic organ prolapse among women at a teaching and referral hospital, identifying several contributing factors such as age, parity, and menopausal status. Consequently, healthcare professionals were better equipped to devise prevention and treatment approaches that could substantially impact women's sexual and holistic health throughout the aging process. In another study, Hu et al. scrutinized an evaluation method for product design solutions aimed at fostering healthy aging companionship. This research emphasized the importance of creating products that facilitated companionship and social interaction among older adults, ultimately contributing positively to their mental and emotional well-being. The study underscored the need for product designers to consider the unique needs and challenges confronted by older adults when devising products that could bolster healthy aging.

Designing for companionship: promoting mental health in aging

Focusing on China, Wang et al. investigated loneliness, anxiety, and depressive symptoms among older adult migrants. The study discovered that perceived stress and resilience served as mediators between these psychological factors, highlighting the necessity for social and emotional support for older adult migrants. This research illuminated the importance of addressing the unique challenges faced by older adult migrants and formulating efficacious strategies to bolster their mental and emotional well-being. Cheng et al. explored the prevalence and risk factors correlated with multimorbidity, falls, and fear of falling among older adults in eastern China. Understanding these factors was indispensable in devising effective prevention and treatment approaches that could foster healthy aging and avert falls and related injuries.

Intergenerational relationships and depressive symptoms in the older adults

Intergenerational relationships play a vital role in the emotional well-being of older adults and can significantly impact their depressive symptoms. These relationships involve interactions between individuals from different age groups, typically older adults and their children, grandchildren, or even great-grandchildren. Positive intergenerational relationships can serve as a source of emotional support, companionship, and a sense of purpose for older adults.

The relationship between the brain, aging, and depression among older adults is a complex and multifaceted one. As individuals age, their brains undergo various structural and functional changes that can influence their susceptibility to depression (7, 8).

One of the key factors in this relationship is the natural aging process itself. As people age, there is a gradual decline in cognitive functions, such as processing speed and working memory, which can affect how they perceive and react to life's challenges. These cognitive changes can contribute to feelings of frustration and helplessness, potentially increasing the risk of depression (9). Moreover, age-related changes in brain chemistry also play a role. Alterations in neurotransmitter systems, such as serotonin and dopamine, have been linked to mood disorders like depression. These changes can make older adults more vulnerable to developing depressive symptoms (Figure 1; 10).

The correlation between these brain regions and depression among aging individuals highlights the intricate neurobiology of late-life depression. Changes in brain structure and function in these regions can contribute to the onset and persistence of depressive symptoms in older adults (11). Additionally, older adults often face significant life transitions and losses, such as retirement, the death of loved ones, or declining physical health (12). These stressors can trigger or exacerbate depression, and the way the brain processes and copes with these stressors may change with age.

Zheng et al. conducted a study on CHARLS data, examining the effect of intergenerational exchange patterns and intergenerational relationship quality on depressive symptoms in the elderly. This research underscored the importance of addressing mental health concerns in older adults, especially those with chronic illnesses, by understanding the complex interrelation between mental health, age, resilience, and frailty.

Furthermore, Zhang et al. investigated the interplay between health beliefs, lifestyle, and cognitive aging among Chinese community residents. By understanding this complex interrelation, healthcare professionals could develop targeted interventions that promoted healthy aging and prevented cognitive decline.

Access to psychological assistance for older adults: prevalence and determinants

Meng et al. probed the interrelation between depression, age, resilience, and frailty among HIV-positive adults. This investigation emphasized the need to address mental health concerns in older adults, particularly those grappling with chronic ailments like HIV. Additionally, Coşkun et al. scrutinized the prevalence and determinants of psychological assistance services for older adults in Turkish society. This research accentuated the importance of accessible and culturally tailored mental health services for older adults.

Lastly, Cao et al. investigated the impact of hearing loss on cognitive impairment and explored the mediating role of depressive symptoms and the moderating role of social relationships. This research highlighted the importance of addressing hearing loss and its potential impact on cognitive function, as well as the need to consider the mediating and moderating factors that could influence this relationship.

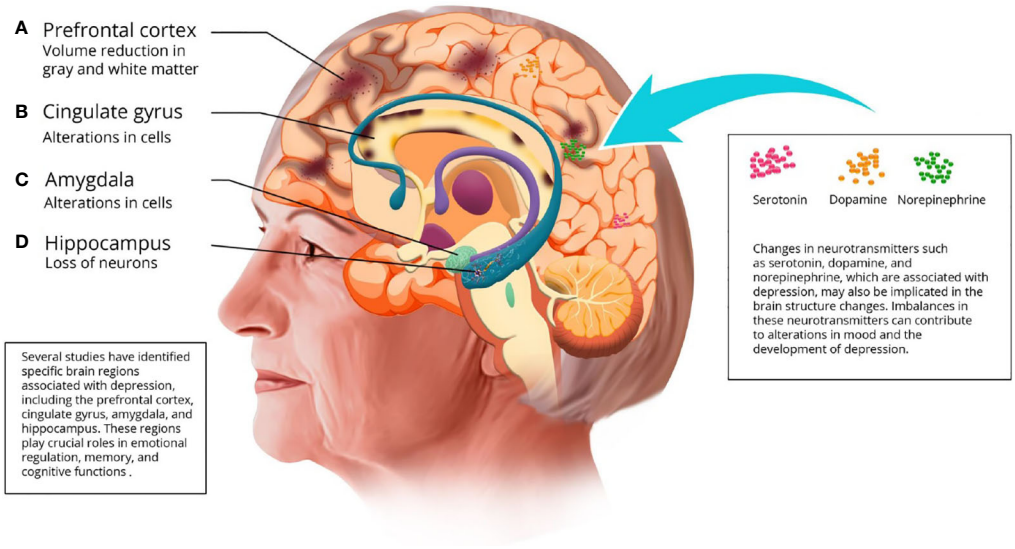

FIGURE 1
Correlation between brain structure, aging and symptoms of depression. Figure 1 indicates that the prefrontal cortex, cingulate gyrus, amygdala, and hippocampus are interconnected brain regions that collectively play a crucial role in regulating emotions, memory, and mood. When considering their correlation with depression among aging individuals, it's important to understand how changes in these brain regions can contribute to depressive symptoms: **(A)** Prefrontal Cortex (PFC): The PFC, particularly the dorsolateral prefrontal cortex (DLPFC), is involved in executive functions, decision-making, and emotional regulation. In aging individuals, there can be a decline in PFC function, which may lead to difficulties in managing emotions and making adaptive choices. This decline can contribute to depressive symptoms, as individuals may struggle to cope with life changes and stressors. **(B)** Cingulate Gyrus: The cingulate gyrus, a part of the limbic system, is involved in emotional processing and regulation. Changes in the cingulate gyrus, such as alterations in connectivity, can affect emotional control. Dysfunction in this region has been linked to depression in older adults, as it can lead to heightened emotional responses and difficulties in regulating negative emotions. **(C)** Amygdala: The amygdala is responsible for processing emotions, particularly fear and anxiety. In older adults with depression, the amygdala may show increased activity or abnormal functioning, leading to heightened emotional reactivity and persistent negative emotional states. **(D)** Hippocampus: The hippocampus is vital for memory consolidation and spatial navigation. In aging individuals, the hippocampus can undergo structural changes, such as atrophy and decreased neurogenesis. These changes are associated with memory problems and an increased risk of depression. Additionally, a smaller hippocampus has been linked to a poorer response to treatment for depression.

Addressing the unique needs and challenges among older adults

Psychological well-being entails maintaining positive relationships with others and living a life filled with purpose and significance. Research has shown that individuals who possess a positive psychological well-being tend to experience greater ease and derive more satisfaction from their lives (13). Understanding and addressing the unique needs and challengesof healthy aging, mental health, and sexuality to promotecomprehensive well-being in older adults.

Understanding and addressing the unique needs and challenges of healthy aging, mental health, and sexuality to promote comprehensive well-being in older adults. By comprehending these concerns and devising efficacious prevention and treatment strategies, we can facilitate healthy aging and aid older adults in maintaining a gratifying and satisfying intimate life. It is imperative to persist in investing in research and formulating policies and programs that endorse healthy aging while bolstering older adults' mental and physical health. One of the cardinal takeaways from this Research Topic is the significance of apprehending the distinctive needs and challenges faced by older adults. Whether it involves understanding the risk factors correlated with pelvic organ prolapse or conceiving products that foster companionship and social interaction among older adults, it is vital to contemplate the specific needs and challenges encountered by older adults when developing prevention and treatment strategies.

The aging gut undergoes various transformations that encompass the mechanical breakdown of food, gastrointestinal motility, food passage, integrity of the intestinal wall, and chemical digestion (14). These modifications progressively contribute to a diminished capacity to provide the body with sufficient nutrient levels, ultimately leading to the emergence of malnutrition. Moreover, research indicates that gastrointestinal disorders, and particularly malnutrition, detrimentally impact the quality of life. A deeper comprehension of the pathophysiology underlying malnutrition in the elderly is imperative to enhance our understanding of age-related shifts in appetite, dietary intake, internal balance, and body composition. This knowledge is pivotal in formulating more effective strategies for prevention and intervention, aimed at fostering healthy aging (15). Another salient takeaway is the importance of addressing mental health issues in older adults. Depression, anxiety, and loneliness are pervasive concerns among older adults, particularly those contending with chronic illnesses. By crafting potent strategies to bolster the mental and emotional well-being of older adults, healthcare professionals can champion healthy aging and enhance the overall quality of life for older adults.

The Healthy Ageing Strategy encompasses pivotal domains that seamlessly converge to facilitate mobility, foster secure engagement, and nurture meaningful interactions. These foundational areas encompass the promotion of physical activity, the enhancement of

mobility and connectivity, the assurance of adequate housing, employment, and financial stability, the prioritization of safety, the facilitation of continuous learning and knowledge exchange, and the holistic approach to health while embracing diversity. These holistic efforts collectively empower and equip individuals to lead active, engaged, and thriving lives within our vibrant community (16). For instance, the Healthy Ageing Strategy of New Zealand paints a vision where senior citizens bask in a high quality of life, embrace graceful aging, and find solace in a dignified end-of-life phase, all within communities tailored to cater to their unique needs. Similarly, the Inner West Council's Healthy Ageing Strategy for 2022-2025 in Australia expounds upon the Council's responsibilities, delineating strategic domains that endorse secure participation and foster enriching lifestyles among individuals (17).

Navigating the nexus of healthy aging, mental health, and sexuality

The World Health Organization (WHO) provides an encompassing definition of sexuality that spans a wide spectrum of human experiences. It includes sex, gender identities and roles, sexual orientation, eroticism, pleasure, intimacy, and reproduction. This multifaceted aspect of life is not limited to physical actions but extends to thoughts, fantasies, desires, beliefs, attitudes, values, behaviors, practices, roles, and relationships. It's profoundly influenced by an array of factors ranging from biological and psychological to societal, economic, political, cultural, ethical, legal, historical, religious, and spiritual dimensions (18, 19).

Within the context of adulthood, factors related to sexuality take on a profound significance. Life satisfaction, often regarded as a fundamental indicator of successful aging, is a composite of several elements, including the absence of disease, good physical and mental health, active social participation, and overall contentment with life. Yet, it's remarkable that the sexual dimension of aging has been relatively underexplored within the broader framework of successful aging and warrants a more focused examination (20).

Sexuality is an integral component of a fulfilling adulthood. Engaging in sexual activity can exert a positive influence on emotional, mental, and physical well-being, thereby contributing to an enhanced quality of life. With the extension of human lifespans and an increasing number of older individuals engaging in sexual activity, there's a corresponding rise in older adults aged 65 and above seeking medical guidance for various sexual concerns or challenges (21). This shifting landscape reflects evolving perspectives, beliefs, and attitudes that underscore the significance of maintaining a healthy sexual life in later stages. Furthermore, ongoing developments in medical treatments and interventions have empowered individuals to sustain a satisfying sexual life irrespective of their age, effectively facilitating continued sexual activity as people progress into their later years. As we delve into the intricate interplay between healthy aging, mental health, and sexuality in this Research Topic, it becomes evident that these facets of life are not isolated but rather deeply interconnected. This Research Topic presented in this collection shed light on various dimensions of this correlation, offering valuable insights that contribute to a comprehensive understanding of how these factors influence one another.

Conclusion

Successful aging can be assessed from both a community and an individual perspective. From a community standpoint, it is characterized by factors related to health and active participation in strategies to enhance well-being. Conversely, for an individual, it is defined by considerations such as physical health, biological and mental function, and social engagement. As healthy aging is a complex concept encompassing various dimensions of physical, functional, cultural, and mental well-being, it is crucial to consider all these aspects when analyzing the process, both from empirical data and personal circumstances. In essence, meaningful results cannot be obtained by solely examining either the individual or the community, as multiple factors contribute to the overall health of older adults (22).

This Research Topic underscores the importance of advocating healthy lifestyles and beliefs to encourage healthy aging and cognitive function. By fostering salubrious behaviors such as regular exercise, wholesome eating, and social interaction, healthcare professionals can advance healthy aging and support older adults' physical and mental well-being (23). Discerning the critical issues associated with healthy aging, mental health, and sexuality is essential in promoting healthy aging and ameliorating the overall quality of life for older adults (16). By investing in research, formulating effective prevention and treatment strategies, and endorsing healthy lifestyles and beliefs, we can assist older adults in sustaining a fulfilling and satisfying intimate life and advocate healthy aging for generations to come. It is crucial to prioritize the unique needs and challenges confronted by older adults to ensure they receive the support and care requisite for living healthy, gratifying lives.

Author contributions

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Andrew Wister,
Simon Fraser University, Canada
Hon Lon Tam,
Kiang Wu Nursing College of Macau,
Macao SAR, China
Yonggang Su,
Shandong University, China

*CORRESPONDENCE
Jun Yao
yaojun@njmu.edu.cn

†These authors have contributed equally to this work and share first authorship

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Chinese elderly migrants' loneliness, anxiety and depressive symptoms: The mediation effect of perceived stress and resilience

Hao Wang[1†], Yanjie Hou[2†], Lin Zhang[2], Man Yang[1], Ruyue Deng[2] and Jun Yao[1,2,3*]

[1]School of Nursing, Nanjing Medical University, Nanjing, China, [2]School of Health Policy and Management, Nanjing Medical University, Nanjing, China, [3]Institute of Healthy Jiangsu Development, Nanjing Medical University, Nanjing, China

Elderly migrants who face the dual challenges of aging and migration are more likely to suffer psychological disorders. Existing research has demonstrated a link between loneliness and psychological disorders in the general elderly population. However, we know little about the relationships among elderly migrants, and the psychological mechanisms linking them. This study aims to examine the effects of loneliness on anxiety and depressive symptoms among Chinese elderly migrants, and explore the mediating roles of perceived stress and resilience. All 654 participants were recruited in Nanjing, Jiangsu Province, China. Results showed that loneliness was significantly correlated with anxiety and depressive symptoms ($p < 0.001$). Perceived stress and resilience mediated the relationship between loneliness and anxiety symptoms. The mediating effect of perceived stress was 0.128 (Bootstrap 95% CI: 0.092–0.168, Ratio = 37.4%). Resilience was 0.026 (Bootstrap 95% CI: 0.005–0.049, Ratio = 7.6%). Furthermore, perceived stress and resilience also mediated the relationship between loneliness and depressive symptoms. The mediating effects were 0.111 and 0.043, respectively (Bootstrap 95% CI: 0.073–0.151, Ratio = 27.9%; Bootstrap 95% CI: 0.020–0.069, Ratio = 10.8%). All the mediating effects were significant because the bootstrap 95% CIs did not contain zero. Overall, our findings suggested that loneliness not only can directly influence elderly migrants' anxiety and depressive symptoms but also by increasing perceived stress or decreasing resilience.

KEYWORDS

loneliness, anxiety, depression, elderly migrants, mediation analysis

Introduction

Population migration is a key issue and a significant factor in the sustainable population development of China (1). Population migration is a complex process involving multiple changes, which can bring about a series of problems such as lack of social networks and social support, language and cultural differences, and discrimination,

all of them may have a negative effect on migrants' mental health (2, 3). According to "Report on China's Migrant Population Development", during the 15 years from 2000 to 2015, the number of elderly migrants increased from 5.03 to 13.04 million, with a 6.3% annual increase (1). With the rapid increase of elderly migrants, more and more researchers have begun to pay attention to their physical and mental health.

Anxiety and depression are two common psychological disorders in later life (4–7), and are significantly associated with low quality of life and high risk of suicide (8–11). The West China Health and Aging Trend Study shows that 20.8% elderly people have the anxiety symptoms, and 19.6% have depressive symptoms (7). Over the past few decades, researchers have carried out numerous studies on the factors that may put people at risk of anxiety and depression. Previous studies have confirmed that loneliness is a key predictor of anxiety and depressive symptoms (6, 12). However, researchers did not deliberately distinguish elderly migrants from non-migrants, although previous studies have shown that migrants are more likely to suffer psychological disorders than non-migrants (13–15). And little is known the psychological mechanisms linking them. So, we conducted this study aimed at examining the effects of loneliness on anxiety and depressive symptoms among Chinese elderly migrants, and attempted to explore the mediating roles of perceived stress and resilience.

Loneliness, anxiety and depression

Loneliness refers to the subjective feeling of inadequate social relations (16) and has become a public health problem (17). A national survey including 20,255 Chinese elderly people aged 60 and above showed that 29.6% participants reported "often felt lonely" (18). For elderly people, they will face a shrinking of social network, decrease of social interaction, and loss of social roles as they age, all of them may make them feel lonely (6). An overview of 40 systematic reviews found that loneliness is associated with the increased mortality and negative mental health outcomes (19).

Anxiety and depression are common mental health problems in the elderly and are the hot topics of gerontological research. Numeral studies have confirmed that loneliness is associated with anxiety and depressive symptoms in the elderly (6, 12). Creese et al. (20) found that loneliness was a risk factor for anxiety and depression in the elderly both before and during COVID-19 (20). In addition, a 5-year longitudinal study conducted in Chicago found that loneliness can predict the subsequent increase of depressive symptoms in the elderly (21).

The mediating role of perceived stress and resilience

Stress is an important risk factor for physical and mental health, and can affect health not only directly through autonomic and neuroendocrine responses, but also indirectly through changes in health-related behaviors (22). Perceived stress is the assessment of the level of threat from the stressor they face (23, 24). In past studies, researchers have found that people with high levels of perceived stress have high risks to suffer anxiety and depression (21). Loneliness is a painful experience, and has been confirmed as a stressor (25, 26). Burke and Segrin (25) found that loneliness had a positive effect on perceived stress. Similarly, Cacioppo et al. (27) found that people who felt lonely had a higher level of perceived stress than non-lonely people, even when they were exposed to a similar frequency and intensity of stressor, and even when they were relaxed. Moreover, several studies in Chinese elderly population confirmed that perceived stress was a crucial mediator between the relationship of loneliness and mental health (28–30). So, we speculate that perceived stress plays a crucial role between the relationships of loneliness on anxiety and depressive symptoms among Chinese elderly migrants.

Resilience refers to the ability of a person to adapt to and recover from trauma, adversity and stressor (31, 32). It is well-known that resilience is a protective factor for health and wellbeing, and is a key contributor of successful aging (33–35). Several empirical studies have confirmed that people with high resilience are at a low risk to suffer anxiety and depression (6, 36). Kumpfer's resilience framework suggests that resilience can mediate the relationships between adversity and its outcomes and propel a person to grow by facing adversity (37). A study in nursing homes found that loneliness had a negative effect on elderly people' depression and resilience played a mediating role between this association (38). Moreover, researchers argued that resilience can be influenced by internal factors (biological and psychological) and external factors (environmental) (34, 39). For the elderly migrants, the environmental changes coming with migration may influence their resilience (40). So, we think that elderly migrants' resilience is worth investigating and it may play a crucial role between the relationship of loneliness on anxiety and depressive symptoms among Chinese elderly migrants.

The current study

From what has been discussed above, we can find that there exists a significant reciprocal relationship between loneliness, perceived stress, resilience, anxiety and depressive symptoms, and perceived stress and resilience maybe play crucial roles

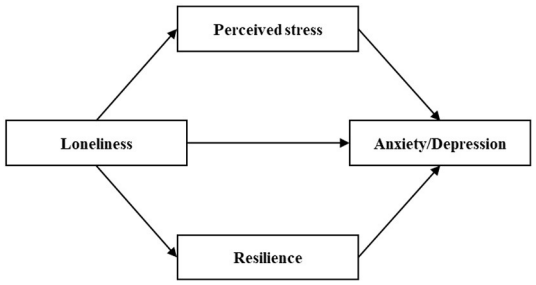

FIGURE 1
Hypothesized relationships between loneliness, perceived stress, resilience, anxiety and depression.

between the relationships of loneliness on anxiety and depressive symptoms. Elderly migrants who face the dual challenges of aging and migration are more likely to suffer psychological disorders. However, most of the previous studies on the effects of loneliness on anxiety and depression did not distinguish elderly migrants from non-migrants. The purpose of this study is to examine the relationships between loneliness on anxiety and depressive symptoms among Chinese elderly migrants, and explore the mediating roles of perceived stress and resilience. Thus, we propose the following hypotheses (Figure 1).

Hypothesis 1. Loneliness is a positive predictor of anxiety and depressive symptoms among Chinese elderly migrants.

Hypothesis 2. Perceived stress plays a mediating role in the relationship between loneliness and anxiety symptom among Chinese elderly migrants.

Hypothesis 3. Perceived stress plays a mediating role in the relationship between loneliness and depressive symptom among Chinese elderly migrants.

Hypothesis 4. Resilience plays a mediating role in the relationship between loneliness and anxiety symptom among Chinese elderly migrants.

Hypothesis 5. Resilience plays a mediating role in the relationship between loneliness and depressive symptom among Chinese elderly migrants.

Methods

Participants

The data in this study came from the National Social Science Foundation Project of China "A follow-up study on the mechanism of intergenerational relationship on the mental health of elderly migrants". This project was performed from September 2019 to September 2020 in Nanjing, Jiangsu Province, China. The project first randomly selected seven districts in Nanjing (Qinhuai, Qixia, Gulou, Xuanwu, Jianye, Yuhuatai, and Jiangning District), then randomly selected three communities in each district, and finally recruited elderly migrants who met the inclusion criteria in these 21 communities. All participants were informed of the purpose of the study and volunteered to participate. All participants were face-to-face interviewed using a structured questionnaire. All interviewers had medical research background and received uniform and standardized training prior to the project. This study used the first phase survey data of the project. Inclusion criteria were: (1) aged 60 and above; (2) household registration not moved to Nanjing; (3) moved to Nanjing $\leq$ 10 years. A total of 654 participants were included in this study after screening. The mean number of years that participants moved to Nanjing was 3.96 $\pm$ 1.96. The necessary permission to conduct this study was obtained from the ethics committee of the university.

Measures

Loneliness

The UCLA 3-item loneliness scale was used to measure loneliness of elderly migrants (41). Each item is scored on a scale from 1 (hardly ever or never) to 3 (almost always) and the total score ranges from 3 to 9. Higher scores indicate higher feeling of loneliness. The Chinese version has high reliability and validity in the elderly (42, 43). Cronbach's α for the present sample was 0.866.

Perceived stress

Perceived Stress Scale (PSS) was used to measure perceived stress of elderly migrants over the past month (23). PSS consists of 14 items and two subscales: sense of uncontrollable and sense of nervous. Items 4, 5, 6, 7, 9, 10, and 13 belong to the uncontrollable dimension and are scored in reverse. Items 1, 2, 3, 8, 11, 12, and 14 belong to the nervous dimension. Each item is scored on a scale from 0 (never) to 4 (always) and the total score ranges from 0 to 56. Higher scores indicate higher perceived stress. The Chinese version is translated by Yang and Huang (44), and has high reliability and validity (44, 45). Cronbach's α for the present sample was 0.809.

Resilience

The 10-item Connor–Davidson Resilience Scale (CD-RISC-10) was used to measure resilience of elderly migrants (46). CD-RISC-10 contains 10 items. Each item is scored on a scale from 1 (never) to 5 (always) and the total score ranges from 10 to 50. Higher scores indicate higher resilience. Several studies have shown that CD-RISC-10 has high reliability and validity in the

Chinese population (47, 48). Cronbach's α for the present sample was 0.922.

Anxiety

The Hospital Anxiety and Depression Scale-Anxiety (HADS-A) was used to measure anxiety of elderly migrants (49). HADS-A is a screening scale for anxiety which consists of seven items. Each item is scored on a scale from 0 to 3 and the total score ranges from 0 to 21. Higher scores indicate higher risks to suffer anxiety. Several studies have shown that HADS-A also has a high reliability and validity in the general population (5, 50). Cronbach's α for the present sample was 0.787.

Depression

The 9-item Patient Health Questionnaire (PHQ-9) was used to measure depression of elderly migrants over the past 2 weeks (51). PHQ-9 is a screening scale for depression which consists of 9 items. Each item is scored on a scale from 0 (never) to 3 (almost every day) and the total score ranges from 0 to 27. Higher scores indicate higher risks to suffer depression. The Chinese version has been widely used and demonstrated a high reliability and validity among elderly people (52, 53). Cronbach's α for the present sample was 0.806.

Demographic variables

Demographic data such as age, sex, marital status, education level, religious belief, household registration, retirement pension and yearly income were collected. Marital status was categorized into: divorced or widowed, married and having a spouse. Education level was classified as primary school or lower, junior or senior high school, and college or higher. Yearly income was categorized as: 0–5,000¥, 5,001–10,000¥, 10,001–20,000¥, and >20,000¥.

Analytic strategies

Scale items were presented in Table 1. All analyses were conducted in the SPSS 26.0 software and the significance level was set at 0.05 (two-tailed). Firstly, we implemented descriptive analysis to describe the demographic characteristics of the participants. Then, we conducted the Pearson correlation analysis to examine the bivariate correlations of loneliness, perceived stress, resilience, anxiety and depression. Finally, we used the SPSS PROCESS macro 4.0 (54) to explore the mediating role of perceived stress and resilience between the relationship of loneliness and psychological distress. PROCESS Model 4 was used to build the multiple mediation models with a bootstrap sample of 5,000. The mediating effect was significant if the bootstrap 95%CI did not contain zero.

TABLE 1 Scale items of UCAL-3, PSS and CD-RISC-10.

Scale	Items
UCAL-3	How often do you feel the lack of company?
	How often do you feel that life is boring?
	How often do you feel isolated from others?
PSS	Feeling distracted by something that cannot be expected to happen.
	Feeling unable to control the important things in your life.
	Feeling jittery and stressed.
	Successfully deal with annoying life troubles.
	Feel that you can effectively deal with important changes in your life.
	Feel confident in being able to handle your own personal issues.
	Feel that things are going well.
	Find yourself unable to handle all the things you have to do.
	There are ways to control the annoying things in your life.
	Feel like you are in charge of things.
	You are often angry because many things are happening beyond your control.
	You often feel that there are things you have to accomplish.
	Able to master the way of time arrangement.
	Feel that difficult things are piling up and you can't get over them.
CD-RISC-10	I can adapt to changes.
	I can handle anything.
	I can find the humorous side of things.
	Dealing with stress makes me stronger.
	I can bounce back after illness and hardship.
	Even with the obstacles, I can still achieve my goals.
	Under pressure, I can still focus and think clearly.
	I don't get discouraged easily by failure.
	I consider myself a strong person.
	I can deal with unpleasant feelings.

Results

Demographic characteristics

The demographic characteristics of all 654 participants were shown in Table 2. In this study, the mean age of elderly migrants was 66.05 years old (SD = 4.67; Range = 60–86), 216 (33.0%) were males and 438 (67.0%) were females. One hundred and one (15.4%) elderly migrants had a terrible marital status (divorced or windowed). Three hundred and fifty-four (54.1%) had a low level of education (primary school or lower). Ninety-nine (15.1%) had a religious belief. Four hundred and fifty-three (69.3%) had a rural household registration. Four hundred and three (61.6%) had a retirement pension.

TABLE 2 Demographic characteristics of 654 participants.

Variables	Category	*N*	Mean ± SD/percentage
Age		654	66.05 ± 4.67
Gender	Male	216	33.0%
	Female	438	67.0%
Marital status	Divorced or widowed	101	15.4%
	Married with spouse	553	84.6%
Education level	Primary school or lower	354	54.1%
	Junior or senior high school	262	40.1%
	College or higher	38	5.8%
Religious belief	No	555	84.9%
	Yes	99	15.1%
Household registration	Rural	453	69.3%
	Town	201	30.7%
Retirement pension	No	251	38.4%
	Yes	403	61.6%
Yearly income (¥)	0–5,000	249	38.0%
	5,001–10,000	126	19.3%
	10,001–20,000	87	13.3%
	>20,000	192	29.4%

TABLE 3 The results of Pearson correlation analysis.

Variables	Mean	SD	1	2	3	4	5
1. Loneliness	4.02	1.43	1				
2. Perceived stress	20.87	7.66	0.398***	1			
3. Resilience	33.06	7.53	−0.298***	−0.607***	1		
4. Anxiety	11.20	3.36	0.361***	0.499***	−0.378***	1	
5. Depression	5.00	3.99	0.430***	0.517***	−0.444***	0.521***	1

***p < 0.001 (two-tailed).

Bivariate correlations of the key variables

The bivariate correlations of the key variables were presented in Table 3. The results showed that loneliness, perceived stress, resilience and anxiety were significantly correlated with each other ($p < 0.001$). As hypothesized, loneliness was positively correlated with perceived stress ($r = 0.398$, $p < 0.001$) and negatively correlated with resilience ($r = -0.298$, $p < 0.001$). In addition, loneliness was positively correlated with anxiety ($r = 0.361$, $p < 0.001$) and depression ($r = 0.430$, $p < 0.001$). Perceived stress was negatively correlated with resilience ($r = -0.607$, $p < 0.001$), and positively correlated with anxiety ($r = 0.499$, $p < 0.001$) and depression ($r = 0.517$, $p < 0.001$). Resilience was negatively correlated with anxiety ($r = -0.378$, $p < 0.001$) and depression ($r = -0.444$, $p < 0.001$). Based on the bivariate correlations between variables, we further conducted the multiple mediation analyses to explore the mediating roles of perceived stress and resilience in the following section.

Mediation analyses

The results of the multiple mediation analyses were shown in Tables 4, 5 and Figures 2, 3. In the multiple mediation model, loneliness was entered as the independent variable; anxiety and depression as the dependent variables; perceived stress and resilience as the mediating variables, and age, gender, marital status, education level, religious belief, household registration, retirement pension and yearly income as the control variables.

Table 4 and Figure 2 showed the mediating role of perceived stress and resilience in the relationship between loneliness and anxiety. The total effect of loneliness on anxiety was 0.342 ($p < 0.001$). When perceived stress and resilience entered as mediators, the effect decreased ($\beta = 0.188$, $p < 0.001$). The total indirect effect was 0.154 (95% CI: 0.116, 0.195) and the ratio to the total effect was 45.0% (0.154/0.342). The indirect effect of perceived stress was 0.128 (95% CI: 0.092, 0.168; Ratio = 37.4%). Resilience was 0.026 (95% CI: 0.005, 0.049; Ratio = 7.6%). All the indirect effects were significant because the bootstrap 95% CIs did not contain zero. Hypothesis 1, hypothesis 2 and hypothesis 4 were confirmed. In addition, the indirect effect of perceived stress was significantly higher than resilience, as the bootstrap 95% CIs did not contain zero (95% CI: 0.055, 0.153).

Table 5 and Figure 3 showed the mediating role of perceived stress and resilience in the relationship between loneliness and depression. The total effect of loneliness on depression was 0.398 ($p < 0.001$). When perceived stress and resilience entered as mediators, the effect decreased ($\beta = 0.244$, $p < 0.001$). The total indirect effect was 0.154 (95% CI: 0.115, 0.194; Ratio = 38.7%). The indirect effect of perceived stress was 0.111 (95% CI: 0.073, 0.151; Ratio = 27.9%). Resilience was 0.043 (95% CI: 0.020, 0.069; Ratio = 10.8%). All the indirect effects were significant because the bootstrap 95% CIs did not contain zero. Hypothesis 1, hypothesis 3 and hypothesis 5 were confirmed. In addition, the indirect effect of perceived stress was significantly higher than resilience, as the bootstrap 95% CIs did not contain zero (95% CI: 0.016, 0.120).

Discussion

The main purpose of this study is to examine the relationships between loneliness, anxiety and depression among Chinese elderly migrants, and explore the psychological mechanisms linking them. In line with our expectations, all hypotheses we presented before were confirmed. Through

TABLE 4 The results of the multiple mediation model.

Path	Effect	Boot SE	Boot LLCI	Boot ULCI	Ratio
Total indirect effect	0.154[a]	0.020	0.116	0.195	45.0%
Indirect effect 1 (X → M1 → Y)	0.128[a]	0.020	0.092	0.168	37.4%
Indirect effect 2 (X → M2 → Y)	0.026[a]	0.011	0.005	0.049	7.6%
Compare 1 (Indirect effect 1 minus 2)	0.103[a]	0.025	0.055	0.153	

X, Loneliness; **Y, Anxiety**; M1, Perceived stress; M2, Resilience. Ratio, the ratio of the indirect effect to the total effect.
[a]The bootstrap 95% CIs not contain zero. Age, sex, marital status, education level, religious belief, household registration, retirement pension and yearly income were analyzed as control variables. All values have been standardized.

TABLE 5 The results of the multiple mediation model.

Path	Effect	Boot SE	Boot LLCI	Boot ULCI	Ratio
Total indirect effect	0.154[a]	0.020	0.115	0.194	38.7%
Indirect effect 1 (X → M1 → Y)	0.111[a]	0.020	0.073	0.151	27.9%
Indirect effect 2 (X → M2 → Y)	0.043[a]	0.012	0.020	0.069	10.8%
Compare 1 (Indirect effect 1 minus 2)	0.068[a]	0.026	0.016	0.120	

X, Loneliness; **Y, Depression**; M1, Perceived stress; M2, Resilience. Ratio, the ratio of the indirect effect to the total effect.
[a]The bootstrap 95% CIs not contain zero. Age, sex, marital status, education level, religious belief, household registration, retirement pension and yearly income were analyzed as control variables. All values have been standardized.

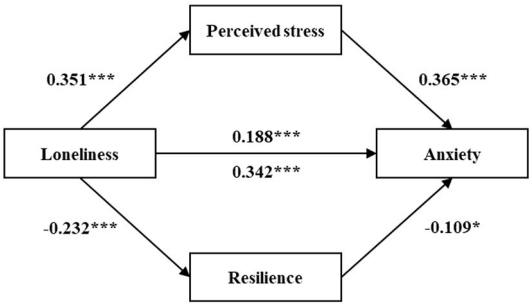

FIGURE 2
The multiple mediation model of the association between loneliness and **anxiety** through perceived stress and resilience. *p < 0.05, ***p < 0.001 (two-tailed). All values have been standardized.

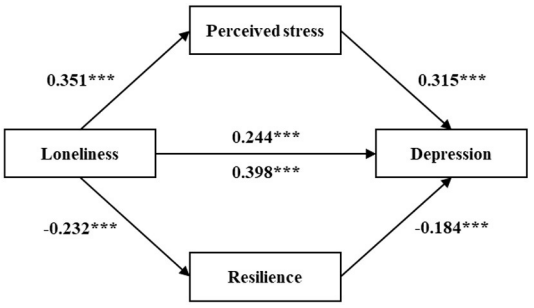

FIGURE 3
The multiple mediation model of the association between loneliness and **depression** through perceived stress and resilience. ***p < 0.001 (two-tailed). All values have been standardized.

the Pearson correlation analysis, we found that there was a significant pairwise correlation between loneliness, perceived stress, resilience, anxiety and depression. Based on these correlations, we further conducted the multiple mediation analyses. One major finding of the multiple mediation analysis is that loneliness is a positive predictor of anxiety and depression among Chinese elderly migrants, meaning that elderly migrants with higher loneliness have greater anxiety and depression. Another one is that elderly migrants' reported status of perceived stress and resilience strongly mediated the relationship of loneliness on anxiety and depression. The total mediating effects of perceived stress and resilience are 45.0 and 38.7%, respectively, revealing that our mediating variables play crucial roles in explaining the relationships of loneliness on anxiety and depression. In short, loneliness can not only directly affect anxiety and depression, but also can indirectly affect them by perceived stress or resilience.

The direct effect of loneliness on anxiety and depression

In line with hypothesis 1, loneliness is a positive predictor of elderly migrants' anxiety and depression. Higher loneliness is associated with greater anxiety and depressive symptoms. The result is consistent with those in the general elderly

population (6, 20). However, the scores of loneliness, anxiety and depression are lower than previous studies in the general elderly population, which are contrary to what we envisioned. This phenomenon may be explained by the multidimensional properties of loneliness and the characteristics of Chinese elderly migrants. Loneliness is regarded as a multidimensional concept that includes social loneliness and emotional loneliness, the former being influenced by social networks, and the latter by intimate relationships (55, 56). Previous studies have found that both of social loneliness and emotional loneliness are significant associated with psychological health (57, 58). For the elderly migrants, they usually face a shrinking of social network and difficulties of social integration due to the change of environment as well as language and cultural differences that come with migration (3, 59, 60). In addition, due to the fact that the main purpose of migration among Chinese elderly migrants is providing care for their grandchildren, the average age of the samples in the study of elderly migrants is significantly lower than in the study of the general elderly population (66.05 ± 4.67 in this study) and the intimate relationship may be improved. We think that all of these lead to the difference between our study and studies in the general elderly population.

The mediating role of perceived stress and resilience

In line with our hypotheses, perceived stress plays a mediating role between the relationship of loneliness on anxiety and depression. The mediating effects of perceived stress are 37.4 and 27.9%, respectively. This finding is consistent with previous studies revealing that loneliness is a risk factor for anxiety and depression, and is associated with high levels of perceived stress (28, 61). Previous studies have found that loneliness is a stressor and positively associated with perceived stress. Loneliness usually demonstrates the lack of social and intimate relationships which shrinks the ways to copy stress (27). As a result, it is easy to suffer psychological problems such as anxiety and depression.

Our results also found that resilience was an important mediator between the relationship of loneliness on anxiety and depression among Chinese elderly migrants. The mediating effects of resilience are 7.6 and 10.8%, respectively. This finding agrees with Kumpfer's resilience framework, where resilience can mediate the relationship between adversity and its outcomes (37). In this study, loneliness is regarded as an adversity, with anxiety and depression as its negative outcomes. As mentioned above, loneliness can limit individuals' recourses to seek help when they suffer adversities, which are a manifestation of resilience. However, resilience is helpful to increase the belief to overcome elderly migrants' negative outcomes (62). Thus, the relationships between loneliness, resilience, anxiety and depression among Chinese elderly migrants are clear. Loneliness can not only directly influence anxiety and depression, but also through the mediating effect of resilience. In addition, the comparisons of the mediating effects of perceived stress and resilience showed that the effects of perceived stress were significantly stronger than resilience both in the relationship between loneliness and anxiety and in the relationship between loneliness and depression. In short, perceived stress and resilience play crucial roles in explaining the relationships of loneliness on anxiety and depression among Chinese elderly migrants. For elderly migrants who feel lonely, they are more likely to suffer anxiety and depression. According to the findings of this paper, the interventions that combine components of reducing perceived stress or increasing resilience are important to improve their anxiety and depression. The community can organize some activities and lectures to provide a platform for elderly migrants to get out of their house and communicate and interact with others. And adult children should communicate more with their elderly parents with the experience of migration to identify and help them cope with adversities in a timely manner.

Limitation

Firstly, the cross-sectional research design makes it difficult to reveal causal relationships between the key variables. Secondly, the information collected through participant self-reports may affect the reliability of our results, although we have assessed the reliability of the used scales and gained a positive result. Thirdly, the project was not originally designed to measure the effects of loneliness on psychological distress, so some potential control variables were not measured. For example, the age at which older migrants move may have an impact on our results, as those who move at age 50 and older may have different experiences than those who move at age 60 and older. Lastly, all participants were recruited from Nanjing, Jiangsu Province, and may not apply to other regions with different geographic and cultural backgrounds. In future studies, conduct a longitudinal study In future studies, a longitudinal study design is needed to clarify the causal relationship between loneliness and psychological disorders. In addition, we will try to collect samples of elderly migrants from different regions of China and fully consider the possible influencing factors to fill the gaps in the current study.

Conclusion

This study was an important extension of the literature on elderly migrants, not only confirming the important role of loneliness in anxiety and depressive symptoms, but also finding the crucial mediating roles of perceived stress and resilience. The present findings showed that loneliness was

positively associated with anxiety and depressive symptoms among Chinese elderly migrants. Loneliness can not only directly affect anxiety and depressive symptoms, but also affect them by increasing perceived stress or decreasing resilience. Loneliness, anxiety and depression are prevalent in elderly people, and all of them can pose serious threats to elderly people' health and wellbeing. The findings of this study suggest that loneliness puts elderly migrants at risk for anxiety and depressive symptoms. But we can mitigate the negative effects of loneliness by reducing the level of perceived stress or increasing the level of psychological resilience (especially by reducing perceived stress).

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 Nanjing Medical University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

HW: conceptualization, methodology, formal analysis, and writing—original draft. YH: formal analysis and writing—original draft. LZ, MY, and RD: investigation and data curation. JY: conceptualization, supervision, and writing—review and editing. All authors have approved the final manuscript.

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Conflict of interest

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

Publisher's note

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Antonio Simone Laganà,
University of Palermo, Italy
Bedru Jemal,
Dilla University, Ethiopia

*CORRESPONDENCE
Mohammed Suleiman Obsa
msuleiman43@gmail.com

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Risk factors of pelvic organ prolapse at Asella Teaching and Referral Hospital: Unmatched case control study

Mohammed Suleiman Obsa[1]*, Tahir A. Worji[1], Nemo A. Kedir[2] and Negeso G. Kute[3]

[1]Department of Anesthesia, Wolaita Sodo University, Sodo, Ethiopia, [2]School of Medicine, Arsi University, Asella, Ethiopia, [3]Department of Anesthesia, Hawassa University, Hawassa, Ethiopia

Background: Prolapse is one of the sub-types of pelvic floor dysfunction (PFD) which occurs due to abnormal fall of the pelvic organs from their normal anatomic positions. Although the cause of prolapse is multifactorial, it primarily occurs due to pregnancy and vaginal delivery. Hence, the present study aimed to identify risk factors of prolapse among women who undergo gynecological surgery.

Materials and methods: Facility-based-unmatched case–control design was employed. Cases were all gynecological women who were diagnosed with pelvic organ prolapse (POP) at Asella teaching referral hospital (ATRH) while controls were all charts of gynecological women who were diagnosed with other gynecological problems rather than POP at ATRH. For each case, two controls were selected using a simple random sampling technique. The data were entered into Epidata version 4.3.1 and finally exported to SPSS version 25 for further analysis. Then variables that had an association in the bivariate model ($p < 0.25$) were entered and analyzed by a multivariable conditional logistic regression model to identify the independent effect of different factors. Statistical significance was declared at $p < 0.05$.

Results: A total of 147 cases and 293 controls were included in this study. Women who had a history of chronic cough, previous pelvic floor surgery, constipation, and vaginal tear during delivery, history of pelvic trauma, age of the women, rural resident, and maternal gravidity were strongly associated with prolapse at p-value of <0.05. Multigravida [adjusted odds ratio (*AOR*) 2.987 (95% *CI* 1.237–6.853), $p = 0.014$], age >50 years [*AOR*: 2.496 (95% *CI* 1.372–4.539), $p = 0.003$], women with a history of pelvic floor surgery [*AOR*: 0.3.666 (95% *CI* 1.328–10.124), $p = 0.012$], women who had diabetes mellitus [*AOR*: 4.676 (95% *CI* 0.908–24.075), $p = 0.065$], and resided in rural areas [*AOR* = 1.878; (95% *CI*: 0.984–3.585), $I^2 = 47.5\%$, $p = 0.056$] were the independent predictors were of prolapse.

Conclusions: In this study, women with diabetes mellitus, previous pelvic floor surgery, rural residents, being multigravida, and age >40 were independent predictors of prolapse. Therefore, delivering health education by focusing on the identified risk factors was strongly recommended.

KEYWORDS

pelvic organ prolapse, pelvic floor dysfunction, maternal health, risk factors, Asella

Introduction

Prolapse occurs when abnormal descent of the pelvic organs occurs from their normal anatomic positions. It is primarily a common gynecological condition that is considered as a medical and social problem, deeply rooted with poor health services and socio-cultural beliefs affecting women in childbearing age and post-menopausal age (1, 2). Patients generally present with several complaints, such as bladder, bowel, and pelvic symptoms; however, with the exception of vaginal bulging, none is specific to prolapse. Women with symptoms suggestive of prolapse should undergo pelvic examination and medical history checkups. However, many patients with pelvic organ prolapse are asymptomatic and do not need treatment (3). In a general population, only 12% of women aged between 45 and 85 years women are symptomatic though over two-thirds of these women have anatomical evidence of pelvic organ prolapse (POP) (4, 5). However, women with symptomatic pelvic floor dysfunction PFD suffer from physical and emotional distress which has a great negative impact on women's social, physical, and psychological wellbeing (6, 7).

Therapeutic options for POP include surgery and conservative treatments. Although surgical management of POP is currently adopted, non-surgical treatments such as pessaries, pelvic floor muscle training, or both can be useful in symptomatic improvement (8, 9) as well as weight loss in case of obesity. Nevertheless, most of these treatments are not helpful for women with severe prolapse; therefore, surgical therapy is more appropriate in these cases. The surgical management, depending on the type of POP, includes apical suspension (sacral colpopexy and sacrospinous ligament fixation), anterior and posterior (colporrhaphy, perineorrhaphy, and obliterative procedures) vaginal prolapse repair (8).

Surgical repair is the first choice of treatment in case of severe POP (stage III–IV, according to the International Continence Society POP-Q classification (10). Surgery usually includes hysterectomy, performed through different approaches (vaginal, laparoscopic/robotic, and abdominal) (11). The two most accepted surgical techniques for primary VPP are laparoscopic sacrocolpopexy (LSC) and sacrospinous fixation (SF) (12). The second recurrence of vaginal vault prolapse (VVP) is defined as prolapse of the vaginal vault or upper vagina after two previous reconstructive surgeries. The recurrence of VVP occurs when the top of the vagina descends below a point that is 2 cm less than the total vaginal length above the plane of the hymen (13).

Although the exact prevalence of pelvic organ prolapse is unknown, the lifetime risk of requiring at least one operation to correct prolapse has been roughly estimated at 11% (14). Prolapse procedures are known to have a high reoperation rate, with a lifetime risk for surgery of 10–20% (15). Although several approaches are available for the management of POP, the best strategy in case of recurrence after vaginal vault prolapse still remains debated (16, 17). However, it is assumed that the success rate of POP surgery would increase by combining surgery with PFMT (18). Recent systematic reviews have concluded that PFMT reduces POP symptoms and severity stage (17). PFMT has been shown to increase pelvic floor muscle (PFM) strength and endurance, reduce the levator hiatus area, lift the bladder and rectal ampulla, increase PFM volume, and reduce PFM length (18).

The cause of prolapse is primarily related with pregnancy and vaginal delivery, which lead to direct pelvic floor muscle and connective tissue injury. These defects may be due to stretching and tearing of the endopelvic fascia, levator muscles, and perineal body during childbirth (19). The combinations of anatomical, physiological, genetic, lifestyle, and reproductive factors that interact throughout a woman's lifespan also contribute to PFD. Hysterectomy, pelvic surgery, and conditions associated with sustained episodes of increased intra-abdominal pressure, such as obesity, chronic cough, constipation, and repeated heavy lifting, also contribute to prolapse (20).

The prolapse affects severely affects women's quality of life in several ways. Women with POP can feel different prolapse symptoms like "something coming down" and other urinary, bowel, and sexual symptoms. It has socioeconomic and health consequences, affecting overall health and sexual function (21). These women frequently report disorders of sexual desire, arousal, orgasm, and pain and these problems can decrease the quality of life and affect the relationship between partners (22). The disease impairs healthcare seeking behavior of women due to a series of socio-cultural myths, lack of familial support, treatment cost, women's reluctance and wrong perception of the prolapse as a malignancy (23).

A previous study conducted in northern Ethiopia showed that sphincter damage, family history of POP, being uneducated, having $\geq$ 4 vaginal deliveries, carrying heavy objects, maternal gravidity, and BMI $<$ 18.5 kg/m^2 as determinants of POP (24). However, this study identified additional factors like chronic cough, previous pelvic floor surgery, constipation, vaginal tear during delivery, history of trauma, age of the women, rural resident as associated and, women with diabetes mellitus, previous pelvic floor surgery, rural resident, being multigravida and age $>$40 years as the independent predictors of POP. Besides, there may be different in sociodemographic, socioeconomic, and lifestyles differences between south-eastern Ethiopia and northern Ethiopia. Hence, this study aimed to identify risk factors of pelvic organ prolapse among gynecological patients who underwent surgery at Asella Teaching and Referral Hospital in order to segment interventional on identified risk factors.

Abbreviations: ATRH, Asella Teaching Referral Hospital; BMI, body mass index; UVP, *utero* vaginal prolapse.

TABLE 1 Sociodemographic of patients with pelvic organ prolapse at Asella Teaching Referral Hospital (ATRH), 2021.

Variable	Category	Frequency	Percentage
Marital status	Single	23	5.22
	Married	416	94.55
Residence	Urban	97	22.05
	Rural	343	77.95
Age of respondent	18–24	47	10.70
	25–29	67	15.22
	30–34	59	13.41
	35–39	99	22.5
	40–44	28	6.36
	45–49	65	14.77
	>50	75	17.05

Materials and methods

This retrospective unmatched case–control study was conducted using a simple random sampling technique from February to March 2021 at Asella Teaching Referral Hospital (ATRH), South East Ethiopia. Age at the first delivery was used to calculate the final sample size as it gave the maximum sample size, 440 [147 cases and 293 controls] with the following assumptions (24): 91.9% proportion of exposed control, 64.9% proportion of case (24), 95% confidence interval (CI), 80% power, 6.1 odds ratio, 2:1 controls to cases ratio. The case definition of this study was charts of women who reported to have at least one of the pelvic floor disorders (*utero*-vaginal prolapse, rectocele, cystocele, vault prolapse, and delivered myoma) with stages two and above (23). On the other hand, all charts of women who were diagnosed gynecological problems other than pelvic floor disorders were controls. In this study charts of women with both pelvic floor disorder and other gynecological problems, charts of women with stage one pelvic floor disorder and charts with at least three incomplete identified risk factors were excluded. Before selecting cases and controls, all 2 years charts of women with all gynecological problems were identified. After that, a simple random sampling technique was used to separately select both cases and controls from its respective group. Four nurse degree holders' and two masters of Science degree holders were recruited as data collectors and supervisors, respectively. The training was given for the data collectors and supervisors for 2 days. The aim of the training was to make understanding on the objective of the study, data collection tool, data quality assurance, and data collection procedures. Data were entered into Epidata version 4.3.1 and then exported to Stata v14.0 (Statacorp, College Station, Texas, USA) software for analyses. Then variables that had an association in the bivariate model ($p < 0.25$) were transported and analyzed by a multivariable logistic regression model to identify the independent effect of different factors. A stepwise approach will be performed to select variables for inclusion in modeling. Statistical significance will be declared at $p < 0.05$. To check co-linearity between risk factors, tolerance and variance inflation factor (VIF) were used (25). Adjusted odds ratio (*AOR*) with a 95% *CI* was used to measure the strength of association. Calibration of the model was determined by a non-significant Hosmer–Lemeshow goodness of fit test (26).

Result

Sociodemographic characteristics of the patient

A total of 440 women were included in this case–control study to determine risk factors of pelvic organ prolapse. The majority of the patients with pelvic organ prolapse were found in the age >50 years and the lowest percentage of women were found between the age group of 18–24 years. The mean age of respondents was 35.3386 ± *SD* (10.77292), (minimum 18 and maximum 65). In addition, the majority of women were from rural areas 343 (77.95%). The regarding the residence of women, about 94.55% of all patients were from rural areas while the remaining 22% were from urban. Majorities of the patients 94.5% of all women were married (Table 1).

Bivariate analysis on sociodemographic, medical, and other risk factors of POP

Among all sociodemographic and other determinants, intra-abdominal mass and marital status were not associated with POP on bivariable analysis at p value of <0.25; hence excluded from the multivariable analysis. On the other hand, sociodemographic and other factors which were associated on bivariable analysis were history of chronic cough, constipation, history of walking long distance, history of carrying heavy wood, history of trauma, age of the women, and resident of women (Table 2).

Obstetrics and surgery-related risk factors

All obstetrics- and gynecological-related determinants of POP were associated on bivariable analysis at p value of <0.25; hence transported to multivariable analysis. These factors include previous pelvic floor surgery, vaginal tear during delivery, operative vaginal delivery, birth weight, history of prolonged labor, history, home delivery, maternal parity, and gravidity (Table 3).

TABLE 2 Bivariable analyses of sociodemographic, medical, and other risk factors of POP at ATRH, 2021.

Variables		Case	Control	Sig.	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Age category	≥40	54	206	0.000	2.756	1.661	4.573
	<40	93	87	0.564	0.875		
Residence	Rural	23	74	0.023	1.822	1.086	3.055
	Urban	124	219	0.000	1.766		
Marital status	Yes	5	19	0.287	1.969	0.720	5.384
	No	142	274	0.000	1.930		
Intra-abdominal mass	Yes	81	140	0.261	0.775	0.520	1.156
	No	66	151	0.000	2.258		
Diabetes mellitus	Yes	10	10	0.112	0.482	0.196	1.186
	No	136	282	0.000	2.074		
Chronic cough	Yes	54	41	0.000	0.280	0.175	0.449
	No	93	252	0.000	2.710		
Walking long distance	Yes	75	92	0.000	0.439	0.293	0.660
	No	72	201	0.000	2.792		
Carrying heavy wood	Yes	66	69	0.000	0.378	0.248	0.577
	No	81	224	0.000	2.765		
History of pelvic trauma	Yes	18	8	0.000	0.198	0.084	0.467
	No	127	285	0.000	2.244		
Chronic constipation	Yes	38	20	0.000	0.210	0.117	0.377
	No	109	273	0.000	2.505		

Risk factors of pelvic organ prolapse

In this study, women who had a history of chronic cough, previous pelvic floor surgery, constipation, vaginal tear during delivery, history of trauma, age of the women, rural resident, and maternal gravidity were strongly associated with pelvic organ prolapse at p value of <0.05. The result of multivariable analysis also showed women with diabetes mellitus, previous pelvic floor surgery, rural residents, being multigravida, and age >40 years independent predictors of factors of pelvic organ prolapse. Women who had diabetes mellitus had about five times more likely to have pelvic organ prolapse than patients who had no diabetes mellitus [(*AOR*: 4.676 (95% *CI* 0.908–24.075), $p = 0.065$].

The odds of having pelvic organ prolapse were two times more prevalent among women who resided in rural areas than those who were living in urban areas [(*AOR* = 1.878; 95% *CI*: 0.984–3.585), $I^2 = 47.5\%$, $p = 0.056$].

Women who had a history of walking long distance were 89.3% more likely to develop POP than those who were not [*AOR*: 0.893 (95% *CI* 0.437–1.825), $p = 757$]. Additionally, women who had a history of carrying heavy wood were about 105.8 more likely to develop POP than who were not [*AOR*: 1.058 (95% *CI* 0.463–2.422), $p = 0.893$].

Being multigravida women had about three times more likely to develop POP when compared to single gestation [*AOR* 2.91 (95% *CI* (1.237–6.853)], $p = 0.014$). The odds of having pelvic organ prolapse were about 2.5 and 3.7 times among women aged >50 years and women with a history of pelvic floor surgery [*AOR*: 2.496 (95% *CI* 1.372–4.539), $p = 0.003$] and [*AOR*: 0.3.666 (95% *CI* 1.328–10.124), $p = 0.012$], respectively (Table 4).

Discussion

Pelvic organ prolapse is downward descent of female pelvic organs, such as the bladder, uterus or post-hysterectomy vaginal cuff, and the small or large bowel, resulting in protrusion of the vagina, uterus, or both. The most valid symptom of POP is the sensation of a bulge in the vagina (27). It is a major female health problem that causes considerable physical and emotional distress, bothers quality of life and influence a large financial burden (15). The effect of disorder is not only limited to the physical health, sexual lives, ability to work, and earn a livelihood of the individual women, but also it affects their families, caregivers, and society at large (22, 24). Hence, women want to preserve their physique and capacity for sexual function well beyond menopause (1).

TABLE 3 Obstetric and surgical risk factors of POP at ATRH, 2021.

Variables		Case	Control	Sig.	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Pelvic floor surgery	Yes	16	18	0.077	0.530	0.262	1.072
	No	129	274	0.000	2.124		
Operative delivery	Yes	15	9	0.003	0.275	0.117	0.644
	No	130	284	0.000	2.185		
Vaginal tear	Yes	33	14	0.000	0.170	0.088	0.330
	No	112	279	0.000	2.491		
Prolonged labor	Yes	51	35	0.000	0.255	0.156	0.417
	No	96	258	0.000	2.687		
Home delivery	Yes	53	45	0.000	0.322	0.203	0.511
	No	94	248	0.000	2.638		
Macrocosmic baby	Yes	20	7	0.000	0.155	0.064	0.377
	No	127	286	0.000	2.252		
Multipara	Multipara	30	76	0.202	1.366	0.846	2.204
	Nulliparous	117	217	0.000	1.855		
Gravidity	Primigravida	9	52	0.000			
	Multigravida	104	207	0.000	5.778	2.463	13.551
	Grandmultipara	34	34	0.011	1.990	1.171	3.383

This study showed that previous pelvic floor surgery was independent predictors of POP which is in line with other studies (28, 29). Another population-based study has shown that at least 30% of women treated surgically for pelvic organ prolapse, urinary incontinence, or both will require subsequent surgery for a recurrence of these conditions (30, 31). It was also founded by another study that the first vaginal delivery and forceps delivery are risk factors of POP (32). In contrast to the current study, operative vaginal delivery and vaginal tear during birth were not associated with POP (4, 33). On the other hand, elective cesarean delivery was protective when compared with spontaneous or operative vaginal delivery (19).

The present study found that multiparty was one of the independent predictors of POP which agrees with other similar studies (34–36). It was also revealed by other studies that pregnancy and childbirth are considered as risk factors for POP (32, 33). This might be due to the fact that repeated pregnancy and birth damages sphincter muscles and ligaments, which sometimes never fully regain its strength and elasticity. However, another study found that operative vaginal delivery other than forceps delivery, age at last delivery, and gravidity were not significantly associated with POP (35).

Like other several studies, we found that the risk of POP increases with age (33, 37–43). Similarly, another study conducted in Jimma, southwest Ethiopia revealed that women aged ≥ 40 years were about three times more likely to have had POP compared to its counterpart (38). The findings of the review article showed that odds of having pelvic organ prolapse were about seven times more likely among women having more than 40 years old than in the younger population (23). The increase in prevalence of POP as age increases might be due the weakening sphincter muscles and surrounding tissues as the age increases (44, 45).

According to the findings of this study, rural resident was independent predictors of POP which agrees with another study (38). A systematic review and meta-analysis done on the burden of pelvic organ prolapse in Ethiopia showed that the odds of having pelvic organ prolapse were 3.29 times more prevalent among women who resided in rural areas than those who were living in urban areas (23). This might be due to the fact that rural women had been assisting in farmland, marketing, wood and water fetching, child rearing and carrying the baby on the back even during pregnancy which has detrimental effects for the loss of genitourinary supporting structures.

The finding of the current study also revealed that chronic cough and chronic constipation were strongly associated with POP which agrees with another study (46). In contrast, other studies found that chronic cough and chronic constipation were associated with prolapse (33, 41, 47). These might be due to the fact that conditions such as chronic cough, constipation, and obesity may predispose some women to disruption, stretching, or dysfunction of the levator anti complex, connective-tissue attachments of the vagina, or both, resulting in prolapse (46).

In this study, diabetes mellitus was identified as among independent predictors of POP. Similarly, another study found that diabetes mellitus was significantly associated with primary

TABLE 4 Risk of pelvic organ prolapse at ATRH, 2021.

Variables in the Equation	B	S.E.	Wald	D.f	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Diabetes mellitus	1.542	0.836	3.404	1	0.065	4.676	0.908	24.075
History of chronic cough	−0.884	0.360	6.041	1	0.014	0.413	0.204	0.836
Walking long distance	−0.113	0.364	0.096	1	0.757	0.893	0.437	1.825
History of carrying heavy wood	0.057	0.422	0.018	1	0.893	1.058	0.463	2.422
Pelvic floor surgery	1.299	0.518	6.285	1	0.012	3.666	1.328	10.124
Operative vaginal delivery	−1.181	0.618	3.649	1	0.05	0.307	0.091	1.031
Vaginal tear during delivery	−1.435	0.508	7.979	1	0.005	0.238	0.088	0.645
History of prolonged labor	0.075	0.413	0.033	1	0.856	1.078	0.480	2.422
History of home delivery	−0.552	0.291	3.586	1	0.05	0.576	0.325	1.020
History of pelvic trauma	−1.303	0.659	3.909	1	0.048	0.272	0.075	0.989
Macrocosmic baby	−0.732	0.681	1.153	1	0.283	0.481	0.127	1.829
Chronic constipation	−0.912	0.411	4.939	1	0.026	0.402	0.180	0.898
Age >50 years	0.915	0.305	8.986	1	0.003	2.496	1.372	4.539
Multigravida	1.069	0.437	5.987	1	0.014	2.911	1.237	6.853
Rural resident	0.630	0.330	3.647	1	0.056	1.878	0.984	3.585

POP (4, 41). Other studies also revealed that obesity (BMI $\geq$ 25 kg/m^2) could increase the risk of POP (48, 49). The findings of systematic review and meta-analysis revealed a contrary finding that being underweight (BMI, 18.5 kg/m^2) increases the risk of POP by a threefold (48, 50). However, we did not collect BMI of the patient.

Limitations of this study

The main limitations of the present study included failure to assess some important variables like age at first delivery, age at last delivery, and BMI of women as our data were secondary source. However, we tried to assess all other documented factors and important characteristics.

Conclusions

In conclusion, women who had a history of chronic cough, previous pelvic floor surgery, constipation, vaginal tear during delivery, history of trauma, age of the women, rural residents, and being gravida women were strongly associated with prolapse. And the independent predictors of POP were women with diabetes mellitus, previous pelvic floor surgery, rural residents, being multigravida, and age >40 years. Therefore, delivering health education by focusing on the identified risk factors was strongly recommended. Further, multicenter cohort studies with a higher sample size should be conducted to further investigate the risk factors responsible for occurrences of POP.

Data availability statement

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

Author contributions

MO and TW were involved in the conception, study design, execution, acquisition of data, analysis and interpretation of data, took part in drafting the article, and revising it critically for important intellectual content. NGK and NAK were involved in study design, execution, acquisition of data, analysis, interpretation, drafted, and final manuscript writing. All authors reviewed and agreed on all versions of the manuscript before submission, agreed to submit to the current journal, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Conflict of interest

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

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Rita Almendra,
University of Lisbon, Portugal
Jakub Więckowski,
West Pomeranian University of Technology, Poland
Lluís Granero,
University of Valencia, Spain

*CORRESPONDENCE
Min Guo
gm_201910983@outlook.com

†These authors have contributed equally to this work

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An evaluation method for product design solutions for healthy aging companionship

Shan Hu†, Qi Jia†, Linlin Dong, Jialin Han, Min Guo* and Weiqi Guo

School of Industrial Design, Hubei University of Technology, Wuhan, China

Background: With the development trend of healthy aging and intelligent integration, escort products have become a new means of healthy aging. Healthy old-age care pays attention to the convenience and informatization of life. To meet the needs, designers often design multiple accompanying product solutions, and it is very important to use reasonable evaluation methods to decide on the optimal solution.

Purposes: A new comprehensive evaluation method is proposed to reduce the subjectivity and one-sidedness of the selection process of intelligent escort product design solutions, and to make the decision more objective and reasonable. Such decisions can enhance the experience and naturalness of the elderly using intelligent products.

Methods: First, a large number of user interviews were analyzed using the grounded theory, gradually refine through theoretical coding, and abstracted with the design scheme evaluation index. Second, the idea of game-theoretic weighting is used to optimize a linear combination of subjective and objective weights to determine the final weights of each evaluation indicator. Finally, the evaluation and selection are completed based on the solution ranking determined by the approximate ideal solution ranking method (TOPSIS). It is applied for the selection of the elderly escort robot design, and the usability test is conducted using the PSSUQ to verify the selection results.

Results: A new comprehensive evaluation method can better complete the preferential selection of product design solutions for healthy aging escorts, and reduce the subjectivity and one-sidedness of the evaluation.

Conclusion: This method compensates for the reliance on personal experience in the selection of options, and improve the subjectivity of the evaluation index determination process and the deviation of index weighting. Improving the objectivity and scientificity of decision-making reduces the blindness of design and production. It also provides a theoretical reference for the research scholars of healthy aging companion products.

KEYWORDS

healthy aging, product solutions decision, comprehensive evaluation method, game theory portfolio empowerment, rooted in theory, TOPSIS method

Introduction

With the demographic changes, Chinese society has shifted from mild aging to moderate aging, and the accompanying health care has become the focus of social attention. Relying on the maturity and popularity of information technology, smart aging as a new concept began to be widely used in the field of elderly care. Its purpose is to use smart products to help the elderly improve the convenience and informatization of their lives and achieve healthy retirement. For example, (1) summarized and elaborated on the introduction and development of the concept of smart wellness, which can enhance the possibility of self-care for the elderly and reduce the burden of elderly care through the popular application of smart platforms and products. Anghel et al. (2) investigated that intelligent environments and intelligent technologies, such as machine learning and robot assistance, can support the independent living of the elderly and provide friendly nursing services to enable the elderly to have a safer and more independent healthy aging. At the same time, there are more and more researches on smart products for the elderly, from the aspects of product user needs, product solution conception, product development, usability testing, and user acceptance. For example, Neira-Rodado et al. (3) explained the changing needs, ambiguous user requirements, and interrelationships between design criteria; Propose a new intelligent product design process that directly translates user needs into product functions, and validates the new intelligent product design process with hip replacement surgery for the elderly. Wei et al. (4) conducted a research on smart wearable health monitoring products for preventing elderly diabetes, including user information source channels, concerns, and satisfaction with the product, and verified the proposed scheme through a large number of experimental evaluations to solve the problem (said problem). Daher et al. (5) developed an indoor tracking and fall detection system for the elderly, based on smart tiles to detect falls of the elderly, locate and identify human activities, and provide necessary assistance when needed. Kim et al. (6) developed usability testing standards for elderly communication service robots from four aspects: safety, controllability, efficiency, and satisfaction, which are a good measurement tools to help users and developers of elderly service robots. Ghorayeb et al. (7) discussed older adults' perceptions of smart home technology and developed sensor platforms for home health and lifestyle and found that older adults' acceptance increases with time and use. In addition, it is also very important to select smart products that meet the needs of the elderly from the design scheme.

In the design stage of information technology products, designers cannot objectively and rationally select the one that best meets the needs of users among various design schemes. As a result, the final product does not conform to the cognitive behavioral habits of the elderly and reduces the quality of healthy life of the elderly, so healthy aging cannot be achieved. At the same time, healthy aging is reflected in all aspects of daily life. Through design, the needs of the elderly are solved one after another, not only to meet the needs of the elderly but also to meet personal expectations through the optimization of design solutions. The optimal decision of product design scheme is an important link in the overall design process which can reduce design blindness, and improve objectivity and scientificity (8). The evaluation results can affect the value and performance of the product and even the production cost of the company (9), which ultimately and indirectly affects elderly users and their daily lives. The optimization of the design scheme involves multiple criteria and multiple objectives. In the actual design decision-making process, designers often evaluate and select programs based on personal experience, lack of uniform standards, at the same time, as a special group of the elderly, their cognitive ability continues to decline, and smart products should be designed to reduce their cognitive difficulties. Therefore, many scholars choose the method according to the existing design scheme, and draw on the knowledge research and evaluation methods of operations research, management, mathematics and other disciplines, mainly including AHP (10–12), entropy weight method (13–15), TOPSIS Method (16–18), and comprehensive evaluation method (19–21), etc. Continuously experiment and summarize the optimal method of design scheme. In the literature mentioned above, many scholars often use expert interviews and questionnaires to establish evaluation indicators and evaluation systems, and the hierarchy of interviewees is randomly selected during the interviews. At the end of the interviews, the raw material obtained was not refined by scientific theories and analytical tools, but rather consolidated on the basis of subjective perceptions. Indicators are often derived based on direct induction by the researcher, which is highly subjective, unsupported by theory, and one-sided; and the establishment of evaluation indicators lacks guidance from qualitative research methods. The weight value calculation process is often a single calculation method, and even the combined weighting method uses the conventional multiplicative normalization (22) and linear weighting of subjective preference coefficients when combining subjective and objective weights, so that the multiplicative effect problem of larger and smaller weight values will exist subjectively and arbitrarily, which eventually causes bias for the evaluation results.

Faced with the shortcomings of the existing evaluation methods in the optimization of the scheme, grounded theory and game theory combined empowerment are introduced. Grounded theory is a bottom-up qualitative theoretical research method and is one of the scientific qualitative research methods (23). The researcher does not make theoretical assumptions at the beginning of the study, but starts directly from practical observations and finds the core concept representing the essence of things from the systematically collected data, which is characterized not by its empirical nature, but by the new

concepts and ideas it abstracts from the empirical facts. More and more scholars are applying grounded theory to qualitative research in various fields. For example, Goodall et al. (24) used grounded theory to study how older people who "age in place" find health information and the role that digital technology plays in this. Seesawang et al. (25) used grounded theory to develop a theory on the perceived risk experience of older men with hypertension in rural Thailand. Wang et al. (26) applied it to the study of factors influencing the demand for smart health care. In addition, the grounded theory uses a semi-structured interview method, which is somewhat free and open, is not influenced by existing views, is able to discover factors that are overlooked in current ideas or theories, and to a certain extent can scientificize and objectify inductive summaries that rely on experience. At the same time, many scholars have proposed the use of two or more evaluation methods to combine the weighting, to avoid a single method to determine the weight of indicators is too one-sided and no reference value; game theory combination of weighting is one of them, which is widely used by many scholars for comprehensive evaluation. For example, Men et al. (27) used it for the evaluation decision of power equipment suppliers to provide a reference. Geng and Bo (28) used it to analyze the relationship between customer needs. Game theory combination assignment adopts the idea of reducing the deviation of subjective and objective weights to fully combine the advantages of the two, to a certain extent to improve scientific rationality, not only to avoid the problem of subjective arbitrariness in the subjective assignment, but also to avoid the problem of objective assignment based only on inherent information without highlighting the relative importance of indicators.

In summary, we found that many scholars focus on product development, mostly the idea research before product development and the method research of the development process. Few scholars pay attention to the evaluation stage of the product scheme, while the evaluation of the product design scheme is related to scheme optimization, value maximization, inaccurate evaluation and lack of screening of solutions will lead to blindness in production, affecting product performance or even not meeting user needs. In addition, designers do not have an objective evaluation decision model as a reference for program selection, which makes designers' decision-making vague and subjective, resulting in unsatisfactory results. Therefore, it is very necessary to establish an objective evaluation decision model and apply it to the selection of intelligent escort product solutions. The paper aims to apply the combination of grounded theory and game theory to improve the subjectivity of the index determination process and the bias of the index assignment, and then use the TOPSIS method to decide on the optimal solution, to propose a new comprehensive evaluation method combining qualitative and quantitative research methods, improve the objectivity and science of the evaluation. Providing theoretical references for enterprises and designers to help them evaluate the optimal solution to serve the elderly better and improve the user experience and the health of the elderly life.

Method

Theoretical overview

Grounded theory

Grounded Theory was proposed by sociologists Glaser and Strauss (29), and its main idea is to build a theory based on empirical information, summarize and gradually refine the information obtained from semi-structured interviews, and then rise to a systematic theory. On the basis of systematically collecting data, the core concepts that reflect the essence of things and phenomena are sought (30), and then relevant social theories are constructed through the connections between these concepts. The process is problem selection, data collection, data analysis, theory building, theory saturation testing, and conclusion formation. Open, spindle, and selective coding are the three key steps in forming a theory, and when theory saturation does not meet the criteria, then further data collection and analysis are required for validation.

Game theory portfolio empowerment

Game theoretic portfolio assignment is based on the idea of the game set model, which coordinates conflicts between different decision makers and seeks consistency, minimizing the deviation between each weight and the optimal weight, so as to obtain a relatively balanced and coordinated combined weight vector, and increases the accuracy of weights (31). The method can combine the advantages of subjective and objective assignments, find agreement and compromise between subjective and objective weights with Nash equilibrium as the coordination objective, and find the maximum common interest among indicators. It can take into account both subjective and objective weights, optimize their combination, and improve the scientific rationality of indicator assignments. It not only takes into account the inherent information of indicators but also reduces the subjective arbitrariness and avoids the weighting values from being too one-sided.

Comprehensive evaluation method construction

The evaluation process of the new comprehensive evaluation method proposed in the paper is divided into three parts. In the first part, based on the grounded theory, the semi-structured interview data are summarized, analyzed, and coded step by step to extract the evaluation indicators, and the corresponding

evaluation hierarchy system is constructed. In the second part, the subjective and objective weights of the evaluation indicators are calculated by the subjective weighted fuzzy analytic hierarchy process and the objective weighted entropy method. The linear combination of the two weights is optimized using the game theory combination weighting, and the combination weight is derived. In the third part, the combined weights of the evaluation indicators are applied to the ranking calculation of the TOPSIS scheme, and the preferred scheme is obtained. The evaluation decision model is constructed as shown in Figure 1.

Evaluation levels and indicator construction

The establishment of evaluation criteria and indicators is based on an in-depth analysis of the original information based on the grounded theory, refining and summarizing the hidden laws as well as connections, so as to form a theory that is the evaluation hierarchy and indicators. Therefore, the selection of interviewees should be representative and extensive, preferably with frequent contact with the evaluated subjects and a strong willingness to cooperate, to ensure the comprehensiveness of data collection.

Integrated weight value calculation

The triangular fuzzy analytic hierarchy process (TFAHP) is based on the analytic hierarchy process (AHP), which introduces a triangular fuzzy number set and transforms the fuzziness of the qualitative index evaluation process into corresponding fuzzy numbers for quantification. This not only retains the advantages of AHP but also avoids the inaccuracy of evaluation caused by the fuzziness of human thinking and the structural redundancy caused by the consistency test.

The basic idea of the entropy weight method is to determine the objective weight according to the size of the degree of difference of indicators. The degree of difference is the size of the entropy weight of the indicator, and the greater the entropy weight of the evaluation indicator, the greater the degree of contribution of the indicator to the product evaluation.

Subjective weighting calculation

First, the evaluation criteria were scored for two comparisons to construct a fuzzy mutual inverse judgment matrix for the target layer. Judges were asked to use a scale of 1–9 to judge the adjudication, and the quantification and meaning of the defined terms are shown in Schedule S1 Table. The general process of triangulated fuzzy hierarchical analysis is as follows (32, 33):

(1) Taking the target layer element Q and its corresponding first-level criterion $M_1, M_2, \ldots, M_n$ of the criterion layer as an example, the fuzzy mutual inverse judgment matrix is constructed as follows:

$$A = (r_{ij})_{n\times n} \tag{1}$$

Where the fuzzy set of r_{ij} is (l_{ij}, m_{ij}, u_{ij}), and the n-term criterion is compared for judgment, then we get:

$$A = \begin{bmatrix} r_{11} & r_{12} r_{13} & \cdots r_{1n} \\ r_{21} & r_{22} & r_{23} \cdots r_{2n} \\ r_{31} & r_{32} & r_{33} \ldots r_{3n} \\ \vdots & \vdots & \vdots \quad \ddots \vdots \\ r_{n1} & r_{n2} & r_{n3} \ldots r_{nn} \end{bmatrix} \tag{2}$$

(2) The criteria of each level of each scheme were scored by z experts, and the data were aggregated and processed using the Delphi method (34) to establish the $Q-M$ level fuzzy mutual inverse judgment matrix. Assuming that the scorers have similar levels of knowledge as well as judgment, the arithmetic average method is used to synthesize the scoring information, and thus a comprehensive fuzzy mutual inverse judgment matrix for the $A-R$ layer can be obtained as follows.

$$\begin{aligned} A &= \left(\frac{\sum_{t=1}^{z} l_{ij}^{t}}{z}, \frac{\sum_{t=1}^{z} m_{ij}^{t}}{z}, \frac{\sum_{t=1}^{z} u_{ij}^{t}}{z} \right)_{n\times n} \\ &= \left(L_{ij}, M_{ij}, U_{ij},\right)_{n\times n} \end{aligned} \tag{3}$$

Where, r_{ij} denotes the importance between element i and element j, and $r_{ij} = r_{ij}^{-1}$.

(3) Defuzzification of the matrix: The mean area method is generally used, as shown in Equation (4).

$$A = \left(\frac{L_{ij}+2M_{ij}+U_{ij}}{4} \right)_{n\times n} = (r_{ij})_{n\times n} \tag{4}$$

(4) Weight value calculation: After the defuzzification process, the calculation of the weight vector of each matrix is started, and since the calculation steps are common calculation methods, the specific procedure is referred to the literature (35).

(5) Consistency test: Due to the vagueness and limitations of human thinking and the complexity of judging things, there may be inconsistencies in the judgments given by decision-makers in the judging process, so the consistency of the matrix needs to be tested, and the selection of the average random consistency criterion RI, CI, and the calculation steps of the consistency ratio CR refer to the literature (36).

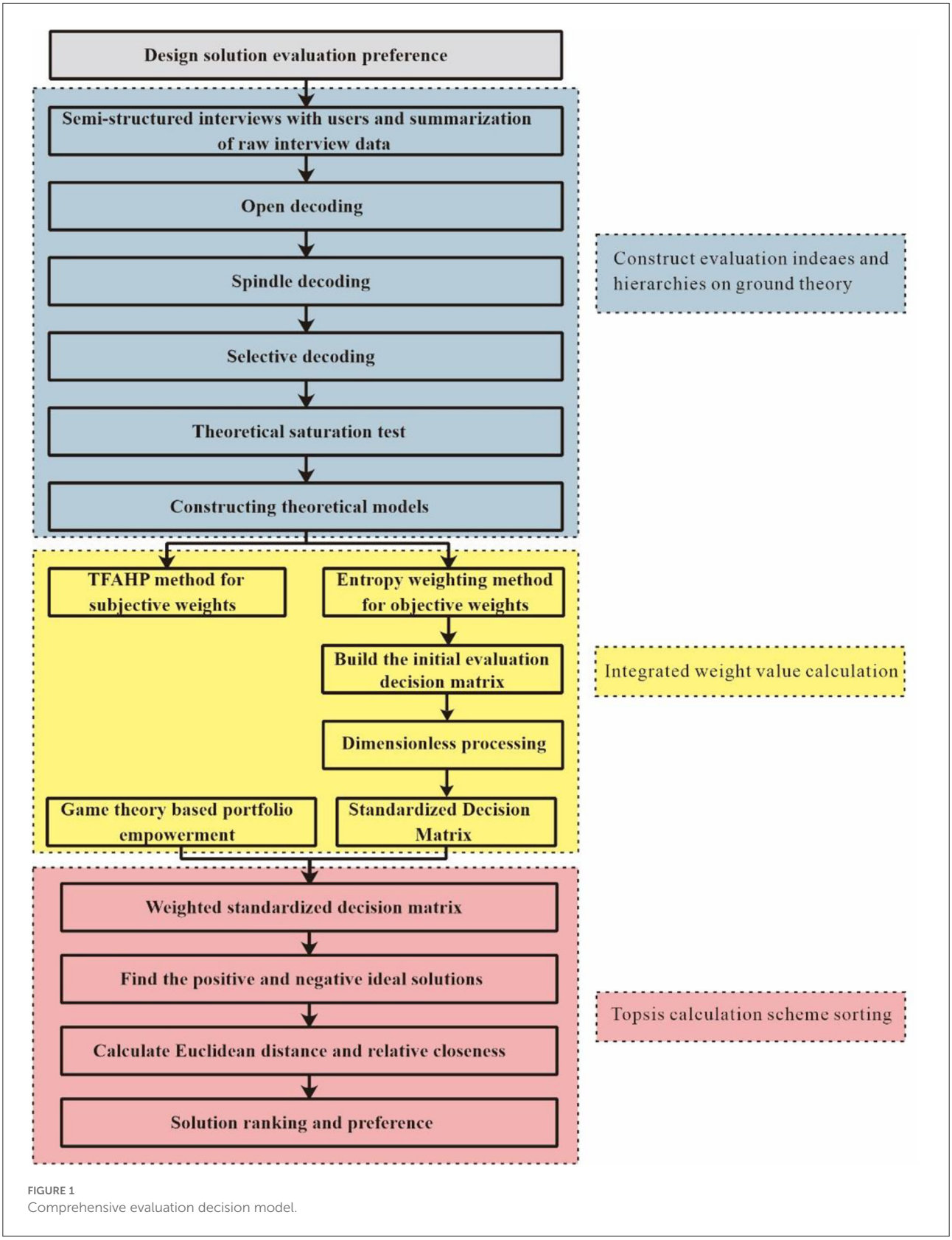

FIGURE 1
Comprehensive evaluation decision model.

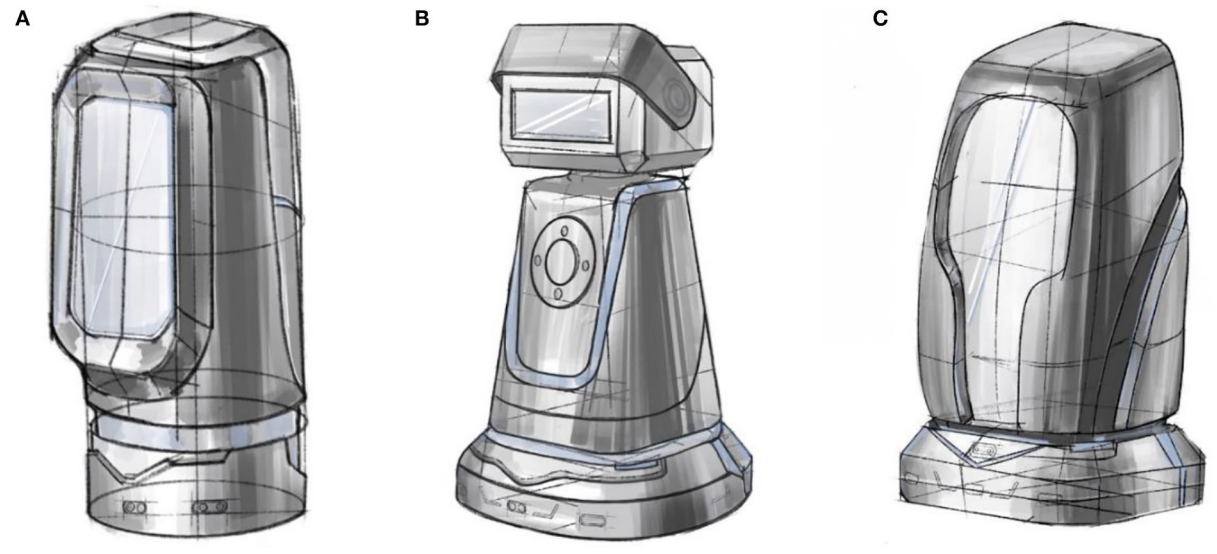

FIGURE 2
Design solutions. **(A)** Scenario a is equal to Scenario 1, **(B)** Scenario b is equal to Scenario 2, and **(C)** Scenario c is equal to Scenario 3.

TABLE 1 Open coding process.

Representative statements of original information	Initial concept	Category
The placement of buttons is not convenient for the operation	Function buttons are well placed	Interface layout rationalization
The color of the words in the interface and the background color are not very different. They will be mixed together, and cannot be seen	The use of color is more conspicuous	Color Matching
Some words are so small that you can't read them without glasses	The font of important instructions should be large	Font Matching
Some functions have too many steps and can be confusing to use	The operation steps should be simple and straightforward	Convenience of operation
I find it very convenient to be able to talk directly by voice	Wake up by direct voice or gesture operation	Interaction pattern naturalness
The human-like appearance of the escort product makes me feel unnatural	The appearance is not rigid and innovative	Novelty of appearance
More like that material is more smooth and does not look cold	Lightweight, smooth and comfortable material	Material comfort
What a function suggests doesn't make me understand what it means	Functional semantics in line with elderly cognition	Product Adaptability
The warm exterior color makes us old people at home feel comfortable and warm	Warm color tones have a sense of intimacy	Color Affinity
I hope there will be a reply soon for my operation whether it is correct or not	Give quick feedback on user operations	Immediacy
Sometimes the feedback like vibrating and flashing lights are not much guidance for my next operation	Whether the feedback is useful for user actions	Validity
Sometimes some of the feedback can be wrong	The semantic expression of the feedback is correct	Accuracy
Because the hands and feet are not very flexible, often touch by mistake, this situation will also have a reaction to the product, the elderly will be nervous	No random alarms for user misuse	Fault Tolerance
We have poor learning ability, some functions can not be taught several times to use	For each function can be learned with little effort	Easy to understand and learn
Hope more functions and cheaper	Inexpensive and functional to meet demand	Practicality
My children are not around, sometimes I would like to video with them	There are parent-child interactions and other human care functions	Caring and friendly
I hope there will not be regular problems, because we are not able to repair them	No frequent problems, more stable	Stable and durable

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TABLE 2 Axial coding process.

Main category	Sub-categories	Connotation
Human-computer interaction	Interface layout rationalization	Reasonable layout of operation interface (buttons, screens)
	Color Matching	The correct color match is convenient for the elderly to identify
	Font Matching	The rational use of fonts in the interface reduces the cognitive difficulty
	Convenience of operation	No complicated operation steps required
	Interaction pattern naturalness	The easiest and most convenient way to wake up and command the terminal
Product Design	Novelty of appearance	Novel appearance but without losing care for the elderly
	Material comfort	Reasonable materials to improve the comfort of use
	Product Adaptability	The semantic meaning conveyed by the interaction operation matches the cognition of the elderly
	Color Affinity	The color is not too beautiful
Feedback method	Immediacy	The feedback given can be quickly and easily understood by older adults
	Validity	The information conveyed is guiding and helpful for the elderly to operate
	Accuracy	Whether the semantics of the feedback message is consistent with the purpose of the user's operation
	Fault Tolerance	The degree to which the feedback system is fault-tolerant to malfunctions
User Experience	Easy to understand and learn	Easy to learn operation steps
	Practicality	Practical function and high-cost performance
	Caring and friendly	Humanistic care for the elderly
	Stable and durable	Less prone to breakdowns and long life

TABLE 3 Selective coding process.

Typical path relationships	Nature of relationship	Connotation
Human-computer interaction→User satisfaction→Design decisions	Agency Relations	Whether human-computer interaction is natural affects user satisfaction and thus indirectly influences decision making
Product Design→User satisfaction→Design decisions	Agency Relations	Product design affects user satisfaction and thus indirectly influences decision making
Feedback method→User satisfaction→Design decisions	Agency Relations	Feedback methods can affect user satisfaction and thus indirectly influence decision making
User Experience→User satisfaction→Design decisions	Agency Relations	Whether the user experience is good or not affects user satisfaction and thus indirectly affects decision making

Objective weighting calculation

When determining the objective weights using the entropy weighting method, the entropy weighting coefficient method is used to calculate them. The general process is as follows (37):

(1) To express the degree of variation in the evaluation of evaluation indicators by different decision makers, the entropy of evaluation attributes is calculated using the following equation:

$$\begin{aligned} H_j &= -k \sum_{i=1}^{m} p_{ij} \ln\left(p_{ij}\right) \\ &= -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln\left(p_{ij}\right),\ j = 1, 2, \ldots, n \end{aligned} \tag{5}$$

It is assumed that $\ln\left(p_{ij}\right) = 0$ when $p_{ij} = 0$. The higher the value of $1 - H_j$, the more important the evaluation index is, and the higher the weight. The entropy weight of the evaluation index can then be expressed by the following equation:

$$w_j = \frac{1 - H_j}{n - \sum_{j=1}^{n} H_j},\ j = 1, 2, \ldots, n \tag{6}$$

(2) Construct a comprehensive fuzzy decision matrix. From the z scorers in the previous TFAHP using the linguistic variables fuzzy numbers in Schedule S2 Table to evaluate the n indicators of m sets of solutions, a fuzzy initial decision matrix is constructed, which is also expressed by triangular fuzzy numbers, denoted as $g_{ijz} = \left\{\left(l_{ijz}, m_{ijz}, u_{ijz}\right) | i = 1, 2, \ldots m, j = 1, 2, \ldots n, z = 1, 2, \ldots Z, \right\}$. After aggregating the evaluation values of multiple

evaluators, each element of the decision matrix $g_{ij} = \{(l_{ij}, m_{ij}, u_{ij}) | i = 1, 2, \ldots m, j = 1, 2, \ldots n\}$:

$$\begin{cases} l_{ij=}\{l_{ijz}\} \\ m_{ij} = \frac{1}{Z}\sum_{z=1}^{Z}\{m_{ijz}\} \\ u_{ij} = \{u_{ijz}\} \end{cases} \quad (7)$$

The mean area method is used to defuzzify the process. The equation is as follows:

$$F = [f_{ij}]_{m\times n}, f_{ij} = \frac{(l_{ij}+2m_{ij}+u_{ij})}{4} \quad (8)$$

Normalization of the matrix:

$$p_{ij} = \frac{f_{ij}}{\sum f_{ij}},\ i = 1, 2, \ldots, m \quad (9)$$

(3) The objective weights were calculated from the entropy weight coefficient method using Equations (5) and (6).

Game theory portfolio empowerment

The game theory-based combined assignment method is to minimize the deviation of subjective and objective weights to find the maximum common interest among indicators. The steps are as follows (38):

(1) Basic weight vector set $w_k = \{w_{k1}, w_{k2}, \ldots, w_{kn}\}\ (k = 1, 2, \ldots, K)$, n is the number of evaluation indicators of the evaluated object, K is the number of weighting methods, and K is taken as 2. Let the linear combination of weighting coefficients $\alpha = \{\alpha_1, \alpha_2, \ldots, \alpha_K\}$. Any linear combination of these vectors is:

$$w = \sum_{k=1}^{n} \alpha_k w_k^T \quad (10)$$

Where: w is a linear combination of weights; α_k is the weight coefficient; w_k^T is the transpose matrix of the basic weight vector set w.

(2) Optimal combination: K linear weight combinations with coefficients α_K are optimized to obtain the most satisfactory weights. Then the objective function is:

$$\min_k \left\| \sum_{k=1}^{n} \alpha_k w_k^T - w_k \right\| 2\ (k = 1, 2, \ldots, K) \quad (11)$$

Where, α_k is the weight coefficient; w_k^T is the transpose matrix of the basic weight vector set w_k; w_k is the basic weight vector set.

(3) Combination weights: After normalizing the obtained optimized combination coefficients α_k, the combination weights $w^* = (w_1, w_1, \ldots, w_n)$ are obtained by the following equation:

$$w^* = \sum_{k=1}^{n} \alpha_k{}^* w_k^T \quad (12)$$

where, w^* is the weight of the game theory portfolio assignment; $\alpha_k{}^*$ is the weight coefficient after normalization process.

Scheme sorting and selection

There are many methods for multi-attribute decision problems (39, 40), and the TOPSIS method is the more commonly used, it is an intuitive and easy-to-understand method. This method can use the distance between each scheme and the positive and negative ideal solutions in the multi-dimensional space to measure the pros and cons of the scheme. The principle is derived from the theory of compromise planning and reference solution, which is in line with the logic and habit of comparing with a certain index as a reference in the decision-making of product design scheme optimization. The initial decision matrix of the entropy weighting method in which z scorers evaluate n indicators of m sets of solutions is dimensionless according to Equation (13) to construct the standardized decision matrix $X = (x_{ij})_{m\times n}$.

$$x_{ij} = \begin{cases} \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{m_j^+}, \frac{u_{ij}}{l_j^+} \wedge 1\right), \textit{The bigger the better type}; \\ \left(\frac{l_j^-}{u_{ij}}, \frac{m_j^-}{m_{ij}}, \frac{u_j^-}{u_{ij}} \wedge 1\right), \textit{The smaller the better type}. \end{cases} \quad (13)$$

Multiplying this with the combination weights yields the weighted normalized decision matrix $Y = (y_{ij})_{m\times n}$ as:

$$y_{ij} = w_j p_{ij}\ (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n) \quad (14)$$

In the constructed weighted normalized decision matrix Y, the positive ideal solution Y^+, the optimal vector consisting of the maximum value of each sub-criterion, and the negative ideal solution Y^-, the worst vector consisting of the minimum value of each sub-criterion is identified.

$$Y^+ = \left\{Y_1^+, Y_2^+, \ldots, Y_m^+\right\}$$
$$Y^- = \left\{Y_1^-, Y_2^-, \ldots, Y_m^-\right\}$$

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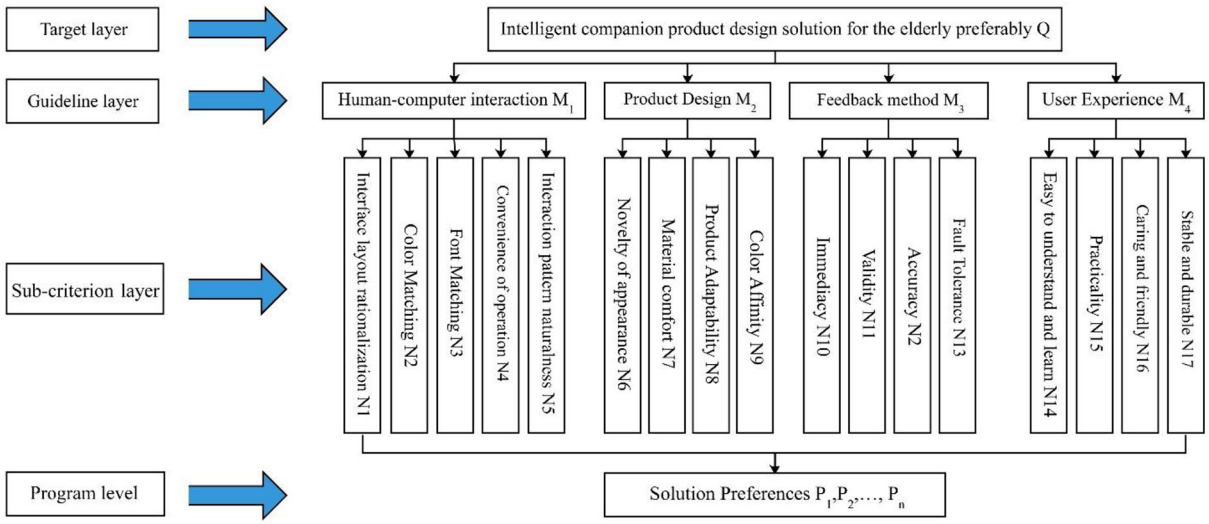

FIGURE 3
Evaluation hierarchy model of intelligent companionship products for the elderly.

TABLE 4 Consistency ratios of the first-level criterion judgment matrix and their weights.

A	M_1	M_2	M_3	M_4	W_1	
M_1	1.0000	3.3300	3.0000	0.3975	0.2766	$\lambda_{max} = 4.1931$
M_1	0.3003	1.0000	0.2600	0.1650	0.0660	
M_1	0.3333	3.8462	1.0000	0.3775	0.1634	$CR = 0.0723$
M_1	2.5157	6.0606	2.6490	1.0000	0.4940	

TABLE 5 Consistency ratio of HCI criterion judgment matrix and its weights.

M_1	N_1	N_2	N_3	N_4	N_5	W_2	
N_1	1.0000	4.3300	7.0000	0.2600	0.3775	0.0465	$\lambda_{max} = 5.4137$
N_2	0.2309	1.0000	4.0000	0.1725	0.2125	0.0190	
N_3	0.1429	0.2500	1.0000	0.1350	0.1450	0.0087	$CR = 0.0923$
N_4	3.8462	5.7971	7.4074	1.0000	3.0000	0.1293	
N_5	2.6490	4.7059	6.8966	0.3333	1.0000	0.0731	

TABLE 6 Product design criteria judgment matrix consistency ratio and its weights.

M_2	N_6	N_7	N_8	N_9	W_3	
N_6	1.0000	0.3975	0.2125	0.2725	0.0051	$\lambda_{max} = 4.2624$
N_7	2.5157	1.0000	0.3775	3.0000	0.0168	
N_8	4.7059	2.6490	1.0000	4.0000	0.0345	$CR = 0.0983$
N_9	3.6697	0.3333	0.2500	1.0000	0.0096	

TABLE 7 Consistency ratio of judgment matrix of feedback mode criteria and its weights.

$\mathbf{M}_2$	$\mathbf{N}_{10}$	$\mathbf{N}_{11}$	$\mathbf{N}_{12}$	$\mathbf{N}_{13}$	$\mathbf{W}_4$	
N_{10}	1.0000	0.3975	0.2725	3.6700	0.0250	$\lambda_{max} = 4.1680$
N_{11}	2.5157	1.0000	2.0000	5.6700	0.0729	
N_{12}	3.6697	0.5000	1.0000	5.3300	0.0558	$CR = 0.0629$
N_{13}	0.2725	0.1764	0.1876	1.0000	0.0097	

TABLE 8 Consistency ratio of user experience criteria judgment matrix and its weights.

$\mathbf{M}_2$	$\mathbf{N}_{14}$	$\mathbf{N}_{15}$	$\mathbf{N}_{16}$	$\mathbf{N}_{17}$	$\mathbf{W}_4$	
N_{14}	1.0000	0.3775	0.1450	3.0000	0.0501	$\lambda_{max} = 4.2313$
N_{15}	2.6490	1.0000	0.1625	3.3300	0.0862	
N_{16}	6.8966	6.1538	1.0000	7.3300	0.3308	$CR = 0.0866$
N_{17}	0.3333	0.3003	0.1364	1.0000	0.0269	

Calculate the Euclidean distance d_i^+ to the positive ideal solution and the Euclidean distance d_i^- to the negative ideal solution for each scenario.

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(y_{ij} - y_j^+\right)^2} i = 1, 2, \ldots, m \quad (15)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(y_{ij} - y_j^-\right)^2}, \; i = 1, 2, \ldots, m \quad (16)$$

Calculate the relative closeness C_i of each scheme concerning the ideal solution and rank all schemes according to the value of H_i.

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}, \; i = 1, 2, \ldots, p \quad (17)$$

It can be seen that $C_i \in (0, 1]$, a higher value of C_i means that the solution is closer to the optimum, and vice versa, closer to the worst. After ranking all the solutions, the solution preference and decision are made according to the final result.

Analysis and results

The purpose of smart aging is for the use of smart products to help the elderly to age healthily with the principle of data sharing and privacy protection (41). The elderly population needs more care and companionship, and children cannot be with them all the time. Such companion smart products can enhance the happiness of the elderly, help them live more conveniently, and promote the health of their elderly life. The project team has designed a total of three solutions for intelligent escort robots for the elderly, which are selected in this paper as the evaluation object, as shown in Figure 2, and the new comprehensive evaluation method proposed in the paper was used to make a preferential ranking of them.

Evaluation levels and indicators establishment

User sample selection

Considering that the elderly are a special group of people with weak information literacy and expression ability, the selection of interviewees should be extensive, and finally, 30 elderly people were selected as the interviewees of this study, including different genders (16 men and 14 women), different age groups (10 persons aged 55–60; 14 persons aged 61–65; 6 persons aged 66–70), different education levels (elementary school and below, junior high school and above, college and University, and bachelor's degree and above), and different familiarity with intelligent escort products (occasional use, more familiar, and frequent use), and the interview time was 20–30 min.

Primary data collection

Following the interview rules proposed in Section Theoretical overview, in-depth interviews were conducted with 30 older adults based on a semi-structured interview outline (Schedule S3 Table) (42), and they were encouraged to speak freely but not induced at appropriate times during the interview, and recorded by means of audio recording after obtaining the consent of the interviewees.

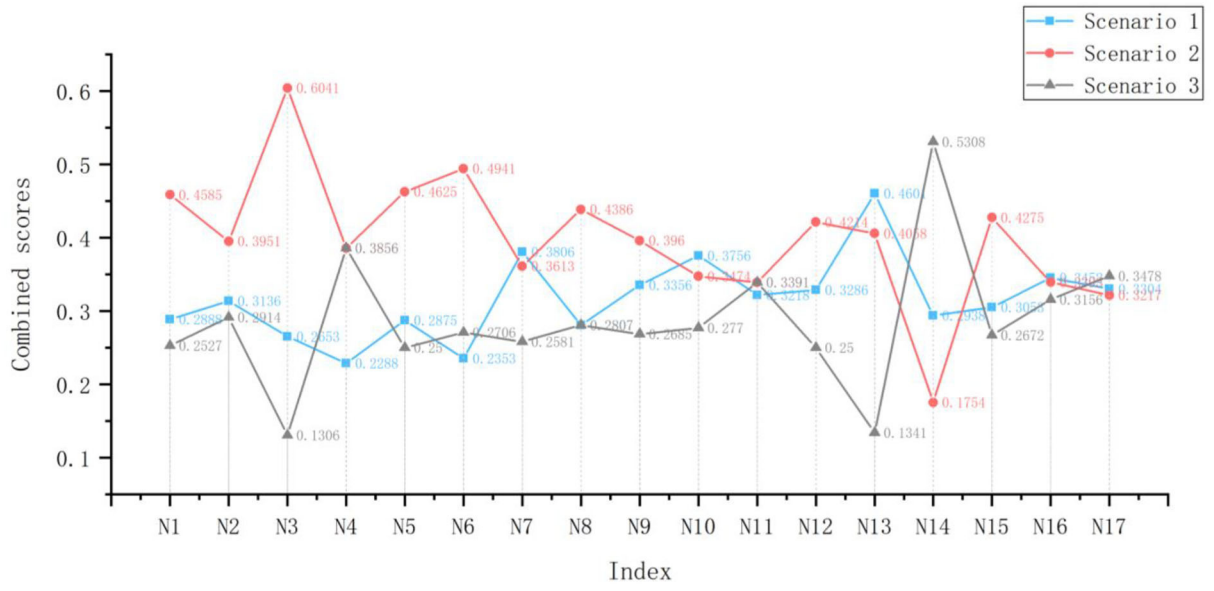

FIGURE 4
Combined scores of the programs after normalization. Scenario a is equal to Scenario 1, Scenario b is equal to Scenario 2, Scenario c is equal to Scenario 3.

Open coding

The recordings were converted to text and analyzed with the aid of decoding using the Nvivo12 software. The process of open coding is to conceptualize the source material, analyzing it word by word and extracting concepts and categories in an objective manner while avoiding the influence of existing research and personal factors. Through continuous summarization, analysis, and refinement of the original information, 17 categories are finally obtained in the paper. The open decoding process is shown in Table 1.

Axial coding

The spindle decoding is to further summarize and refine the mutually independent concepts and categories to arrive at the main category of the research problem. After the 18 categories obtained from the open decoding were pushed, organized, and itemized several times, five main categories were finally refined, which are human–computer interaction, product design, feedback methods, and user experience. The main axis decoding process is shown in Table 2.

Selective coding

Taking the logical relationship as the starting point to explore the path relationship, structural relationship and connotation between them, the open decoding process is shown in Table 3. After selective decoding, the results need to be tested for theoretical saturation. Using the five copies of the original data reserved for the realization of the three-stage coding according to the above process, no new concepts or categories were generated, according to which theoretical saturation can be known.

Theoretical modeling

Through the above research process, it can be seen that there are four factors that affect the satisfaction of elderly users with intelligent escort products, so the four main categories and 17 sub-categories can be used as evaluation indexes for design solution preference decisions and to build evaluation hierarchy. The evaluation hierarchy model of elderly smart companion products is shown in Figure 3.

Determination of the weight of each indicator combination

Subjective weighting calculation

To determine the subjective weight of each evaluation criterion, five experts in the field of escort product research were selected for unified evaluation. Three of them are professors from domestic universities, specializing in elderly health care research, intelligent product design and guide design research, and have been engaged in the teaching industry for more than 20 years. Two are designer directors, engaged in the design and development of intelligent monitoring and escort products, with

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TABLE 9 Entropy values and objective weights of evaluation indicators.

	H_j	W_j
N_1	0.9684	0.0540
N_2	0.9920	0.0136
N_3	0.8396	0.2735
N_4	0.9761	0.0407
N_5	0.9663	0.0575
N_6	0.9489	0.0871
N_7	0.9876	0.0211
N_8	0.9783	0.0371
N_9	0.9888	0.0191
N_{10}	0.9928	0.0123
N_{11}	0.9997	0.0005
N_{12}	0.9798	0.0344
N_{13}	0.9035	0.1646
N_{14}	0.9115	0.1509
N_{15}	0.9814	0.0317
N_{16}	0.9993	0.0012
N_{17}	0.9995	0.0008

about 10 years of product design and development experience, and the fuzzy mutual inverse judgment matrix was obtained after the fuzzy scoring was completed using the 1–9 scale according to Equations (1) and (2), and the scores of all evaluators were summarized and collated according to Equation (3) to obtain all the comprehensive fuzzy mutual inverse judgment matrices.

According to Equation (4), the defuzzification process is carried out, and the weight values of each evaluation index in the criterion layer are calculated. Then, the consistency test is performed on each judgment matrix to obtain the final evaluation index weights and the consistency ratio of each judgment matrix, and the results are shown in Tables 4–8.

Objective weighting calculation

The above three experts were again invited to evaluate the 17 evaluation indicators of the three programs using the fuzzy numbers of linguistic variables shown in Schedule S2 Table to construct the initial evaluation decision matrix, and the comprehensive evaluation value of each program was obtained after aggregating the evaluation values of multiple evaluators according to Equation (7). The mean area method was used to defuzzify according to Equation (8) and normalized according to Equation (9) to obtain the final composite score, which is shown in Figure 4 and Schedule S4 Table. After that, the entropy values and objective weights are found according to Equations (5) and (6), as shown in Table 9.

Game theory portfolio weight calculation

According to Equations (10)–(12), the subjective and objective weights are linearly optimized and combined to obtain the combination weights of each index, which are shown in Schedule S5 Table. The comparison of the three weights is shown in Figure 5, and it can be seen that the combined assignment of opportunity game theory clearly combines the advantages of the two assignment methods, making the final weights more stable and objective.

Scheme sorting and selection

The initial decision evaluation constructed in the entropy weight coefficient method for objective weights is dimensionless according to Equation (13) to obtain the standardized decision matrix X. The matrix is then transformed into a weighted standardized decision matrix Y according to Equation (14), as shown in Figure 6 and Schedule S6 Table.

Finding the positive and negative ideal solutions is based on the weighted normalized decision matrix. To facilitate the operation, all elements in the weighted normalized decision matrix Y are expanded equally by a factor of 100, and the positive ideal solution Y^+ and the negative ideal solution Y^- are found after two decimal places are retained.

$$Y^+ = \left\{ \begin{matrix} 4.18, 1.47, 12.87, 7.21, 5.99, 4.25, 1.60, 3.31, \\ 1.21, 1.68, 3.11, 3.82, 7.22, 8.47, 4.99, 15.20, 1.25 \end{matrix} \right\}$$

$$Y^- = \left\{ \begin{matrix} 2.25, 1.17, 3.37, 4.46, 3.61, 2.36, 1.13, 2.29, \\ 0.86, 1.03, 2.93, 2.36, 3.25, 4.01, 3.24, 14.11, 1.19 \end{matrix} \right\}$$

The Euclidean distances d_i^+ and d_i^- and the relative closeness C_i of each scheme to the positive and negative ideal solutions are calculated according to Equations (15)–(17), and the ranking is completed according to the size of C_i, as shown in Table 10.

By judging the value of C_i, the larger the value of C_i, the closer the scheme is to the positive ideal solution, and the farther it is from the negative ideal solution, the better the scheme is. It can be found through Table 10 that scenario b is obviously better than the other two schemes.

Feasibility assessment

To verify whether the evaluation results are correct and reasonable and whether the evaluation methods are practical and feasible, researchers often use some standardized questionnaires to measure user's experience, so as to verify the reasonableness of the evaluation results. Mainstream standardized questionnaires

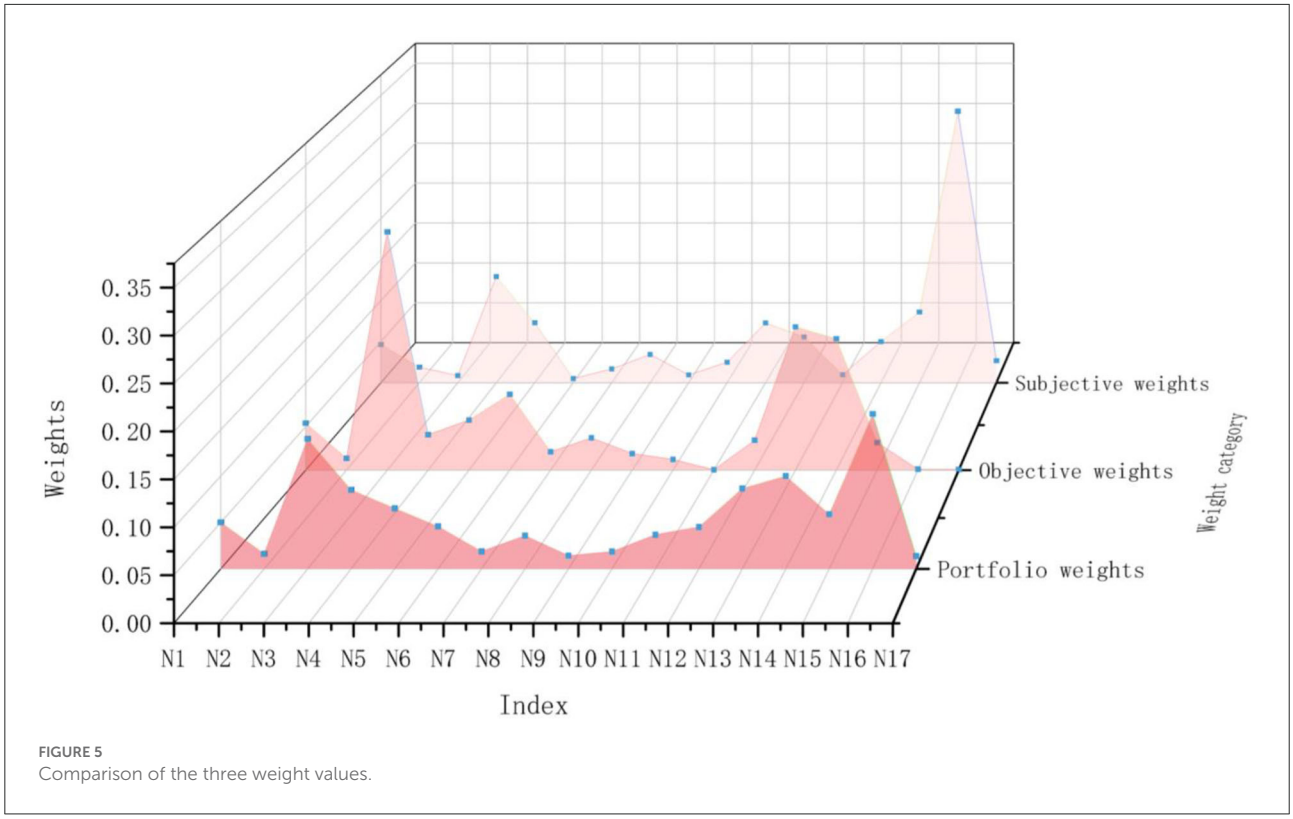

FIGURE 5
Comparison of the three weight values.

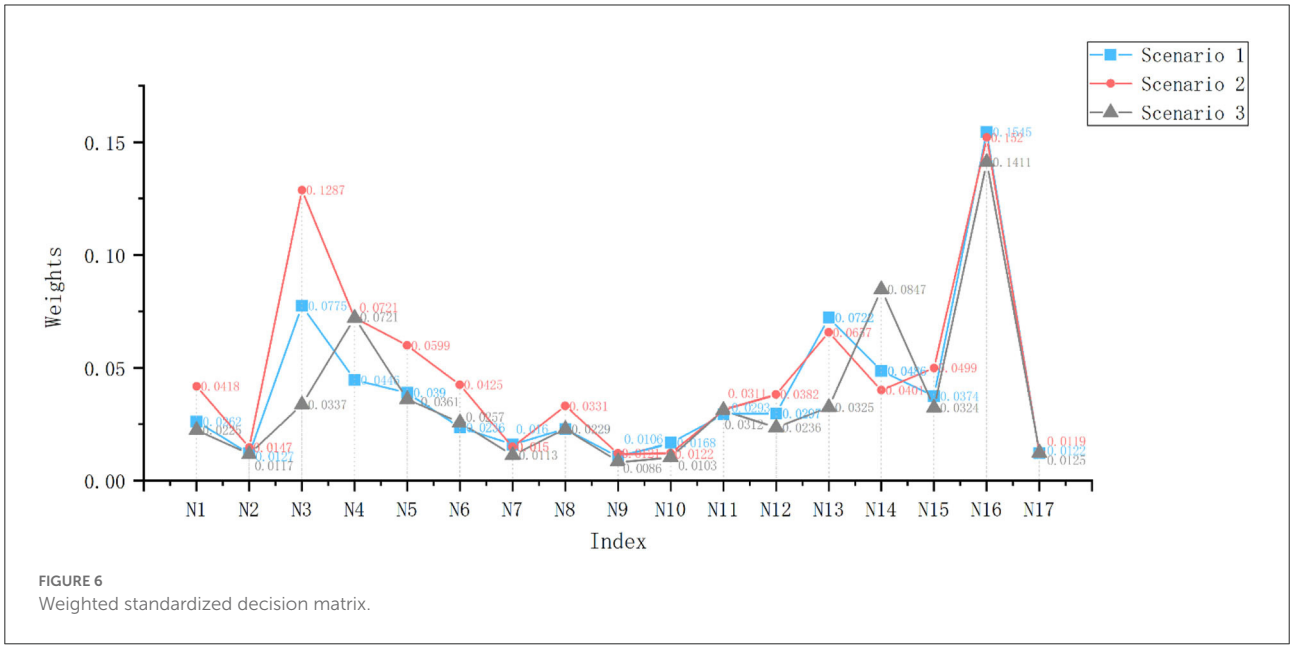

FIGURE 6
Weighted standardized decision matrix.

used internationally are Questionnarie for User Interaction Satisfaction(QUIS) (43), The Post-Study System Usability Questionnaire (PSSUQ) (44), The System Usability Scale (SUS) (45), etc. The feasibility test using a standardized questionnaire not only allows us to judge the correctness of the evaluation results but also allows us to understand through user feedback whether the preferred solution is effective in terms of the degree of health of the elderly in their old age. The above three solutions were made into functional prototypes, as shown in Figure 7, and 100 elderly people with experience in

TABLE 10 Euclidean distance and relative closeness.

Scenario	d_i^+	d_i^-	C_i
a	7.7906	6.244389	0.444915
b	14.41117	16.9398	0.540328
c	11.24728	5.247657	0.318138

using intelligent escort products in a senior citizen University in Wuhan were selected for experimental verification. The 100 participants included different genders (54 males and 46 females), different age groups (51 persons aged 55–65; 42 persons aged 66–75; 7 persons aged 76 and above), and different educational levels (26 persons with compulsory education level), 32 people with high school education level, 42 people with college education level or above), different intelligent product service years (3 people under 1 year, 38 people in 2–5 years, 59 people over 5 years). A total of 100 elderly users were asked to use each of the three functional prototypes and fill out the PSSUQ questionnaire based on their experience after use. The questionnaire was used to compare the three home recreation and care companion robots and verify the evaluation results through user satisfaction with the three products.

The PSSUQ is used to assess the user's perceived satisfaction with a computer system, product, or application and is consistent with the goal of assessing user satisfaction with an escort robot user. Questionnaire style reference is shown in Schedule S7 Table. The questionnaire was scored on a 7-point Likert scale, with 1 for strongly disagree and 7 for strongly agree. The overall assessment usability questionnaire has four indicators: Overall, System quality, Information quality, and Interface quality. Each indicator is averaged over the set of its corresponding question items, with higher scores indicating higher satisfaction and vice versa.

A total of 100 questionnaires were distributed, and 94 valid questionnaires were finally obtained through screening. The alpha coefficient of the questionnaire was calculated by SPSS 26.0 as 0.991, indicating that the reliability of the questionnaire was high and met the requirements. The four indicators of overall, system quality, information quality, and interface quality of the three solutions were compared and analyzed. Figure 8 shows that scenario b scored significantly higher than the other two solutions, and the results are consistent with the results obtained by using the game theory combination of weighting and TOPSIS method, indicating that the above method is feasible to be applied to the evaluation of recreation and health intelligent product design. At the same time, according to the feedback of 100 elderly users, all said that scenario b is more suitable for use than the other two scenarios, which can bring more convenience in life and promote mental and life health.

Discussion

Regarding research on older adults, many scholars currently focus on physical health studies of older adults or those factors that can have an impact on older adults' cognition, such as Noguchi et al. (46) who used multiple linear regression methods to study the effects of social relationships on older adults' cognitive abilities. Few studies have been conducted on the evaluation of intelligent escort products used by older people. The development of a comprehensive evaluation method will not only help designers to evaluate design solutions more objectively and rationally, but also preferably select the product solution that best meets the needs of older people and ultimately benefits them.

First, the article coded a large amount of user interview data at three levels based on the grounded theory and constructed theoretical models as evaluation indexes scientifically and rationally by qualitative research methods, which to some extent overcame the defects of many scholars in constructing evaluation systems based on their own experience and subjective induction of evaluation indexes. Second, the article uses game theory combination assignment as the quantitative analysis method to calculate the final weights of each evaluation index, makes the preferential decision of the scheme according to the TOPSIS method, and also introduces triangular fuzzy numbers to transform the fuzziness in the evaluation process of qualitative indexes into the corresponding fuzzy numbers for quantification, which reduces the evaluation inaccuracy caused by the fuzziness of human thinking in the evaluation process.

In the introduction part of the article, we also put forward the relationship between health care and product design solutions. With a mature solution decision-making theory or method, designers can well avoid the blindness of choice, so that high-quality products can flow into the market to enhance the experience of the elderly and promote healthy elderly life. In the decision-making process, for multi-criteria decision-making, the single use of the scoring method will cause inconsistencies between the evaluation results. The comprehensive score of the indicators in Figure 4 is the calculation result of the single use of the entropy weight method. The indicators N_3, N_6, N_{13}, *and* N_{14}, have a large gap between the scores of different schemes. However, after using the comprehensive evaluation method, the idea of minimizing dispersion will complement the advantages of the subjective and objective weights. It is not difficult to see from the comparison of the three weights in Figure 5 that the comprehensive weight is more stable than the other two weights, and there will be no maxima or minima. In addition, Figure 6 shows us that the index weight difference of different schemes is within a small range of change. When we map the index evaluation to the scheme optimization decision, it is difficult to directly observe the pros and cons of the scheme, while TOPSIS provides us with an

FIGURE 7
Functional prototypes. **(A)** Scenario a is equal to Scenario 1, **(B)** Scenario b is equal to Scenario 2, and **(C)** Scenario c is equal to Scenario 3.

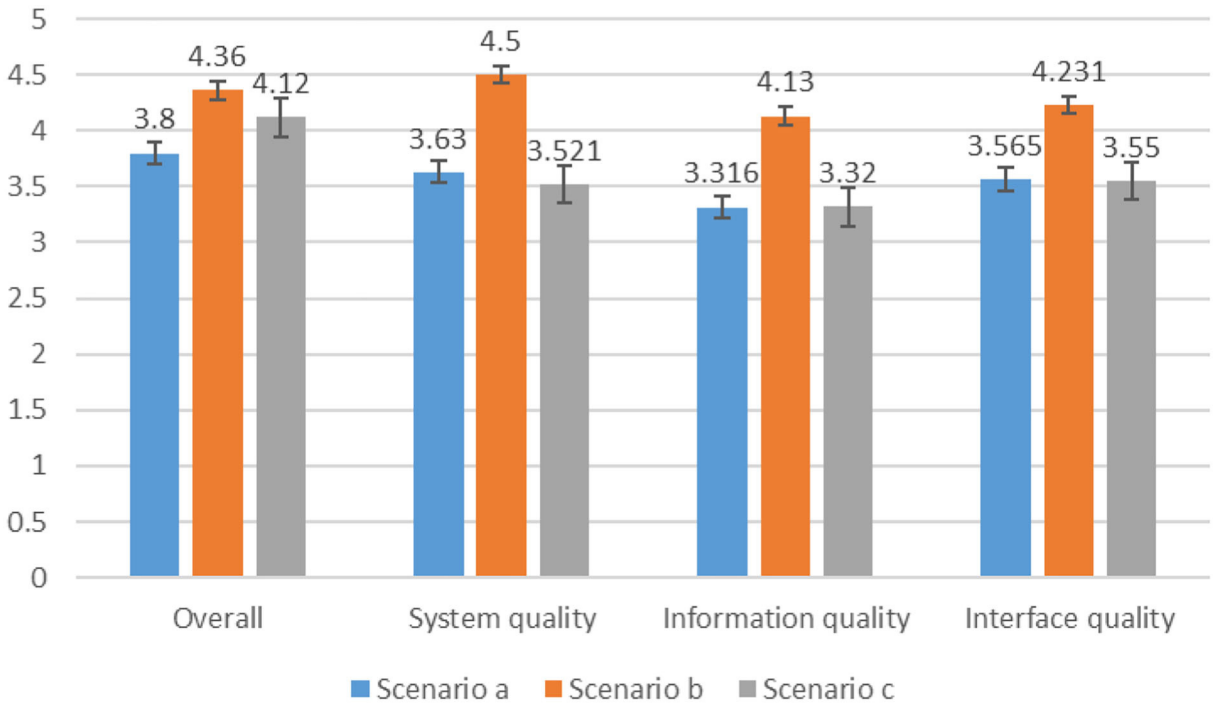

FIGURE 8
PSSUQ evaluation scores for the three scenarios.

opportunity to achieve decision-making through rational and scientific calculations.

Strengths and limitations

The new comprehensive evaluation method proposed in the article is better than the traditional evaluation method, solves the problem of multiplier effect in the determination of weight values in the general evaluation method, is more scientific and objective for the determination of evaluation indexes, saves the production cost of enterprises, and indirectly improves the quality of healthy life of the elderly.

There are some limitations in the study regarding self-reported data. First, as a special group, older people have limited cognitive abilities and have an inherent mindset about smart products, which can lead to overstated and unrealistic interview results. Second, the population interviewed was not divided in detail; the cognitive abilities of older people in rural areas are different from those in urban areas, and the results of the interviews will differ between people in different areas. Motohiro et al. (47) investigated the role of community

environmental factors in cognitive performance in old age. Therefore, this study could be explored in the future for different age groups or different regions of the elderly population to analyze whether differences in the environment affect the judging results.

The measures used to collect data in this study remain implausible. The scoring process in the study was subjective, and although the use of fuzzy thinking avoided subjectivity to a certain extent, the number of experts scoring was small, and the results obtained were not completely objective and had limitations. A follow-up study will use the instrument to collect relatively objective data as an evaluation set, which will lead to further refinement of the evaluation.

The focus of this stage of research is to propose an evaluation method to help designers make product decisions and to show the possibility of comprehensive evaluation in the optimization of health care products. Aiming at the problem that the overall process of the proposed evaluation method is complicated and the cost is high in the daily use of designers, the focus of the next stage of this research is to compare the analysis results of different multi-attribute decision-making methods, select the optimal solution, improve and simplify the comprehensive evaluation method, and enhance the practicality of the method.

Conclusion

Due to the decline in cognitive ability, mobility, and information literacy of the elderly, they are increasingly disconnected from information technology products and have barriers to the use of smart products in their lives, which seriously reduces the healthiness of senior living. Designers often generate multiple design solutions based on the multiple needs of older adults, and it is critical to use reasonable evaluation methods to decide on the optimal solution. In this paper, a new comprehensive evaluation method is proposed using a combination of qualitative research methods and statistical methods, three escort robot solutions are preferentially evaluated, and reasonable results are finally obtained. The article concludes with an assessment of the reasonableness of the evaluation results and the feasibility of the method, which shows that the method is highly feasible and helpful for designers to conduct program evaluation and improve the health of elderly people's retirement life.

Data availability statement

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

Ethics statement

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

Author contributions

SH and QJ are responsible for the identification and review of core elements such as research ideas and experimental protocols. MG is responsible for the writing of the manuscript. LD and JH were responsible for the compilation of the interview data and the drawing of the figures. WG was responsible for the final corrections to the manuscript. All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.919300/full#supplementary-material

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Mei Chi Jacqueline Ho,
Hong Kong Polytechnic University,
Hong Kong SAR, China
Hon Lon Tam,
The Chinese University of Hong Kong, China

*CORRESPONDENCE
Jinghui Zhu
zhujh@wmu.edu.cn
Guilin Liu
guilinliu88@163.com

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Effect of intergenerational exchange patterns and intergenerational relationship quality on depressive symptoms in the elderly: An empirical study on CHARLS data

Ranran Zheng[1], Mingyang Yu[2], Li Huang[1], Fang Wang[1], Baizhi Gao[1], Duanduan Fu[1], Jinghui Zhu[1]* and Guilin Liu[1]*

[1]School of Public Health and Management, Wenzhou Medical University, Wenzhou, China, [2]Integrated Office of Party and Government, First Affiliated Hospital Zhejiang Chinese Medicine University, Hangzhou, China

Background: As the population ages with fewer children, depression symptoms are increasing among the elderly who lack companionship. Intergenerational support is closely related to depression in the elderly; hence how the behavioral patterns and emotional quality of intergenerational support affect depressive symptoms in the elderly should be further explored.

Objective: To study the effects of intergenerational exchange patterns and intergenerational relationship quality on depressive symptoms in the elderly.

Methods: A total of 8,015 people over 60 years old in CHARLS in 2018 were selected as the object of this study. First, the correlation between demographics, economic conditions, health status, intergenerational support patterns, intergenerational relationship quality, and depressive symptoms in the elderly were analyzed. Three regression analysis models were established to analyze the relationship between control variables, intergenerational support patterns, intergenerational relationship quality, and depressive symptoms in the elderly. Results: Among the intergenerational economic, care, and emotional exchange modes, the risk of depressive symptoms in the elderly in the mutual support group was 31.8, 38.4, and 25.5% lower than that in the non-communication group. Compared with the elderly with very poor intergenerational relationship quality, the elderly with good, very good, and excellent intergenerational relationship quality had 74.5, 84.0, and 85.6% lower risk of depressive symptoms.

Discussion: Different cultural backgrounds also affect intergenerational exchange patterns and depression in the elderly. During the study of depressive symptoms, two aspects relating to intergenerational support should be considered behaviorally and emotionally: the intergenerational exchange model and the intergenerational relationship quality. As depression in the elderly is affected by multiple factors, the participation and joint efforts of the whole society are required to reduce depressive symptoms in the elderly and realize active aging.

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Conclusion: The intergenerational exchange pattern of mutual support and the higher quality of the intergenerational relationship can significantly reduce the depressive symptoms of the elderly.

KEYWORDS

intergenerational exchange pattern, intergenerational relationship quality, active aging, the elderly, depressive symptoms

Introduction

About 20% of people over 60 years old have varying degrees of depression worldwide (1). They have a significantly reduced quality of life, and severe ones have suicidal tendencies (2, 3). Among those who have committed suicide, 50–70% have suffered from depression (4). Depression and suicide in older adults have garnered much attention because of their vulnerability (5). China has entered an aging society, with the proportion of the elderly in the total population rising to 18.7% (6). According to the World Health Organization (WHO), the prevalence of depression among people aged 65 years and above exceeded 10% in 2018, suggesting that depression has become a significant disease that impairs the health of the elderly (7). The outbreak and continuous spread of Covid-19 in recent years have significantly challenged the mental health of the elderly (8, 9). How to release the depression of the elderly and achieve active aging has become a global social problem (10, 11).

Studies show that intergenerational support is closely related to depressive symptoms in the elderly (12–14). Intergenerational support refers to the economic, care, and emotional interactions between parents and their children within a family, including intergenerational resource exchange and intergenerational relationship quality.

Intergenerational support patterns

According to the different combinations of the content and direction of intergenerational resource exchange, an intergenerational exchange can be divided into different patterns. Studies on the relationship between intergenerational support and elderly depressive symptoms mainly concentrate on two aspects. The first is the study on the relationship between the content of intergenerational resource exchange and depressive symptoms in the elderly. In terms of economic support, Marie et al. (15) showed that intergenerational economic support could meet the material needs of the elderly, thus increasing their life satisfaction by 14.4%. However, according to the research by Fingerman (16), excessive intergenerational economic support could damage the self-esteem of the elderly, making them feel powerless and thus damaging their mental health. Tang et al. (17) found that intergenerational care support could enable the elderly to get good care, alleviate diseases, and help maintain good health. Other studies have shown that the influence of intergenerational care support on the mental health of the elderly is not insignificant (18) and even harmful (19). In the field of intergenerational emotional support, Roh et al. (20) showed that compared with the above two factors, emotional support could more effectively maintain the mental health of the elderly and reduce the prevalence of depression. However, this effect was not as apparent for excessive or insufficient emotional support, according to research by Teixeira et al. (21). The second is the study on the relationship between the intergenerational support direction and depressive symptoms in the elderly. The intergenerational support direction can be divided into forwarding (parents provide support for children), backward (children provide support for parents), and mutual (children and parents provide support for each other) support. Bonsang et al. (22) found that care support from children hurt fathers' self-rated health and economic support for mothers' self-rated health. Guoping et al. (23) found that intergenerational support from the elderly with poor economic conditions in rural areas could increase children's life stress and the risk of depression in them. Abolfathi et al. (24) found that the elderly who could give feedback to their children for receiving intergenerational support was less depressed because they felt that they were "important" and "useful".

Intergenerational relationship quality

Essentially, intergenerational support is a kind of purposeful interaction between generations. Beyond the essential characteristics of the two interacting parties, the expression form and result of interactive behavior in real life are also affected by the subjective emotion factor of both parties: the quality of intergenerational relationships. This is a critical factor to investigate (25). Most scholars measure it with such objective indicators as the intensity and frequency of intergenerational support. Huang et al. (26) measured the intergenerational relationship by using the intensity of intergenerational support, finding that older people who interacted with their children more closely were mentally

healthier. Teixeira et al. (21) discovered a link between the frequency of intergenerational support and the mental health of the elderly. Yang et al. (27), using children's subjective evaluation to measure the intergenerational relationship, found that the intergenerational relationship had effects on the health and well-being of both generations. The content, direction, and quality of intergenerational support had specific effects on the level of depression in the elderly, but no uniform conclusion has been reached.

The current study

There are two limitations to current studies. First, most studies only analyze the relationship between the content or direction of intergenerational resource exchange and the depressive symptoms in the elderly separately, with few focusing on the combination of the content and direction. Second, both the content and direction of intergenerational support are closely related to depressive symptoms in the elderly. The results will inevitably be biased if we only study one of them. While there are few studies on the relationship between intergenerational relationship quality and depressive symptoms in the elderly, objective indicators such as the intensity and frequency of intergenerational support are often used as alternative variables of intergenerational relationship quality, which is indirect speculation that is not very accurate. Intergenerational relationship quality is more of a subjective feeling, and the elderly's subjective evaluation of the intergenerational relationship can better reflect its intergenerational relationship.

The innovations of this study mainly include two aspects. First, the content and direction of intergenerational support are integrated and conceptualized as intergenerational exchange patterns to comprehensively study the relationship between different intergenerational exchange patterns and depressive symptoms in the elderly. Second, the elderly's subjective evaluation of the intergenerational relationship is taken as an indicator to measure the intergenerational relationship quality, and the relationship between the intergenerational relationship quality and intergenerational exchange patterns and the depressive symptoms in the elderly is investigated.

Methods

Participants

Data for this study were obtained from the China Health and Retirement Longitudinal Study (CHARLS) in 2018. The CHARLS began in 2008 and was followed up every 2–3 years, with samples collected through stratified random sampling from 150 county-level and 450 village-level units nationwide. In 2018, 19,744 samples were obtained from CHARLS. Respondents aged 60 years and above as of December 31, 2018, were selected as participants of this study, from which those with missing data were eliminated, and finally, 8,015 valid samples were obtained. All the respondents signed informed consent at the time of participation, and this study was approved by the Institutional Review Board of Peking University (IRB00001052-11014).

TABLE 1 CES-D-10 Scale items.

Scale	Items
CES-D-10	(1)I was bothered by things that don't usually bother me.
	(2)I had trouble keeping my mind on what I was doing.
	(3)I felt depressed.
	(4)I felt everything I did was an effort.
	(5)I felt hopeful about the future.
	(6)I felt fearful.
	(7) My sleep was restless.
	(8)I was happy.
	(9)I felt lonely.
	(10)I could not get "going".

Measures

Depressive symptoms

In this paper, whether the elderly have depressive symptoms was regarded as the dependent variable. In the CHARLS, Andresen's 1994 revision of the Center for Epidemiologic Studies Depression Scale of the 10-item short table (CES-D-10) was used to measure the degree of depression in respondents. The scale consists of ten questions with four answer options assigned to 0, 1, 2, and 3, from positive to negative, respectively. Respondents were asked to rate the ten questions based on their feelings and behaviors in the previous week, and the total score was the final score, ranging from 0 to 30. The questionnaire is listed in Table 1. Those with a final score $\geq$10 were determined to have depressive symptoms (28), and the answer was assigned 1; those with a final score $<$10 were determined to have no depressive symptoms, and the answer was assigned 0. The study showed that the CES-D-10 scale has sufficient reliability and validity (29). Besides, studies based on CHARLS have confirmed that the CES-D-10 can effectively measure the depression level of the elderly population in China (30). With a short response time and high recovery rate, the scale has greater application potential in ample survey research. However, it is primarily used to assess the severity of depressive symptoms rather than as a diagnostic tool.

Intergenerational support patterns

In this study, three types of intergenerational support were explored: the economic ties between participants and their children (economic support), mutual care between participants and their children (care support), and regular meetings or contact between participants and their children (emotional support). To measure whether the elderly received or provided intergenerational support, participants were asked questions about it. See Table 2 for specific questionnaires.

Based on the responses of receiving and providing intergenerational support, the exchange modes were divided into four types: no exchange, only provide, only receive, and mutual support. The first type of "no exchange" means that the respondent has neither provided nor received any support for a year. The second "only receive" means that the respondent only received support without providing any support. The third "Only provide" means that the respondent only provided support without receiving any support for 1 year. The last "mutual support" means that the respondent received and provided support simultaneously. Because effective support is bidirectional, there are two types of intergenerational emotion exchange modes: no exchange and mutual support.

Intergenerational relationship quality

The subjective evaluation of the respondents was used in this paper to measure the quality of intergenerational relationships. CHARLS asked respondents to answer, "Are you satisfied with your relationship with your children?", and the answers were "extremely satisfied," "very satisfied," "relatively satisfied," "not very satisfied," and "very dissatisfied." These answers represented five grades of intergenerational relationship quality: "excellent," "very good," "good," "not good," and "extremely poor".

Demographic variables

Other control factors, including demographics, economic conditions, and health status, also affect the presence of depressive symptoms in the elderly (31, 32). In this paper, the three types of control variables were introduced, among which demographic variables included age, gender, and marital status; economic condition variables included working status, education, residence, and medical insurance status; and health status variables included the presence of chronic diseases and disabilities.

Analytic strategies

First, CHARLS database indicators were screened, grouped, and assigned. Variables and assignments are shown in Table 3. Second, a descriptive analysis of the participants' variables was carried out, including their demographics, financial and health status, intergenerational exchange patterns, and the quality of their intergenerational relationships. Third, a one-way ANOVA was conducted to determine whether there was a significant correlation between control variables, intergenerational support patterns, intergenerational relationship quality, and depressive symptoms in the elderly. Fourth, three binary logistic regression models were established to study the effects of control variables, intergenerational support patterns, and intergenerational relationship quality on depressive symptoms in the elderly.

Results

Demographic characteristics

Table 4 describes the investigation samples. Depressive symptoms were found in 37.8% of the sample. The quality of intergenerational relationships was relatively good (39.1%) or very good (49.1%). In terms of the mode of intergenerational exchange, more than half (54%) of the elderly said they had no intergenerational economic exchange with their children. In the intergenerational care exchange mode, the elderly in the only receiving group accounted for the largest proportion (45.7%); more than half (59.3%) had no emotional exchange with their children.

Bivariate correlations of the key variables

Table 5 shows the analysis of the correlation between various factors and depressive symptoms in the elderly. Results showed that in addition to age, other control variables, including gender, marital status, working status, education, residence, medical insurance status, chronic diseases, and disabilities, were significantly correlated with the depressive symptoms in the elderly; intergenerational economic, care and emotional exchange patterns had a significant impact on the presence or absence of depressive symptoms in the elderly; intergenerational relationship quality was significantly correlated with depressive symptoms in the elderly.

Regression analysis on influencing factors of the key variables

Table 6 shows three binary logistic regression models. Model 1 studied the effect of control variables on depressive symptoms in the elderly. Model 2, based on Model 1, included intergenerational exchange pattern variables in regression models to study the effect of intergenerational exchange patterns on depressive symptoms in the elderly after controlling control variables. Model 3, based on Model 2, included intergenerational relationship quality variables in regression models to study the

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TABLE 2 Questionnaire of intergenerational support.

Scale	Items	Response options	Categorization
Intergenerational economic support	(1) During last year, what was the amount of economic support received from [Child Name]?	>0	Receive
		<0	No receive
	(2) During last year, what was the amount of economic support provided to [Child Name]?	>0	Provide
		<0	No Provide
Intergenerational care support	(3) Who most often helps you with (dressing, bathing, eating, getting out of bed, using the toilet, controlling urination and defecation, doing chores, preparing hot meals, shopping, managing money, making phone calls, taking medications)?	Children	Receive
	(4) Suppose that in the future, you needed help with basic daily activities like eating or dressing. Do you have relatives or friends (besides your spouse/partner) who would be willing and able to help you over a long period of time?	Other options	No receive
	(5) During last year, did you/your spouse spend time in taking care of your grandchildren?	Yes	Provide
		No	No Provide
Intergenerational emotional support	(6) How often do you contact with [Child Name] on phone/by message/ on WeChat/ by mail/ by email?	Almost never	No receive
		Other options	Receive
	(7) How often do you contact with [Child Name] on phone/by message/ on WeChat/ by mail/ by email?	Almost never	No Provide
		Other options	Provide

TABLE 3 Variables and assignments.

	Variable	Assignment
Dependent variable	Depressive symptoms	0 = No depressive symptoms, 1 = With depressive symptoms
Independent variables	Intergenerational economic exchange pattern	1 = No exchange, 2 = Only provide, 3 = Only receive, 4 = Mutual support
	Intergenerational care exchange pattern	1 = No exchange, 2 = Only provide, 3 = Only receive, 4 = Mutual support
	Intergenerational emotional exchange pattern	0 = No exchange, 1 = Mutual support
	Intergenerational relationship quality	1 = Extremely poor, 2 = Not good, 3 = Good, 4 = Very good, 5 = Excellent
Control variables	Gender	0 = Male, 1 = Female
	Age	1 = 60–69 years, 2 = 70–79 years, 3 = over 80 years
	Marital status	0 = Unmarried, 1 = Married
	Working status	0 = Non-working, 1 = Working
	Education	1 = Illiteracy, 2 = Primary school, 3 = Junior high school, 4 = Senior high school and above
	Type of medical insurance	1 = No insurance, 2 = Medical insurance for urban workers, 3 = Medical insurance for urban and rural residents, 4 = Medical insurance for urban residents, 5 = New rural cooperative medical insurance, 6 = Other
	Living environment	0 = Rural, 1 = Urban
	Disability status	0 = No, 1 = Yes
	Chronic diseases	0 = No, 1 = Yes

effect of intergenerational relationship quality on depressive symptoms in the elderly after controlling control variables and intergenerational exchange pattern variables. Collinearity analysis was performed on three models before the inclusion of variables, and the results showed that VIF (Variance Inflation Factor) <10 and no collinearity problems occurred (33). Meanwhile, the Hosmer test results showed $P > 0.05$, suggesting that the models fit well (34).

TABLE 4 Basic characteristics of survey samples (n = 8,015).

Variable	Category	Frequency	Percentage%
Gender	Female	3900	48.7
	Male	4115	51.3
Age	60–69 years	5232	65.3
	70–79 years	2309	28.8
	Over 80 years	474	5.9
Marital status	Unmarried	1405	17.5
	Married	6610	82.5
Working status	Non-working	6770	84.5
	Working	1245	15.5
Education	Illiteracy	2019	25.2
	Primary school	3690	46
	Junior high school	1428	17.8
	Senior high school and above	878	11
Residence	Rural	5739	71.6
	Urban	2276	28.4
Type of insurance	No insurance	196	2.4
	Medical insurance for urban workers	1309	16.3
	Medical insurance for urban and rural residents	989	12.3
	Medical insurance for urban residents	350	4.4
	New rural cooperative medical insurance	4950	61.8
	Other	213	2.7
Chronic diseases	No	4252	53.1
	Yes	3763	46.9
Disabilities	No	6917	86.3
	Yes	1098	13.7
Intergenerational economic exchange pattern	No exchange	4326	54
	Only provide	514	6.4
	Only receive	2179	27.2
	Mutual support	996	12.4
Intergenerational care exchange pattern	No exchange	2280	28.4
	Only provide	745	9.3
	Only receive	3664	45.7
	Mutual support	1326	16.5
Intergenerational emotional exchange pattern	No exchange	4755	59.3
	Mutual support	3260	40.7
Intergenerational relationship quality	Extremely poor	90	1.1
	Not good	275	3.4
	Good	3130	39.1
	Very good	3935	49.1
	Excellent	585	7.3

Model 1 studied the effects of 8 control variables, including gender, marital status, working status, education, residence, medical insurance status, chronic diseases, and disabilities, on depressive symptoms of the elderly. Among them, gender is a risk factor for depressive symptoms; the risk of depressive symptoms in older women was significantly higher (1.597 times) than in older men. Being working and married are protective factors for depressive symptoms in the elderly; the risk of depressive symptoms in the working elderly was 29.8% lower than in non-working ones, and that in the married was 22.7% lower than the unmarried. With the improvement of educational levels, the elderly's depressive symptoms were somewhat reduced. Compared with illiterate older people, there was no significant difference in the risk of depressive symptoms

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TABLE 5 Correlation analysis on the influencing factors of depressive symptoms (n = 8,015, n/%).

Variable	Category	Non-depressive	Depressive	*P*-value
Gender	Female	2129 (54.59)	1771 (45.41)	0.000
	Male	2857 (69.43)	1258 (30.57)	
Age	60–69 years	3289 (62.86)	1943 (37.14)	0.132
	70–79 years	1397 (60.5)	912 (39.5)	
	Over 80 years	300 (63.29)	174 (36.71)	
Marital status	Unmarried	752 (53.52)	653 (46.48)	0.000
	Married	4234 (64.05)	2376 (35.95)	
Working status	Non-working	4081 (60.28)	2689 (39.72)	0.000
	Working	905 (72.69)	340 (27.31)	
Education	Illiteracy	1057 (52.35)	962 (47.65)	0.000
	Primary school	2215 (60.03)	1475 (39.97)	
	Junior high school	1025 (71.78)	403 (28.22)	
	Senior high school and above	689 (78.47)	189 (21.53)	
Residence	Rural	3358 (58.51)	2381 (41.49)	0.000
	Urban	1628 (71.53)	648 (28.47)	
Type of Insurance	No insurance	103 (52.55)	93 (47.45)	0.000
	Medical insurance for urban workers	1009 (77.08)	300 (22.92)	
	Medical insurance for urban and rural residents	625 (63.2)	364 (36.8)	
	Medical insurance for urban residents	239 (68.29)	111 (31.71)	
	New rural cooperative medical insurance	2844 (57.45)	2106 (42.55)	
	Other	161 (75.59)	52 (24.41)	
Chronic diseases	No	2883 (67.8)	1369 (32.2)	0.000
	Yes	2103 (55.89)	1660 (44.11)	
Disabilities	No	4478 (64.74)	2439 (35.26)	0.000
	Yes	508 (46.27)	590 (53.73)	
Intergenerational economic exchange pattern	No exchange	2774 (64.12)	1552 (35.88)	0.000
	Only provide	350 (68.09)	164 (31.91)	
	Only receive	1184 (54.34)	995 (45.66)	
	Mutual support	678 (68.07)	318 (31.93)	
Intergenerational care exchange pattern	No exchange	1305 (57.24)	975 (42.76)	0.000
	Only provide	430 (57.72)	315 (42.28)	
	Only receive	2395 (65.37)	1269 (34.63)	
	Mutual support	856 (64.56)	470 (35.44)	
Intergenerational emotional exchange pattern	No exchange	2839 (59.71)	1916 (40.29)	0.000
	Mutual support	2147 (65.86)	1113 (34.14)	
Intergenerational relationship quality	Extremely poor	18 (20)	72 (80)	0.000
	Not good	84 (30.55)	191 (69.45)	
	Good	1832 (58.53)	1298 (41.47)	
	Very good	2637 (67.01)	1298 (32.99)	
	Excellent	415 (70.94)	170 (29.06)	

in older people with primary school education, while there were significant differences in those with junior high school education and those with senior high school education and above (the risk of depressive symptoms decreased by 28.3 and 41.4%, respectively). Compared with the elderly without medical insurance, there was no significant difference in the risk of depressive symptoms in those with new rural cooperative medical insurance and medical insurance for urban and rural residents, while there were significant differences in those with basic medical insurance for urban workers, medical insurance for urban residents, and other medical insurance (the risk of depressive symptoms decreased by 48.8, 31.2, and 46.7%). Diseases are a risk factor for depressive symptoms in the elderly; older people with chronic diseases and disabilities had

TABLE 6 Analysis of the relationship between intergenerational relationship quality and intergenerational exchange patterns and the depressive symptoms in the elderly ($n = 8,015$).

Type of variable	Name of variable	Model 1	Model 2	Model 3
Independent variables	Intergenerational relationship quality (extremely poor)			
	Not good			0.704
	Good			0.255***
	Very good			0.160***
	Excellent			0.144***
	Intergenerational economic exchange pattern (no exchange)			
	Only provide		0.878	0.863
	Only receive		1.050	1.088
	Mutual support		0.682***	0.719*
	Intergenerational care exchange pattern (no exchange)			
	Only provide		1.047	1.014
	Only receive		0.625**	0.674**
	Mutual support		0.616***	0.660***
	Intergenerational emotional exchange pattern (no exchange)			
	Mutual support		0.745***	0.759*
Control variables	Gender (male)			
	Female	1.597***	1.698***	1.728***
	Marital status (unmarried)			
	Married	0.773**	0.842*	0.898
	Working status (non-working)			
	Working	0.702**	0.738**	0.744***
	Education (illiteracy)			
	Primary school	0.967	0.964	0.945
	Junior high school	0.717**	0.701***	0.686***
	Senior high school and above	0.586***	0.571***	0.564***
	Residence (rural)			
	Urban	0.790*	0.788*	0.794*
	Type of insurance (no insurance)			
	Medical insurance for urban workers	0.512**	0.526**	0.503**
	Medical insurance for urban and rural residents	0.740	0.785	0.784
	Medical insurance for urban residents	0.679*	0.684	0.689
	New rural cooperative medical insurance	0.902	0.936	0.948
	Other	0.533*	0.542*	0.521*
	Chronic diseases (no)			
	Yes	1.632***	1.636***	1.619***
	Disabilities (no)			
	Yes	1.883***	1.876***	1.844***
	Constant	0.681*	0.927	4.047***
Mode fitting effect	Hosmer and lemeshow test	0.949	0.648	0.82

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

a significantly increased risk of depressive symptoms, which was 1.632 and 1.883 times that of healthy people.

After controlling control variables, Model 2 studied the effects of different intergenerational exchange patterns on the risk of depressive symptoms in the elderly. In the economic exchange pattern, compared with the group having no exchange, there were significant differences in the risk of depressive symptoms in the elderly in the mutual support group (the risk in the mutual support group was 31.8% lower than the group having no exchange), while there was no significant difference in the group only providing support and the group receiving support. In the care exchange pattern, compared

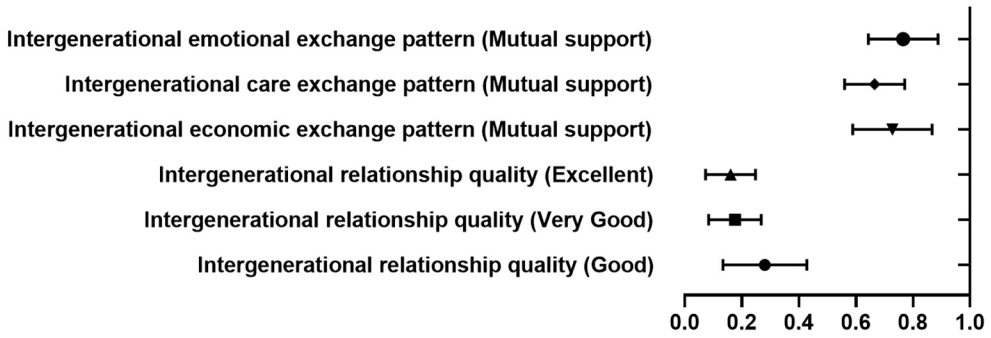

FIGURE 1
Forest diagram of factors influencing depressive symptoms in the elderly.

with the group having no exchange, there were significant differences in the risk of depressive symptoms in the elderly in the group receiving support and the mutual support group (the risks in the two groups were 37.5 and 38.4% lower than the group having no exchange, respectively), while there was no significant difference in the group only providing support. In the emotional exchange pattern, there were significant differences in the risk of depressive symptoms in the elderly between the group having no support and the mutual support group (the risk in the latter was 25.5% lower than in the former). To sum up, the risks of depressive symptoms in the elderly in the mutual support group were significantly lower than those in the group having no exchange in the economic, care, and emotional exchange patterns.

Model 3 studied the effect of intergenerational relationship quality on depressive symptoms in the elderly after optimizing control variables and intergenerational exchange pattern variables. There were significant differences in the risk of depressive symptoms in the elderly with extremely poor intergenerational relationships and other groups, and the risks in the elderly with good, very good, and excellent intergenerational relationships were 74.5, 84.0, and 85.6% lower than those with extremely poor intergenerational relationships. The results are shown in Figure 1. This shows that intergenerational relationship quality is a protective factor toward depressive symptoms in the elderly, and the risk of depressive symptoms in the elderly gradually decreases as intergenerational relationship quality improves.

Discussion

Effects of the intergenerational exchange pattern on depressive symptoms in the elderly

In different exchange patterns, the elderly have the lowest risk of depressive symptoms when there is mutual economic, care, and emotional support between generations, which is consistent with several conclusions based on Chinese data. For example, Dura et al. (35) found that intergenerational exchange with children could directly enhance parents' well-being; Huang et al. (26) found that intergenerational exchange was conducive to the elderly's self-rated health, and the closer the intergenerational exchanges, the better for the elderly's physical and mental health. Nevertheless, most studies based on non-Chinese data have not supported this conclusion. Lowenstein et al. (26) found that older people were more likely to be the "givers" in intergenerational exchange, in which they could realize their self-value while receiving support from their children could only hurt their self-esteem and thus affect their mental health. Cultural differences may be the root cause of the differences in research results. In western countries where freedom and independence are advocated, parents are responsible for bringing up their children, but children have no obligation to support their parents (36). In this case, parents play the role of a "giver." On the contrary, in China and even East Asia, the norm of filial piety still significantly affects family relations. Exchange is sustainable only through reciprocity and balance between generations (37). We can see from family relationships that the elderly feel depressed when they are unable to support their children, thus hurting their mental health. They perceive themselves as responding to their children's support and recognize that they are needed. This move can improve their self-esteem and thus reduce the risk of depression (24). This is in line with the results of this study, which showed that the mutually supportive intergenerational exchange model could greatly reduce the risk of depression in the elderly.

Effects of intergenerational relationship quality on depressive symptoms in the elderly

As the intergenerational relationship quality enhances, the risk of depressive symptoms in the elderly significantly

decreases. Compared with the results obtained using the intensity of intergenerational exchange to expect intergenerational relationship quality, this study directly measured intergenerational relationship quality with the elderly's subjective evaluation, which was more significantly correlated with the level of depressive symptoms in the elderly (27, 28). The reason may be that the high intensity of intergenerational exchange does not inevitably mean good intergenerational relationships, and negative intergenerational exchange (such as quarrels and frequently asking for money) may cause trouble for older people and thus increase the risk of depressive symptoms. The quality of intergenerational relationships is a cross-cultural concept, and good intergenerational relationships are an important determinant of older adults' well-being wherever and whenever they occur (27, 38). In China, home-based care, as the most traditional form of old-age care, still has a major position (39), while the quality of the intergenerational relationship, the core social relationship in the elderly's life, has a greater impact on the elderly. According to Amato and Booth, intergenerational support should be influenced not only by demographics but also by prospects for intergenerational interaction such as the number and availability of relatives (40). This means that the study of intergenerational support should be performed not only at the behavioral level, such as frequency of contact, giving, and receiving of support, but also at the emotional level, such as the feelings, values, and perspectives of intimacy and connection. In addition, intergenerational support is affected not only by the measurable exchange but also by normative issues such as the amount of support given and received between members, the importance of filial duty, and values in the parent-child relationship (41). This study suggests that improving the quality of intergenerational relationships can effectively reduce the risk of depressive symptoms in the elderly.

Effects of multiple factors on depression in the elderly

The depressive symptoms in the studied elderly were high, with significant internal heterogeneity. According to the WHO report in 2017, the prevalence of depressive symptoms was 7.5% in women and over 5.5% in men aged 55–74 years (42). In the sample in this paper, up to 37.80% of the elderly had depressive symptoms, including 30.57% of men and 45.41% of women, much higher than the world average, suggesting that the depressive symptoms in the elderly are serious in China. There were significant differences in the degree of depressive symptoms in the elderly of different genders, marriage, urban and rural areas, education level, type of insurance, and health status. Compared with the urban elderly, the rural elderly suffered from a significantly higher risk of depression. Perhaps, due to the impact of urbanization and population aging, young people in rural areas flooding into cities for better development, and the increase of empty-nested elderly, these factors exacerbate the aging degree in rural areas. The elderly living alone have difficulties communicating with their children without intergenerational emotional support and intergenerational care support, thus creating an unrelieved depression in the elderly in rural areas. In parallel, studies have shown that rural areas are provided with scarce health care resources and low availability of medical professionals (43). These negative factors lead to deeper depression in the elderly who cannot get help in time.

Under the background of increasing aging, it is necessary to improve the quality of intergenerational relationships and establish a positive intergenerational exchange mode to reduce the level of depression in the elderly. Firstly, the government should encourage intergenerational communication by providing more adequate family leave and more time for intergenerational communication. Secondly, society should provide daily care services for the elderly, including routine physical examination, psychological consultation, and daily activity places, to meet the needs of the elderly in time. Thirdly, family members should take the initiative to communicate with the elderly; children should actively meet or call them, and teachers should learn to use communication tools to help the elderly keep up with the pace of society as much as possible. Lastly, the elderly should also learn to change their mindset, seek help from their children, and strengthen mutual support between generations.

Limitation

There are several limitations to this study. First, intergenerational relationship quality is a dimensionally rich concept, and it is inadequate to measure it using a single subjective indicator. Emotional evaluation is somewhat subjective and unstable; therefore, the results should be interpreted more carefully. Second, the causal relationship should also be determined carefully in cross-sectional studies, and if conditions permit, targeted follow-up can be carried out to verify the conclusions of this study. In the future, the panel data can be used to further verify the conclusions of this paper. Alternatively, targeted follow-up surveys can be performed focusing on the measurement indicators of intergenerational relationship quality to further explore the relationship between intergenerational relationship quality and depression in the elderly. Additionally, we look forward to continuing exploring the gender and urban-rural differences in the influence of intergenerational relationships on depression in the elderly to reduce their level of depression and provide more targeted suggestions for active aging.

Conclusion

In conclusion, intergenerational relationship quality and intergenerational exchange patterns significantly affect depressive symptoms in the elderly, and high-quality intergenerational relationships and the intergenerational exchange pattern of mutual support can greatly reduce the risk of depressive symptoms in the elderly. This study not only added to the theories of related studies but also pointed in the right direction for reducing the severity of depressive symptoms in the elderly. The quality of intergenerational relationships can be improved by encouraging closer economic, care, and mutual emotional support between generations.

Data availability statement

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

Ethics statement

All the respondents signed informed consent at the time of participation, and this study was approved by the Institutional Review Board of Peking University (IRB00001052-11014).

Author contributions

RZ took responsibility for the integrity of the data and the accuracy of the data analysis. RZ, MY, and GL study design. JZ, LH, BG, FW, and DF contributed to the writing of the manuscript and statistical analysis. JZ and GL study supervision. All authors contributed to this article and approved the submitted version.

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Conflict of interest

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

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Huaxuan Liu,
Fujian Normal University, China
Kostas Konstantopoulos,
University of Peloponnese, Greece
Edoardo Nicolò Aiello,
University of Milano-Bicocca, Italy

*CORRESPONDENCE
Yanni Yang
yangyanni@tmmu.edu.cn

†These authors have contributed equally to this work and share first authorship

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Health beliefs, lifestyle, and cognitive aging among Chinese community residents: A structural equation model analysis

Jinying Zhang†, Xiao Liu†, De Gong, Yan Peng, Hua Li and Yanni Yang*

School of Nursing, Third Military Medical University/Army Medical University, Chongqing, China

Background: Lifestyle factors may could help maintain cognitive function and reduce the risk of dementia. The application of the Health Belief Model (HBM) has been verified by incorporating lifestyle changes for dementia risk reduction; however, the influence of health beliefs on cognitive aging through lifestyle remains unknown. To facilitate research-based interventions to promote successful cognitive aging, we explored the relationship between health beliefs, lifestyle, and cognitive aging based on the HBM using path analysis.

Methods: This cross-sectional study recruited middle-aged and older community residents from a community health service center in Chongqing, China, through convenience sampling. Motivation to Change Lifestyle and Health Behaviors for Dementia Risk Reduction (MCLHB-DRR), Lifestyle for Dementia Risk Reduction (LDRR), and the Montreal Cognitive Assessment (MoCA) were employed to measure participants' beliefs, lifestyle, and cognitive function, respectively. The associations between the beliefs, lifestyle, and cognitive function were analyzed, and a structural equation model was constructed.

Results: A total of 202 participants completed the questionnaires, of whom only 17 (8.4%) were classified as having successful cognitive aging. The model demonstrated the data to have an acceptable fit and elucidated 39.3 and 18.2% of the variance in lifestyle and the grade of cognitive aging, respectively. Positive and negative beliefs had opposite effects on the grade of cognitive aging through lifestyle. Cues to action had opposite effects on the grades of cognitive aging through positive and negative beliefs; however, the total effects canceled each other out.

Conclusions: Positive beliefs have a positive effect on lifestyle, thereby promoting successful cognitive aging, whereas negative beliefs have a negative effect on lifestyle, thereby hindering successful cognitive aging. Health education and media publicity, as specific aspects of cues to action, can have a meaningful impact on healthy behavior and successful cognitive aging by promoting positive beliefs and controlling negative beliefs. The model suggests the strengthening and weakening of the positive and negative beliefs,

respectively, of middle-aged and older community residents in the formulation of relevant public health strategies in the future, thereby enabling them to adapt to a healthy lifestyle promoting successful cognitive aging.

KEYWORDS

Health Belief Model, lifestyle, cognitive aging, structural equation modeling, middle-aged and older adults

Introduction

Cognitive aging describes the transformation of cognitive function with aging, which is characterized by a decline in attention, information processing speed, executive function, and episodic memory (1). Usually, cognitive decline is slow and acceptable, and does not seriously affect older adults' daily life. Unusual cognitive aging is associated with a variety of neurological diseases, especially dementia, which has been a major cause of disability in older adults and exerts a considerable burden on society and the economy (2). With increase in global aging, dementia has increased rapidly in recent years. An estimated 50 million people worldwide were living with dementia in 2018, and this number is expected to increase to 152 million by 2050 (3). Although dementia is characterized by symptoms of cognitive dysfunction, it is not an inevitable consequence of cognitive aging. Multiple factors result in cognitive dysfunction, which is difficult to reverse; however, its preventability is being explored and supported by an increasing amount of evidence.

It's not just cognitive dysfunction that needs to be improved, and usual cognitive aging also wouldn't be the ultimate goal of cognitive interventions in older adults. Despite not reaching the stage of cognitive dysfunction, significant differences exist among individuals in terms of cognitive aging. Based on the heterogeneity of cognitive aging (4), Rowe and Kahn (5) proposed the concept of successful cognitive aging, which differs from the concept of usual cognitive aging and highlights a higher level of cognitive function preservation and improvement. In the study by Hartley et al. (6), cognitive aging was classified into three grades: unsuccessful, usual, and successful. Exploring the common characteristics of successful cognitive aging could be helpful in providing targets for cognitive intervention and facilitating the individual's transition to successful cognitive aging.

Previous studies have found that usual cognitive aging may be influenced by certain physiological, psychological, behavioral, and social factors; modifying these factors could aid in the prevention or delay of cognitive decline and further prevent dementia (7). Approximately 40% of dementia is attributable to a combination of the following 12 risk factors: less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, low social contact, alcohol consumption, traumatic brain injury, and air pollution (8). It is widely recommended to maintain a healthy lifestyle (9), which can help maintain a higher level of cognitive and physical function and reduce neuropathological damage in neurodegenerative diseases associated with cognitive aging (10). Therefore, we propose in hypothesis 1 that adherence to a cognitive-related lifestyle promotes cognitive aging. However, the lifestyle of most people still falls short of the recommended guidelines owing to various barriers between theoretical guidance and practicality (11). Therefore, exploring the internal factors of people's adoption of cognitive-related healthy lifestyles and providing evidence for developing specific intervention strategies are necessary for successful cognitive aging.

The Health Belief Model (HBM) could be helpful in understanding the beliefs and motivations for adopting a cognitive-related healthy lifestyle. The HBM, which is one of the earliest and most widely used theories in the field of health behavior, is capable of exploring internal factors and elucidating the internal decision-making process of the individual's health behavior. HBM is most commonly used for prevention-related and asymptomatic health problems, such as early cancer detection and hypertension screening, in which beliefs are just as or more important than obvious symptoms (12). Six dimensions were described in the HBM, including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. Compared with five other behavioral change models (e.g., Health Locus of Control, Theory of Reasoned Action/Theory of Planned Behavior, Self-efficacy Theory, Stage of Change/Transtheoretical Model of Change, and Common Sense Model of Self-regulation), the HBM was considered the best model to elucidate the mechanism of risk reduction of dementia (13). Thus, exploring the related

Abbreviations: CFA, confirmatory factor analysis; CFI, Comparative fit index; CI, confidence interval; DW, dementia worry; HBM, Health Belief Model; HPLP-II, Health Promoting Lifestyle Profile-II; HZ, Henze-Zirkler test; IQR, interquartile range; LDRR, Lifestyle for Dementia Risk Reduction; MCLHB-DRR, Motivation to Change Lifestyle and Health Behaviors for Dementia Risk Reduction; MoCA, Montreal Cognitive Assessment; ML, maximum likelihood; MLM, maximum likelihood parameter estimates with standard errors and a mean-adjusted chi-square test statistic; RMSEA, root mean square error of approximation; SD, standard deviation; SES, socioeconomic status; TLI, Tucker–Lewis index; WLSMV, weighted least squares with mean and variance adjusted.

mechanism from the perspective of the HBM is important when establishing a healthy lifestyle for successful cognitive aging.

Previous studies have focused more on the status and influencing factors of dementia prevention beliefs and their correlation with willingness to engage in health-related behaviors (14–17). Akyol et al. (16) conducted a survey on the dementia prevention beliefs of 284 Turkish people over the age of 40 years; the results demonstrated that age, years of education, family history of dementia, subjective memory complaints, and willingness to understand their own risks were influencing factors of dementia prevention beliefs. Moreover, a study by Seifan et al. (15) demonstrated that individuals' beliefs in dementia prevention would affect their willingness to engage in health-related behaviors, such as actively seeking help from professional doctors, actively identifying personal risk of dementia, and actively learning knowledge of dementia prevention. However, the effect of the individuals' beliefs on cognitive-related behaviors and the characteristics of beliefs deserve attention in dementia prevention. In a recent study, Li et al. (18) found that different health beliefs had either positive or negative effects on health-promoting lifestyle. However, the scale used in Li et al. (18) study was the Chinese version of the Health Promoting Lifestyle Profile-II (HPLP-II), which was lack of pertinence to assess the lifestyles that reduce the risk of dementia. In addition, the belief-lifestyle exploration in this study did not extend to the final cognitive outcome. The contribution of beliefs in dementia prevention on cognitive aging by influencing cognitive-related healthy lifestyles should be explored more deeply.

In this study, our classification of health beliefs referred to the findings revealed by Li et al. (18). Furthermore, according to the HBM (19), as an external cause, cues to action can directly affect health behaviors or indirectly affect health behaviors by acting on other belief dimensions. Based on the study of Li et al. (18), in combination with the theory of HBM, the health belief was re-divided into three dimensions in this study: positive beliefs, negative beliefs, and cues to action. Therefore, we propose in hypothesis 2 that positive beliefs have a promoting effect on lifestyle, negative beliefs have a hindering effect on lifestyle, and cues to action can directly affect lifestyle, and can also indirectly affect lifestyle through positive and negative beliefs. The Reduced Risk of Dementia Lifestyle Measure (LDRR) (20), which measures cognitive-related healthy lifestyles, was designed in our previous studies based on the HPLP-II and the latest evidence on dementia prevention, and has been verified to have good reliability and validity. The LDRR focusing on multiple healthy lifestyles that reduce the risk of dementia, and is suitable for this study to explore the relationship between beliefs, lifestyles and cognitive aging. We propose in hypothesis 3 that health beliefs affect cognitive aging by influencing cognitive-related healthy lifestyle.

Based on the HBM, this study aimed to describe the status of dementia prevention beliefs of the individuals and establish a structural model of beliefs, lifestyle, and cognitive aging. This study aimed to elucidate whether dementia-prevention beliefs have a direct impact on cognitive-related healthy lifestyles; successful cognitive aging is related to a healthy cognitive-related lifestyle; and dementia-prevention beliefs have an indirect effect on cognitive aging through lifestyle. Figure 1 shows our constructed model for the hypothesis testing.

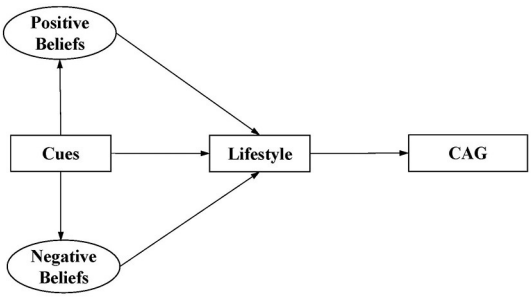

FIGURE 1
Constructed model for hypothesis testing.

Materials and methods

Study design

This cross-sectional study employed a structural equation model.

Study setting

A questionnaire-based survey was conducted from March to October 2021 in a community health service center in Chongqing, China. The community health service center has jurisdiction over five communities with a total area of 2.9 km^2 and permanent residents over 56,000.

Participants

Through convenience sampling, middle-aged and older adults who participated in free physical examinations at the community health service center were recruited. The inclusion criteria were as follows: (1) age ≥45 years, (2) attended free physical examination and established health records at the community health service center, (3) gave informed consent, and (4) had normal communication and comprehension skills, and able to read and fill in the required questionnaire independently (or through the researcher). The exclusion criteria were as follows: (1) had a clear diagnosis of various types of dementia, (2) inability to complete the investigation owing to serious physical

illness, and (3) had severe visual or hearing impairment and inability to communicate normally.

Data collection

All the data collectors accepted uniform training before the study to ensure familiarity with all the questionnaires and the survey process and avoid bias during data collection. The participants completed the questionnaires with the assistance of the data collectors only after they received a clear statement of the study's objectives and meaning and provided written informed consent. Incomplete questionnaires triggered a second interview. Participants who could not be re-contacted were excluded from the study. Since the sample size required to construct the structural equation model is at least 100, preferably 200 or more (21), a total of 221 adults were invited to participate in this study, and 202 (91.4%) completed all the questionnaires. This study was approved by the Medical Ethics Committee of Army Medical University (2021 No.18-02).

Measures

Demographic characteristic questionnaire

The participants' general characteristics, including gender, age, education level, marital status, living conditions, personal monthly income, family history, and contact history of dementia, were self-reported by the participants based on the questionnaire.

Motivation to change lifestyle and health behaviors for dementia risk reduction

The MCLHB-DRR is a 27-item scale developed by Kim et al. (13) in 2014 to measure beliefs about lifestyle and behavioral changes for dementia risk reduction. Seven subscales were included: perceived susceptibility (four items), perceived severity (five items), perceived benefits (four items), perceived barriers (four items), cues to action (four items), general health motivation (four items), and self-efficacy (two items). All the items were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A higher score indicates a higher level of motivation to change their lifestyle. The scale was cross-culturally adapted in our previous study (22), and the Chinese version has been validated, which showed that the Kaiser–Meyer–Olkin value of the scale was 0.74, and the Cronbach's alpha for the scale was 0.76.

Lifestyle for dementia risk reduction

The LDRR (20) was designed in our previous studies to assess an individual's lifestyle related to dementia risk reduction. This is a 32-item scale with eight dimensions: health responsibility (four items), brain-benefiting exercise (five items), mental leisure activity (two items), brain-benefiting diet (five items), tobacco control behavior (two items), interpersonal relationship (five items), stress management (four items), and spiritual growth (five items). Items were rated on a 4-point Likert scale from 1 (never) to 4 (always), while one was scored in reverse. The total score ranges from 32 to 128, with a higher score indicating a healthier lifestyle to reduce the risk of dementia. This finding has been validated in the Chinese population. Exploratory factor analysis showed that the cumulative variance contribution rate was 60.189% and the factor loadings ranged from 0.403 to 0.866. The fitness indices of the confirmatory factor analysis reached acceptable levels. Moreover, Cronbach's alpha of this scale was 0.855, and its test-retest reliability was 0.864.

Montreal cognitive assessment

The MoCA, developed by Nasreddine et al. (23) in 2004, measures eight cognitive domains: orientation, language, working memory, concentration, short-term memory, attention, executive function, and visuospatial ability. The MoCA is a widely used screening tool for general cognitive function, with a total score of 30; a higher score indicates a higher level of cognitive function. The Beijing version (24) of the MoCA used in this study has been modified from a cultural and linguistic perspective. The sensitivity of the Beijing version of the MoCA was 83.8, 80.5, and 96.9% for all cognitive impairments, mild cognitive impairments, and dementia, respectively; the specificity for identifying cognitively normal was 82.5% (25).

Based on a study by Hartley et al. (6), cognitive aging was divided into three grades in different age groups. Age was divided into several groups with the 10-year-old range in this study, including 45–59 (since the range of 45–49 years old is less than 10 years old, this age group was combined with 50–59 years old), 60–69, 70–79, and 80–89 years. Moreover, the standard score of MoCA was used, which was calculated using the original MoCA score and the mean and standard deviation (SD) scores, as follows: standard score = (MoCA-mean)/SD. Participants whose standard scores were more than 1 standard deviation above the mean in their age group would be classified as "successful cognitive aging" (Score>Mean+1×SD); those with more than 1 standard deviation below the mean in their age group were "unsuccessful cognitive aging" (Score<Mean-1×SD); and those in between were "usual cognitive aging" (Mean-1×SD≤Score≤Mean+1×SD).

Statistical analysis

SPSS software (version 24.0) was used for statistical analysis. Statistical significance was set at $p \leq 0.05$. Frequency and

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TABLE 1 Sociodemographic and cognitive aging characteristics [*n* (%)].

Characteristics	All ($n = 202$)	Successful group ($n = 17$)	Normal group ($n = 155$)	Impaired group ($n = 30$)	Mean of rank	*Z*/*Hc*	*P*
Gender						−1.176[a]	0.240
Male	70 (34.7)	3 (1.5)	63 (31.2)	4 (2.0)	106.40		
Female	132 (65.3)	14 (6.9)	92 (45.5)	26 (12.9)	98.90		
Age group (years)						0.464[b]	0.927
45∼59	36 (17.8)	5 (2.5)	24 (11.9)	7 (3.5)	101.96		
60∼69	95 (47.0)	11 (5.4)	69 (34.2)	15 (7.4)	103.35		
70∼79	60 (29.7)	1 (0.5)	52 (25.7)	7 (3.5)	98.64		
80∼89	11 (5.5)	0 (0.0)	10 (5.0)	1 (0.5)	99.59		
Education level						39.655[b]	<0.001
Primary or below	60 (29.7)	0 (0.0)	37 (18.3)	23 (11.4)	72.54		
Middle school	74 (36.6)	6 (3.0)	64 (31.7)	4 (2.0)	109.97[c]		
Senior high school or above	68 (33.7)	11 (5.4)	54 (26.7)	3 (1.5)	117.83[c]		
Marital status						−1.856[a]	0.063
Married	157 (77.7)	13 (6.4)	126 (62.4)	18 (8.9)	104.52		
Single/divorced/widowed	45 (22.3)	4 (2.0)	29 (14.4)	12 (5.9)	90.98		
Living conditions						−0.647[a]	0.518
Living alone	22 (10.9)	3 (1.5)	16 (7.9)	3 (1.5)	107.11		
Other	180 (89.1)	14 (6.9)	139 (68.8)	27 (13.4)	100.81		
Individual monthly income (RMB)*						14.756[b]	0.001
<1000	22 (10.9)	1 (0.5)	11 (5.4)	10 (5.0)	69.86		
1000∼3000	72 (35.6)	4 (2.0)	52 (25.7)	16 (7.9)	92.22[c]		
3000∼5000	86 (42.6)	10 (5.0)	72 (35.6)	4 (2.0)	113.70[cd]		
>5000	22 (10.9)	2 (1.0)	20 (9.9)	0 (0.0)	115.82[cd]		
Family history of dementia						−0.788[a]	0.430
No	181 (89.6)	16 (7.9)	139 (68.8)	26 (12.9)	102.31		
Yes	21 (10.4)	1 (0.5)	16 (7.9)	4 (2.0)	94.48		
Contact with dementia patients						−0.140[a]	0.888
No	102 (50.5)	9 (4.5)	77 (38.1)	16 (7.9)	101.08		
Yes	100 (49.5)	8 (4.0)	78 (38.6)	14 (6.9)	101.93		

*One RMB was about 0.15 USD. [a]Mann-Whitney U-test, [b]Kruskal-Wallis H-test, [c]Represents $p < 0.05$ compared with the first layer, [d]Represents $p < 0.05$ compared with the second layer. Bonferroni correction method was used for pairwise comparison test.

percentage were used to describe participant demographics. The mean and SD or median and interquartile range (IQR) was used to describe the MCLHB-DRR, LDRR, and MoCA scores. The Mann–Whitney U test and Kruskal–Wallis *H*-test were used to test the differences in cognitive aging grades for each demographic characteristic. After that, Bonferroni correction method was used for pairwise comparison test for variables with three categories and above. Spearman correlation coefficient was used to test the associations between various health beliefs and lifestyles. Version 8.3 of Mplus software was used for path analysis and construction of the structural equation model as well as for the confirmatory factor analysis (CFA) of the measurement model. Before running CFA, we used Henze-Zirkler (HZ) test to test the multivariate normality of the variables in Stata software (version 17.0). Maximum likelihood (ML) method was used for CFA if it is consistent with multivariate normal distribution, otherwise, maximum likelihood parameter estimates with standard errors and a mean-adjusted chi-square test statistic (MLM) method was used for CFA. Considering the classified outcome variables used in this study, weighted least squares with mean and variance adjusted (WLSMV) estimation, instead of maximum likelihood (ML) estimation, was used to estimate the model. Considering the classified outcome variables, WLSMV is considered a suitable estimation and better than ML (26, 27). The comparative fit index (CFI), Tucker–Lewis index (TLI), and root mean square error of approximation (RMSEA) were used to evaluate the goodness of fit of the model. Acceptable model fitting was determined by RMSEA < 0.08 and CFI and TLI values > 0.90 (28).

Results

Demographic characteristics and cognitive aging grades

A total of 202 participants provided their complete data. The mean age of the participants was 67.10 ± 7.62 years old. Most participants were female (132, 65.3%), married (157, 77.7%), living with someone (180, 89.1%), had a primary education or below (60, 29.7%), and had a monthly income of 1000 RMB (22, 10.9%). Furthermore, only 21 (10.4%) participants had a family history of dementia, while nearly half of the participants (100, 49.5%) had prior contact with patients with dementia.

Considering the cognitive aging grades, there were 17 (8.4%), 155 (76.7%), and 30 (14.9%) participants in the "successful cognitive aging," "usual cognitive aging," and "unsuccessful cognitive aging" groups, respectively. Statistically significant differences in the cognitive aging grades were observed among participants with different educational levels ($Hc = 39.655$, $p < 0.001$) and personal monthly incomes ($Hc = 14.756$, $p = 0.001$). Further pairwise comparison test showed that the cognitive aging grade was lower in those with primary school education or below ($p < 0.05$), and personal monthly incomes <1000 RMB. The detailed data are presented in Table 1.

Bivariate correlations between health beliefs and lifestyle

The mean lifestyle score in this study was 89.71 (SD = 11.61). The mean scores for each health belief subscale are shown in Table 2. In this study, perceived susceptibility and perceived barriers negatively correlated with lifestyle, while perceived benefits, general health motivation, and self-efficacy positively correlated with lifestyle (Table 3). Perceived severity was positively correlated with perceived susceptibility ($R = 0.265$, $p < 0.001$) and perceived barriers ($R = 0.229$, $p < 0.01$), which are negative beliefs. Perceived severity is also a perceived threat, similar to perceived susceptibility. Thus, although the correlation coefficient between perceived severity and lifestyle was not statistically significant, it would be better to consider perceived severity as a negative belief, together with perceived susceptibility and perceived barriers in this study.

TABLE 2 Descriptive statistics of health beliefs and lifestyle ($N = 202$).

Variable	Range	Min	Max	Mean ± SD/Median (IQR)
Health beliefs	27∼135	67.00	129.00	102.70 ± 12.15
Perceived susceptibility	4∼20	4.00	20.00	10.00 (6.00–12.00)
Perceived severity	5∼25	5.00	25.00	19.00 (14.00–22.25)
Perceived benefits	4∼20	8.00	20.00	20.00 (18.00-20.00)
Perceived barriers	4∼20	4.00	20.00	7.00 (4.00–12.00)
General health motivation	4∼20	6.00	20.00	20.00 (18.00–20.00)
Self-efficiency	2∼10	2.00	10.00	10.00 (8.00–10.00)
Cues to action	4∼20	4.00	20.00	10.00 (14.00–16.00)
Lifestyle	32∼128	62.00	117.00	89.71 ± 11.61

Measurement model of latent constructs

Henze-Zirkler test showed that the variables used for two CFA were not multivariate normal distribution (positive beliefs: HZ = 25.27, $p < 0.001$; negative beliefs: HZ = 1.28, $p < 0.001$). Therefore, MLM was used for CFA. The measurement model was tested by estimating the association between each item and its hypothetical potential construct (Table 4). For positive beliefs, CFA showed that all the items were significantly loaded with corresponding factors, with first-order standardized factor loads ranging from 0.330 to 0.913 ($p < 0.001$) and second-order standardized factor loads ranging from 0.567 to 0.818 ($p < 0.001$). The goodness of fit of the measurement model was acceptable (CFI = 0.975, TLI = 0.963, RMSEA = 0.034, 90% confidence interval = 0.000–0.067). For negative beliefs, CFA showed that all the items were also significantly loaded with corresponding factors, with first-order standardized factor loadings ranging from 0.490 to 0.944 ($p < 0.001$) and second-order standardized factor loadings ranging from 0.428 to 0.641 ($p < 0.001$). The goodness of fit of the measurement model was acceptable (CFI = 0.988, TLI = 0.985, RMSEA = 0.030, and 90% confidence interval = 0.000–0.054). The detailed data are shown in Table 4.

Structured path model of health beliefs, lifestyle, and cognitive aging grade

Figure 2 shows an acceptable model with CFI = 0.907, TLI = 0.894, RMSEA = 0.036, and 90% confidence interval (CI) = 0.023–0.047. Positive beliefs significantly correlated with the negative beliefs ($R = -0.393$, $p = 0.002$). Statistical significance was shown in the path from cues to action to positive beliefs ($\beta = 0.415$, $p < 0.001$) and negative beliefs ($\beta = 0.485$, $p < 0.001$), the path from positive beliefs ($\beta = 0.372$, $p < 0.001$) and negative beliefs ($\beta = -0.459$, $p = 0.003$) to lifestyle, and the path from lifestyle to cognitive aging grades ($\beta = 0.426$, $p < 0.001$), supporting hypothesis 1 and 2. There was no statistically significant difference in the path from cues to action to lifestyle

TABLE 3 Correlations between variables of health beliefs and lifestyle among community-dwelling middle-aged and elderly individuals in China (N = 202).

	1	2	3	4	5	6	7	8
Perceived susceptibility	1.000	0.265***	−0.042	0.181*	0.036	−0.101	0.255***	−0.157*
Perceived severity		1.000	0.117	0.229**	0.053	0.066	0.273***	−0.094
Perceived benefits			1.000	−0.125	0.196**	0.424***	0.267***	0.415***
Perceived barriers				1.000	−0.017	−0.203**	0.149*	−0.217**
General health motivation					1.000	0.291***	0.233**	0.280***
Self-efficacy						1.000	0.203**	0.427***
Cues to action							1.000	0.074
Lifestyle								1.000

*p <0.05, **p < 0.01, ***p < 0.001.

($\beta = 0.173$, $p = 0.223$), which was inconsistent with hypothesis 2 that "cues to action can directly affect lifestyle". The model explained 39.3 and 18.2% of the differences in lifestyle and cognitive aging grades, respectively.

Table 5 shows the indirect effects of health beliefs on lifestyle and cognitive aging grades. Positive beliefs had indirect positive effects on cognitive aging grades ($\beta = 0.158$, $p = 0.005$). Negative beliefs had indirect negative effects on cognitive aging grades ($\beta = -0.196$, $p = 0.014$). Cues to action had indirect positive effects on lifestyle ($\beta = 0.154$, $p = 0.002$) and cognitive aging grades ($\beta = 0.066$, $p = 0.015$), as well as had indirect negative effects on lifestyle ($\beta = -0.223$, $p = 0.019$) and the cognitive aging grades ($\beta = -0.095$, $p = 0.033$), supporting hypothesis 3. However, the total influence of cues to action on lifestyle and cognitive aging grades is not statistically significant.

Discussion

In this study, the participants were divided into three groups: successful cognitive aging, usual cognitive aging, and unsuccessful aging, based on the study of Hartley et al. (6). According to the HBM, this study explored the relationship among beliefs, lifestyle, and cognitive aging grades.

In this study, 8.4% of the participants achieved successful cognitive aging, which was lower than that (16.0%) in the study of Hartley et al. (6). This difference could be related to regional, population, economic, and cultural differences. Currently, no comprehensive and statistical data exist on the proportion of successful cognitive aging in previous studies; however, some studies have demonstrated the proportion of successful memory aging to be approximately 6–40% (29). Univariate analysis showed that the lower the educational level and monthly incomes, the lower the cognitive aging grade. Education status and income are both socioeconomic status (SES) factors. A previous study suggested that low SES is a risk factor for cognitive impairment in older adults (30). Low SES may exacerbate unequal cognitive impairment among older adults, because people with higher SES often have more opportunities to diagnose cognitive impairment, rectify adverse factors, and avoid further deterioration in cognitive function than those with lower SES (31). Such differences in access to medical resources may accumulate over time (32).

The results of this study suggest that a cognitive-related healthy lifestyle has a direct and positive impact on cognitive aging grades. The cognitive-related healthy lifestyle explained 18.2% of the variation in cognitive aging in this study. Notably, dementia is mainly controlled by age and genetic factors (33). Only 40% of cases of dementia are attributable to a combination of modifiable risk factors, including not only lifestyle factors but also traumatic brain injury, air pollution, and other chronic diseases (8). Therefore, the explanation of the rate of variation in this study (18.2%) is reasonable and understandable. Although the impact of lifestyle interventions on individuals may be modest, modifying the individual's lifestyle could have a greater social impact owing to its superior cost-effectiveness compared with other modifiable factors. An increasing number of studies (9, 34–36) have focused on lifestyle interventions for cognitive improvement, and modifying the lifestyle concerning physical activity, smoking, alcohol consumption, diet, social activities, and the management of chronic diseases, such as hypertension, diabetes, obesity, and dyslipidemia, is widely recommended. The LDRR used in this study was also developed according to the recommendations of related studies and guidelines and was more targeted than the general lifestyle scale.

In this study, the health beliefs were divided into three dimensions, including positive beliefs, negative beliefs, and cues to action, based on the study by Li Hua et al. (18), and the HBM. The path analysis in this study showed the specific path and mechanism of these beliefs on lifestyle and cognitive aging grades, as well as the direct and indirect influences among them. Health beliefs accounted for 39.3% of the variation in lifestyle, suggesting that interventions with health beliefs may effectively promote the adoption of cognitive-related healthy lifestyles. In this study, positive beliefs included perceived benefits, general health motivation, and self-efficacy, which

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TABLE 4 Unstandardized and standardized loading for second-order measurement model of positive beliefs and negative beliefs ($N = 202$).

Parameter estimate	Unstandardized loading (*SE*)	Standardized loading (*SE*)
Positive beliefs second-order confirmatory factor analysis model		
Fit indices: CFI = 0.975, TLI = 0.963, RMSEA = 0.034, 90% CI: 0.000-0.067		
Self-efficacy→ SE 1	1.000	0.913 (0.035)***
Self-efficacy→ SE 2	0.864 (0.098)***	0.894 (0.049)***
Perceived benefits→ Benefit 1	1.000	0.677 (0.074)***
Perceived benefits→ Benefit 2	0.985 (0.129)***	0.783 (0.050)***
Perceived benefits→ Benefit 3	0.399 (0.121)**	0.543 (0.080)***
Perceived benefits→ Benefit 4	0.823 (0.167)***	0.838 (0.069)***
General health motivation→ HealthM 1	1.000	0.330 (0.078)***
General health motivation→ HealthM 2	0.628 (0.269)*	0.596 (0.126)***
General health motivation→ HealthM 3	1.160 (0.173)***	0.566 (0.105)***
General health motivation→ HealthM 4	0.803 (0.204)***	0.757 (0.099)***
Positive belief→ Self-efficacy	1.000	0.818 (0.130)***
Positive belief→ Perceived benefits	0.515 (0.224)*	0.676 (0.152)***
Positive belief→ General health motivation	0.325 (0.139)*	0.567 (0.157)***
Negative beliefs second-order confirmatory factor analysis model		
Fit indices: CFI = 0.988, TLI = 0.985, RMSEA = 0.030, 90% CI: 0.000-0.054		
Perceived barriers→ Barrier 1	1.000	0.738 (0.056)***
Perceived barriers→ Barrier 2	0.979 (0.136)***	0.705 (0.061)***
Perceived barriers→ Barrier 3	0.977 (0.155)***	0.690 (0.073)***
Perceived barriers→ Barrier 4	0.910 (0.148)***	0.647 (0.075)***
Perceived susceptibility→ Sus 1	1.000	0.812 (0.033)***
Perceived susceptibility→ Sus 2	1.193 (0.069)***	0.944 (0.023)***
Perceived susceptibility→ Sus 3	1.053 (0.070)***	0.852 (0.028)***
Perceived susceptibility→ Sus 4	0.690 (0.076)***	0.582 (0.055)***
Perceived severity→ Sev 1	1.000	0.710 (0.050)***
Perceived severity→ Sev 2	0.924 (0.109)***	0.691 (0.047)***
Perceived severity→ Sev 3	0.658 (0.089)***	0.552 (0.055)***
Perceived severity→ Sev 4	0.850 (0.102)***	0.635 (0.053)***
Perceived severity→ Sev 5	0.651 (0.105)***	0.490 (0.069)***
Negative belief→ Perceived barriers	1.000	0.428 (0.120)***
Negative belief→ Perceived susceptibility	1.199 (0.470)*	0.521 (0.119)***
Negative belief→ Perceived severity	1.683 (0.708)*	0.641 (0.135)***

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

described people's concerns about their own health, recognition of the benefits of changing lifestyles, and confidence in adhering to the lifestyle (13). We found that these positive beliefs have a direct and positive impact on lifestyle and indirectly contribute to successful cognitive aging.

This study also showed that negative beliefs had a direct and negative impact on lifestyle and further indirectly impeded the achievement of successful cognitive aging, which was different from the usual cognition of the HBM. According to the HBM (19), perceived susceptibility and perceived severity are used to describe people's perception of threats to diseases, which could stimulate the adoption of a healthier lifestyle to reduce threats. However, considering cognitive aging and dementia prevention, perceived susceptibility and perceived severity may have a hindering effect rather than a promoting effect on people's adoption of healthy behaviors. This could be explained by the concept of dementia worry (DW). DW is defined as an emotional response to the perceived threat of dementia (37). A moderate level of DW leads to adaptive responses, whereas a high level of DW leads to maladaptive responses. Thus, people who perceive acceptable fear and risk of dementia may be more willing to adopt a cognitive-related healthy lifestyle; in contrast, people who are too fearful concerning dementia and even engage in dementia risk reduction may be more willing to avoid behavioral change (17). In addition, previous studies have found that negative perceptions of dementia and aging are

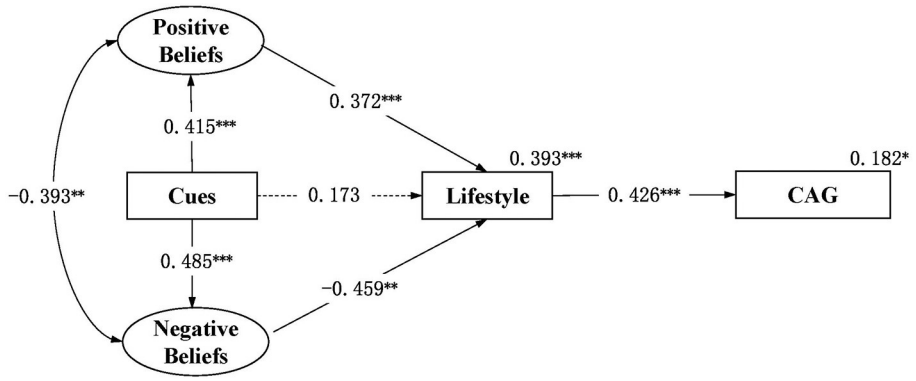

FIGURE 2
Structured path model of health beliefs, lifestyle and cognitive aging grade among community-dwelling middle-aged and elderly individuals in China ($N = 202$). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Fit index: RMSEA = 0.036, 90% CI 0.023–0.047, CFI = 0.907, TLI = 0.894; CAG, cognitive aging grade; Cues, cues to action. Significant paths were shown in solid lines for simplicity. Dotted lines were the primary paths of interest but not statistically significant. All path coefficients shown were standardized. The oval represents a latent construct measured by multiple items which are not shown in the diagram for simplicity.

TABLE 5 Indirect and total effects of positive belief, negative belief and cues to action on lifestyle and cognitive aging grade among community-dwelling middle-aged and elderly individuals in China (N =202).

Total pathway	Total indirect effect		Specific pathway	Indirect effect of path		Total effect	
	β	*P*		*β*	*P*	*β*	*P*
Positive belief→ CAG	0.158	0.005	Positive belief→ Lifestyle→ CAG	0.158	0.005	0.158	0.005
Negative belief→ CAG	−0.196	0.014	Negative belief→ Lifestyle→ CAG	−0.196	0.014	−0.196	0.014
Cues→ Lifestyle	−0.068	0.603	Cues→ Positive belief→ Lifestyle	0.154	0.002	0.104	0.158
			Cues→ Negative belief→ Lifestyle	−0.223	0.019		
Cues→ CAG	0.044	0.179	Cues→ Lifestyle→ CAG	0.074	0.232	0.044	0.179
			Cues→ Positive belief→ Lifestyle→ CAG	0.066	0.015		
			Cues→ Negative belief→ Lifestyle→ CAG	−0.095	0.033		

CAG, cognitive aging grade; Cues, cues to action.

associated with DW, including dementia stigma and negative age-related stereotypes (38–40), which may further influence cognitive-related lifestyle changes. The results of this study suggest that the negative effects of negative beliefs on health behaviors should be considered in educational programs for dementia prevention and cognitive aging, especially for people at a high risk of dementia (e.g., those with a family history of dementia). When people present obvious perceived threat (susceptibility and severity) and concern for dementia, medical focus should be transferred to provide feasible interventions on the perceived benefits and self-efficacy to enhance the belief that dementia can be prevented and controlled.

This study found that both positive and negative beliefs were promoted by cues to action. Cues to action are factors that remind individuals to participate in healthy behaviors. Few studies have explored the role of cues to action. Some studies have found that cues to action may indirectly affect behaviors through other health beliefs or may directly affect behaviors (41). Cues to action reportedly work mainly through perceived threats (19). In the MCLHB-DRR, cues to action include amnesia symptoms, dementia risk, media publicity of dementia-related knowledge, and family history of dementia. In this study, cues to action may promote negative beliefs through amnesia symptoms, dementia risk, and a family history of dementia, which may trigger people's perception of dementia threat (perceived susceptibility and severity). Furthermore, cues to action may promote positive beliefs through media publicity, which could provide information on how to adhere to healthy lifestyles and reduce the risk of dementia. However, the overall effect of cues on lifestyle could be weakened because positive and negative beliefs have opposing effects on lifestyle. These results further suggest that, in lifestyle intervention programs, education and advocacy should be used as incentives to reduce negative beliefs and promote positive beliefs.

This study provided evidence for the development of public health interventions. First, community cognitive health management should pay more attention to older adults with limited SES. It would be better to develop targeted healthy

lifestyle interventions for older adults with limited SES based on their specific conditions, available resources, and barriers to maximize their use of public medical resources. Moreover, reducing the negative impact of negative beliefs on healthy lifestyles should be recommended in media publicity and health education programs. Targeted interventions on general health motivation, perceived benefits, and self-efficacy may be better for people with high perceived susceptibility and severity (e.g., people with a family history of dementia). It may be necessary to employ these targeted interventions to improve people's awareness of the preventability and controllability of dementia and promote positive belief for adhering to a healthy lifestyle. Finally, interventions can be designed from a more positive perspective to promote successful cognitive aging and encourage people to adopt a more positive attitude toward a cognitive-related healthy lifestyle.

This study had certain limitations. First, owing to the lack of the earlier cognitive function data of the participants, this study only explored the cognitive aging grades from a cross-sectional perspective and classified the cognitive aging grades based on the general cognitive function of community residents who were middle aged and older. With regard to measurement tools, MoCA, as a cognitive screening scale, is inadequate in measuring the general cognitive function of subjects. Moreover, the classification of cognitive aging grade was based on standard score of MoCA, which is the relative standard distance between an individual's cognitive score and the average cognitive score of the group. The cutoff value of cognitive aging grade divided by this method was not constant, and it will vary with samples of different characteristics, which is not conducive to comparison with other studies. Additionally, this classification could hardly explore the rate and trajectory of cognitive decline, and could be biased for different individuals. Second, a single-center survey and limited sample size were employed in this study owing to the limitation of human and economic resources, as well as the barriers brought about by the coronavirus disease 2019. Lastly, considering accessibility, only community residents who had attended free physical examinations in the community health service center were recruited in this study. Compared with those who had not attended free physical examination in the community health service center, participants in this study may have possessed higher levels of health literacy and higher acceptance of cognitive-related healthy lifestyles, which could have resulted in some overestimation in this study for the lifestyle among community residents who were middle aged and older. In the future, the follow-up studies are warranted to further explore successful cognitive aging in individuals from a longitudinal perspective. And additional studies with a larger sample size and wider sampling area, and more fine-grained neuropsychological assessment methods (e.g., attention, speed of information processing, executive function, and episodic memory) should be conducted to further test the model.

Conclusions

In this study, a limited number of participants achieved successful cognitive aging based on the criteria of this study. Moreover, lifestyle had a direct and positive impact on the cognitive aging grades. Positive beliefs had a positive effect on lifestyle, thus promoting successful cognitive aging. Negative beliefs had a negative effect and hindered the realization of successful cognitive aging. The results suggested that primary medical staff could strengthen the positive beliefs of community residents and weaken their negative beliefs to guide them to adhere to cognitive-related healthy lifestyles and promote successful cognitive aging.

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 Army Medical University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

YY developed the ideas, administrated the project, provided significant academic guidance on manuscript, and revised the manuscript critically for intellectual content. JZ and XL collected the data, conducted the data analysis, interpreted the results, drafted, and revised the manuscript. DG and YP collected the data, edited, and revised the manuscript. HL collected the data and edited the manuscript. All authors agreed to be accountable for the content of the work, read, and approved the final manuscript.

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Conflict of interest

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

Publisher's note

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EDITED BY
Elsie Yan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Yuanyuan Fu,
Beijing Normal University, China
Shahrul Bahyah Kamaruzzaman,
University of Malaya, Malaysia

*CORRESPONDENCE
Li Yang
✉ 1367842170@qq.com

†These authors have contributed equally to this work

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Factors influencing the social participation ability of rural older adults in China: A cross-sectional study

Minghui Cheng[1†], Wenli Su[1†], Huiju Li[1], Linjie Li[2], Minghui Xu[1], Xue Zhao[1], Mengdie Han[1] and Li Yang[3*]

[1]School of Nursing, Lanzhou University, Lanzhou, Gansu, China, [2]Fenyang College of Shanxi Medical University, Fenyang, Shanxi, China, [3]Internal Department of Special Care, Lanzhou University Second Hospital, Lanzhou, Gansu, China

Objective: To investigate the epidemiology and influencing factors of social participation ability of rural older adults in China.

Methods: From March to April 2021, 3450 older adults in poverty aged 60 and above registered in Jishishan County (J County) were selected by cluster sampling for a cross-sectional questionnaire survey and their social participation ability was assessed using the Ability Assessment of older adults (MZ/T039-2013). The results were statistically analyzed and an ordered multi-category logistic regression analysis was used to analyze the effect of influencing factors on the social participation ability of rural older adults.

Results: 3,346 questionnaires were collected, with an effective recovery rate of 96.99%. Out of all the participants, 1,355 (40.5%) of the 3,346 cases had intact social participation ability, while 1,991 (59.5%) had different degrees of loss of social participation ability, of which 1,393 (41.14%) were mildly impaired, 419 (12.5%) were moderately impaired and 179 (5.3%) were severely impaired. Age, educational level, religious belief, living status, whether suffering from dementia and the occurrence of accidents in recent 30 days were influencing factors on the social participation ability ($p < 0.05$).

Conclusion: The rate of impaired social participation ability among older adults was >50% and age, educational level, religious beliefs, living status, whether suffering from dementia, and the occurrence of accidents in recent 30 days (such as falls, choking, loss) were significant factors influencing the ability of social participation of rural older adults.

KEYWORDS

elder adults, social participation, level, influencing factors, cross-sectional

1. Introduction

The promotion of active aging has become a common practice adopted by the international community to combat the challenges associated with an aging population. One of the core elements of active aging is the social participation of older adults (1–4). Social participation is a form of social interaction or community involvement that may include activities with friends, family, and other individuals, telephone conversations, religious activities, participation in cultural activities, or participation in exercise groups

(5). In addition to the societal benefits of social participation by the elderly (6), accumulating evidence has shown that social participation can help to reduce the costs of long-term elderly care and help to improve individual psychological and health conditions. Indeed, participation in social activities has been demonstrated to positively impact rates of depression and loneliness, and to improve cognitive functioning (5–8).

Previous studies (9, 10) have identified age, level of education, marital status, and health conditions as influencing factors of social participation. However, these studies have focused on urban older adults or patients with identified diseases while little is known about social participation and the influencing factors thereof among rural older adults in impoverished areas. Jishishan County (J County) has unique characteristics (11), as the only multi-ethnic autonomous county in Gansu Province. At the same time, it is a poverty-stricken county, and its economic and social development is far behind that of Gansu Province and of the rest of the country. This is also reflected in material scarcity and in a lack of access to tangible and intangible resources (11). To this end, social participation, a process that facilitates information exchange, strengthens ties to the community and access to resources, promotes a healthy physiological state, and fosters social support systems, may bring social and economic upliftment to J country, particularly to its elderly inhabitants.

Therefore, this study sought to investigate the capacity for social participation of elderly inhabitants in the J county region of rural China and the factors influencing this social participation in the aim of promoting active aging.

2. Materials and methods

2.1. Study design and participants

A cross-sectional study was conducted in the rural J county of Gansu province in northwest China from March to April 2021. Participants were recruited using a cluster sampling method. The inclusion criteria for participants were set as (1) aged >60 years old and (2) voluntary participation in the survey. If the participants are unable to communicate directly with investigators due to mental, speech, or hearing impairments, the family members were allowed to answer the questions. Exclusion criteria: (1) the death of a registered older adult and/or (2) the individual was no longer in the locality or was uncontactable during the course of the study.

2.2. Procedures

Data was collected through means of a questionnaire. The cover page of the questionnaire explained the research purpose and process. Participants signed an informed consent form before filling out the questionnaire. The questionnaires were filled out in private with investigators on-site to handle any questions. The completeness of the questionnaires was checked on-site by the investigators. Three thousand and four hundred and fifty older adults were invited to participate, and 104 incomplete questionnaires were excluded. Ultimately, 3,346 (96.99%) valid questionnaires were analyzed and included in this study.

2.3. Measurements

The "Ability Assessment of the older adults" (MZ/T039-2013) was used to evaluate the respondents. This assessment tool was developed by the Ministry of Civil Affairs of the People's Republic of China. It has good reliability and validity, with a Cronbach's α score of 0.889. The assessment contains two parts: (1) Basic information about the older adults, including gender, age, education level, religion, marital status, living status, and accidents in the recent 30 days (e.g., choking, falls, or having gone missing). (2) The social participation ability assessment section of the form included five items of life ability, ability to work, time/space orientation, person orientation, and social interaction ability. Each item was scored by participants on a 5-point scale, ranging from 0 to 4, with a total possible score of 20 points. The social participation ability was assessed according to a score of 0 to 2. A total score of 3–7 was categorized as level 1, indicating mild impairment; a total score of 8–13 was assigned to level 2, indicating moderate impairment; a total score of 14–20 was assigned to level 3, indicating a severe impairment.

2.4. Statistical methods

After the questionnaires were collected, the data were initially organized using Excel, and SPSS 26.0 statistical software was used for statistical analysis. The (M ± SD) was used to assess the data, and the counted data were described by frequency and composition ratio. Nonparametric statistical tests (Mann-Whitney U test and Kruskal-Wallis test) were used for Univariate analysis and ordered multi-categorical logistic regression analyses were used to explore the effect of the influencing factors on the level of social participation. A difference where $P < 0.05$ was regarded as statistically significant.

2.5. Ethical considerations

Before enrolling in the study, eligible participants signed a consent form. After the survey was completed, all data were

stored anonymously without names or identifying information to protect participants' confidentiality.

3. Results

3.1. Basic characteristics of rural older adults

A total of 3,346 older adults were collected in this study, with an effective recovery rate of 96.99%, of which 48.8% were male. In terms of the age of participants, 1,278 cases (38.2%) were aged 60 and above, 1,529 cases (45.7%) were aged 70 and above, and 539 cases (16.1%) were aged 80 and above. Most of the older adults (88.5%) were illiterate (Table 1).

3.2. Rating of social participation ability of older adults

The results showed that 558 (16.7%) had complete life skills, 98 (2.9%) had complete work skills, 1,950 (58.3%) had complete time/space orientation skills, 2,598 (77.6%) had complete person orientation skills, and 2,343 (70.0%) had complete social interaction skills. Moreover, the results showed that 1,355 (40.5%) had intact social participation ability; 1,991 had varying degrees of impaired social participation ability, with an impairment rate of 59.5%, of which the mild, moderate, and severe damage rates were 41.14% (1,393/3,346), 12.5% (156/3,346) and 5.3% (62/3,346), respectively.

3.3. Univariate analysis of factors associated with social participation ability

The analysis showed that gender, age, ethnicity, education, religious belief, marital status, living status, whether suffering from dementia and the occurrence of accidents in the past 30 days were factors influencing the ability to participate in social interactions ($p < 0.05$, Table 1).

3.4. Ordered multi-categorical logistic regression analysis of the influencing factors of social participation

An ordered multi-categorical logistic regression analysis was conducted using the social participation ability level of the older adults as the dependent variable (intact = 0, mildly impaired = 1, moderately impaired = 2, and severely impaired = 3), and gender, age, ethnicity educational level, religious belief, marital status, residence status, diagnosis of dementia, and accident incidence in the past 30 days as the independent variables. There was no multicollinearity found among the independent variables (VIF in the range of 1.005 to 4.688) and the parallelism test met the requirements ($\chi^2 = 41.804$, $P = 0.115$). In summary, the results showed that age, educational level, religion, marital status, living status, and whether participants had dementia, and/or accidents in the past 30 days were influential factors in the social participation ability of the rural older adults ($P < 0.05$, Table 2).

4. Discussion

4.1. High rate of impaired social participation among rural older adults

This study used the "Ability Assessment of the older adults" to determine the social participation ability of older adults with time/space orientation, person orientation, and other dimensions taken into account to diversify the measurements of social participation level of older adults (12). In this study, the social participation ability of older adults was intact in 1,355 cases, accounting for 40.5%, and impaired to varying degrees in 1,991 cases, with an impairment rate of 59.5% which was much higher than the results of a study by Shi et al. (12) on the level of social participation of rural elderly in Henan province (20.84%).

The social participation ability of the rural older adults was found to be inconsistent with the literature in several dimensions. Among them, the proportion of intact character orientation ability was 77.6%, which was inconsistent with previous research results (where the proportion was 92.78%) (12). Similarly, the proportion of intact ability in the five dimensions of life ability (16.7%), workability (2.9%), time/space orientation ability (58.3%), person orientation ability (77.6%), and social interaction ability (70.0%) were all lower than that observed in previous studies (12). The reasons for these differences may include: (1), appropriate income as an important contributor to achieving active participation of older adults in society (13). Indeed, J County was, until recently, one of the 23 counties in the province with deepest levels of poverty and although it exited poverty status in 2020 the economic level is still considerably low compared to other provinces and cities, especially for poor older adults. Consequently, older adult residents are under more significant pressure to meet their basic needs to survive. Secondly, the high number of ravines in the mountainous areas of County J and the lack of access to transportation means that older people have fewer interactions with the outside world; most of them live in mountainous areas, with long distances between families and less communication between neighbors. Thirdly, the low average level of education of the population in the area (with an illiteracy rate of 88.5%) and the limited

TABLE 1 Demographic characteristics and univariate analysis of social participation.

	Intact	Mild	Moderate	Severe	Total	*Z/H*	*P*
Gender							
Male	685(41.9%)	693(42.4%)	181(11.1%)	74(4.5%)	1,633	−2.701	0.007
Female	670(39.1%)	700(40.9%)	238(13.9%)	105(6.1%)	1,713		
Age(years)							
60∼	671(52.5%)	474(37.1%)	94(7.4%)	39(3.1%)	1,278	268.089	0.000
70∼	590(38.6%)	672(44.0%)	199(13.0%)	68(4.4%)	1,529		
80∼	94(17.4%)	247(45.8%)	126(23.4%)	72(13.4%)	539		
Nationality							
Han	566(40.7%)	576(41.4%)	166(11.9%)	82(5.9%)	1,390	23.528	0.001
Hui	579(40.1%)	618(42.8%)	178(12.3%)	68(4.7%)	1,443		
Dongxiang	72(30.3%)	106(44.5%)	42(17.6%)	18(7.6%)	238		
Baoan	89(49.4%)	57(31.7%)	25(13.9%)	9(5.0%)	180		
Sala	35(51.5%)	25(36.8%)	6(8.8%)	2(2.95)	68		
Tu	10(47.6%)	9(42.9%)	2(9.5%)	0(0.0%)	21		
Zang	4(66.7%)	2(33.3%)	0(0.0%)	0(0.0%)	6		
Educational level							
illiteracy	1,137(38.4%)	1,263(42.7%)	390(13.2%)	170(5.7%)	2,960	−7.029	0.000
literacy	218(56.5%)	130(33.7%)	29(7.5%)	9(2.3%)	386		
Religion							
Without	534(43.3%)	493(40.0%)	135(10.9%)	71(5.8%)	1,233	−2.367	0.018
With	821(38.9%)	900(42.6%)	284(13.4%)	108(5.1%)	2,113		
Marital status							
Single/divorced/widowed	396(29.2%)	474(34.0%)	155(37.0%)	97(54.2%)	1,122	−5.638	0.000
Married	959(70.8%)	919(66.0%)	264(63.0%)	82(45.8%)	2,224		
Living status							
live alone	129(45.7%)	108(38.3%)	30(10.6%)	15(5.3%)	282	141.586	0.000
Live with spouse	885(46.9%)	761(40.3%)	185(9.8%)	55(2.9%)	1,886		
Live with others	341 (35.3%)	524(44.5%)	204(17.3%)	109(9.3%)	1,178		
Dementia							
Without	1,346(41.2%)	1,366(41.8%)	401(12.3%)	152(4.7%)	3,265	−8.432	0.000
With	9(11.1%)	27(33.3%)	18(22.2%)	27(33.3%)	81		
Number of chronic diseases							
None	593(42.5%)	539(38.6%)	178(12.8%)	86(6.2%)	1,396	4.619	0.099
1∼2	712(39.7%)	781(43.5%)	217(12.1%)	84(4.7%)	1,794		
3∼	50(32.1%)	73(46.8%)	24(15.4%)	9(5.8%)	156		
Accidents in recent 30d							
Without	1,208(42.4%)	1,153(40.5%)	352(12.4%)	136(4.8%)	2,849	−5.355	0.000
With	147(29.6%)	240(48.3%)	67(13.5%)	43(8.7%)	497		

TABLE 2 Ordered multi-categorical logistic regression analysis of influencing factors of social participation level.

	B	SE	Wald χ^2	P	OR (95%CI)
Gender					
Male	−0.015	0.070	0.049	0.825	0.99 (0.14–5.62)
Age (years)					
60∼	−1.479	0.103	204.215	0.000	0.23 (0.19–0.28)
70∼	−0.969	0.097	100.181	0.000	0.38 (0.31–0.46)
Nationality					
Han	0.998	0.901	1.229	0.268	2.71 (0.46–15.85)
Hui	0.233	0.904	0.066	0.797	1.26 (0.21–7.42)
Dongxiang	0.838	0.910	0.847	0.357	2.31 (0.39–13.76)
Baoan	−0.001	0.914	0.000	0.999	0.80 (0.13–5.02)
Sala	−0.217	0.934	0.054	0.816	1.03 (0.16–6.80)
Tu	0.487	1.001	0.237	0.626	1.63 (0.23–11.58)
Educational level					
illiteracy	0.665	0.115	33.409	0.000	1.94 (1.55–2.44)
Religion					
Without	−0.801	0.144	30.890	0.000	0.45 (0.34–0.60)
Marital status					
Single/divorced/ widowed	−0.559	0.117	22.847	0.000	0.57 (0.45–0.72)
Living status					
Live alone	−0.542	0.131	17.030	0.000	0.58 (0.45–0.75)
Live with spouse	−1.017	0.109	87.001	0.000	0.36 (0.29–0.45)
Dementia					
Without	−1.987	0.212	87.869	0.000	0.14 (0.09–0.21)
Accidents in recent 30d					
Without	−0.514	0.093	30.624	0.000	0.60 (0.50–1.39)

knowledge and skill levels of the population in the use of modern communication and other forms of media limits the content and methods of social participation available to this population.

4.2. Factors influencing the social participation of older adults

In this study, the risk of impaired social participation ability was 0.23 and 0.38 times higher among 60–69 and 70–79-year-olds respectively than among 80-year-olds and above. Guo et al. (14) showed that after controlling the effects of other variables, the level of social participation ability among older urban adults in Guangdong Province was significantly higher in the lower age group (60–75 years) than in the higher age group (>75 years), which is consistent with our results. In addition, aging inevitably leads to increased incidence of various physical ailments (15), making older people's social participation more homogeneous and narrowed in terms of the range of social participation activities. This leads to an increased rate of impaired social participation in this group, in line with previous research findings (16). Therefore, older adults should be encouraged to participate in various activities to improve their social participation ability according to their health status and physical and cognitive abilities.

The results of this study showed that illiterate older adults are 1.94 times more at risk of impaired social participation than literates, which is consistent with the results of existing studies (15, 16). The higher the level of education and the more open-minded and receptive people are to new things, the relatively more motivated people are to participate in society (17) the easier it is to integrate into the society's culture. However, Liu et al. and Yang et al. (18, 19) found a low correlation between the educational level and social participation of older people. This difference may be due to the small number cohort of the two studies or due to the use of the different research methods. Our findings indicate that we should pay more attention to the lesser-educated older adults and use the village council as a vehicle to change their attitudes toward social participation, using methods such as publicity and peer education to encourage active participation in social activities.

The results of this study showed that dementia and unexpected life events (falls, suicide, being lost) within the last 30 days were influential factors on social participation ability. Yang et al. (20) proposed that chronic diseases and mental illness constrain the social participation of older people in China. Due to the absence or abnormality of one or more physical or mental functions, older adults with such diseases have a weaker ability to take care of themselves (21). The reduced ability of self-care not only limits their ability to be socially active but also leads to adverse emotional reactions in older adults, thus potentially limiting their ability to engage in social participation (22). Older adults with functional disabilities should therefore be provided with appreciative social activities based on maintaining their abilities.

Compared to older adults without spouses, those with spouses are more likely to participate in social activities. Shi et al.

(12) conducted a questionnaire survey on rural older adults aged 60 and above in Henan Province, and the results showed that the social participation ability of the older adults with spouses was higher than that of the older adults without spouses, which was consistent with the results of this study. In China, where kinship is vital, living with a spouse or relative enhances the level of family support for older people, which can significantly increase their sense of well-being (23), and improves their ability to participate in society. For older adults living alone, the lack of family companionship can cause loneliness in their lives and can be detrimental to their psychological well-being, leading to a decline in their social participation ability. Therefore, older adults living alone should be encouraged to participate in social activities when their physical condition allows, and at the same time, it is recommended that more social services and financial support be provided to those living with other relatives.

4.3. Strengths and limitations

This study is the first large-scale survey on the social participation ability of older adults in poor areas in China. Our findings may help to improve the capacity of the government, village committees, social workers, and other social forces in helping to strengthen social participation and build social support systems for older adults in poor areas. There are limitations to this study: (1) Due to the survey data, this study only analyses some aspects of social participation and does not study the specific content of social participation. This study could be improved in future research, by collecting more comprehensive data on social participation, and by exploring the relevant influencing factors in depth. (2) The study investigated the social participation ability of older adults in J County. As J County is a gathering place of ethnic minorities and its economic level is of a low-income society, the results of the study may not represent the social participation level of older adults in the country. (3) The data is all self-reported and is therefore based on participants perceived ability rather than their tested ability.

5. Conclusion

In conclusion, the rate of impaired social participation of rural older adults in J county, China is 59.5%, and age, religion, education level, living status, and functional deficits are important influencing factors of social participation ability. Ensuring the integrity of older rural adults' social participation ability can effectively reduce the medical care burden for older adults in rural areas, where social participation can significantly promote healthy aging in China. In order to improve the social participation ability of rural older adults, firstly the township hospital needs to be equipped with professional medical staff to monitor the health of older adults, regularly promote health information, and provide question-answering and consulting services. Secondly, given that older adults in J County are currently largely limited to a single form of recreation and a few amateur cultural activities, it is necessary to speed up the promotion of public services for recreation and culture, reduce the difference between urban and rural areas and promote the participation of older adults in social activities in rural areas. We can strengthen rural infrastructure through financial subsidies, social donations, and corporate philanthropy to provide a concrete material basis for the social participation of older people in rural areas. Finally, the low level of social participation of older people in J county may be because older people have fewer channels to obtain information about these activities. We should therefore use appropriate tools to publicize the activities that are available to older adults broaden the publicity channels, and promote social participation overall.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

MC, WS, HL, and LY contributed to conception and design of the study. LL, MX, XZ, and MH wrote sections of 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

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Hon Lon Tam,
The Chinese University of Hong Kong, China
Nathalia Alves de Oliveira,
Federal University of São Carlos, Brazil

*CORRESPONDENCE
Ömer Alkan
✉ oalkan@atauni.edu.tr

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Prevalence and predictors of psychological assistance services for older individuals in Turkish society

Hüseyin Coşkun [1], Ibrahim Yildiz [2] and Ömer Alkan [3]*

[1]Department of Finance, Banking and Insurance, Vocational School of Social Sciences, Bayburt University, Bayburt, Turkey, [2]Department of Management Information Systems, Faculty of Economics and Administrative Sciences, Ataturk University, Erzurum, Turkey, [3]Department of Econometrics, Faculty of Economics and Administrative Sciences, Ataturk University, Erzurum, Turkey

Background/aim: Due to the high contribution of psychological problems to the decline in the comfortable lifestyle of the older individuals, determining the factors that affect individuals' receiving psychological services and searching for solutions based on these factors is one of the primary concerns of national and international decision-makers. This study aimed to identify the factors that affect older individuals' access to psychological assistance services in Turkey.

Methods: In this study, the Turkish Health Research micro dataset, which was conducted by the Turkish Statistical Institute (TURKSTAT) in 2016 and 2019, was employed. In this dataset, the data of 7,252 older individuals were analyzed. Using binary logistic analysis, the factors that are effective for obtaining psychological assistance for the older individuals were identified.

Results: According to the results of the analysis, factors such as gender, education, general health status, disease status, payment of health expenditures, and body mass index affected older individuals who received psychological assistance.

Conclusion: In recent years, there has been a rise in the availability of psychological assistance services for the older individuals. By identifying factors that increase the likelihood of receiving psychological assistance services, this study is expected to contribute to the creation and regulation of psychological assistance services to prevent possible psychological problems that may occur in old age, minimize the problems experienced by individuals, and promote a more comfortable lifestyle.

KEYWORDS

aging, psychological support, Turkey, elderly, binary logistic regression, older individuals

1. Introduction

The aging process is a biological fact, with its dynamics largely beyond human control. Old age refers to the decline in an individual's ability to adapt to an environment beyond his or her control, and chronologically denotes those aged 60 and older (1). Furthermore, aging is a phenomenon that should be evaluated by

combining the psychological and biological internal capacity of individuals, the reserves accumulated throughout life, and the composition of social processes. There are biological, psychological, and social factors that affect the aging process of each individual (2). Biologically induced aging is the result of a wide variety of molecular and cellular damage accumulating over time. This results in a gradual decline in physical and mental capacity, an increase in disease risk, and ultimately death (3). People of all ages may experience very common life stressors, such as loss of functional ability due to aging (4). For numerous reasons, older individuals often experience feelings of isolation, depression, and physical inactivity (5). Sixty percent of hospitalized patients over the age of 65 have or will acquire mental health problem, such as dementia, delirium, or depression (6). Therefore, evaluating mental health problems in older individuals is complex due to various problems and diseases seen with physical illnesses (7). Healthy older individuals' psychological problems may be alleviated by participating in social activities (8). Otherwise, exposure to social discrimination may cause psychological problems and reduce individuals' quality of life of individuals (9). Evaluating mental health problems in older individuals is complicated by the variety of problems and co-morbidities associated with physical illness (10).

Mental health is essential for a comfortable life, including the capacity to form relationships, maintain schooling and a career, and make daily decisions (11). Therefore, early treatment is necessary to protect older adults from the negative effects of physical and mental health issues (5, 12). The most prevalent functional disease among older people who experience mental health issues is depression. Depression can be expressed as a change in someone's mood, self-blame, self-punishment requests, and changes in activity levels (13). Depression can cause worse functional disorders in daily life than those with chronic medical conditions, such as lung disease, hypertension, or diabetes. In addition, negative health effects, such as dementia, death anxiety, inability to have children, somatic sickness, cognitive impairment, functional impairment in activities connected to daily life, and lack of social connections, may arise in the older after depression (4, 5, 14–16). Psychological distress, a general unpleasant mood state associated with anxiety or depression, may increase with age (17). Individuals experiencing psychological distress are not open to professional psychological help, and often seek help from individuals without mental health training. However, inadequate or delayed help-seeking behavior is an obstacle to effective treatment (12, 18). As older individuals increasingly receive care in the community as opposed to hospitals, both their physical and social functioning should be evaluated (19). The evaluation of social functions can assist in the development of effective health interventions and policies for the older (20), because weak social support networks pose a threat to the psychological and physical health of the older (21). How older individuals can be treated for psychological problems and how to reach the aged has become a global problem (22, 23). The disagreement between those who provide services in this field centers on how older individuals living in these conditions can be best serve (24).

Globally, the life expectancy of those aged 60 and above is increasing. As a result of decreasing birth rates and rising life expectancy, global populations are aging, and the share of older population in the global population is increasing (3). According to the International Population Report, the average age of the global population has increased at an unpredictably high rate, and corresponding social and demographic shifts have occurred. The report stated that the age group of 60 and over constituted 7% of the world's population and reached 506 million in 2008 (25). The older population is increasing every year. This share, which reached approximately 1 billion at the beginning of 2020, increased to 1.4 billion at the end of 2020. Moreover, it is estimated that by 2030, one out of every six individuals on the planet will be 60 or older, and that number will reach nearly 2.1 billion by 2050 (3, 5). In Turkey, the proportion of the older population to the overall population climbed from 8.2% in 2015 to 9.5% in 2020. According to population projections, it is predicted that the proportion of the older population will be 11.0% in 2025, 12.9% in 2030, 16.3% in 2040, 22.6% in 2060 and 25.6% in 2080, respectively (26).

With the expansion in the world's older population, the psychological problems associated with aging and the health services provided to prevent or solve these problems have been the focus of research and investigation from numerous angles. It is thought that identifying the factors that affect the older in receiving psychological assistance services will contribute to the determination of where psychological support services should be focused, thus allowing the older to live a pleasant life. Studies in this area in Turkey are limited. Therefore, the question addressed in this study is, "What are the factors that are effective in getting psychological assistance services for the older individuals in Turkey?" To address the issue, comprehensive data collection was used to model the factors affecting the older individuals' receipt of psychological assistance services in Turkey.

2. Methods

2.1. Data source

In this study, the Turkish Statistical Institute's 2016 and 2019 micro datasets for the Turkey Health Survey was used. The Turkey Health Survey is one of the most thorough studies conducted to produce many indicators that cannot be derived from administrative records in the field of health and to create a data source for decision-makers and researchers on this subject. The scope of the research was the households in all

settlements within Turkey's borders. The stratified two-stage cluster sampling method was used in the sample design of the Turkey Health Survey (27, 28). The stratified two-stage cluster sampling method is a sampling technique used to obtain an efficient estimation by selecting certain elements in selected clusters. Stratified two-stage cluster sampling has been widely used for effective estimations due to time and cost (29). The rural-urban distinction was used as an external stratification criterion (Settlements with a population of 20,000 and below are considered rural, and settlements with a population of 20,001 and above are considered as urban). The first stage sampling unit was randomly selected blocks from clusters (blocks) containing an average of 100 addresses; the second stage sampling unit was the household addresses selected randomly from each selected cluster (27, 28). Data from a total of 7,252 older individuals, 3,250 men and 4,002 women aged 60 and over, were used, and all data were included in the analysis since there were no missing observations.

2.2. Outcome variable

In the Turkey Health Survey, the following questions were asked about individuals receiving psychological assistance services: "Have you seen a psychologist for yourself in the last 12 months?" "Have you seen a psychotherapist for yourself in the last 12 months?" "Have you seen a psychiatrist for yourself in the last 12 months?" Older individuals participating in the study were considered to have received psychological assistance if they answered "yes" to one or more of the questions listed above. As a result, the dependent variable of the study was the status of receiving psychological assistance service for the older who received the code 1 if they had seen a psychologist, psychotherapist, or psychiatrist in the last 12 months, and 0 if they had not visited any of them.

2.3. Independent variables

In this study, which examined the factors that affect older individuals receiving psychological assistance services, some sociodemographic and health status questions posed to the survey participants were examined, and some variables that were predicted to be effective were included in the model. The variables included in the model were survey year (2016, 2019), age (60–64 years, 65 years and older), education level (illiterate or not completed school, primary school, elementary school, high school, or university), general health status (poor or very poor, moderate, and good or very good), disease status, and body mass index (thin, normal weight, overweight, obese, and extremely obese).

While the questionnaire did not ask about any physical or mental illness, the question "Do you have a disease or health problem that has lasted for 6 months or longer or is expected to last?" was asked (yes or no). Regarding the difficulty in paying for healthcare, the following questions were asked: "In the last 12 months, have you ever needed medical care but could not afford it?"; "In the last 12 months, have you been unable to afford the prescribed medication you needed?"; and "In the last 12 months, have you ever needed mental treatment (by a psychiatrist, etc.) but could not afford?" If the answer was "yes" to at least one of these questions, the participant was evaluated as having difficulty paying for healthcare.

All of the variables addressed here are categorical variables with either ordinal or two-state scales. Ordinal and nominal variables were defined as dummy variables so that the effects of the categories of all variables to be included in the binary logistic regression model could be observed (30, 31).

2.4. Statistical analysis

Survey statistics in Stata 15 (Stata Corporation) were used to account for the complex sampling design and weights (32). Weighted analysis was performed (33, 34). First, frequencies and percentages of older individuals were determined according to their psychological support status. The Chi-square independence test was used to examine the relationship between psychological support status and independent variables. Then, risk factors that are effective in receiving psychological support were determined using the binary logistic regression analysis (35, 36).

3. Results

3.1. Characteristics of study participants

This section interprets the frequency and percentages of the independent variables associated with the model to be developed. The chi-square test statistics are presented in Table 1, together with the factors that affect the older individuals' receipt of psychological assistance services.

According to the findings presented in Table 1, 44.8% of the older individuals were male, and 55.2% were female. Individuals aged 65 and above constituted 68.5% of the study sample. Of the study's participants, 37.2% were either illiterate or had not completed high school, while 6.8% were university graduates. Those with good or very good general health constituted 26.9% of the study population, while 29.0% had poor or very poor health. Older individuals with health problems lasting 6 months or longer constitute 83.7% of the study. Older individuals, who could not afford medical care, prescribed medication, or psychological support in the last 12 months constituted 8.8% of the study. According to the body mass index, 1.4% of the sample population was underweight, 40.2% was overweight, and 2.3% was obese. The chi-square test statistics of all variables except education were found to be significant.

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TABLE 1 Prevalence of factors affecting older individuals' receiving psychological assistance services and chi-square test statistics.

Variables	Status of receiving physiological assistance service		*n* (%)	χ^2	*P*
	No	Yes			
Year					
2016	3,490 (51)	167 (40.9)	3,657 (50.4)	15.595	0.000[a]
2019	3,354 (49)	241 (59.1)	3,595 (49.6)		
Gender					
Male	3,123 (45.6)	127 (31.1)	3,250 (44.8)	32.751	0.000[a]
Female	3,721 (54.4)	281 (68.9)	4,002 (55.2)		
Age					
60–64 years	2,138 (31.2)	144 (35.3)	2,282 (31.5)	2.936	0.087[c]
65 and over	4,706 (68.8)	264 (64.7)	4,970 (68.5)		
Education					
Illiterate or not completed a school	2,555 (37.3)	143 (35)	2,698 (37.2)	5.412	0.248
Primary school	2,980 (43.5)	181 (44.4)	3,161 (43.6)		
Elementary school	380 (5.6)	19 (4.7)	399 (5.5)		
High school	477 (7)	27 (6.6)	504 (6.9)		
University	452 (6.6)	38 (9.3)	490 (6.8)		
General health status					
Very good or good	1,904 (27.8)	50 (12.3)	1,954 (26.9)	63.173	0.000[a]
Moderate	2,968 (43.4)	180 (44.1)	3,148 (43.4)		
Poor or very poor	1,972 (28.8)	178 (43.6)	2,150 (29.6)		
Disease status					
Yes	5,686 (83.1)	387 (94.9)	6,073 (83.7)	39.199	0.000[a]
No	1,158 (16.9)	21 (5.1)	1,179 (16.3)		
Difficulty in health care payments					
Yes	572 (8.4)	69 (16.9)	641 (8.8)	34.966	0.000[a]
No	6,272 (91.6)	339 (83.1)	6,611 (91.2)		
Body mass index					
Thin (Under 18.5 kg/m^2)	99 (1.4)	4 (1)	103 (1.4)	15.379	0.004[a]
Normal weight (18.5–24.999 kg/m^2)	1,942 (28.4)	83 (20.3)	2,025 (27.9)		
Overweight (25–29.999 kg/m^2)	2,738 (40)	175 (42.9)	2,913 (40.2)		
Obese (30–39.999 kg/m^2 and over)	1,906 (27.8)	138 (33.8)	2,044 (28.2)		
Extremely obese (40 kg/m^2 and over)	159 (2.3)	8 (2)	167 (2.3)		

[a]$p < 0.01$, [c]$p < 0.10$.

3.2. Multivariate analyses

In this study, the binary logistic regression model was used to determine the factors that affect whether or not the older obtain psychological assistance services. The estimated model results and the marginal effects of the factors affecting the psychological support status of the older are shown in Table 2.

When Table 2 is examined, it is seen that the variables of survey year, gender, education level, general health status, disease status, inability to pay for health care and body mass width (overweight, obese) are significant. Additionally, multicollinearity between the model's independent variables was investigated. Those with variance inflation factor (VIF) values of 5 or above are thought to generate significant multicollinearity,

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TABLE 2 Estimated model results and marginal effects on factors effective in receiving psychological assistance services for older individuals.

Variables	β	Std. error	95% CI		ME (%)	Std. error	VIF
			Lower	Upper			
Year (reference: 2016)							
2019	0.412[a]	0.125	0.167	0.657	38.95[a]	0.118	1.020
Gender (reference: male)							
Female	0.612[a]	0.137	0.344	0.881	57.97[a]	0.130	1.240
Age (reference: 60–64 years)							
65 years of age and over	−0.207	0.131	−0.464	0.049	−19.52	0.123	1.080
Education (reference: university)							
Illiterate or not completed a school	−1.249[a]	0.233	−1.706	−0.792	−115.26[a]	0.209	4.62
Primary school	−0.780[a]	0.210	−1.193	−0.367	−70.80[a]	0.186	4.32
Elementary school	−0.739[b]	0.354	−1.434	−0.044	−66.97[b]	0.324	1.72
High school	−0.673[b]	0.283	−1.227	−0.119	−60.84[b]	0.256	1.89
General health status (reference: very good or good)							
Moderate	0.620[a]	0.202	0.225	1.016	59.46[a]	0.194	1.86
Poor or very poor	0.998[a]	0.217	0.573	1.422	94.72[a]	0.207	2.08
Disease status (reference: no)							
Yes	0.733[b]	0.290	0.165	1.301	70.13[b]	0.281	1.36
Difficulty in health care payments (reference: no)							
Yes	0.369[b]	0.164	0.046	0.691	34.52[b]	0.153	1.04
Body mass index [reference: normal weight (18.5–24.999 kg/m^2)]							
Thin (Under 18.5 kg/m^2)	−0.463	0.568	−1.577	0.651	−44.72	0.552	1.04
Overweight (25–29.999 kg/m^2)	0.390[b]	0.164	0.068	0.712	36.98[b]	0.156	1.48
Obese (30–39.999 kg/m^2 and over)	0.421[b]	0.175	0.078	0.764	39.89[b]	0.166	1.52
Extremely obese (40 kg/m^2 and over)	−0.048	0.441	−0.913	0.817	−4.59	0.423	1.09

[a]$p < 0.01$, [b]$p < 0.05$.

and those with VIF values of 10 or higher cause a high degree of multicollinearity (37, 38). According to the VIF results presented in Table 2, none of the variables are responsible for the multicollinearity problem between the variables.

According to the binary logistics model presented in Table 2, other variables being constant, an older individual who participated in the study in 2019 was 39% more likely to receive psychological assistance services than an older individual who participated in the same study in 2016. Older women are 58% more likely to receive psychological assistance than older men. Older individuals over the age of 65 who were illiterate or had not completed high school were 115% less likely to receive psychological assistance than those with a university degree. Primary school graduates were 71% less likely than university graduates to receive psychological assistance. Graduates of elementary schools were 67% less likely to receive psychological assistance than university graduates. Those with a high school diploma were 61% less likely to receive psychological assistance than those with a university degree. An older individual with a moderate general health status was 60% more likely to receive psychological assistance than an older individual with a good or very good health status. An older individual with a poor or very poor health status was 95% more likely to receive psychological assistance services than an older individual with a good or very good health status. Older individuals with health problems lasting 6 months or longer, or expected to last, were 70% more likely to receive psychological assistance than those without health problems. In the previous 12 months, those who were unable to pay for medical care, prescription medication, or psychological support were 35% more likely to receive psychological assistance than those without financial difficulties. Overweight older individuals were 37% more likely to receive psychological assistance than normal-weight older individuals. Obese older individuals were 40% more likely to

receive psychological assistance services than normal-weight older individuals.

4. Discussion and conclusions

Binary logistic regression analysis is used to analyze the effective factors for older individuals in Turkey to receive psychological assistance services. The study included older individuals living in Turkey, and the data obtained for two different years. According to the findings of the study, the probability of receiving psychological assistance services for older individuals has increased in recent years. Women received greater psychological assistance than men as they aged. A high degree of education improved the likelihood of older individuals receiving psychological assistance. The worse of the general health status of older individuals, the less likely they were to receive psychological assistance services. Exposure to disease for at least 6 months increased the probability of seeking psychological assistance. Older patients with problems paying for healthcare were more likely to receive psychological assistance. Those who were overweight or obese were more likely to seek psychological assistance services.

According to the findings, older individuals who participated in the survey in 2019 were more likely to receive psychological assistance than those participated in 2016. With the rising participation of women in the workforce and the restructuring of family structures into nuclear families, care for the older has become increasingly challenging in recent years. Studies on the older who do not live with their families focus mostly on issues such as treatment, meeting their daily needs, and improving their social relationships. However, psychological services appear to have flaws (39). In addition to the persistence of these problems in the past, it is thought that the rapid increase in the proportion of the older population has reduced the likelihood that older individuals will receive psychological assistance over time.

According to the results of the estimation, older women in Turkey were more likely to receive psychological assistance services than older men. In a similar study conducted in Turkey, it was determined that the rate of married persons declined with age, the rate of those who lost their wives and became widowed in old age increased, and widowhood produced significant psychological problems, such as loneliness (40). A study conducted on older women revealed that women were removed from economic and social life due to their longer average life expectancy and traditional gender roles; therefore, older women experienced more economic and psychosocial issues today (41). In many countries, women have lower social standing and earn less than men. It has been stated that this poses a significant health risk (42). Another study revealed that gender had a significant impact on the degree of depression among the older adult groups participating in the survey and that women's average mental health score was significantly lower than that of the men (43). In addition to the findings of these studies conducted in Turkey, it can be stated that the higher social pressure on women in underdeveloped regions, the low rate of women's workforce participation, and the fact that a large portion of the domestic workload falls on women are effective in increasing the likelihood of older women receiving psychological support.

One of this study's noteworthy findings is related to the education. Older individuals who were illiterate or did not complete high school, primary school graduates, elementary school graduates, and high school graduates were less likely to obtain psychological assistance services than older individuals who had graduated from university. It was observed that the likelihood of receiving psychological support increased with higher levels of education. The expectations that people have of life will rise along with the amount of education. The inability to meet expectations arising from sociological, physiological, and psychological changes that occur in old age may reveal the need for psychological support in older individuals. Older individuals generally receive support from the community rather than professional units (19). However, individuals with a high level of education know how to reach institutions where they can receive psychological support. In addition, unlike those living in rural areas, where health services are lacking, people living in urban areas, where the level of education is higher, are able to access health services more easily (44, 45). It is thought that the ease of accessing health services will increase the probability of receiving psychological support for those with a high education level compared to those with a low level of education.

It has been determined that older individuals with a moderate general health status are more likely to receive psychological assistance than those with a good or very good general health status, and those with a poor or very poor general health status are more likely to receive such services than those with a moderate general health status. When disease condition was considered, it has been observed that older individuals with health difficulties projected to last 6 months or more are more likely to receive psychological assistance than those without health issues. According to some studies in the literature, individuals with chronic diseases are unable to sustain self-care, cannot perform daily living activities, require the assistance of another person, and have lower levels of adaption to old age (46–49). On the basis of these findings, it is thought that negative factors, such as movement restrictions and loss of ability due to chronic diseases, cause negative changes in the psychological status of older individuals, and therefore, increase the possibility of receiving psychological assistance services.

When the variable of insolvency in health was considered, it was determined that the older who could not afford medical care, taking prescribed medication, or psychological support in the past 12 months were more likely to receive psychological assistance services than the older who did not

have payment difficulties. The fact that older individuals who had lost their income due to retirement or who did not have a regular income had difficulty paying the contribution fees that must be paid for individual treatment and medical supplies may increase their health concerns, which may lead to psychological problems and increase their likelihood of receiving psychological assistance services.

It was observed that older individuals who were overweight and obese were more likely to receive psychological assistance services than those with normal weight. These findings confirmed research demonstrating that overweight and obesity may be associated with a variety of psychological issues (50, 51). Especially in older individuals, the issue of excessive weight can result in movement difficulties and a sense of personal inadequacy. It is thought that older individuals who cannot overcome these problems may need psychological support.

In Turkey, private and public older care organizations and older care centers belonging to non-governmental organizations provide care and rehabilitation services to older people who can meet their own needs or need private residential care. However, services are provided for those who apply for older care in Turkey, and even if they need the service, other older people who do not apply or cannot access the service cannot be reached. There is no common standard in the services provided, and it cannot be disseminated in all local governments. In addition, preventive and protective services in older care are insufficient, and lifelong learning studies for the older have not been developed enough to raise awareness among the older individuals and their relatives (52). It is of great importance for both society and the family to build the social support programs required to improve the quality of life of the older population, which will constitute a substantial portion of the future Turkish population, and to ensure that they live an active life.

In addition, it is important to determine the reasons why the older individuals seek psychological support, as well as to establish a common standard in the services provided in Turkey, to identify individuals who need psychological support services, and to expand service organizations in all local governments. Considering that the factors affecting the mental health of the older individuals may differ in different countries, revising the practices in different countries by integrating cultural features or creating new practices would be of great benefit to the mental health development of the older individuals. This study is expected to contribute to the creation and regulation of psychological support services to prevent possible psychological problems that may occur in old age, to minimize the problems experienced by older individuals, and to promote a more comfortable lifestyle by identifying factors that increase the likelihood of receiving psychological assistance services. Furthermore, in future research on the psychological problems of old age and the elimination of these problems, the different econometric models and variables used in the findings of this study can be applied.

To protect and improve community mental health, the systems of countries with high happiness rates should also be examined. To protect the mental health of the community, resources should be increased, and a service model adopted by the community should be created. Cross-sectoral cooperation is necessary for the fight against mental health problems. For this, intersectoral cooperation should take place. To increase the appropriate counseling outreach skills of the personnel who will work in mental health services, there should be compulsory training that will improve their communication and counseling skills (53).

Implementing initiatives that increase hope for the older individuals, strengthen emotional support, and provide quality health care may benefit the lives of those who have retired and deserve a peaceful, comfortable old age. Telephone and video conference calls for older individuals who cannot meet with their loved ones during this period can help increase their life satisfaction. In addition, emotional support and active social participation should be provided to older individuals to promote their happiness.

4.1. Limitations of the study

This study has several limitations. First, the data in this study were secondary data. The variables required for statistical analysis consisted of the variables in the dataset. However, some variables, such as occupation and homeownership, that were not included in the data set could not be included in the analysis. Second, because the data are cross-sectional, the definite causal relationship between verbal violations and related socio-economic factors cannot be inferred (54). Third, the data on questions asked about receiving psychological assistance services to individuals were the individuals' own answers. Therefore, the data obtained in this data collection method may be biased.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data underlying this study is subject to third-party restrictions by the Turkey Statistical Institute. Data are available from the Turkish Statistical Institute (bilgi@tuik.gov.tr) for researchers who meet the criteria for access to confidential data. The authors of the study did not receive any special privileges in accessing the data. Requests to access these datasets should be directed to bilgi@tuik.gov.tr.

Author contributions

HC, IY, and ÖA: design and development of the study and writing-original draft. HC and ÖA: conceptualization,

methodology, formal analysis, and data curation. HC: editing. HC and IY: supervision. ÖA: software and visualization. ÖA and IY: writing - review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University, Hong Kong SAR, China

REVIEWED BY
Zhong Li,
Nanjing Medical University, China
Siyu Zhou,
Hangzhou Normal University, China
Wei Sun,
China Medical University, China

*CORRESPONDENCE
Fanlei Kong
✉ kongfanlei@sdu.edu.cn
Xiaolei Guo
✉ guoxiaolei@126.com

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The relationship between oral health status, loneliness, and sleep quality among the migrant elderly following children in Weifang, Shandong Province, China: A comparative analysis on different migration types

Xiaoxu Jiang[1,2], Guangwen Liu[1,2], Jing Xu[1,2], Hexian Li[1,2], Jieru Wang[1,2], Mingli Pang[1,2], Shixue Li[1,2], Lingzhong Xu[1,2], Xiaolei Guo[3]* and Fanlei Kong[1,2]*

[1]Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China, [2]NHC Key Lab of Health Economics and Policy Research, Shandong University, Jinan, China, [3]Shandong Center for Disease Control and Prevention, Academy of Preventive Medicine, Shandong University, Jinan, China

Background: The migrant elderly following children (MEFC) are a vulnerable group that emerged during fast urbanization in China. The MEFC faced physical and psychological discomfort upon their arrival in the inflow city, particularly those who came from rural areas.

Objective: This study aimed to explore the relationship between oral health status, loneliness, and sleep quality among the MEFC in China and to clarify the disparities in the above mentioned relationship by migration type.

Methods: In 2021, a cross-sectional survey was conducted in Weifang, Shandong Province, using multistage cluster random sampling to collect data from the MEFC aged 60 years and over. In total, 613 respondents [525 rural-to-urban (RTU) and 88 urban-to-urban (UTU)] were included in the final database. The chi-square test, *t*-test, and structural equation modeling (SEM) were used to investigate the relationship between oral health status, loneliness, and sleep quality among the RTU and UTU MEFC.

Results: Total scores [mean ± standard deviation (SD)] for oral health status, loneliness, and sleep quality were 54.95 ± 6.47, 8.58 ± 3.03, and 4.47 ± 3.60, respectively. SEM revealed that, among the RTU and UTU MEFC, oral health status was positively and significantly related to sleep quality; however, the correlation was slightly stronger in the UTU MEFC. In both groups, there was a significant negative correlation between oral health status and loneliness, which was stronger in the UTU MEFC. In the RTU MEFC, a significant negative correlation between loneliness and sleep quality was observed, and in the UTU MEFC, no significant association between loneliness and sleep quality was observed.

Conclusion: The sleep quality among the MEFC in this study was higher compared to previous studies. Oral health status was negatively correlated with loneliness and

positively associated with sleep quality, whereas loneliness was negatively correlated with sleep quality. These three associations differed significantly between the UTU and RTU MEFC. The government, society, and families should take measures to improve oral health and reduce loneliness among the MEFC to improve their sleep quality.

KEYWORDS

oral health status, loneliness, sleep quality, migrant elderly following children, migration type disparity, structural equation modeling

1. Introduction

The aging population is rapidly growing worldwide (1). Meanwhile, population aging is much faster in China than in other developing countries, with the proportion of people aged 60 years and above increasing from 12.4% in 2010 to 28% in 2040 (2). Urbanization in China has also accelerated over the past few decades, resulting in the highest number of domestic migrants worldwide (376 million) in 2021 (3, 4). The migrant elderly following children (MEFC) are a vulnerable group that emerged during rapid urbanization in China. They are the elderly who migrate with their children to urban cities to take care of their grandchildren (5). Geographical mobility could affect the health of the migrant elderly (6); therefore, the MEFC face physical and psychological discomfort upon their arrival in the inflow city (7), especially those who migrated from rural areas (8, 9). Therefore, it is vital to conduct research on the MEFC groups to achieve healthy aging in China (10).

Previous studies confirmed an empirical relationship between oral health and sleep quality. For instance, a cross-sectional study in Brazil uncovered a negative association between the number of teeth and sleep quality (11). Al-Zahrani et al. (12) observed that the loss of a posterior tooth could cause bite imbalances and that tooth pain and discomfort could negatively affect sleep quality and duration. In a Japanese study, older people with <10 teeth were more likely to experience sleep disorders than those with ≥ 20 teeth (13). Therefore, it is necessary to study the mental and physical health of the elderly (14).

Loneliness is a common phenomenon among older people and has become a major public health challenge (15). Social distancing during the pandemic exacerbated loneliness among older adults (16). Few studies attempted to clarify the link between loneliness and sleep quality. A British study found that loneliness contributed to sleep disturbances and increased morbidity and mortality among older people (17). An Israeli study confirmed that loneliness was related to more sleep challenges: a stronger feeling of loneliness correlated with worse sleep quality (18). A longitudinal study found that loneliness represented a weaker social network and worse mood, causing the brain to secrete substances, i.e., cortisol, which could further affect sleep duration and quality (19).

Previous studies also indicated that oral diseases in older people may cause mental impairment (20), such as cognitive decline (21), emotional challenges (22), and reduced daily activities (23). Rouxel et al. noted that oral health was an individual risk factor for loneliness in older people, including oral diseases and tooth losses, which significantly influences the quality of life and wellbeing among older people (15). Walther et al.'s study uncovered that loneliness increased when self-rated health decreased, and dental appointments were postponed due to costs among older women (24). Qi et al.'s study of the Chinese elderly indicated that the remaining number of teeth and the rate of tooth loss were closely related to social isolation and loneliness (25). Therefore, the aging population requires more attention due to their physical fragility (26).

Previous studies have explored the relationship between (1) oral health and sleep quality, (2) oral health and loneliness, (3) loneliness and sleep quality separately. However, no study has investigated the simultaneous association between oral health status, loneliness, and sleep quality among the MEFC. Thus, this study aimed to assess the abovementioned relationships and further investigate the migration type disparity among the MEFC in Weifang, Shandong Province to provide evidence-based policy to improve the health status among the MEFC.

2. Materials and methods

2.1. Study location

The data for this study were collected from Weifang, Shandong Province, China in August 2021. Weifang, located in the center of the Shandong Peninsula, is a prefecture-level city in Shandong Province, known as the capital of kites. Weifang has 12 districts, and its gross domestic product (GDP) would increase by 9.70% over the previous year to RMB ¥701.06 billion (USD $103.76 billion) in 2021 (27). In 2020, the migrant population in Weifang would be 237.55 million, an increase of 112.17% from 2010 (28).

2.2. Data collection and research participants

For the selection of study subjects, multistage cluster random sampling was used. In the first stage of data collection, four of the 12 districts were chosen as primary sampling units (PSUs) based on their economic development and geographical region. In the second stage, four subdistricts were chosen as secondary sampling units (SSUs) from each of the PSUs. In the third stage, four communities from each SSU were chosen. The total sample for this study included all migrants over the age of 60 who had followed their children to Weifang in these four communities. The inclusion criteria for the respondents were: (1) participants >60 years; (2) participants who followed their children to Weifang; (3) participants with communication ability; and (4) participants who participated voluntarily and signed informed consent.

In total, 25 university students were trained as investigators based on their background knowledge, questionnaire content, and

social survey methods during the survey. Participants and researchers participated in in-person interviews for 30 min to gather data. In total, 616 questionnaires were collected. However, 613 older adults were eventually included due to significant logical errors or incomplete questions in all three questionnaires.

2.3. Ethical approval

The survey and data were obtained with informed consent from all participants. The Ethics Committee of Shandong University reviewed and approved this study (No. 20180225).

2.4. Measurements

2.4.1. Sociodemographic characteristics

Sociodemographic information included sex, age, education level, marital status, pension, and migration years and space range. Educational level was classified as primary school and below; junior high school; high school or technical secondary school; and a university degree or above. In this study, marital status was determined by the presence or absence of a spouse. Respondents were asked whether they received a pension. Years of migration was subdivided into more than 5 years and <5 years. Regarding the migration space range, there were three options: cross-district/county, cross-prefecture-level cities, and cross-provincial.

2.4.2. Oral health status

Oral health status is measured by the Geriatric Oral Health Assessment Index (GOHAI). The GOHAI is a self-report instrument that measures the oral health status among older adults. It focuses on oral health function and psychosocial impact and has three dimensions: physical function, psychosocial function, and pain and discomfort. The GOHAI is determined using a five-point Likert scale: 1 = always, 2 = often, 3 = sometimes, 4 = rarely, and 5 = never. The total score of GOHAI is 12–60, and the higher the score, the better the oral health status. Wang et al. demonstrated the reliability and validity of GOHAI with excellent internal consistency in elderly people in mainland China (29).

2.4.3. Loneliness

Loneliness was assessed using the UCLA (University of California Los Angeles) Loneliness Scale. The scale measures the emotions of loneliness caused by the discrepancy between the desired level of social engagement and the one that occurs. The full scale has 20 items, the options are on a Likert-type scale: l = never, 2 = rarely, 3 = sometimes, and 4 = always. This study uses the ULS-6, which is a simplified version of the UCLA Loneliness Scale and includes the following six items: often feel a lack of friends, often feel no one could be trusted, often feel left out, often feel separated from others, often feel shy, and often feel surrounded by people but not cared for. It can be concluded that the ULS-6 has shown good reliability in evaluating loneliness in Chinese older adults (30). In this study, Cronbach's alpha of the ULS-6 is 0.82, Kaiser–Meyer–Olkin (KMO) coefficient is 0.84, and Bartlett's sphericity test has a $p < 0.05$, indicating that the scale has good reliability and validity.

2.4.4. Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) assessed subjective sleep quality in the previous month. It comprises 19 self-rated and five other-rated items, totaling seven components scored on a scale of 0–3. The total PSQI score is the sum of the scores for each component and ranges from 0 to 21, with higher scores indicating worse sleep quality. In the elderly Chinese population, the PSQI has high reliability and validity (31). The seven components are subjective sleep quality, latency, continuity, habitual efficiency, disorder, use of sleep medication, and daytime dysfunction.

2.5. Statistical analysis

The sociodemographic characteristics of all participants in this study were characterized using descriptive statistics. The migration disparity in the sociodemographic characteristics of the MEFC was determined using the chi-square test. The migration disparity in oral health status, loneliness, and sleep quality was determined using the *t*-test. Statistical significance was set at 0.05, and all analyses were carried out using the Statistical Package for Social Sciences version 26.0 (SPSS, IBM, Armonk, New York, USA). Structural equation modeling (SEM) was used to investigate the impact of migration type on the association between oral health status, loneliness, and sleep quality among the MEFC in Weifang, Shandong Province. The best fit model was estimated using the maximum likelihood estimate. This study used fitness indices; goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). Hypothetical models were considered well-fitted to the data when GFI was >0.90, AGFI was >0.90, CFI was >0.90, and RMSEA was <0.05 (32). SEM was run using AMOS version 24.0 (IBM, Armonk, New York, NY, USA).

3. Results

3.1. Sample characteristics

Table 1 presents the demographic characteristics of the sample, with 613 MEFC included in the data analysis; 525 from rural areas and 88 from urban areas, indicating that the MEFC in this study were mainly from rural areas. Among the rural-to-urban (RTU) MEFC, 400 MEFC were women (76.2%), revealing that most RTU MEFC were elderly women; 496 were aged between 60 and 75 years (94.5%); most had a low educational level, 322 had only a primary school diploma or less (61.3%), and only two had a university education (0.4%); 459 had a spouse (87.4%); 234 received a pension (44.6%), confirming the low pension coverage for the rural elderly; 303 had moved in <5 years (57.7%), indicating that the main purpose of their migration was to take care of their grandchildren; 381 people moved across districts and counties (72.6%), 114 across prefecture-level cities (21.7%), and only 30 across provinces (5.7%), suggesting that most RTU MEFC migration distances were not too far. Concerning the urban-to-urban (UTU) MEFC, 48 were women (54.5%); 72 were aged between 60 and 75 years (81.8%); 24 had primary school education level or below (27.3%), 16 had a university degree (18.2%), revealing that most UTU MEFC were well educated; 80 had a spouse (90.9%); 80 received a pension (90.9%), indicating that the urban elderly had a wider pension coverage; 43 had moved in <5 years

(48.9%); 49 moved across districts and counties (55.7%), 16 moved across prefecture-level cities (18.2%), and 23 were across provinces (26.1%).

The differences between the RTU and UTU MEFC were significant in sex, age, education level, pension, and migration space range. Specifically, the RTU MEFC had more women than the UTU MEFC, and pension coverage was much lower in the RTU MEFC than in the UTU MEFC. Additionally, there were more people over the age of 75 in the UTU MEFC than in the RTU MEFC, and a higher percentage of people with higher education in the UTU MEFC than in the RTU MEFC. Additionally, more people moved across provinces compared to the RTU MEFC.

Table 2 presents the general characteristics of oral health status, loneliness, and sleep quality according to migration type. The total GOHAI score was 54.65 ± 6.69 for the RTU MEFC and 56.72 ± 4.62 for the UTU MEFC, suggesting that the GOHAI scores were higher in the latter. Statistical differences were observed between the RTU and UTU MEFC in the total GOHAI score ($t = -2.786$, $p < 0.001$), physical function ($t = -2.468$, $p < 0.01$), psychosocial function ($t = -1.975$, $p < 0.01$), and pain and discomfort ($t = -2.568$, $p < 0.01$), indicating that the RTU MEFC obtained lower GOHAI scores than the UTU MEFC in all three aspects.

The total loneliness score for the RTU and UTU MEFC was 8.63 ± 3.06 and 8.27 ± 2.89, respectively, with no significant differences ($t = 1.019$, $p = 0.353$). There were significant differences between the two items: often feeling without friends ($t = 1.641$, $p < 0.05$) and feeling left out ($t = 1.354$, $p < 0.05$), implying that the RTU MEFC felt more without friends and left out.

No statistical significance was observed in the total sleep quality score between the RTU (4.57 ± 3.57) and UTU (3.88 ± 3.34) MEFC. However, there were significant differences between sleep latency ($t = 4.546$, $p < 0.05$) and the use of sleep medications ($t = 7.055$, $p < 0.05$), indicating that the RTU MEFC had poor sleep quality.

3.2. The structural model

3.2.1. Measurement consistency across migration types

The related fit statistics of the invariance of measures across migration type and fitness index for the five chosen models are presented in Table 3. First, the fitness indices of the RTU and UTU MEFC were compared to determine whether the variable "migration type" was suitable for group comparison.

The GFI, AGFI, CFI, and RMSEA were the model fitness indices used in this study. The fitness indices of the RTU and UTU MEFC were identical in M_1 and M_2 (GFI = 0.924, AGFI = 0.897, CFI = 0.929, and RMSEA = 0.042), as shown in Table 3. This indicates that we could further examine the measurement invariance of the RTU and UTU MEFC on the other models that follow.

Measurement invariance was then evaluated using ΔCFI and ΔRMSEA between M_3 (unconstrained model), M_4 (measurement weights model), and M_5 (structural weights model). In the model, M_3 did not restrict any coefficients; M_4 assumed that the indicator loadings for the corresponding construct in each group are the same; and M_5 restricted the indicator loadings of the corresponding construct as well as the structural coefficients between the groups.

According to Table 3 ΔCFI was 0.001 between M_4 and M_3 and 0.002 between M_5 and M_4. The fact that all ΔCFI values are <0.010 indicates that the models of M_1, M_2, M_3, M_4, and M_5 have established measurement invariance across migration types. Between M_4 and M_3, ΔRMSEA was 0.001, and between M_5 and M_4, it was 0. The fact that all the ΔRMSEA values being <0.015 also indicates that the models M_1, M_2, M_3, M_4, and M_5 in the RTU and UTU MEFC groups have established measurement invariance.

3.2.2. Model fitness indices

Figures 1, 2, which show the proposed models for the RTU and UTU MEFC, respectively, contain three variables: oral health status, loneliness, and sleep quality. Table 3 displays the model fitness indices for various models, with M_1 (RTU MEFC) and M_2 (UTU MEFC) being the focus here. The RTU and UTU MEFC both had the same estimated value for model fitness: GFI = 0.924 > 0.90, AGFI = 0.897 > 0.80, CFI = 0.929 > 0.90, and RMSEA = 0.042 < 0.05, indicating that the theoretical model perfectly matched the empirical data for both RTU and UTU MEFC.

3.3. Assessment of the relationship between oral health status, loneliness, and sleep quality with SEM

3.3.1. Association between oral health status and sleep quality

The association between oral health status, loneliness, and sleep quality is shown in Figures 1, 2 and Table 4.

Oral health status and its indicators directly or indirectly affected sleep quality. Oral health status had a positive and direct effect on sleep quality among both RTU (standardized direct effects = 0.292) and UTU MEFC (standardized direct effects = 0.417). Oral health status could positively and indirectly affect sleep quality among the RTU MEFC (standardized indirect effects = 0.042). There was no indirect effect for the UTU MEFC. The positive effect of oral health status on sleep quality was stronger for the UTU MEFC than for the RTU MEFC (standardized total effects = 0.407 for the UTU MEFC; standardized total effects = 0.334 for the RTU MEFC). The standardized total effect was statistically significant for both groups.

3.3.2. Association between oral health status and loneliness

Oral health status directly affected loneliness negatively for the RTU and UTU MEFC (standardized total effects = −0.242 for the RTU MEFC; standardized total effects = −0.582 for the UTU MEFC), indicating that better oral health among the MEFC correlated with less loneliness. A significant relationship was observed between oral health status and loneliness for the RTU and UTU MEFC; nevertheless, the association was higher in the UTU MEFC than in the RTU MEFC.

TABLE 1 Characteristics of the migrant elderly following children (MEFC) by migration type.

Variables	Total ($n = 613$) n (%)	Migration type		χ^2/P
		RTU ($n = 525$) n (%)	UTU ($n = 88$) n (%)	
Gender				
Male	165 (26.9)	125 (23.8)	40 (45.5)	17.950***
Female	448 (73.1)	400 (76.2)	48 (54.5)	
Age				
60–75	568 (92.7)	496 (94.5)	72 (81.8)	17.753***
76 years old and above	45 (7.3)	29 (5.5)	16 (18.2)	
Education level				
Primary school and below	346 (56.4)	322 (61.3)	24 (27.3)	109.561***
Junior high school	158 (25.8)	135 (25.7)	23 (26.1)	
High school/technical secondary school	91 (14.8)	66 (12.6)	25 (28.4)	
University degree or above	18 (3.0)	2 (0.4)	16 (18.2)	
Marital status				
With a spouse	539 (87.9)	459 (87.4)	80 (90.9)	0.860
No spouse	74 (12.1)	66 (12.6)	8 (9.1)	
Having a pension				
Yes	314 (51.2)	234 (44.6)	80 (90.9)	64.769***
No	299 (48.8)	291 (55.4)	8 (9.1)	
Years of migration				
5 years and below	346 (56.4)	303 (57.7)	43 (48.9)	2.401
More than 5 years	267 (43.6)	222 (42.3)	45 (51.1)	
Migration space range				
Cross-district/county	430 (70.1)	381 (72.6)	49 (55.7)	39.863***
Cross prefecture level cities	130 (21.2)	114 (21.7)	16 (18.2)	
Cross-provincial	53 (8.7)	30 (5.7)	23 (26.1)	

RTU, rural-to-urban; UTU, urban-to-urban.
***$p < 0.001$.

3.3.3. Association between loneliness and sleep quality

Regarding the relationship between loneliness and sleep quality, loneliness among the RTU MEFC had a direct negative effect on sleep quality (standardized total effects = −0.174), indicating that a higher feeling of loneliness was associated with poor sleep quality. However, the relationship between loneliness and sleep quality among the UTU MEFC was not significant.

4. Discussion

4.1. Key study findings

This was the first study to explore the relationship between oral health status, loneliness, and sleep quality among the MEFC using SEM. We observed that oral health status was positively associated with sleep quality and negatively correlated with loneliness. In addition, loneliness was negatively associated with sleep quality. Significant differences were observed in the three aforementioned associations between the UTU and RTU MEFC.

4.2. Demographic characteristics of participants

Most RTU MEFC in this study were women. This might be because women take on more childcare responsibilities than men in traditional Chinese culture (33). Therefore, in this study, women accounted for a higher proportion of the MEFC who moved with their children to the city to care for their grandchildren than men. In addition, the UTU MEFC had a higher level of education, according to existing research findings, and demonstrated the persistent urban–rural divide in China (34). Most UTU MEFC received pensions, while fewer than half of the RTU MEFC received pensions, indicating that the government

TABLE 2 General characteristics of the Geriatric Oral Health Assessment Index (GOHAI), loneliness, and sleep quality among the participants by migration type [mean ± standard deviation (SD)].

Variables	Total	Migration type		t/*P*
	(*n* = 613)	RTU (*n* = 525)	UTU (*n* = 88)	
GOHAI				
Total	54.95 ± 6.47	54.65 ± 6.69	56.72 ± 4.62	2.786***
Physical function	17.35 ± 3.44	17.21 ± 3.49	18.18 ± 3.03	−2.468**
Psychosocial function	24.10 ± 2.06	24.03 ± 2.15	24.50 ± 1.35	1.975***
Pain and discomfort	13.50 ± 2.12	13.41 ± 2.14	14.03 ± 1.86	−2.568**
Loneliness (ULS-6)				
Total	8.58 ± 3.03	8.63 ± 3.06	8.27 ± 2.89	1.019
Often feel lack of friends	1.53 ± 0.79	1.55 ± 0.79	1.40 ± 0.75	1.641*
Often feel no one can be trusted	1.47 ± 0.73	1.47 ± 0.74	1.47 ± 0.69	0.032
Often feel left out	1.37 ± 0.62	1.38 ± 0.63	1.28 ± 0.55	1.354*
Often feel separated from others	1.37 ± 0.67	1.37 ± 0.67	1.38 ± 0.67	−0.071
Often feel shy	1.36 ± 0.64	1.37 ± 0.64	1.32 ± 0.62	0.675
Often feel surrounded by people but not cared	1.49 ± 0.72	1.50 ± 0.73	1.43 ± 0.64	0.765
Sleep quality (PSQI)				
Total	4.47 ± 3.60	4.57 ± 3.57	3.88 ± 3.34	1.197
Subjective sleep quality	0.88 ± 0.83	0.89 ± 0.82	0.80 ± 0.83	0.100
Sleep latency	1.11 ± 1.20	1.15 ± 1.21	0.92 ± 1.14	4.546*
Sleep Continuity	0.84 ± 0.91	0.84 ± 0.90	0.85 ± 0.94	0.629
Habitual sleep efficiency	0.16 ± 0.50	0.17 ± 0.51	0.11 ± 0.49	2.948
Sleep disorder	0.97 ± 0.56	0.99 ± 0.56	0.84 ± 0.52	2.003
Use of sleep medicine	0.13 ± 0.55	0.14 ± 0.57	0.06 ± 0.38	7.055**
Daytime dysfunction	0.52 ± 0.78	0.53 ± 0.78	0.43 ± 0.75	1.452

RTU, rural-to-urban; UTU, urban-to-urban.
*p < 0.05, **p < 0.01, ***p < 0.001.

TABLE 3 Multi-group model invariance test.

Model	χ^2	df	χ^2/df	GFI	AGFI	CFI	RMSEA	ΔCFI	ΔRMSEA
M_1	410.613***	200	2.053	0.924	0.897	0.929	0.042	–	–
M_2	410.613***	200	2.053	0.924	0.897	0.929	0.042	0	0
M_3	410.613***	200	2.053	0.924	0.897	0.929	0.042	0	0
M_4	428.586***	213	2.012	0.921	0.900	0.928	0.041	0.001	0.001
M_5	437.204***	216	2.024	0.919	0.898	0.926	0.041	0.002	0

M_1, RTU MEFC; M_2, UTU MEFC; M_3, unconstrained; M_4, measurement weights; M_5, structural weights. χ^2, Chi-square; df, degrees of freedom; GFI, goodness-of-fit index; AGFI, adjusted goodness-of-fit index; CFI, comparative fitness index; RMSEA, root mean square error of approximation; ΔCFI, change of CFI; ΔRMSEA, change of RMSEA.
***p < 0.001.

should increase the pension for the rural elderly (35). Most RTU MEFC migration included cross-district/county (followed by cross-prefecture-level and cross-provincial cities). In contrast, almost half of the UTU MEFC's migration was cross-district/county (followed by cross-provincial- and cross-prefecture-level cities). This may be because rural people have fewer resources than people from urban areas, which results in different migration space ranges (the RTU MEFC have a shorter migration space range than the UTU MEFC).

4.3. Status of MEFC's oral health, loneliness, and sleep quality

In this study, the MEFC had a higher GOHAI score compared to previous Chinese studies (36, 37), indicating better oral health. This may be because Weifang City is famous for its high vegetable production, and the intake of more vegetable fiber benefits oral health (38). Regarding the migration type difference, the UTU MEFC had better oral health than the RTU MEFC, in accordance with previous

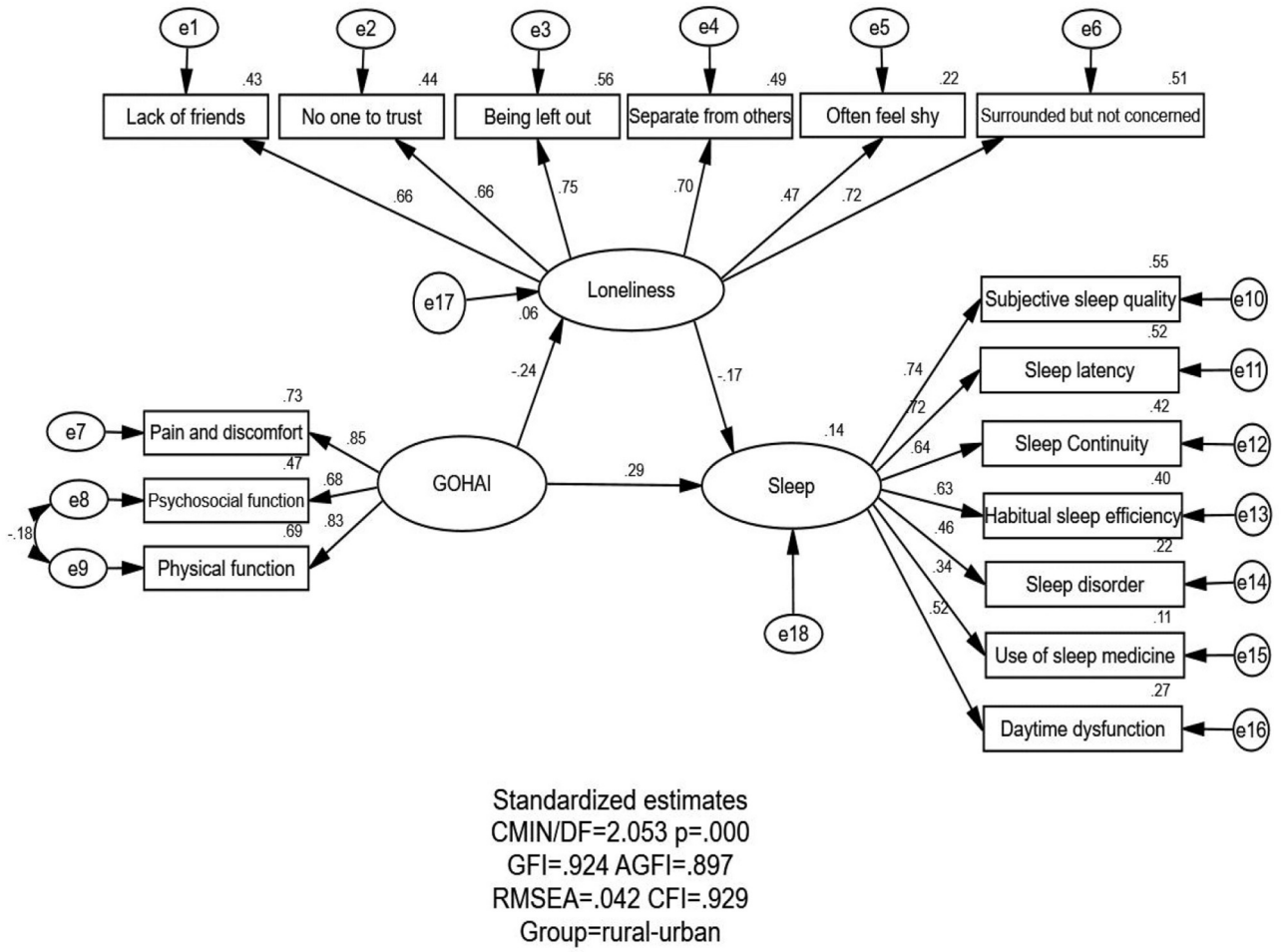

FIGURE 1
Structural equation modeling (SEM) analysis of the association between oral health status, loneliness, and sleep quality among the RTU MEFC ($n = 525$). All parameter estimates were statistically significant ($p < 0.05$). χ^2, chi-square; GFI, goodness-of-fit index; AGFI, adjusted goodness-of-fit index; CFI, comparative fitness index; RMSEA, root mean square error of approximation.

findings among older people in the USA (39), Indonesia (40), and Brazil (41). The reason may be that older rural people use less oral health services and have poor hygiene practices (42).

In this study, the UTU and RTU MEFC had fairly low loneliness, which differed from existing studies in the USA (43), Korea (44), and the Philippines (45) that revealed loneliness to be higher in the migrant elderly. A reason may be that accompanying family members in the inflow city decrease loneliness among the MEFC. Moreover, the RTU MEFC had longer sleep latency and used sleep medications more frequently than the UTU MEFC. This is consistent with previous studies on poor sleep quality among older Chinese people in rural areas (46, 47).

4.4. The relationship between oral health status, loneliness, and sleep quality

4.4.1. Oral health status and sleep quality

This study uncovered a positive association between oral health status and sleep quality among the MEFC, in accordance with the results of studies in the Korean (48) and Italian (49) elderly. The results also explained why people with poor oral health had poor sleep quality. Wang et al. observed that oral health was strongly associated with sleep and a major determinant of sleep quality among the Chinese elderly (50). Yuan et al. also revealed that sleep quality was worse in patients with periodontitis than in those without periodontitis among elderly Chinese dental patients, with patients with severe periodontitis having the worst sleep quality (51). Previous studies explored the effects of cognition (52), depression (53), and chronic diseases (54, 55) on sleep quality among the elderly. Yet, few studies have clarified the influence of oral health on sleep quality among the migrant elderly. Therefore, this study extends beyond previous studies.

Concerning the migration type difference, the relationship between oral health status and sleep quality was stronger in the UTU MEFC than in the RTU MEFC. A reason can be that the UTU MEFC may be more health literate (56) and have a healthier lifestyle and more focus on their health than the RTU MEFC, which may further result in a higher correlation between oral health status and sleep quality. Moreover, for the RTU MEFC, due to their migration from rural areas, the new urban environment, interpersonal relationships, and living habits may have a greater impact on them, which may lead to the neglect of their oral health and less attention paid to sleep quality.

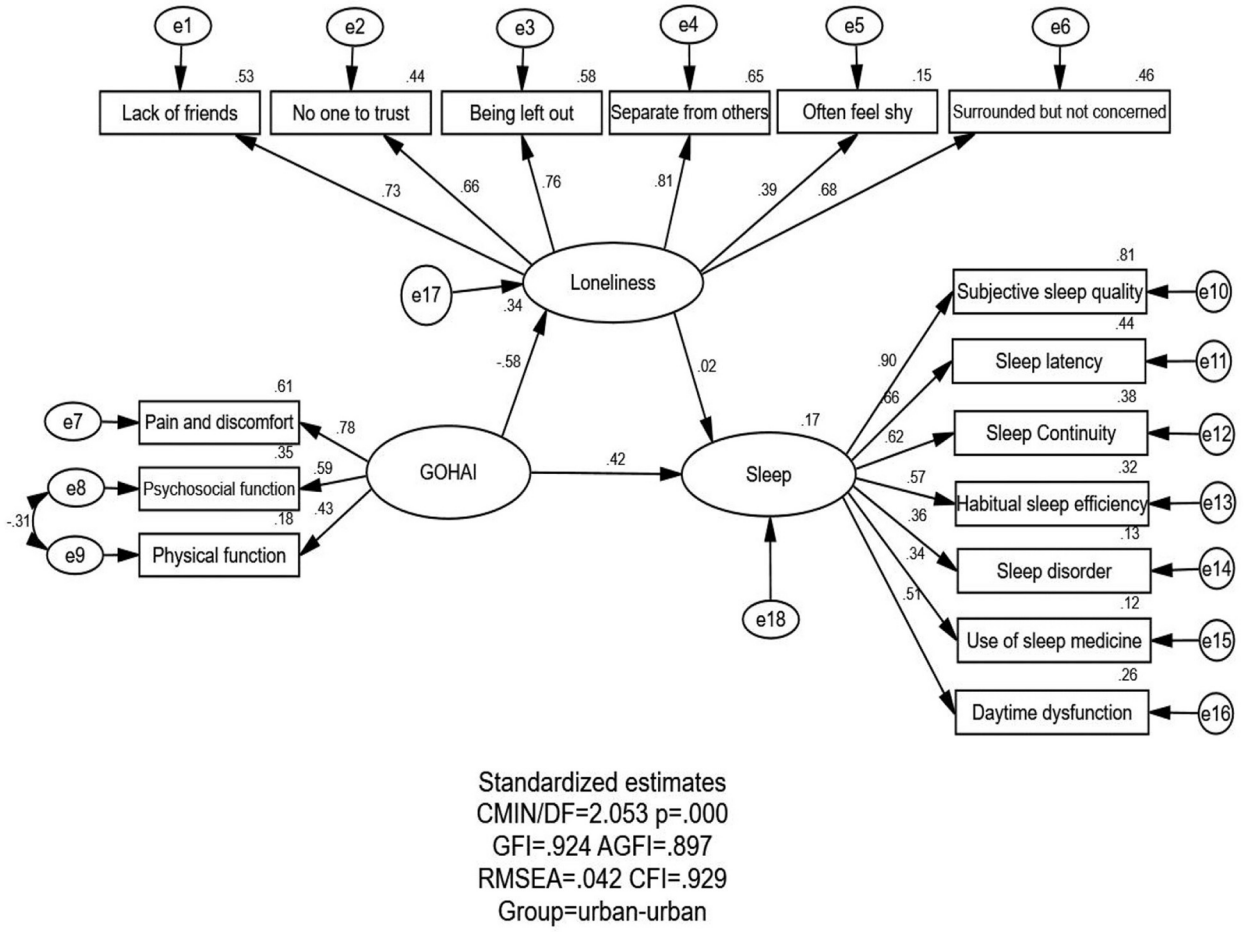

FIGURE 2
SEM analysis of the association between oral health status, loneliness, and sleep quality among the UTU MEFC ($n = 88$). The loneliness → sleep quality pathway was not significant, and the remaining parameter estimates were statistically significant ($p < 0.05$). χ^2, chi square; GFI, goodness-of-fit index; AGFI, adjusted goodness-of-fit index; CFI, comparative fitness index; RMSEA, root mean square error of approximation.

TABLE 4 Standardized effects between GOHAI, loneliness, and sleep quality by migration type.

Variable	Direct		Indirect		Total	
	RTU	UTU	RTU	UTU	RTU	UTU
GOHAI → Sleep quality	0.292**	0.417*	0.042***	−0.010	0.334**	0.407*
Loneliness → Sleep quality	−0.174**	−0.018	–	–	−0.174**	−0.018
GOHAI → Loneliness	−0.242**	−0.582**	–	–	−0.242**	−0.582**

*p < 0.05, ** p < 0.01, *** p < 0.001.

4.4.2. Loneliness and sleep quality

Loneliness was negatively correlated with sleep quality among the MEFC in this study, consistent with Griffin et al.'s study, which showed that higher levels of loneliness were associated with more sleep disturbance among older Americans (57). Fu et al.'s study of older people in Shandong Province also revealed that subjective sleep quality, time to sleep, sleep disturbance, and daytime dysfunction were significantly associated with loneliness (58).

Regarding the migration type difference, loneliness had a negative association with sleep quality for the RTU MEFC. However, no such association was observed for UTU MEFC in contrast to Cao's study in China (59), which revealed that loneliness was significantly associated with sleep quality among the retired elderly in cities. A reason might be that the movement of RTU MEFC from a rural area resulted in more environmental or lifestyle differences between the inflow city and their hometown. Thus, they are more anxious and lonelier, resulting in worse sleep quality. However, the differences between the inflow city and their hometowns might be less for the UTU MEFC, resulting in no empirical relationship between loneliness and sleep quality.

4.4.3. Oral health status and loneliness

There was a negative association between oral health status and loneliness among the MEFC in this study, similar to Hajek et al.'s study (60), which revealed that previous studies had confirmed a relationship between oral health and loneliness. Ma's study of older people in the Chinese community revealed that chewing function,

swallowing function, tooth loss, dental function, and toothache were factors influencing loneliness and that attention should be paid to maintaining and promoting oral function and reducing loneliness among the elderly (61).

As for the disparity in migration type, the negative effect of oral health status on loneliness was stronger for the UTU MEFC than for the RTU MEFC. The reason might be that the UTU MEFC enjoyed medical insurance and better oral health services in their hometown (62). In addition, their comparatively better lifestyle may result in better oral health and fewer oral problems. However, when oral health challenges occur, the disconnection of medical insurance after migration from their hometown to the inflow city, and their unfamiliarity with the medical facilities and medical services, make them feel lonely. In contrast, the hometown lifestyle of RTU MEFC may not be as good as that of the UTU MEFC, resulting in more oral problems to which they would have adapted, even when the oral problems occurring in the inflow city may still cause fewer mental fluctuations and loneliness.

4.5. Future implications

As a large group in the urbanization process, more attention should be paid to the health status of the MEFC. Due to the huge urban–rural disparity in China, different supportive measures need to be taken for the UTU and RTU MEFC. First, health education on oral health, loneliness, and sleep should be provided to the MEFC, especially the RTU MEFC. Second, the government should increase the pension of the RTU MEFC groups to reduce the urban–rural disparity. Third, because oral health status was positively correlated with sleep quality and negatively correlated with loneliness, relevant policies (i.e., increasing the reimbursement ratio of dental services) are needed to improve the oral health status of the MEFC group. Fourth, as a negative relationship between loneliness and sleep quality only existed in the RTU MEFC group in this study, it is suggested that the community pay more attention to the RTU MEFC (such as by organizing more community activities and visiting them more often). At the same time, family members should provide more care to them to reduce their loneliness and help them adapt to a new life in the inflow city.

4.6. Limitations

This study had several limitations. First, this was a cross-sectional study, and causality could not be predicted. Second, the study was conducted using a self-assessment scale, which might have introduced some bias. Third, other confounding factors that might also affect sleep quality among the MEFC were not included in this study (such as stress and depression) and should be included in future studies. Fourth, this study could not be conducted in other places, such as Shanghai, due to the epidemic. Therefore, no further areas could be validated.

5. Conclusions

This study clarified sleep quality among the MEFC and an empirical relationship between oral health status, loneliness, and sleep quality among the MEFC in Weifang, Shandong Province. The total sleep quality score of the MEFC was 4.47 ± 3.60, which was higher than that in previous studies. Oral health and sleep quality were significantly and positively correlated for the RTU and UTU MEFC, with a slightly stronger association for the UTU MEFC. There was a significant negative correlation between oral health and loneliness among the RTU and UTU MEFC, with a stronger correlation in the UTU MEFC. Therefore, loneliness could negatively impact sleep quality among the RTU MEFC. However, no statistical association was observed in the UTU MEFC.

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 Ethical Committee of Shandong University (No. 20180225). The patients/participants provided their written informed consent to participate in this study.

Author contributions

Conceptualization, writing—review and editing, and supervision: SL, LX, FK, and XG. Methodology, validation, resources, and data curation: FK. Software, formal analysis, and writing—original draft preparation: XJ. Investigation: XJ, GL, JX, HL, JW, and MP. The published version of the manuscript has been approved by all authors who have read it.

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Conflict of interest

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

Publisher's note

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR,
China

REVIEWED BY
Vicente Estrada,
San Carlos University Clinical Hospital,
Spain
Pariya Wheeler,
University of Alabama at Birmingham,
United States

*CORRESPONDENCE
Xingli Li
✉ lixingli@csu.edu.cn

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A moderated mediation analysis of depression and age on the relationship between resilience and frailty among HIV-positive adults

Lijun Meng[1], Dan Chen[2], Peiwu Hu[3], Meng Yao[1], Cui Zhou[1] and Xingli Li[1]*

[1]Department of Epidemiology and Health Statistics, Xiang Ya School of Public Health, Central South University, Changsha, Hunan, China, [2]Wuhan Health Information Center, Wuhan, Hubei, China, [3]Scientific Research Department, Xiangya Hospital of Central South University, Changsha, Hunan, China

Background: Given the continuing challenges frailty poses among people living with human immunodeficiency virus (HIV) (PLHIV), accumulating evidence suggests that frailty is linked to psychological factors. However, the mutual influences of resilience, depression, and frailty have not yet been clarified. This study aimed to identify the potential mechanistic pathway through which psychological factors mitigate frailty.

Methods: Data were collected from June to August 2019 by trained investigators through face-to-face interviews with 375 HIV-positive Chinese adults. Each participant completed structured questionnaires to collect data in respect of their socio-demographic characteristics, and levels of frailty, depression, and resilience. These assessment measures included a self-designed questionnaire, the Tilburg Frailty Indicator (TFI), the 10-item Center for Epidemiological Studies Depression Scale (CES-D-10), and the 10-item Connor-Davidson Resilience Scale (CD-RISC-10). SPSS PROCESS macro was used to analyze the mediation and moderated mediation models.

Results: The overall prevalence of frailty was 26.4%, and the prevalence of frailty among older and younger adults living with HIV was 22 and 31.4%, respectively. Mediation analysis showed that an association between resilience and frailty was mediated by depression, whereas resilience did not mediate the relationship between depression and frailty. Compared to physical frailty, depression was a stronger mediator of resilience to psychological frailty. We further found that age moderated the indirect effect of resilience on psychological frailty, with resilience being a stronger negative predictor of depression and depression being a stronger positive predictor of psychological frailty for older PLHIV than for younger PLHIV.

Conclusion: Lower levels of resilience and greater levels of depression may be significant risk factors for frailty among PLHIV. Levels of resilience influenced frailty directly and frailty was indirectly affected by depression. Therefore, it is recommended that PLHIV, especially older patients, should be encouraged to establish positive psychological coping strategies to slow the progression of frailty.

KEYWORDS

HIV/AIDS, adults, frailty, resilience, depression, age, moderated mediation

1. Introduction

With the extensive use of highly effective antiretroviral therapy, the human immunodeficiency virus (HIV) has gradually been transformed from a lethal infection to a manageable chronic condition, allowing a growing number of people living with HIV (PLHIV) to survive longer with increased quality of life (1, 2). A Dutch cohort study further estimated that by 2030, the median age of HIV- infected patients would increase by 12.7 years compared to the age in 2010, with the proportion of patients aged 50 years or older increasing by 73% (3). These developments have required a greater focus on reducing PLHIV's vulnerability to the adverse effects associated with aging.

Frailty is a common geriatric syndrome that results from the interactions of an individual's physical, psychological, and social environment, which can lead to a series of adverse consequences (4). Previous studies found that HIV infection may accelerate the onset of the detrimental consequences of aging, leaving PLHIV to face the challenge of age-related diseases at an earlier age than their uninfected peers (5, 6). Compared with individuals who are not infected, frailty occurs approximately 10–15 years earlier, and has a higher prevalence in PLHIV, ranging from 5 to 28.6% (7, 8). Although many corresponding indicators of frailty have been identified, there is little known about the psychosocial factors related to frailty among PLHIV.

Resilience is a psychosocial factor that refers to an individual's ability to recover from negative experiences and adapt well to adversity (9). It is becoming increasingly important as a protective factor against negative psychological health outcomes that may enable PLHIV to overcome the negative effects of the challenges facing this specific subsection of the population (10, 11). Studies on non-HIV-infected populations have demonstrated that resilience is inversely correlated with frailty, implying that people with low levels of resilience may experience higher rates of frailty (8, 12). However, the mechanisms underlying the effects of resilience on frailty remain unclear. As a result of this we developed Hypothesis 1 (*H1*) as follows: Resilience is negatively associated with frailty.

Depression, a common mental disorder in PLHIV, is another focus area of research on risk factors of frailty (13). There is mounting evidence of a high prevalence of depression among PLHIV due to the number of chronic HIV-related problems experienced by PLHIV, such as social stigma or inadequate social support (14), with estimates that up to 80% of patients are affected. With this precept, hypothesis 2 (*H2*) was developed in the present study: Depression is positively predictive of frailty. Extensive research on non-HIV infected populations has presented results that suggest that severe depressive symptoms are associated with lower levels of resilience and greater levels of frailty (13, 15, 16). Resilience is a factor known to be associated with positive health outcomes, thus hypothesis 3 (*H3*) was proposed: Resilience plays a mediating role in the relationship between the relationship between depression and frailty. Also, considering the relationship between low resilience and frailty, other potential factors may be involved in the progression from low levels of resilience to severe frailty. Prior studies have examined the mediating role of depression in other relationships (17, 18), yet few studies have explored the underlying mediating mechanisms between resilience and frailty. In light of this, Hypothesis 4 (*H4*) was developed: Depression plays a mediating role in the relationship between resilience and frailty.

Moreover, with the increase in life expectancy and the extension of the period of aging among PLHIV, age-related differences in various health indicators have become more pronounced. On the one hand, the incidence of frailty increases with age, and the risk of occurrence is particularly high in PLHIV aged 50 years or older (7, 19). However, a large body of research has shown that there are some differences in the physical and mental health of PLHIV across age groups, with older adults generally facing additional psychological challenges when compared to their uninfected counterparts (20–22). Therefore, the relationship between resilience and frailty or depression and frailty has different mediating effects and it would seem that these effects are dependent on the age of the individual. Consequently, Hypothesis 5 (*H5*) was developed as follows: Age is a moderator of the mediating effect of depression on the relationship between resilience and frailty or resilience on the relationship between depression and frailty.

To investigate the above five hypotheses and determine the potential mediating mechanism affecting frailty in a sample of HIV-positive Chinese adults, two moderated mediation models were constructed (Figure 1). To the best of our knowledge, there are no previous studies that have been conducted on the effect of psychological factors on frailty in this particular population, and even less is known about the mediating role of the relationship between the variables. We also intended to test the theory that age moderates the mediating relationship associated with frailty.

2. Materials and methods

2.1. Participants and procedure

We selected the First Hospital of Changsha City as the study site since it is the municipal designated hospital for HIV and acquired immune deficiency syndrome (AIDS) treatment in the provincial capital city of Hunan Province. As such it attracts patients with characteristics different from those of most of the surrounding prefecture-level cities. We performed a cross-sectional study of patients receiving in-or out-patient treatment at this hospital for the period June to August 2019. Data in respect of the patients clinical characteristics were obtained from the Chinese AIDS registration system. A pre-survey was conducted before the official start of the study, and the contact details of the participants were obtained. After the participants completed the survey all questionnaires were checked to ensure that they had been completed correctly and in full, and 22 invalid questionnaires had to be excluded.

In the present study, the sample size was estimated based on the formula for the cross-sectional survey being: $n = \frac{Z^2_{\alpha/2} \times p(1-p)}{\delta^2}$, where $Z_{\alpha/2}$ was the statistic of a significance test, p was the expected prevalence rate, and δ was the margin of error. Considering the previous literature on the prevalence of frailty in PLHIV of 40%, $\alpha = 0.05$, $\delta = 0.08$, a sample size of at least 150 individuals was calculated. Considering the validity of the questionnaire and the possibility of incomplete or invalid responses, it was decided that the sample size should be increased appropriately. The participants had to meet the following inclusion criteria: (i) adults (aged ≥18 years) who were not pregnant or lactating, (ii) diagnosed with HIV infection or AIDS, and (iii) understood the aim of the study and were willing and able to complete the questionnaire. This study was designed in

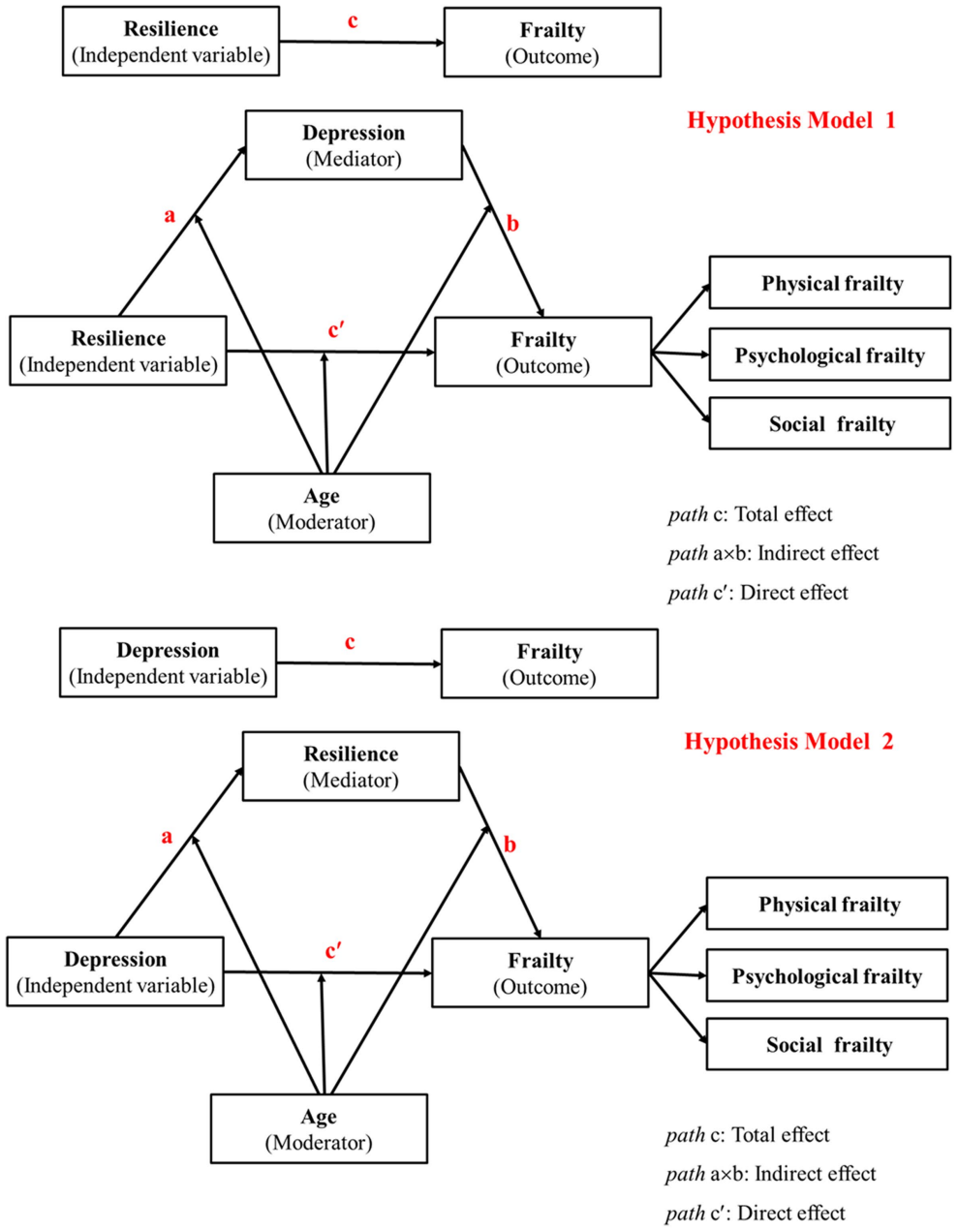

FIGURE 1
Hypothesis models of age as a moderator of the relationship between resilience, depression and frailty.

accordance with the principles of the Declaration of Helsinki and was approved by the Ethical Review Committee of the Xiangya School of Public Health, Central South University (XYGW-2019-20). Informed consent was obtained from the participants before the study began and all data were analyzed after ensuring the participant's details were to be kept confidential (e.g., name and contact details).

2.2. Measures

2.2.1. Socio-demographic characteristics

We conducted face-to-face interviews with a self-designed questionnaire to obtain demographic information and assess HIV-related factors, including age (18–49 years old, ≥50 years old), sex (men, women), ethnicity (Han ethnicity, minority), place of residence (rural, urban), employment status (employed, unemployed), level of education (primary school or less, junior school or above), marital status (married/cohabiting, divorced/separated, other), living status (lives alone, lives with others), monthly income (up to ¥3,000, over ¥3,000), period of infection (<5 years, 5–9 years, ≥10 years), showing clinical symptoms/signs (yes, no) and route of transmission (homosexual transmission, heterosexual transmission, other/unknown). Of these, clinical symptoms/signs refer to the presence of persistent fever, ulcerated rash, thrush, swollen lymph nodes, and other HIV-related symptoms or signs.

2.2.2. Frailty

The Tilburg Frailty Indicator (TFI) is a 15-item questionnaire, including three dimensions of frailty, namely physical frailty (8 items), psychological frailty (4 items) and social frailty (3 items). The questionnaire was designed to quantitatively assess frailty status, with a total TFI score of ≥5 rendering an individual frailty positive (23). Sample items from the scale included "Have you experienced a sudden and significant weight loss?" "Did you feel tired often?" "Did you receive enough help from others?" The responses to all items were scored and added together to obtain a total frailty score ranging from 0 to 15, with higher scores indicating a more severe level of frailty. Previous studies on the Chinese population have demonstrated that the TFI has good cultural adaptability, reliability and validity (24). The Cronbach's α coefficient was 0.677 for the total scale in the present study.

2.2.3. Depression

The Center for Epidemiological Studies Depression Scale (CES-D), which consists of 10 items taken from the original 30-item CES-D Scale (25), was used to evaluate the mental health of the participants during the preceding week. The participants' responses were recorded on a 4-point Likert scale (almost never = 0, sometimes = 1, often = 2, most of the time = 3), and the items "hopeful for the future" and "I am very happy" were reverse scoring items. The possible total score ranged from 0 to 30, with higher scores indicating greater depressive symptoms. The Cronbach's α coefficient of the scale in this sample was 0.814.

2.2.4. Resilience

The Connor-Davidson Resilience Scale-10 (CD-RISC-10) (26) was utilized to measure resilience, which refers to the process and ability of individuals to successfully adapt and recover from adversity or difficult life experiences. Each item was scored on a 5-point Likert scale (never = 1, rarely = 2, sometimes = 3, usually = 4, always = 5), and the total score ranged from 10 to 50, with higher scores reflecting better resilience. The Cronbach's α coefficient for the present study was 0.879.

2.3. Data analysis

Data were analyzed using IBM SPSS Statistics (version 25.0; SPSS Inc., Chicago, United States). Descriptive statistics involving the demographic characteristics of the participants and correlation analysis of the key variables were examined. The mediation and moderated mediation models were tested using the PROCESS macro program for SPSS (*Model 4 and Model 59*) developed by Hayes.[1] The bias-corrected non-parametric percentile bootstrap method was used for parameter estimation. In total 5,000 random samples were used to generate bootstrap confidence intervals to verify whether the indirect effects were significant. If the 95% confidence interval (*CI*) did not include zero, the coefficients and indirect effects were to be considered significant.

1 http://www.processmacro.org

All p values were two-tailed, with the significance level set at 0.05. In addition, employment status, level of education, monthly income, and presence of clinical symptoms/signs were controlled for as covariates in all models, and the study variables were standardized.

3. Results

3.1. Demographic characteristics of participants

A total of 375 PLHIV were interviewed. Their ages ranged from 20 to 79 years, with an average age of 48.26 years. The majority of participants were men (71.2%), of Han ethnicity (95.7%), married (59.2%), and living with others (77.1%). Regarding education level, 81.1% were junior school graduates or higher. In this study, most infections were transmitted sexually. In addition, the prevalence of frailty was higher among participants who were older, more educated, unemployed, had a lower income, and had clinical symptoms or signs (Table 1).

3.2. Correlation between resilience, depression, and frailty

The key variables were not normally distributed according to the results of the Kolmogorov–Smirnov test; thus, the Spearman rank correlation test was used to explore the relationships between the variables. The results of the correlation analysis showed that depression was negatively correlated with resilience ($r_s = -0.658$, $p < 0.01$), whereas it was positively correlated with total frailty ($r_s = 0.593$, $p < 0.01$). The dimension of social frailty was associated with neither depression nor resilience ($p > 0.05$). In addition, higher levels of resilience were associated with lower levels of frailty ($r_s = -0.47$, $p < 0.01$), and older adults reported experiencing increased frailty ($Z = -3.176$, $p < 0.01$; Table 2).

3.3. Testing the mediating role of depression and resilience

Results of the mediating effect between resilience and frailty through depression were shown in Table 3. The total effects of different pathways were significant except for the social frailty dimension, indicating an association between resilience and frailty, in particular that resilience negatively predicted frailty. In addition, the indirect effects between resilience and total frailty or physical frailty or psychological frailty through depression were all significant, supporting the mediating role of depression in the relationship between resilience and frailty was present and valid. The proportion of the mediating effects of depression in total frailty, physical frailty and psychological frailty were 82.2, 56.4, and 88.2%, respectively.

Results of the mediating effect between depression and frailty through resilience were shown in Table 4. The total effect of depression on total frailty, physical frailty, and psychological

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TABLE 1 Different demographic characteristics and the distribution of frailty (n=375).

Characteristic	N (%)	Frailty (n,%)		χ^2	p
		Yes (n=99)	No (n=276)		
Age (years old)					
18 ~ 49	200 (53.3)	44 (44.4)	156 (56.5)	4.270	**0.039***
≥50	175 (46.7)	55 (55.6)	120 (43.5)		
Sex					
Men	267 (71.2)	70 (70.7)	197 (71.4)	0.016	0.900
Women	108 (28.8)	29 (29.3)	79 (28.6)		
Ethnicity					
Han ethnicity	359 (95.7)	93 (93.9)	266 (96.4)	1.060	0.303
Minority	16 (4.3)	6 (6.1)	10 (3.6)		
Residence					
Urban	177 (47.2)	51 (51.5)	126 (45.7)	1.005	0.316
Rural	198 (52.8)	48 (48.5)	150 (54.3)		
Employment status					
Employed	220 (58.7)	47 (47.5)	173 (62.7)	6.948	**0.008****
Unemployed	155 (41.3)	52 (52.6)	103 (37.3)		
Level of education					
Primary school or less	71 (18.9)	26 (26.3)	45 (16.3)	4.708	**0.030***
Junior school or above	304 (81.1)	73 (73.7)	231 (83.7)		
Marital status					
Married/Cohabiting	222 (59.2)	58 (58.6)	164 (59.4)	0.543	0.762
Divorced/Separated	67 (17.9)	16 (16.2)	51 (18.5)		
Other	86 (22.9)	25 (25.3)	61 (22.1)		
Living status					
Lives alone	86 (22.9)	29 (29.3)	57 (20.7)	3.078	0.079
Lives with others	289 (77.1)	70 (70.7)	219 (79.3)		
Monthly income					
Up to ¥3,000	178 (47.5)	58 (58.6)	120 (43.5)	6.669	**0.010***
Over ¥3,000	197 (52.5)	41 (41.4)	156 (56.5)		
Length of infection (years)					
<5	104 (27.7)	33 (33.3)	71 (25.7)	4.573	0.102
5 ~ 9	145 (38.7)	41 (41.4)	104 (37.7)		
≥10	126 (33.6)	25 (25.3)	101 (36.6)		
Clinical symptoms/signs					
Yes	205 (54.7)	80 (80.8)	125 (45.3)	37.092	**<0.001****
No	170 (45.3)	19 (19.2)	151 (54.7)		
Route of infection					
Homosexual transmission	98 (26.1)	21 (21.2)	77 (27.9)	2.048	0.359
Heterosexual transmission	233 (62.1)	64 (64.6)	169 (61.2)		
Others/Unknown	44 (11.7)	14 (14.1)	30 (10.9)		

*p < 0.05, **p < 0.001. Comparison between groups using chi-squared test. Bold p values indicate statistical significance.

frailty was found to be significant, showing that depression was positively associated with frailty. Contrary to our expectations, no statistically significant indirect effects of the different pathways on frailty were observed, revealing that resilience did not play a mediating role in the relationship between depression and frailty.

TABLE 2 Age difference and correlation among resilience, depression and frailty.

Variable	Younger PLHIV (*n*=200)	Older PLHIV (*n*=175)	1	2	3	4	5
	M (*IQR*)	*M* (*IQR*)					
1. Total frailty scores	3.00 (3.00)	3.5 (3.5)**	1.00				
2. Physical frailty scores	1.00 (2.00)	2.00 (3.00)	0.832**	1.00			
3. Psychological frailty scores	1.00 (1.00)	1.00 (1.00)	0.649**	0.376**	1.00		
4. Social frailty scores	1.00 (1.00)	1.00 (1.00)	0.316**	−0.052	−0.028	1.00	
5. Resilience scores	40.00 (11.00)	39.00 (10.00)	−0.470**	−0.387**	−0.493**	0.007	1.00
6. Depression scores	7.00 (6.00)	6.00 (8.00)	0.593**	0.454**	0.682**	0.010	−0.658**

M, median; IQR, interquartile range. **$p < 0.01$. Comparison between groups using Mann–Whitney *U*-test.

TABLE 3 Results of mediating effect for depression between resilience and frailty.

Paths	Bootstrap effects					
	Total effect	LLCI	ULCI	Indirect effect	LLCI	ULCI
Resilience → Depression → Total frailty	−0.455	**−0.542**	**−0.367**	−0.374	**−0.461**	**−0.290**
Resilience → Depression → Physical frailty	−0.477	**−0.618**	**−0.336**	−0.269	**−0.364**	**−0.184**
Resilience → Depression → Psychological frailty	−0.491	**−0.565**	**−0.418**	−0.433	**−0.510**	**−0.361**
Resilience → Depression → Social frailty	0.004	−0.075	0.084	−0.013	−0.100	0.070

LLCI, Lower Limit 95% Confidence Interval; ULCI, Upper Limit 95% Confidence Interval. Bold numbers in the table indicated statistically significant at 0.05, which bootstrap interval did not include 0.

3.4. Testing the moderating effect of age

Moderated mediation analysis was performed in a valid mediating relationship. For total frailty and physical frailty, age only moderated *Path a*, more specifically, age moderated the predictive ability of resilience for depression. However, age did not play a moderating role in *Path b* and direct pathway (*Path c′*). In terms of psychological frailty, age moderated both the first and the second half of the indirect effect of the relationship between resilience and frailty mediated by depression (Table 5). As shown in Table 6, there was convincing evidence that the indirect effect was stronger for older PLHIV than for younger PLHIV, in which the 95% bootstrap *CI* did not include 0. Compared to younger PLHIV, resilience was a stronger negative predictor of depression and depression was a greater positive predictor of psychological frailty in older PLHIV.

4. Discussion

In this study, a moderated mediation model of frailty involving resilience, depression, and age was established in HIV-positive adults. According to our results, the major findings are as follows: (i) frailty was not only highly prevalent among older PLHIV, but also among younger PLHIV; (ii) resilience could predict frailty directly or indirectly, affecting frailty *via* depression; (iii) resilience does not play a mediating role in the relationship between depression and frailty; and (iv) age moderated the indirect effect of resilience on psychological frailty, with the effect of resilience on depression or the effect of depression on psychological frailty being more strongly associated with older PLHIV than with younger PLHIV. Our findings provide the first epidemiological evidence of the mediating role of depression in the relationship between resilience and frailty in HIV-positive adults, implying that the onset of frailty can be mitigated to a certain extent through the development of greater resilience and reduction of depressive symptoms.

The occurrence of frailty among PLHIV not only depends on aging, psychology and social environment but also on the adverse consequences of HIV infection experienced by PLHIV. Mitochondrial dysfunction induced by antiretroviral drug therapy in PLHIV may be associated with increased levels of frailty, causing frailty to occur not only in older PLHIV (27). In addition, the existing literature provides evidence that immune system dysfunction and persistent chronic inflammation caused by HIV infection accelerates the onset and degenerative process of frailty (28, 29). In the present study, frailty was more common in older PLHIV than in younger PLHIV, which is consistent with previous studies (30, 31). In addition, the overall prevalence of frailty among our participants was 26.4%, which is higher than the results of a meta-analysis of older individuals in the Chinese community (which ranged from 5.9 to 17.4%) (32). As frailty can be improved by implementing a wide range of interventions, we submit that

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TABLE 4 Results of mediating effect for resilience between depression and frailty.

Paths	Bootstrap effects					
	Total effect	LLCI	ULCI	Indirect effect	LLCI	ULCI
Depression → Resilience → Total frailty	0.586	**0.510**	**0.662**	0.054	−0.204	0.127
Depression → Resilience → Physical frailty	0.627	**0.497**	**0.758**	0.046	−0.079	0.167
Depression → Resilience → Psychological frailty	0.608	**0.548**	**0.669**	0.081	−0.018	0.142
Depression → Resilience → Social frailty	0.007	−0.070	0.010	−0.012	−0.094	0.064

LLCI, Lower Limit 95% Confidence Interval; ULCI, Upper Limit 95% Confidence Interval. Bold numbers in the table indicated statistically significant at 0.05, which bootstrap interval did not include 0.

TABLE 5 Results of age as a moderator on the relation between resilience on frailty *via* depression.

Outcome, predictor	Indicator		*β*	*SE*	*t*	LLCI	ULCI
	R^2	*F*					
Depression							
Resilience × Age	0.510	54.518**	−0.196	0.074	−2.648**	**−0.342**	**−0.050**
Total frailty							
Depression × Age	0.501	40.791**	−0.059	0.105	−1.580	−0.372	0.041
Resilience × Age			−0.166	0.107	−0.232	−0.411	0.009
Physical frailty							
Depression × Age	0.356	22.436**	−0.058	0.183	−0.319	−0.418	0.301
Resilience × Age			−0.332	0.181	−1.835	−0.688	0.024
Psychological frailty							
Depression × Age	0.566	59.410**	−0.213	0.085	−2.511*	**−0.380**	**−0.046**
Resilience × Age			−0.162	0.084	−1.936	−0.327	0.003

*$p < 0.05$, **$p < 0.001$. LLCI, Lower Limit 95% Confidence Interval; ULCI, Upper Limit 95% Confidence Interval. Bold numbers in the table indicated statistically significant at 0.05, which bootstrap interval did not include 0.

clinicians should focus their attention on attempting to prevent and slow down the onset and process of frailty.

The previous theoretical framework model considered psychological functioning to have a greater impact on frailty than physical function (33), therefore we chose to examine the effects of resilience and depression on frailty in this study. We found a strong negative association between frailty and resilience as well as a strong positive association with depression, with the ultimate results supporting and confirming *H1 and H2*. This finding validates existing evidence that resilience has been reported to be a protective factor against the low health-related quality of life problems such as disability and chronic disease (34, 35), This suggests that high levels of resilience may be useful in improving the well-being and quality of life of PLHIV who experience the onset of frailty. Consistent with the results of previous studies, depression was found to be a risk factor for frailty (36), indicating that depressed PLHIV are more likely to develop frailty.

Furthermore, this study explored the mediating role of depression in the relationship between resilience and frailty among PLHIV. The results confirmed the validity of *H4* and suggested that resilience not only affected frailty directly but also indirectly *via* depression. It is well known that PLHIV suffer many negative physical, psychological, and financial consequences, which may lead to low levels of resilience and eventually depression (37). The evidence to date supports the notion that depression and frailty are distinct structures with moderate overlap. A review of recent clinical and preclinical evidence has emphasized that depression is a risk factor for frailty, which may be explained by several mechanisms. Depressive disorder, a comorbid condition in PLHIV, is associated with impaired motivation and reduced treatment adherence (38). It has also been suggested that individuals with depression have high levels of inflammatory cytokines, which may stimulate the brain and lead to changes in nervous system function (39, 40). Elevated levels of inflammatory cytokines are strongly associated with the onset of neurological dysfunction in the brain (41), and similar biological mechanisms provide a plausible explanation for the strong correlation between depression and frailty.

TABLE 6 Results of the moderating effect of age in the indirect effects of resilience on psychological frailty.

Groups	Resilience→Depression			Depression→Psychological frailty		
	Effect	LLCI	ULCI	Effect	LLCI	ULCI
Younger PLHIV	−0.601	**−0.694**	**−0.508**	0.437	**0.522**	**0.779**
Older PLHIV	−0.767	**−0.880**	**−0.655**	0.650	**0.329**	**0.545**

LLCI, Lower Limit 95% Confidence Interval; ULCI, Upper Limit 95% Confidence Interval. Bold numbers in the table indicated statistically significant at 0.05, which bootstrap interval did not include 0.

Unfortunately, resilience had no indirect effect on the relationship between depression and frailty, implicating that resilience did not play a mediating role. This was unexpected, as a mediating role for resilience was found in previous studies (42). Clearly, a greater impact of depression on frailty compared to the impact of resilience on frailty contributed to the fact that the effect of depression on frailty was not mediated by psychological resilience in this study. Also, it is difficult to compare our sample to the geriatric population and to assess resilience and frailty with different measurements compared to other similar studies.

We further found that age moderated both the first and second half pathways of the indirect effect of resilience on psychological frailty, whereas only the first half of the pathway on physical frailty was moderated. The moderating effect on the relationship between resilience and depression was more pronounced in older PLHIV than in younger patients, indicating that resilience is a stronger negative predictor of depression in older PLHIV. Resilience may be associated with improvements in physical and psychological health and it is likely to increase with age. Earlier studies on the general population confirmed that older people have higher levels of resilience than younger people (34). Older people with high levels of resilience usually have more life experience and are able to cope better with adversity and stress than younger people. In addition, depression was more predictive of psychological frailty in older PLHIV compared to younger PLHIV, which is associated with older PLHIV experiencing the shock of aging, disease distress and HIV infection simultaneously (43). Unexpectedly, no association was evident between the direct and the second half of the indirect pathway of resilience to physical frailty across age subgroups. This suggests a stronger association between physical frailty and aging than the association with psychological function (44).

5. Limitations

This study has several limitations. First, the sample was selected only from the patients who attend the First Hospital of Changsha City, which is not representative of all PLHIV. Second, the data were obtained from participants' subjective reports and may be susceptible to participant bias. Third, this was a cross-sectional research design based on a questionnaire, and the results may not be able to fully determine the causal relationships between the variables. Future longitudinal studies with larger sample sizes are needed to explore the underlying mechanisms of frailty in PLHIV in greater detail. In addition, the complex etiology of frailty requires multidisciplinary intervention and treatment. There may also be other related factors that mediate or moderate the relationship between resilience and frailty, which necessitates further investigation.

Despite these limitations, this study revealed an association between resilience, depression, and frailty in PLHIV. In addition, it also identified a potential pathway for the occurrence of frailty in PLHIV that could provide new insights and suggestions for reducing the incidence of frailty by encouraging positive coping mechanisms in the face of negative events and increasing levels of resilience to buffer against depression.

6. Conclusion

The present study revealed that the issue of frailty in PLHIV should not be trivialized and that the current status of frailty in both older and younger PLHIV is not optimistic. Moreover, we found an association between an early onset of frailty and low levels of resilience, which was mediated by depression. Thus, in addition to focusing on the impact of physical functioning on frailty, it is critical for healthcare staff to take appropriate measures to assist patients develop effective psychological coping strategies to improve mental resilience, especially in older patients. In implementing such interventions, it would be beneficial to promote the maintenance of psychological well-being in PLHIV to reduce depression and ultimately to attempt to mitigate the consequences of frailty to a certain extent.

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 Ethical Review Committee of Xiangya School of Public Health, Central South University (XYGW-2019-20). The patients/participants provided their written informed consent to participate in this study.

Author contributions

LM: methodology, formal analysis, roles and writing-original draft, and writing-review and editing. DC: investigation, data curation, and methodology. PH: supervision, validation, visualization, and resources. MY: investigation and formal analysis. CZ: validation and visualization. XL: funding acquisition, project administration, and

writing-review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

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EDITED BY
Elsie Yan,
Hong Kong Polytechnic University,
Hong Kong SAR,
China

REVIEWED BY
Shanquan Chen,
University of Cambridge,
United Kingdom
Vishal Vennu,
Department of Health Rehabilitation Sciences,
College of Applied Medical Sciences,
King Saud University,
Saudi Arabia

*CORRESPONDENCE
Jiansong Zhou
✉ zhoujs2003@csu.edu.cn

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The impact of hearing loss on cognitive impairment: The mediating role of depressive symptoms and the moderating role of social relationships

Xia Cao[1], Qian Liu[2], Jiali Liu[3], Bingfang Yang[1] and Jiansong Zhou[3]*

[1]Health Management Center, The Third Xiangya Hospital, Central South University, Changsha, China, [2]Department of Psychology, Hunan Normal University, Changsha, China, [3]Department of Psychiatry and National Clinical Research Center for Mental Disorders, The Second Xiangya Hospital, Central South University, Changsha, China

Background: Given the potentially negative effects of hearing loss on mental health and cognitive function, it is critical to gain a better understanding of the mechanisms underlying the link between hearing loss and cognitive impairment. This study aimed to investigate the moderating effects of social relationships, including their components in the role of depressive symptoms as a mediator between hearing loss and cognitive impairment.

Methods: Cross-sectional analyses were conducted with 8,094 Chinese older adults (aged ≥65years) from the Chinese Longitudinal Healthy Longevity Survey in 2018. Simple mediation analysis and moderated mediation analysis were conducted to examine the roles of depressive symptoms and social relationships in the association between hearing loss and cognitive impairment.

Results: There is a significant correlation between hearing loss, depressive symptoms, social relationships, and cognitive function. Depressive symptoms partially mediated the association between hearing loss and cognitive function [standardized regression B-coefficient (B)=−0.114; 95% confidence interval (CI): (−0.158, −0.076)]. Social relationships moderated the effect of hearing loss on cognitive function through both path b (depressive symptoms - cognitive function) [*B*=0.021; 95% CI: (0.008, 0.034)], and path c' (hearing loss-cognitive function) [*B*=0.597; 95% CI: (0.463, 0.730)]. Furthermore, social activities and social networks moderated both the direct and indirect effects of moderated mediation. However, there appeared to be no moderated effect of social support for both the direct and indirect paths.

Conclusion: Social relationships moderated both the direct and indirect effects of depressive symptoms on the association between hearing loss and cognitive impairment. These findings shed light on the mechanisms underlying the relationship between hearing loss and cognitive impairment in Chinese older adults. It might be worthwhile to recommend multidimensional health and social interventions aimed at improving mental health and social inclusion among older adults with hearing loss.

KEYWORDS

hearing loss, cognitive impairment, depressive symptoms, social relationships, older adults

1. Introduction

Hearing loss is highly prevalent among older adults and can negatively impact many aspects of later life if not addressed or if their personal communication needs are not supported. About two-thirds of American adults over the age of 70 suffer from hearing loss, but less than 20% of them receive treatment (e.g., hearing aids) (1). In China, more than two-thirds of older adults over the age of 60 suffer from hearing loss, and this number of patients with hearing loss is expected to rise as the population ages (2). Growing evidence of an association between age-related hearing loss (ARHL) and dementia justifies the identification of ARHL as a potentially modifiable risk factor and a possible approach to improving clinical outcomes in patients with dementia.

With global aging, the prevalence of dementia is expected to double every 20 years, and the number of dementia patients worldwide is estimated to soar from 57.4 million in 2019 to 152.8 million in 2050 (3). According to a nationally representative survey conducted in China, dementia predominates among individuals aged 60 and older at 6.0%, and cognitive impairment is present at 15.5%, totaling 15.07 million people with dementia and 38.77 million people with cognitive impairment (4). A vast population with dementia and cognitive impairment has become a significant health burden not just in China but around the world, necessitating the adoption of more effective anti-dementia measures. Despite advances in treatments, neurodegenerative diseases have only achieved limited success. Since hearing loss is highly prevalent among older adults and greatly undertreated, investigating its impact on mental health and the potential social-psychological mediating or moderating factors is an appealing and potentially influential strategy for promoting healthy aging.

Depression is common in older adults. Concerningly, one in five older persons with hearing loss report clinically significant depressive symptoms that necessitate treatment, and hearing loss is also connected to the gradual introduction of new depressed symptoms over time (5). Hearing loss is associated with 1.47 higher odds of depression in older adults, according to a systematic review and meta-analysis recently (6). Most frequently, the association between hearing loss and depression has been examined in the context of psychosocial changes as people age (6). Among older adults with hearing loss, social and emotional loneliness are more likely to make them depressed (7). Meanwhile, difficulty in completing daily activities (8), reduced social activity, and weak social support services as contributing factors in this process (9). Depression may be a contributing factor to hearing loss and cognitive decline because of the overlap of their potential neuropathological mechanisms with the aging brain (10).

Additionally, behavioral explanations for the potential causal relationship discussed above have been put forth. These include social exclusion, loneliness, decreased mobility, and difficulties in everyday tasks, all of which raise the likelihood of cognitive impairment (11). Social relationships have been identified as an important factor for the maintenance or promotion of mental health and cognition among older adults (12). Social relationships, which rely on social networks, make it easier to engage in social activity and access social support (13). People who have a high level of the cognitive reserve are typically more likely to participate in social activities (14). Hence, the cognitive reserve may reduce dementia risk. Given the positive effects of close social ties on health behavior, social interaction may influence cognitive outcomes (social control hypothesis) (13). An intriguing alternative theory put out by Adolphs et al. (15) suggests that social relationships may influence cognitive performance across several domains. Social support, for example, may reduce stress and improve memory and executive function (16). However, few detailed investigations on how social relationships affect cognitive function *via* different domains have been conducted. In the context of the above theory, interindividual variability in social activity, social networks, and social support may produce different outcomes. Correspondingly, we included all three critical dimensions of social relationships in our analyses.

Overall, it is uncommon for research to be undertaken where both psychological and social pathways are addressed at the same time to comprehend how hearing loss affects cognition. Therefore, the first aim of this study was to determine whether depressive symptoms have a mediating effect on the relationship between hearing loss and cognitive impairment. Another aim of this study was to determine whether social relationships, including their components, have any moderating effect on the direct and indirect correlations between hearing loss and cognitive impairment (Supplementary Figure S1). Specifically, we proposed the following hypotheses:

> *H1*: Depressive symptoms would act as a mediator between hearing loss and cognitive impairment.
>
> *H2*: The direct and indirect correlations between hearing loss and cognitive impairment would be moderated by social relationships, with depressive symptoms acting as a mediator.
>
> *H3*: The direct and indirect correlations between hearing loss and cognitive impairment would be moderated by social activities, social networks, and social support, with depressive symptoms acting as a mediator.

2. Methods

2.1. Study design and participants

We conducted a cross-sectional analysis of the dataset derived from the eighth wave of the Chinese Longitudinal Healthy Longevity Survey (CLHLS) in 2018, a national representative prospective cohort study of Chinese adults aged 65 and older in major provinces (23 out of 31 provinces) in China. Details of the study participants and methods have been reported elsewhere (17). In the CLHLS 2018, in total, 15,874 face-to-face interviews were conducted using a standard questionnaire. A written informed consent form was obtained from each participant or proxy respondent before the survey. The research has been reviewed and approved by the Research Ethics Committee of Peking University (approval number: IRB00001052-13074). Those younger than 65 years of age ($n = 95$) were excluded from the current analysis. And we restricted our final analysis to 8,094 older adults with completed information on the questions we are concerned about. Details of the screening procedure are described in Figure 1.

Participants with no Mini-Mental State Examination (MMSE) scores, data on frailty, depression, or missing data on social ties were eliminated. If any of the sample's important variables have missing

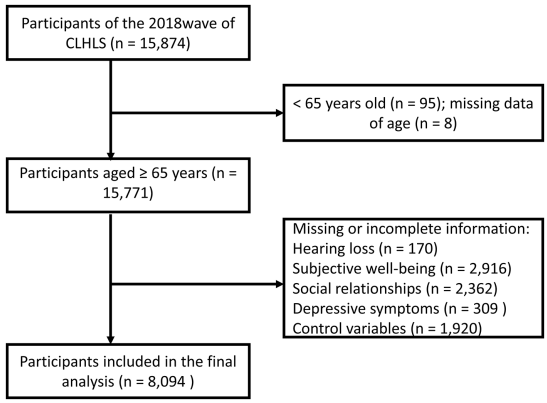

FIGURE 1
Flow chart of the selection of study participants.

values, they will be eliminated as well. This analysis comprised 7,525 individuals' data.

Based on prior research (5, 18, 19) and the design of the CLHLS questionnaire, a set of variables was selected for analysis (Supplementary Table S1).

2.2. Dependent variables

2.2.1. Cognitive function

Based on prior research, the Chinese adaptation of the modified Mini-Mental State Examination (MMSE) was utilized in this study to assess cognitive function (17, 20). The MMSE was modified by the CLHLS research team to facilitate older adults' better understanding and response. It has been widely used in prior studies and has been proven to have good validity and reliability (21–23). Scores ranged from 0 to 30, with a lower score indicating worse cognitive performance. It includes 24 items regarding orientation, attention, registration, calculation, recall, and language. Cognitive impairment was defined as an MMSE score <18, based on previous studies (24, 25). Cronbach's α coefficient of the MMSE for this study was 0.91. More details about this scale can be found in Supplementary Table S2.

2.3. Independent variables

2.3.1. Hearing loss

To assess the participants' self-perceived hearing status, the following question was asked (without hearing aids): "Do you feel you have hearing difficulty?" The response options were "Yes" (coded as having hearing loss)/"No" (signified not having hearing loss) (25, 26). Self-reported hearing loss was defined in this study as a "Yes" response to self-perceived hearing difficulties.

2.4. Mediators

2.4.1. Depressive symptoms

The 10-item Center for Epidemiologic Studies Depression (CES-D-10) was used to assess depressive symptoms, which was a self-reported scale for assessing the symptoms of depression in the past week (27). The CES-D-10 contains 10 items on somatic symptoms, depression impacts, and positive affect. In each item, a score is assigned between 0 and 3 ("rarely" to "almost always"). A total score between 0 and 30, with higher total scores indicating more severe depressive symptoms. A score of 10 or higher indicates possible depression. The CES-D-10 has been validated among older adults in China (27, 28). Cronbach's α coefficient of the CES-D-10 for this study was 0.87.

2.5. Moderator

2.5.1. Social relationships

According to previous studies (19, 29), social relationships were measured as a composite score based on three subdimensions: social activity (ranging from 0 to 3), social networks (ranging from 0 to 4), and social support (ranging from 0 to 6), with a total score ranging from 0 to 13. Detailed variable codes are presented in Supplementary Table S3.

In the context of Berkman et al.'s framework (30), playing cards/mahjong, participating in organized social activity, and visiting experiences were included in the present study, under the subdomain of social activity (29). The concept of social networks can be described as an individual's web of connections (13). It was measured based on four objective domains, including marital status, living arrangements, and having relatives or children visiting them. Based on the definitions of social support (30), the relevant entries were collected in our study based on questions about who is available to assist with six common life scenes (29), as described in Supplementary Table S3.

2.6. Covariates

As covariates, sociodemographic characteristics, lifestyles, and health status were classified as potentially related factors in previous studies (31).

2.6.1. Sociodemographic characteristics

The sociodemographic characteristics contained age (in years), gender (male, female), education (illiterate, literate), residence (rural, urban), and financial support (insufficient, sufficient).

2.6.2. Lifestyle

According to a recent study (32), a combined lifestyle score, ranging from 10 to 50, was created by summing the dietary pattern score and the daily life habits score. Since the missing proportion of the collected data in this domain was less than 5%, we chose to replace the missing values with the average score of each variable. Eight different dietary groups—including staple foods, fresh fruits and vegetables, meat, fish, sugar, milk, and nuts—had their intake frequency monitored (33). A dietary pattern score is equal to the sum of the scores of all eight food groups ranging from 7 to 38, with higher scores indicating healthier dietary patterns, which were described in previous studies (32–34). As part of the survey, participants were also asked to recall the frequency and amount of tobacco and alcohol consumption, as well as the amount of outdoor exercise they did. Scores for tobacco use and alcohol consumption ranged from 1 to 4 and 1 to 3, respectively. A higher score indicated

fewer daily smoking or drinking sessions (32). The participants were asked to rate how frequently they engaged in outdoor activities, with a score ranging from 1 to 5 in ascending order, depending on how frequently they did so. Across all daily life habits, the score ranged from 3 to 12 (32). Detailed variable codes are presented in Supplementary Table S4.

2.6.3. Health status

In this study, health status mainly involves the ability of daily living (ADL) and chronic diseases. The ADL scale was used to evaluate functional ability, which includes six domains: bathing, dressing, eating, toileting, continence, and indoor transfer. Scores were assigned based on the independence of individuals in completing each of the above actions: 1 = complete dependency, 2 = partial independence, and 3 = complete independence. After adding six items, the ADL score ranged from 6 to 18. Responses with higher scores indicated greater independence and functional ability. Cronbach's α coefficient of the ADL for this study was 0.86. Detailed variable codes are presented in Supplementary Table S5. For the health status, the CLHLS adopted a list of 13 chronic diseases or conditions (e.g., hypertension, diabetes, heart diseases, stroke, cancers, Parkinson's disease) to measure comorbidity; an individual was considered to have physical comorbidities (yes or no) if he or she self-reported more than two of these thirteen diseases or conditions at the time of the surveys (35, 36).

2.7. Statistical analysis

Summary statistics were reported as the means and standard deviation for numerical variables and as the frequency for categorical variables. Chi-square tests were employed to examine proportional differences, while t-tests were performed to compute mean differences. Pearson correlation analysis was performed to explore the linear relationships between all the variables. PROCESS SPSS macro (Hayes, A.F., Lawrence, KS, USA) was employed to examine the moderated mediation model (37). In Hayes PROCESS, the coefficients of the conditional indirect effects and conditional mediator tests are estimated along with the bias-corrected bootstrap confidence intervals. The regression-based, path-analytic framework we employed in our investigation contains Model 4, Model 59, and Model 76 from the SPSS macro-PROCESS; relevant methods can be referred to earlier works (19, 38). The relationship between hearing loss and cognitive impairment was tested with Model 4 by testing whether depressive symptoms were a mediating factor. The effect of mediation was significant if the 95% confidence interval (CI) of the indirect effects did not include 0. We then used Model 59 to examine whether social relationships mediated both direct (path c': hearing loss-cognition) and indirect effects (path a: hearing loss-depressive symptoms, and path b: depressive symptoms-cognition). A final step investigated whether the components of social relationships had direct and indirect moderating effects on hearing loss and cognitive impairment by using Model 76. In those models, covariates included age, gender, education level, marital status, residence, financial support, lifestyle scores, ADL scores, and physical comorbidities. The moderated mediation model includes all of the above-mentioned control variables, except for residence and financial support. All analyses were conducted in IBM SPSS 24.0. Significance was determined by a p-value less than 0.05 (two-sided tests).

3. Results

3.1. Sample characteristics

We examine the sample characteristics stratified by the cognitive state in Table 1. Among the 8,094 participants (3,654 male, 4,440 female), 2,248 (27.8%) reported cognitive impairment. Those with cognitive impairment were generally older, female, with lower levels of education, were widowed/separated/single, living in a rural area, with insufficient financial support, had lower lifestyle scores, and had more physical comorbidities ($p < 0.001$). Meanwhile, participants with cognitive impairment were more likely to have hearing loss, depressive symptoms, and poorer social relationships (particularly fewer social activities and fewer social networks) ($p < 0.001$). Neither group had significant differences in ADL scores ($p > 0.05$).

3.2. The correlation between the study variables

As shown in Table 2, regarding the bivariate correlations, significant associations were found between all study variables, including hearing loss, cognitive function, depressive symptoms, and social relationships. Correlation coefficients did not show evidence of severe multicollinearity, and testing of variance inflation factors confirmed that there was no concern with multicollinearity in the data. Based on these results, further studies may be justified to investigate the moderated mediation effects. In terms of specific components of social relationships, the three domains all showed similar correlations ($p < 0.001$).

3.3. The association between hearing loss and cognitive function

As shown in Table 3, Model 1 focuses on the relationship between hearing loss and cognitive function. Results indicated that hearing loss was significantly associated with cognitive function [$B = -4.620$, 95% CI: (-4.880, -4.361)]. Model 2 explored the relationship between hearing loss and cognitive function when adjusting for sociodemographic characteristics, lifestyles, and health status. Hearing loss was significantly associated with cognitive function [$B = -2.249$, 95% CI: (-2.505, -1.994)]. Age [$B = -0.186$, 95% CI: (-0.199, -0.173)], gender [$B = -1.046$, 95% CI: (-1.295, -0.797)], financial support [$B = -0.752$, 95% CI: (-1.084, -0.419)], and ADL [$B = -0.065$, 95% CI: (-0.112, -0.018)] were negatively associated with cognitive function. Education [$B = 1.793$, 95% CI: (1.526, 2.060)] and total lifestyle score [$B = 0.098$, 95% CI: (0.073, 0.124)] were positively associated with cognitive function. The significance and direction of the correlation coefficients between hearing loss and cognitive function did not change from Model 1 to Model 2, indicating that hearing loss is a significant predictor of cognitive function.

4. The mediating role of depressive symptoms in the association between hearing loss and cognitive function

To further elucidate the mechanisms underlying the association between hearing loss and cognitive function,

TABLE 1 Characteristics of the sample stratified by cognitive status.

Characteristics	Total Mean±SD or N (%)	Normal cognition Mean±SD or N (%)	Cognitive impairment Mean±SD or N (%)	χ^2 or t statistics	p-value
N	8,094	5,846	2,248	-	-
Hearing loss	2,781 (34.4)	1,510 (25.8)	1,271 (56.5)	678.93	<0.001
Depressive symptoms	2072 (25.6)	1,292 (22.1)	780 (34.7)	135.28	<0.001
CES-D-10 score	7.20 ± 4.40	6.75 ± 4.15	8.36 ± 4.80	−14.95	<0.001
MMSE score	25.35 ± 5.96	28.19 ± 1.84	16.73 ± 5.86	131.32	<0.001
Social relationships	8.56 ± 1.75	8.81 ± 1.72	7.90 ± 1.65	21.65	<0.001
Social activity	0.95 ± 0.83	1.09 ± 0.83	0.57 ± 0.70	28.98	<0.001
Social network	2.69 ± 0.92	2.83 ± 0.90	2.33 ± 0.87	22.91	<0.001
Social support	4.92 ± 1.25	4.89 ± 1.26	5.00 ± 1.19	−3.63	<0.001
Age (years)	83.43 ± 11.25	80.49 ± 10.24	90.06 ± 10.11	−41.96	<0.001
Gender					
Male	3,654 (45.1)	2,927 (50.1)	727 (32.3)	206.07	<0.001
Female	4,440 (54.9)	2,919 (49.9)	1,521 (67.7)		
Education					
Illiterate	3,657 (45.2)	2059 (35.2)	1,598 (71.1)	843.22	<0.001
Literate	4,437 (54.8)	3,787 (64.8)	650 (28.9)		
Marital status					
Married	3,787 (46.8)	3,210 (45.1)	577 (25.7)	557.98	<0.001
Widowed/separated/single	4,306 (53.2)	2,635 (54.9)	1,671 (74.3)		
Residence					
Rural	2,300 (28.4)	4,046 (69.2)	1748 (77.8)	58.33	<0.001
Urban	5,794 (71.6)	1800 (30.8)	500 (22.2)		
Financial support					
Insufficient	1,039 (12.8)	688 (11.8)	351 (15.6)	21.46	<0.001
Sufficient	7,055 (87.2)	5,158 (88.2)	1897 (84.4)		
Lifestyle score	29.93 ± 4.75	30.37 ± 4.80	28.77 ± 4.39	13.50	<0.001
ADL	16.82 ± 2.34	16.80 ± 2.37	16.80 ± 2.27	−1.590	0.112
Physical comorbidities					
Yes	2,611 (32.3)	1800 (30.8)	811 (36.1)	20.61	<0.001
No	5,483 (67.7)	4,046 (69.2)	1,437 (63.9)		

Comparison was performed using the t-test or Chi-square test. SD, standard deviation. CES-D-10, the 10-item Center for Epidemiologic Studies Depression. MMSE, Mini-Mental State Examination. ADL, the activities of daily living.
Cognitive impairment was defined as an MMSE score < 24.

we examined the mediating role of depressive symptoms. Hearing loss and depressive symptoms were positively correlated [$B = 0.745$, 95% CI: (0.527, 0.964)] in a simple mediation model (Model 4), as shown in Table 4. There was an inverse relation between depressive symptoms and cognitive function [$B = -0.153$, 95% CI: (−0.179, −0.127)]. Hearing loss was also associated with cognitive function [$B = -2.135$, 95% CI: (−2.389, −1.881)]. Furthermore, we found that hearing loss was associated with depressive symptoms, which had a significant indirect effect on cognitive function [$B = -0.114$; 95% CI: (−0.158, −0.076)], accounting for 5.07% of the total effect.

4.1. Moderated mediation effects of hearing loss on cognitive function

As shown in Supplementary Table S6, Model 59 was used to test the proposed moderated mediation model, which indicated that depressive symptoms are not affected significantly by the interaction between hearing loss and social relationships ($B = -0.056$, $p = 0.339$). However, for cognitive function, an interaction effect was observed between depressive symptoms and social relationships ($B = 0.021$, $p = 0.002$), as well as between hearing loss and social relationships ($B = 0.597$, $p < 0.001$). Therefore, the hypothesized model has been

TABLE 2 Correlations for the study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Hearing loss	–														
2. Cognitive function	−0.368**	–													
3. Depression	−0.213**	0.122**	–												
4. Social relationships	0.284**	−0.173**	−0.122**	–											
5. Social activity	0.356**	−0.209**	−0.139**	0.560**	–										
6. Social network	0.302**	−0.209**	−0.153**	0.529**	0.186**	–									
7. Social support	−0.060**	0.050**	0.034**	0.643**	−0.013	−0.119**	–								
8. Age	−0.513**	0.426**	0.100**	−0.309**	−0.362**	−0.473**	0.155**	–							
9. Gender	−0.184**	0.001	0.112**	−0.069**	−0.096**	−0.209**	0.121**	0.107**	–						
10. Education	0.370**	−0.176**	−0.146**	0.154**	0.228**	0.264**	−0.130**	−0.362**	−0.393**	–					
11. Marital status	0.331**	−0.247**	−0.120**	0.290**	0.192**	0.677**	−0.220**	−0.539**	−0.295**	0.316**	–				
12. Residence	−0.079**	0.022**	0.088**	0.079**	−0.061**	0.005	0.147**	−0.031**	0.039**	−0.243**	−0.014**	–			
13. Financial support	−0.053**	0.016	0.235**	−0.035**	−0.045**	−0.023**	−0.002	−0.043**	0.013	−0.066**	0.009	0.121**	–		
14. Lifestyle score	0.174**	−0.074**	0.188**	0.103**	0.176**	0.095**	−0.041**	−0.136**	0.046**	0.187**	0.081**	−0.351**	−0.122**	–	
15. ADL	−0.034**	−0.001	−0.010	0.005	0.007	−0.014	0.013	0.006	−0.007	−0.016	−0.012	0.027*	−0.016	0.007	–
16. Physical comorbidities	0.058**	0.021	0.087**	0.000	0.025*	0.035**	−0.043**	−0.072**	0.011	0.090**	0.041**	−0.198**	0.001	0.165**	−0.070**

ADL, the activities of daily living. *$p < 0.05$. **$p < 0.01$.

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TABLE 3 The association between hearing loss and cognitive function.

	Model 1					Model 2				
	B	SE	*p*-value	LLCI	ULCI	*B*	SE	*p*-value	LLCI	ULCI
Hearing loss	−4.620	0.132	<0.001	−4.880	−4.361	−2.249	0.130	<0.001	−2.505	−1.994
Age						−0.186	0.007	<0.001	−0.199	−0.173
Gender						−1.046	0.127	<0.001	−1.295	−0.797
Education						1.793	0.136	<0.001	1.526	2.060
Marital status						0.219	0.138	0.113	−0.052	0.490
Residence						−0.155	0.138	0.259	−0.425	0.115
Financial support						−0.752	0.169	<0.001	−1.084	−0.419
Lifestyle score						0.098	0.013	<0.001	0.073	0.124
ADL						−0.065	0.024	0.006	−0.112	−0.018
Physical comorbidities						0.074	0.121	0.542	−0.163	0.311

B, standardized regression B-coefficient; SE, standard error; LLCI, lower limit confidence interval; ULCI, upper limit confidence interval. ADL, the activities of daily living. Model 1 investigated the association between hearing loss and cognitive function.
Model 2 investigated the association between hearing loss and cognitive function when adjusting for covariates.

TABLE 4 Testing the mediating effect of hearing loss on cognitive function.

Variable	Path	*B*	SE	LLCI	ULCI
Total effect	Hearing loss-Cognition	−2.249	0.130	−2.505	−1.994
Direct effect	Hearing loss-Depression	0.745	0.111	0.527	0.964
	Depression-Cognition	−0.153	0.013	−0.179	−0.127
	Hearing loss-Cognition	−2.135	0.129	−2.389	−1.881
Indirect effect	Hearing loss-depression-Cognition	−0.114	0.021	−0.158	−0.076

B, standardized regression B-coefficient; SE, standard error; LLCI, lower limit confidence interval; ULCI, upper limit confidence interval.
The mediation model was controlled for covariates (age, gender, education level, marital status, residence, financial support, lifestyle scores, ADL scores, and physical comorbidities).

modified by removing social relationships as a moderating factor on path a (Figure 2). As a result, in both path b and path c' of this model, social relationships moderated the effect of hearing loss on cognitive function, as shown in Table 5 and Figure 3.

As shown in Supplementary Table S7, we also determined whether the effect was moderated by social activity and social networks simultaneously *via* Model 76. As a result, through paths a (hearing loss x social activity: $B = 1.628$, $p < 0.001$), b (depressive symptoms x social activity: $B = 0.082$, $p < 0.001$), and c' (hearing loss x social activity: $B = 1.628$, $p < 0.001$), social activity moderated the impact of hearing loss on cognitive function. While through both path a (hearing loss x social networks: $B = 1.628$, $p < 0.001$) and path c' (hearing loss x social networks: $B = 0.552$, $p = 0.001$), social networks moderated the impact of hearing loss on cognitive function. Moreover, the direct and indirect effects of hearing loss on cognition were tested using Model 59, but neither direct nor indirect paths appeared to be moderated by social support (Supplementary Table S8). According to Table 6, the association between hearing loss and cognitive function was negatively moderated by social relationships at any level. A similar effect was observed for social activity and social networks, except both of them, had higher than one standard deviation (Supplementary Table S9). In addition, the simple slope analysis showed that if the social relationships were below ($\beta = -3.000$, $p < 0.001$) or above ($\beta = -0.908$, $p < 0.001$) one standard deviation, participants with hearing loss had lower cognitive function than participants with normal hearing (Figure 4A). Moreover, the cognitive function score decreased significantly as the CES-D-10 score increased, whether social relationships were below ($\beta = -0.137$, $p < 0.001$) or above ($\beta = -0.060$, $p < 0.001$) one standard deviation (Figure 4B). As well, when social activity and social network were lower, coupled with hearing loss or high CES-D-10 scores, the MMSE score was lower (Figure 5).

5. Discussion

In recent years, there has been an increase in empirical support for the adverse effect of hearing loss on older adults' cognitive function (39, 40). Although hearing loss has been identified as one of the most important modifiable risk factors for dementia and cognitive decline, no causal relationship has been found between these two conditions (41). In addition, there is a lack of knowledge of the moderated mediation mechanisms underlying this association, particularly for older adults who are more susceptible to the influences of hearing loss. To fill this gap, we chose the representative older adults from the CLHLS database, since the included older adults aged 65 and older are known to be susceptible to hearing loss, as well as exhibiting elevated levels of depressive symptoms and cognitive impairment (25), with a diverse range of observed variables. Using the moderated mediation model, we found that depressive symptoms may partially mediate the association between

hearing loss and cognitive impairment in older adults. In addition, the association between hearing loss and cognitive impairment was negatively moderated by social relationships at any level. Moreover, social activity and social networks moderated the direct and indirect path of hearing loss to cognitive impairment, but in the case of social support, the moderation effect was non-significant. In summary, this study sheds light on the impact of hearing loss on cognitive function and its internal social-psychological mediating mechanism among Chinese older adults. The prevalence of cognitive impairment and hearing loss in this study was 27.8 and 34.4%, respectively, which is in agreement with previously reported prevalence levels among older adults (42). Similar to Zhang et al. (19), as shown in our research, a variety of factors may contribute to cognitive impairment, including gender, age, the absence of a spouse, illiterate, living in rural, insufficient financial support, lower lifestyle score, comorbidities, poor social relationships and with depression. We anticipate that identifying the interconnectivity of these risk variables sheds some light on the mechanism of connection between hearing loss and cognitive impairment and that depressive symptoms play an essential part in both, as has piqued our attention. That the identification of the interconnection of these risk factors sheds some light on the mechanism of connection between hearing loss and cognitive impairment, and depressive symptoms play an important role in both, which has piqued our curiosity. These findings serve as starting points for us to identify possible confounders and covariates.

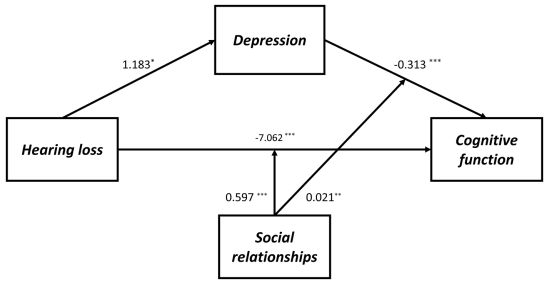

FIGURE 2
The final moderated mediation model: social relationships as moderator of the mediation model of depression between hearing loss and cognitive function (Andrew Hayes's mediation-moderation Model 15, *p<0.05; **p<0.01; ***p<0.001). The moderated mediation model was controlled for covariates (age, gender, education level, marital status, lifestyle scores, ADL scores, and physical comorbidities).

5.1. The mediating role of depressive symptoms

In older adults with hearing impairment, depressive symptoms may contribute to additional cognitive problems beyond those associated with their hearing loss (43). According to cognitive theories of depression (44) and previous empirical studies (45, 46), our results indicated that hearing loss could impair older adults' cognition through depressive symptoms mediation. As reported by Danielle et al., individuals with clinically meaningful hearing loss at levels that may impair communication capability are at risk for accelerated cognitive decline and incident dementia, particularly those who acquire clinically significant depressive symptoms (46). According to cognitive theories of depression, since the significant impact of hearing and communicating effectively on quality of life and behavior, it is possible that additional depressive symptoms may develop. Meanwhile, the onset of a prolonged event—especially if it lasts longer than an acute event—can exacerbate psychosocial or neuropsychological buffers, accelerating cognitive decline among those with hearing loss. Thus, the study emphasizes the role of depression among older adults' poor physical and social function, as well as their poor mental health.

Furthermore, this mediation model involves several stages that need to be discussed. As for the first stage (i.e., hearing loss → depressive symptoms), the results of our study showed that exposure to hearing loss increased the risk of depressive symptoms among older adults. Hearing loss is associated with depressive symptoms in older adults linked to changes in psychosocial experiences and declines in cortical activity (5, 47, 48). On the one hand, hearing loss is related to higher social and emotional isolation in older adults and may become a chronic stressor if left untreated, contributing to the growth of depressive symptoms as an additional stressor (49). As explained by the stress appraisal theory by Lazarus and Folkman, adaptation fails when stressful situations are perceived as threatening, challenging, or harmful, overriding one's capacity to cope (50). On the other hand, there is also evidence that neuropathological mechanisms associated with auditory perception and mood regulation may contribute to hearing loss and depressive symptoms, with the limbic system (which regulates emotion, reasoning, and planning), the frontal cortex (which regulates emotion, reasoning, and planning), and auditory cortex exhibit similar patterns of reduced activity among older adults with hearing loss or depressive symptoms (10). It appears that hearing loss and

TABLE 5 Testing the moderated mediating effect of hearing loss on cognitive function by depression and social relationships.

	Depression					Cognitive function				
	B	SE	*p*-value	LLCI	ULCI	*B*	SE	*p*-value	LLCI	ULCI
Hearing loss (X)	0.700	0.112	<0.001	0.481	0.920	−1.954	0.128	<0.001	−2.206	−1.702
Depression (M)	–	–	–	–	–	−0.136	0.013	<0.001	−0.162	−0.109
social relationships (W)	−0.177	0.029	<0.001	−0.233	−0.120	0.394	0.033	<0.001	0.329	0.459
XxW	––	–	–	–		0.597	0.068	<0.001	0.463	0.730
MxW	–	–	–	–	–	0.021	0.007	0.002	0.008	0.034

B, standardized regression B-coefficient; SE, standard error; LLCI, lower limit confidence interval; ULCI, upper limit confidence interval; X, independent variable; Y, dependent variable; M, mediator.
The moderated mediation model was controlled for covariates (age, gender, education level, marital status, lifestyle scores, ADL scores, and physical comorbidities).

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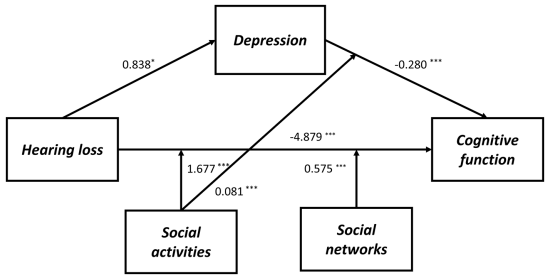

FIGURE 3
The final moderated mediation model: social activities and social networks as moderators of the mediation model of depression between hearing loss and cognitive function (Andrew Hayes's mediation-moderation Model 76, *p<0.05; ***p<0.001). The moderated mediation model was controlled for covariates (age, gender, education level, marital status, lifestyle scores, ADL scores, and physical comorbidities).

TABLE 6 Conditional indirect effects of hearing loss on cognitive function.

Social relationships	*B*	SE	LLCI	ULCI
−1-SD	−0.137	0.033	−0.206	−0.078
Mean	−0.095	0.018	−0.134	−0.062
−1 + SD	−0.060	0.019	−0.099	−0.027

B, standardized regression B-coefficient; SE, standard error; LLCI, lower limit confidence interval; ULCI, upper limit confidence interval.

depressive symptoms are associated with common neural degeneration in older adults. As for the second stage (i.e., depressive symptoms → cognitive impairment), CESD-10 was negatively associated with MMSE score, consistent with the findings of Zhou et al. (51). It has been shown that cognitive impairment and depressive symptoms may share at least three pathways (52). First, the presence of persistent mood symptoms might impair cognitive function *via* neurobiological pathways. Chronic stress-induced immunological dysregulation may have a direct influence on cognition through cumulative exposure to emotional symptoms (53). Second, mood symptoms may contribute to and aggravate poor health behaviors that negatively affect cognitive performance, including unhealthy diet, inactivity, smoking and substance abuse, and medication used to treat symptoms (54). In addition, disability may contribute to cognitive impairment as well as depressive symptoms in a reciprocal manner. Depressive symptoms affect patients' ability to engage in cognitively stimulating activities, as well as their participation in the workforce and mental challenges (55). Meanwhile, people with depressive symptoms tend to have fewer social networks than healthy controls, and they are more likely to experience negative interactions and social strain. Moreover, depressive symptoms are more likely to be associated with poverty and socioeconomic factors could also hinder patients' access to healthy food, safe physical activity areas, and cognitive skills. As a result, older adults suffering from depressive symptoms are more likely to have reduced cognition.

5.2. The moderating role of social relationships

Social relationships negatively correlated with depressive symptoms, as expected. The odds of developing depressive symptoms are lower for older adults who have more social relationships. In line with previous empirical studies (56) and the social support theoretical model (57), this finding suggests that good social relationships could benefit older adults by alleviating the level of depressive symptoms. While older adults with long-term hearing loss face a variety of barriers that may hinder their full and effective access to sufficient social resources (58). The present findings indicated that social relationships moderated the association between hearing loss and depressive symptoms. Those who have strong social relationships are less likely to suffer from depressive symptoms when facing hearing loss than those who have weak social relationships, which suggests that good social relationships may buffer the adverse effects of hearing loss on older adults' mental health. According to the stress-buffering model and main effects model (59), social connections help people cope with stress by providing psychological and material resources. It is believed that stress affects health both by activating physiological systems such as the sympathetic nervous system and the hypothalamic–pituitary–adrenal axis and by promoting behavioral coping responses detrimental to health (smoking, excessive alcohol, lack of sleep, or substance abuse) (59). The main-effect model contends that social connections are advantageous regardless of one's level of stress (60). For example, an empirical study based on the stimulus-organism-response (S-O-R) framework showed that social media use promotes strong social relationships among hearing-impaired older adults, as well as improving aging cognition and depressive symptoms (61).

In line with previous findings that strong social relationships buffers depression (49) and problematic behavior of older adults with hearing loss (62). However, it was not investigated whether the components of social relationships buffer hearing loss and depressive symptoms in these studies. According to our knowledge, this study is the first to confirm that two components of social relationships-social activity and social network-serve as buffers against the negative effects of hearing loss on depressive symptoms in a representative sample of Chinese older adults simultaneously, and the findings extend previous studies.

Furthermore, hearing loss and cognitive impairment were also moderated by social relationships. Specifically, hearing-impaired older adults with low social relationships exhibited lower cognitive function than those with high social relationships. This result is consistent with previous studies and extends them by demonstrating the buffering effect of social relationships and its specific component in the association between hearing loss and cognitive decline among older adults (49, 63). The observed buffering effect of social relationships in the present study might be attributed to several potential factors. First, higher levels of social activity are related to greater cognitive reserve, resulting in activating and strengthening various neural circuits and behavioral pathways, improving the ability to compensate for adverse structural and functional brain consequences caused by hearing loss and depression (19, 64). The opposite was social isolation correlates with both restructuring and functional changes in the brain's social network and in brain regions that are related to mentalizing and social interaction, according to

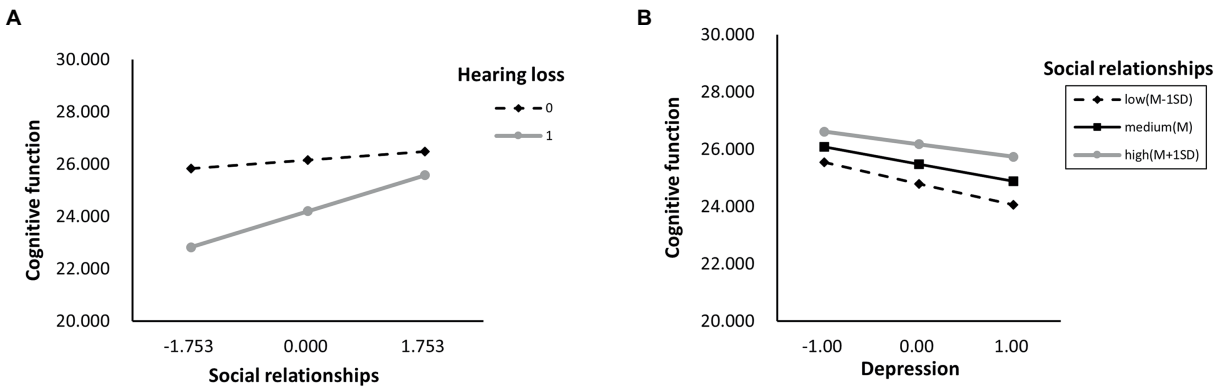

FIGURE 4
The simple plot of path **A** and **B** indicating the relationship between hearing loss, depressive symptoms, and cognitive impairment among different levels of social relationships.

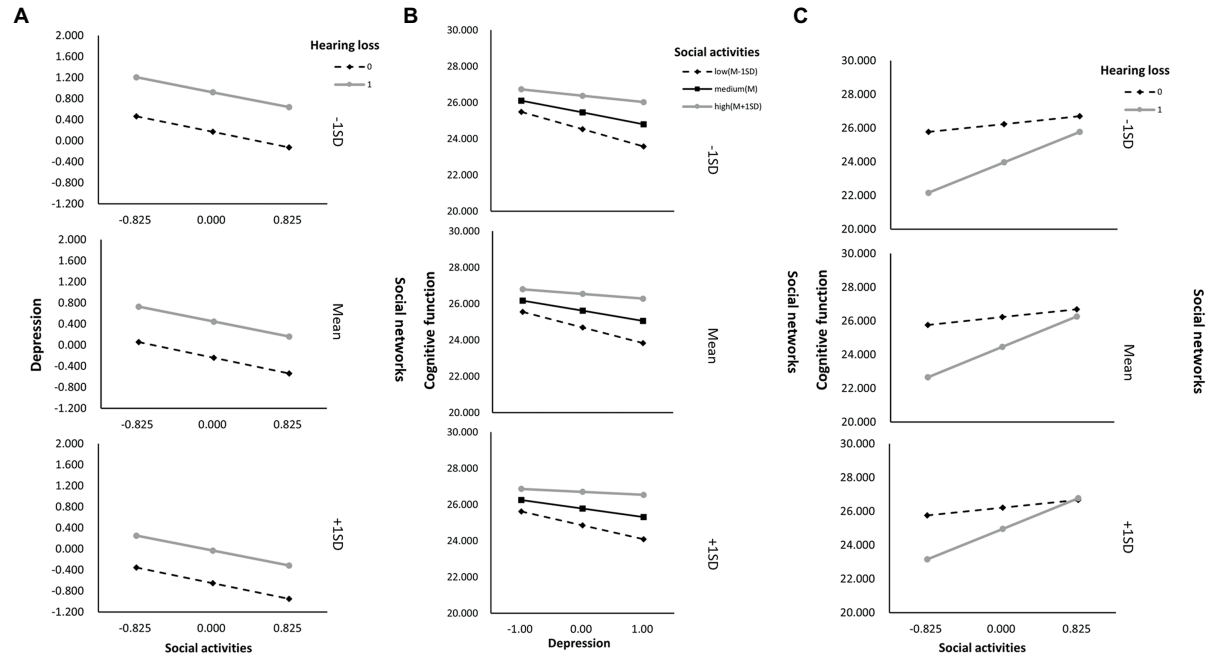

FIGURE 5
The simple plot of path **A**, **B**, and **C** indicating the relationship between hearing loss, depressive symptoms, and cognitive impairment among different levels of social activities and social networks groups.

the social brain hypothesis (65). Second, social networks may be whittled down more rapidly for people with incident hearing problems, and it may be beneficial for them to use targeted coping strategies and auditory rehabilitation methods to cope with the stressful consequences of external threats by obtaining appropriate coping resources (66). Third, although social support' moderating role among hearing loss and cognitive impairment did not reach significance in this study and other CLHLS studies (29), increasing evidence suggests that positive social support is strongly associated with successful hearing aid use and mental health improvement (67). Overall, maintaining positive social relationships may lessen the effects of hearing loss or depressive symptoms on cognitive function.

Some limitations should be addressed in this study. Firstly, the cross-sectional design renders causal inferences about the association between hearing loss, depressive symptoms, and cognitive impairment difficult. The causal direction between hearing loss and cognitive impairment and more accurate mediation estimates could be explored in the future with a longitudinal design. Secondly, self-report measures can be prone to bias and distortion. It is therefore essential to use multiple measures such as an in-depth interview or observation of behavior. Thirdly, since lacked relevant details, the frequency, severity, and duration of hearing loss as well as the information on hearing aids were not considered in this study. Future research should verify whether these factors might be involved in the moderated-mediation model among older adults.

Despite the above limitations, there are theoretical and practical implications to our findings. Based on theoretical considerations, the present findings provide an empirical framework for testing depressive symptoms' mediating role in the association of hearing loss with cognitive impairment, as well as social relationships' moderating role. As a consequence of this framework, we may better understand how hearing loss is related to cognitive impairment among Chinese older adults. Around the world, we must shift the way we look at the hearing, hearing loss, and how hearing rehabilitation impacts the overall quality of life of older adults. From a practical view, because hearing loss increases the likelihood of depressive symptoms among older adults, families, caregivers, healthcare personnel, and institutions should pay more attention to older adults with hearing loss. In rehabilitative practice, broader consultations should especially involve discussing emotional elements of social interaction with patients and how hearing loss affects cognitive and physical functioning. Meanwhile, the identification of vulnerable individuals is essential to ensuring that prevention and early intervention programs are targeted at them. This moderating mediation model has the potential to facilitate earlier identification, enhance motivation for hearing aid and treatment, as well as reduce stigma. Overall, this could be beneficial for older adults with hearing loss, their families and social circles, the healthcare system, and society as a whole.

6. Conclusion

As a whole, we found that depressive symptoms played a partial mediating role in the association between hearing loss and cognitive impairment among a nationally representative sample of Chinese older adults. Furthermore, in addition to social relationships, these two components, i.e., social activity and social network, moderated the association between hearing loss and cognitive impairment. It might be worthwhile to recommend multidimensional health and social interventions aimed at improving mental health and social inclusion among older adults with hearing loss.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number (s) can be found below: https://opendata.pku.edu.cn/dataverse/CHADS.

Ethics statement

The research has been reviewed and approved by the Research Ethics Committee of Peking University (approval number: IRB00001052-13074). The patients/participants provided their written informed consent to participate in this study.

Author contributions

XC and JZ conceived the concept and design of the study. XC and QL contributed to data cleaning and analysis. JL and BY contributed to the writing assistance and proofreading of the article. All authors approved the final version of the manuscript.

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Conflict of interest

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

Publisher's note

Supplementary material

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Ilaria Bortone,
National Research Council (CNR), Italy
Lambert Zixin Li,
Stanford University, United States

*CORRESPONDENCE
Ming Zhao
✉ mzhao@cdc.zj.cn

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Association between multimorbidity and falls and fear of falling among older adults in eastern China: a cross-sectional study

Liuqing You[1], Lihua Guo[1], Na Li[1], Jieming Zhong[1], Yuliang Er[2] and Ming Zhao[1]*

[1]Zhejiang Provincial Center for Disease Control and Prevention, Zhejiang, China, [2]National Center for Chronic and Non-Communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China

Background: Growing evidence has reported an association between multimorbidity and falls and fear of falling (FOF) in older adults, however, the results regarding this association from China are limited. Our study aimed to investigate the association between multimorbidity and falls and FOF in older adults in eastern China.

Methods: We conducted a cross-sectional study in Zhejiang Province, Eastern China, which recruited a provincial representative sample of adults aged ≥ 60years. A structured questionnaire including demographic characteristics, chronic diseases, history of falls in the past 12months, and FOF, was administered by all participants. The exposure variable was multimorbidity, which was defined as the presence of two or more chronic diseases and medical conditions in the same individual. The outcomes included a history of falls and FOF. Multivariate logistic regression was used to evaluate the association between multimorbidity and falls and FOF in older adults.

Results: In total of 7,774 participants were included in the analysis, among whom 3,898 (50.1%) were female, with a mean±standard deviation age is 72.9±8.4years. Multimorbidity was associated with the increased risk of falling in older adults [adjusted odds ratio (OR), 1.99; 95% confidence interval (CI):1.55–2.36]. The ORs for having experienced single fall and repeated falls were 1.85 (95% CI: 1.42–2.42) and 3.45 (95% CI: 1.47–6.97), respectively, with multimorbidity compared with those without chronic diseases. The older adults with multimorbidity were more likely to report FOF compared with those without chronic diseases (adjusted OR, 1.49; 95%CI:1.30–1.70). Moreover, the association between multimorbidity and FOF remained significant in the older adults with a history of fall (OR, 1.57; 95%CI:1.04–2.38).

Conclusion: The association between multimorbidity and falls and FOF is significant in the Chinese population and the effects of multimorbidity on falls and FOF do not vary according to the frequency and history of falls in older adults.

KEYWORDS

multimorbidity, falls, fall risk, fear of falling, older adults, geriatrics

1. Introduction

Falls are highly prevalent and the second leading cause of unintentional injury deaths worldwide (1). Annually, approximately 37·3 million severe falls occur, leading to a significant loss of >17 million disability-adjusted life-years (DALYs) (1). Older adults are more susceptible to fatal falls and other serious consequences, such as hip fractures (2). According to the Global Burden of Disease Study 2019, the DALYs of falls have been in the top 10 in the 75-years-and-older age groups (3). In China, falls among older adults have also become a major health concern, with the recently estimated incidence and mortality due to falls being 3799.4 and 39.2 per 100,000 populations among individuals aged ≥ 60 years (4).

Progressive studies on falls in older adults are increasingly considering fear of falling (FOF). FOF is defined as a lasting concern with falling that results in restricted activity during an individual's daily life (5). The occurrence of falls in older adults might contribute to the development of FOF (6), which might, in turn, increase the risk of fall incidents (7, 8), leading to the establishment of a vicious circle. In addition, FOF in older adults may result in other adverse health outcomes such as decreased quality of life (9). FOF is a common issue among older adults, with estimates suggesting that its prevalence among community-dwelling older adults is 20 to 60% (10–15). Given the heavy burden of falls, FOF, and the aging population trend (16), identifying the vulnerable subgroups at high risk of falling and targeting preventive actions toward them have become priorities to prevent and control falls.

Multimorbidity is defined as the co-occurrence of at least two chronic conditions in the same individual (17). It is common among older adults, with a reported prevalence of 65% in those aged 65–84 years (18, 19). Frailty is considered a major threat to multimorbidity in older adults and may lead to physical functional decline and disability (20, 21). Falls and FOF were associated with poor physical function (e.g., balance, gait speed, and grip strength) (22, 23). Therefore, older adults with multimorbidity may be frail and have worse physical function, leading to a higher risk of falls and FOF.

Several epidemiological studies have linked multimorbidity to a higher risk of falls and FOF in older adults (24–26). However, most of these studies have been conducted in developed countries, and evidence from China is limited. Furthermore, there is a study gap regarding whether the effects of multimorbidity on falls or FOF vary depending on the frequency and history of falls among older adults. Therefore, the present study aimed to evaluate the association between multimorbidity and the risk of falls and FOF among the older adults in China and to explore whether there is a difference in the effects of multimorbidity on single vs. repeated falls and whether this association between multimorbidity and FOF still exists in older adults with a history of falls.

2. Materials and methods

2.1. Study design and participants

The current data analysis was based on a cross-sectional study that used a multistage stratified cluster sampling procedure (Appendix 1) to recruit a representative provincial sample of adults aged ≥ 60 years in Zhejiang Province from June to December 2022. We only included residents living in local communities for >6 months and those who were able to effectively communicate in the sampling frame. Those with critical illness and who could not participate in this survey was excluded. In total of 7,774 participants were included in the analysis. This study was approved by the Ethics Review Committee of the Zhejiang Center for Disease Control and Prevention, and all participants provided written informed consent.

2.2. Data collection

We conducted household surveys or centralized surveys to obtain data. Trained interviewers administered a general questionnaire including information on demographic characteristics, fall-related factors, fall occurrence, and injury occurrence. The demographic information included sex, age, region, educational level, marital status, cohabitation, etc. Fall-related factors included illness, medication, physical activity, and the ability to perform activities of daily living of the surveyed participants. The history of falls included the number of falls in the past year, the time, place, behaviors, cause of fall, the direction of fall, on-site disposal, consultation and treatment, and the effect on the life and psychology of the surveyed participants.

2.3. Chronic diseases and multimorbidity

Chronic disease was measured according to the participant's response to the following question: "Have you been diagnosed with any of the following diseases by a physician at a community health center or above?" The diseases included hypertension, diabetes, coronary heart disease, stroke, asthma, chronic bronchitis, arthritis, osteoporosis, osteocalcin, Parkinson's disease, Alzheimer's disease, visual impairment, foot disease, vertigo, and tumors. Multimorbidity was defined as having two or more self-reported chronic diseases. The participants were then classified into three groups: none, single, or multiple (two or more).

2.4. Falls and fear of falling

In our study, falls were measured according to the participant's response to the following question: "In the past 12 months, have you ever fallen/stumbled, whether injured or not (yes/no)?" Individuals who had not reported any falls during the period of the last 12 months were classified as a non-faller. Fallers can be classified as single or repeated fallers according to the frequency of falls in the past 12 months. FOF was measured according to the participant's response to the following question: "At present are you afraid that you may fall over (yes/no)?"

2.5. Statistical analyses

The participants were categorized into three groups according to multimorbidity. All descriptive statistics are presented as frequencies and percentages for categorical variables, and as means and standard deviations for continuous variables. Differences were tested using a

t-test or non-parametric Wilcoxon test for continuous variables and χ^2 or Fisher's exact test for categorical variables.

The association between multimorbidity and fall and FOF in the older adults was compared using univariate and multivariate logistic regression analyses. The multivariate model was adjusted for age, sex, region, marital status, educational level, and physical activity. To assess the association between multimorbidity and FOF, falls were included as a covariate. For the number of chronic diseases, a specific regression model with the exposure variables as continuous terms was used. Sensitivity analyses were performed by dividing the disease combinations into three common multimorbidity patterns: cardiopulmonary pattern, musculoskeletal pattern and vascular-metabolic pattern (Appendix 2) based on a previous study (27). To assess whether there was a difference in the effects of multimorbidity on single vs. repeated falls, we conducted a logistics regression with single fall as a control. Because multiple comparisons were involved, we used the Bonferroni correction to reduce the risk of type I errors.

Stratified analyses were performed to identify potential effect modifications by age (years; 60–69, 70–79, and 80–), sex (male, female), region (city, rural), marital status (married, others), educational level (primary school and below, middle, and above), and physical activity (yes, no). To assess the association between multimorbidity and FOF, we also perform a stratified analysis according to the falls (yes/no). *p*-values for the differences were calculated by introducing an interaction term between multimorbidity and the modifier in the regression models. All stratified analyses were adjusted for age, sex, region, marital status, educational level, and physical activity. Fall was included as a covariate in the multimorbidity-FOF analysis.

Statistical analyses were perform using in R software 4.1.0. Two-tailed p-values < 0.05 were considered statistically significant. For multiple comparisons, two-tailed p-values < 0.167 (Bonferroni correction: 0.05/3, no fall, single fall, repeated fall) were considered statistically significant.

3. Results

In total, 7,774 community-dwelling older adults (age, 72.9 ± 8.4 years) participated in this study. 50.1% of the participants were women, 40.5% were aged 60–69 years, 58.3% were residing in rural areas, 76.9% were married, 80.8% had educational level of primary school and below, and 33.3% were engaged in physical activity. The characteristics of the sample are listed in Table 1. The overall prevalence of multimorbidity in the sample was 49.3%, with higher proportions among women (53.5%), those aged 70–79 years (35.8%), those residing in rural areas (55.1%), those married (72.0%), and those with primary school and below (83.0%), and those with no physical activity (67.9%).

Table 2 presents the association between multimorbidity and falls in older adults. The adjusted logistic regression analysis showed that those with multimorbidity were more likely to fall than those without chronic diseases [odds ratio (OR), 1.99; 95% confidence interval (CI), 1.55–2.36]. Stratified analyses showed that the estimated association between multimorbidity and falls persisted among the subgroups (Figure 1).

Table 3 shows the association between multimorbidity and single and repeated falls in older adults. The ORs of experiencing single and repeated falls were 1.85 (95% CI: 1.42–2.42) and 3.45 (95% CI, 1.47–6.97), respectively, with multimorbidity compared with those without chronic diseases. Case–case analysis showed that there was no significant difference in the effects of multimorbidity on single and repeated falls (OR:1.87, 95%CI:0.87–4.25).

Table 4 shows the association between multimorbidity and FOF in older adults. Adjusted logistic regression analysis showed that older adults with multimorbidity were more likely to report FOF compared with those without chronic diseases (OR, 1.49; 95%CI:1.30–1.70). Figure 2 shows that the estimated association between multimorbidity and FOF among the subgroups. The association between multimorbidity and FOF remained in the older adults with a history of falls (OR, 1.57; 95%CI,1.04–2.38).

Sensitivity analysis showed that the association between the three and multimorbidity patterns with falls and FOF remained significant (Appendix Table S1).

4. Discussion

The current study explored the association between multimorbidity and falls and FOF in older adults. Older adults with multimorbidity had a significantly higher fall risk compared with those without diseases. In addition, the older adults with multimorbidity were more likely to be afraid of falling when compared with those without chronic diseases. The effects of multimorbidity on FOF did not vary in different subgroups.

Previous studies have indicated a positive association between multimorbidity and falls in older adults. In a Canadian national study comprising 16,357 individuals aged ≥ 65 years, fall risk was significantly greater in individuals with one, two, four, five, and six or more chronic conditions than in those with no chronic conditions (all $p < 0.05$) (25). A population-based cohort study in Sweden demonstrated that individuals defined as "well-functioning with multimorbidity," had higher risk of falling over a longer follow-up period (5 and 10 years), compared with those in the reference group (5-year hazard ratio [HR] = 1.74 [95% CI, 1.02, 2.66], 10-year HR = 1.44 [95%CI, 1.02–2.04]) (28). A positive association was also observed in a sample of centenarians in which a 38.4% higher OR for a history of falls was associated with the number of health conditions (OR = 1.384 [95% CI 1.087, 1.763]) (29). However, the effect of multimorbidity on single and repeated falls was inconsistent. In a Finland study containing 872 older adults, the number of chronic diseases was only related to the risk of recurrent falling, not to the risk of one-time falling (24).

In our study, we found that the older adults with multimorbidity had a 91% higher odds ratio (OR) for falling than those without a chronic disease. We also classified falls into single (one-time) and repeated (recurrent falls) falls according to the frequency of falls and performed logistic regression with single fall as controls. We found that multimorbidity was significantly associated with the risk of single fall and repeated falls, and that there was no significant difference between the two types of falls. This inconsistency may be due to differences in study setting, the sample size, and the study population. It is very difficult to compare association estimates across studies, however, they all confirmed that multimorbidity was an important risk factor for falls in older adults.

TABLE 1 Characteristics of the study population by categories of multimorbidity.

level	All (*n*=7,774)	None (1,568)	Single (2,376)	Multiple (3,830)	*P*-value
Age (years old)	72.9 ± 8.4	70.3 ± 8.1	72.5 ± 8.3	74.3 ± 8.4	<0.001
60–69	3,152 (40.5)	874 (55.7)	992 (41.8)	1,286 (33.6)	<0.001
70–79	2,611 (33.6)	438 (27.9)	802 (33.8)	1,371 (35.8)	
80 and above	2,011 (25.9)	256 (16.3)	582 (24.5)	1,173 (30.6)	
Sex					<0.001
Male	3,876 (49.9)	844 (53.8)	1,250 (52.6)	1,782 (46.5)	
Female	3,898 (50.1)	724 (46.2)	1,126 (47.4)	2,048 (53.5)	
Region					<0.001
City	3,240 (41.7)	623 (39.7)	898 (37.8)	1,719 (44.9)	
Rural	4,534 (58.3)	945 (60.3)	1,478 (62.2)	2,111 (55.1)	
Marital status					<0.001
Married	5,982 (76.9)	1,323 (84.4)	1,900 (80.0)	2,759 (72.0)	
Widowed	1,633 (21.0)	210 (13.4)	433 (18.2)	990 (25.8)	
Other	159 (2.0)	35 (2.2)	43 (1.8)	81 (2.1)	
Educational level					<0.001
Primary school and below	6,282 (80.8)	1,183 (75.4)	1,920 (80.8)	3,179 (83.0)	
Middle school	1,377 (17.7)	355 (22.6)	423 (17.8)	599 (15.6)	
College and above	115 (1.5)	30 (1.9)	33 (1.4)	52 (1.4)	
Physical activity					0.002
No	5,185 (66.7)	987 (62.9)	1,597 (67.2)	2,601 (67.9)	
Yes	2,589 (33.3)	581 (37.1)	779 (32.8)	1,229 (32.1)	

TABLE 2 Association between multimorbidity and falls among the older adults.

Multimorbidity	No-fall	Fall	Unadjusted model	Adjusted model*
None	1,445 (21.1)	123 (13.2)	Ref.	Ref.
Single	2,162 (31.6)	214 (23.0)	1.16 [0.92, 1.47]	1.08 [0.86, 1.37]
Multiple	3,235 (47.3)	595 (63.8)	2.16 [1.76, 2.63]	1.99 [1.55, 2.36]
P for trend			<0.001	<0.001

*Adjusted model was adjusted age, sex, area, marital status, education level, physical activity.

Regarding the mechanism, falls are an inevitable part of the bipedal gait and physical activity (30) and are closely related to physical function such as walking speed and hip strength (31, 32). It has been suggested that multimorbidity often predicts a decline in physical function (33). Moreover, it is associated with poor physical function in older adults (34–36). Hence, multimorbidity may result in physical decline, thereby increasing the risk of falling.

Evidence regarding the association between multimorbidity and FOF is limited. A Brazilian studies demonstrated that the presence of multimorbidity was associated with a higher chance of reporting a FOF (7). Our results were consistent with those of their study and showed that the older adults with multimorbidity were more likely to be afraid of falling than those without multimorbidity. The presence of several chronic diseases can increase negative health self-perception and culminate in frailty (37). Frailty is considered a geriatric syndrome associated with several adverse health outcomes, including the FOF (38). Several studies have reported a robust association between FOF and previous falls (39, 40), and evidence suggests that FOF is not always a consequence of a previous fall (12). In our study, we performed stratified analysis, according to the history of falls, and found that the association between multimorbidity and FOF remained significant in older fallers with previous falls. Our results support the view that FOF is multifactorial and multidimensional.

In addition, older adults with FOF tend to restrict and avoid activities because of a loss of confidence in their ability to perform daily tasks safely (10, 41), which might in turn impact the severity and burden of multimorbidity, leading to the establishment of a vicious circle (42). Hence, attention should be paid to the mental health of older adults with multimorbidity, and psychological support should be provided.

In the future, healthcare professionals should consider assessing multimorbidity as a potential risk factor for falls and FOF in older adults. Identifying and managing chronic conditions in older adults may help prevent falls and improve their quality of life. Public health policies should prioritize the prevention of multimorbidity in older adults to reduce the risk of falls and FOF. This may involve strategies to promote healthy lifestyle behaviors, such as regular physical activity, healthy eating habits, and smoking cessation.

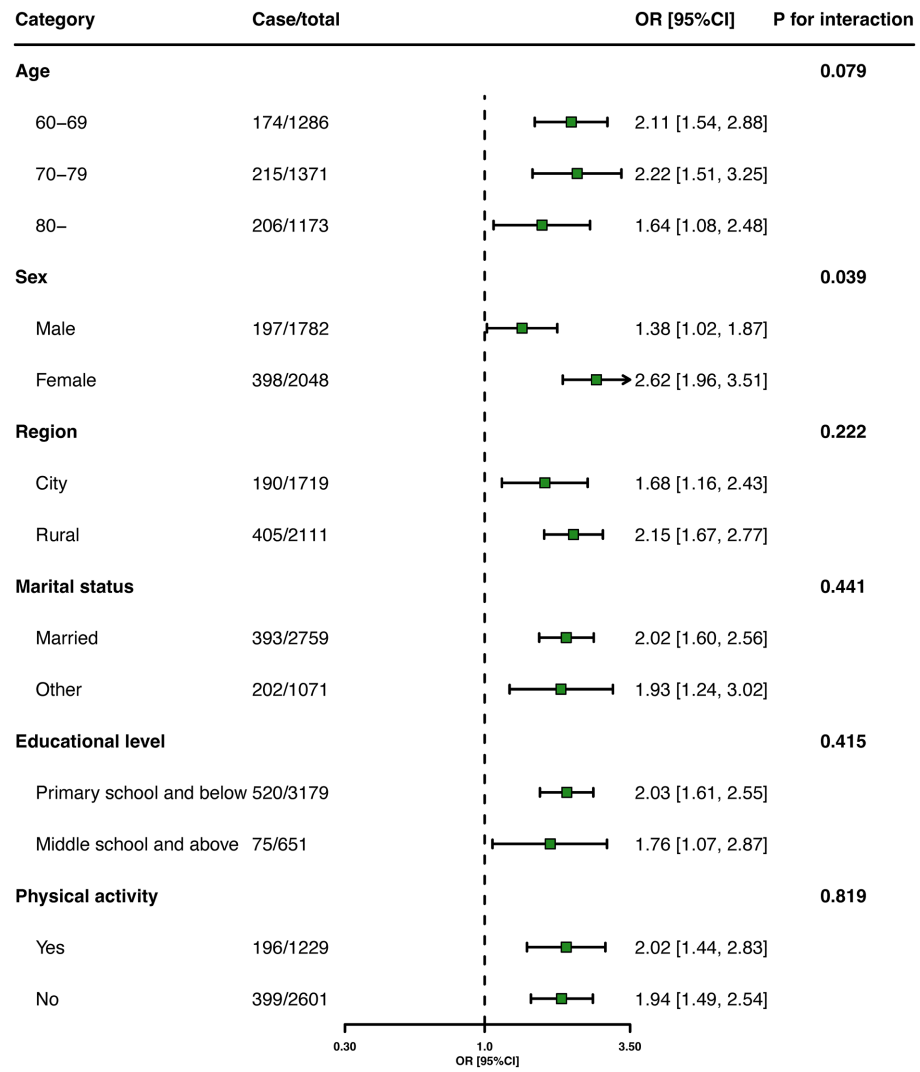

FIGURE 1
Associations between multimorbidity and falls among older adults in stratified analyses.

TABLE 3 Association of multimorbidity with single fall and repeated fall among the older adults.

Multimorbidity	No-fall	Single fall		Repeated fall		Repeated fall vs. Single fall
	N (%)	*N* (%)	OR [95%CI][a]	*N* (%)	OR [95%CI][a]	OR [95%CI][a]
None	1,445 (21.1)	112 (14.0)	Ref.	11 (8.3)	Ref.	Ref.
Single	2,162 (31.6)	183 (22.9)	1.03 [0.76, 1.39]	31 (23.3)	1.71 [0.73, 4.00]	1.69 [0.69, 4.16]
Multiple	3,235 (47.3)	504 (63.1)	1.85 [1.42, 2.42]	91 (68.4)	3.45 [1.47, 6.97]	1.87 [0.82, 4.25]
P for trend			<0.001		<0.001	

[a]Model was adjusted age, sex, area, marital status, education level, physical activity. Two-tailed *p*-values < 0.167 (Bonferroni correction:0.05/3) were considered statistically significant.

Some limitations of this study should be noted when interpreting the results. First, our study used a cross-sectional design, and we were unable to confirm whether a diagnosis of a certain chronic disease was established before or after the occurrence of falls or FOF. Hence, only an association rather than causality could be inferred between multimorbidity and falls or FOF. Further longitudinal research is required to determine the causal association between multimorbidity and falls or FOF. Second, we used traditional survey methods such as interviews and questionnaires, to capture information about multimorbidity, falls, and FOF from the study participants, which might have been subject to recall or social desirability bias, leading to inaccurate study results. We made every effort to ensure the reliability

TABLE 4 Association between multimorbidity and FOF among the older adults.

Multimorbidity	No-FOF	FOF	Unadjusted model	Adjusted model*
None	1,168 (22.0)	400 (16.3)	Ref.	Ref.
Single	1,725 (32.4)	651 (26.5)	1.10 [0.95, 1.27]	1.05 [0.91, 1.22]
Multiple	2,424 (45.6)	1,406 (57.2)	1.69 [1.49, 1.93]	1.49 [1.30, 1.70]
P for trend			<0.001	<0.001

*Adjusted model was adjusted age, sex, area, marital status, education level, physical activity, fall.

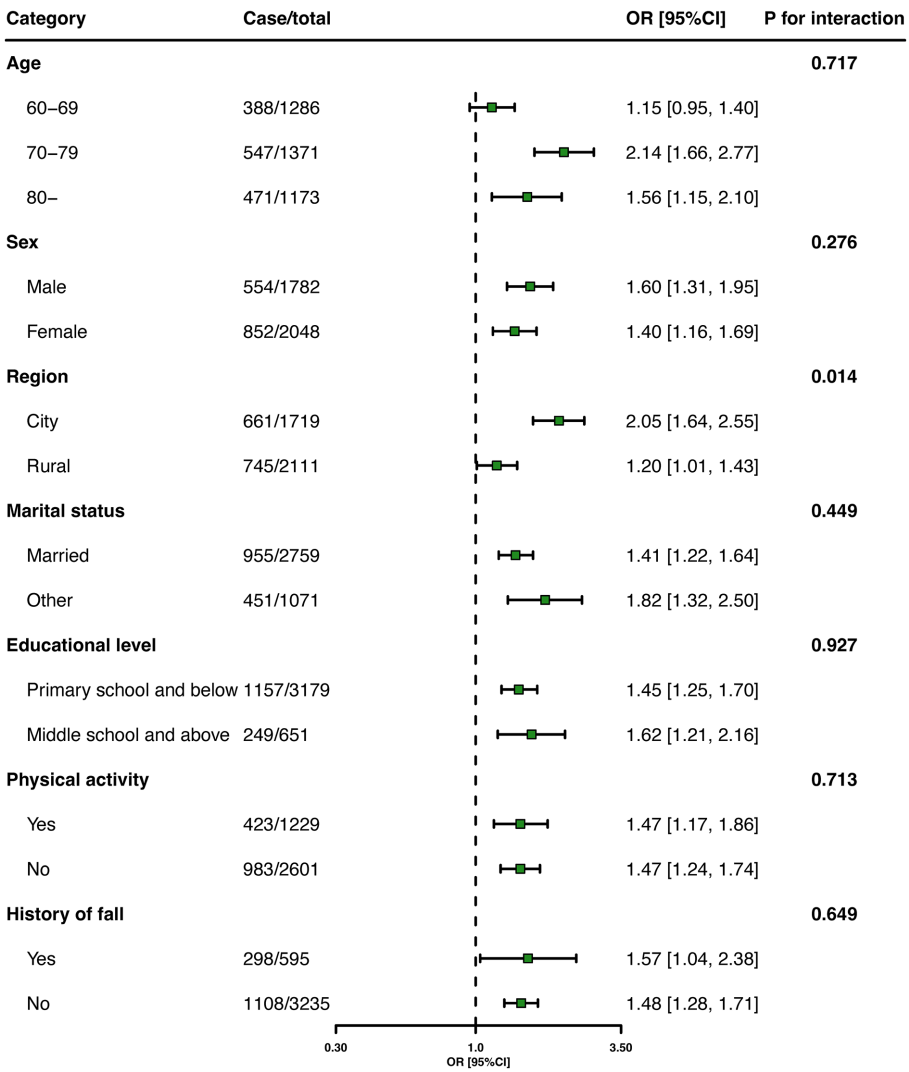

FIGURE 2
Associations between multimorbidity and FOF among older adults in stratified analyses.

and accuracy of the data, including pilot testing; training of interviewers; providing clear instructions on how to report multimorbidity, falls, and FOF; and conducting follow-up interviews to confirm the reported incidents. Third, regarding multimorbidity studies, there was no agreement on which diseases should be included in the multimorbidity assessment is missing, making the comparison of study findings difficult. The definition of multimorbidity does not consider the severity or duration of chronic illness, which may influence their risk of falls or FOF. Fourthly, we obtained information about FOF using a single-question inquiry method rather than using the Falls Efficacy Scale-International (FES-I) scale, which might limit the ability to make meaningful comparisons with other studies that have used the FES-I scale. Finally, our sample may only represent the population within one province. All participants in our study were enrolled from Zhejiang Province, which may limit potential confounders, such as ethnicity, race, and social development levels,

but restrict the generalizability of our results. Thus, nationwide studies are needed to further confirm these findings.

5. Conclusion

The association between multimorbidity and falls and FOF is significant in the Chinese population, and the effects of multimorbidity on falls and FOF do not vary according to the frequency and history of falls in older 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.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Review Committee of the Zhejiang Center for Disease Control and Prevention. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LY: conception and design of the study, data analysis and interpretation, and drafting the manuscript. LG: data collection and revision of the manuscript for intellectual content. NL, JZ, and YE: study supervision and revision of the manuscript for intellectual content. MZ: conception and design of the study, data collection, and revision of the manuscript for intellectual content. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1146899/full#supplementary-material

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Ye Luo,
Clemson University, United States
Keisuke Kokubun,
Tohoku University, Japan

*CORRESPONDENCE
Yan Chen
✉ 20130046@hznu.edu.cn

†These authors have contributed equally to this work and share first authorship

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Social capital and loneliness among older adults in community dwellings and nursing homes in Zhejiang Province of China

Yan Chen*†, Yuchen Zhou†, Min Li, Yanyan Hong, Hongkun Chen, Shanshan Zhu, Yiying Zhou, Shuangyu Yang, Xianlan Wu and Dahui Wang

School of Public Health, Hangzhou Normal University, Hangzhou, Zhejiang, China

Background: Loneliness is an important problem afflicting the health of older adults, and has been proven to be associated with social capital. Previous research in China rarely investigated the differences of social capital and loneliness between older adults living in community dwellings and nursing homes. This study aims to examine the status of social capital and loneliness among older adults living in community dwellings and nursing homes, and analyze the relationship between them.

Methods: A total of 1,278 older adults were recruited for the study from the cities of Hangzhou, Huzhou, and Lishui in Zhejiang Province of China from July to October 2021 by using multi-stage stratified random sampling. Questionnaires were used to collect data on the participants' sociodemographic characteristics, social capital, and loneliness. Hierarchical multiple regression was used to examine the relationship between social capital and loneliness. The interaction of social capital and institutionalization on loneliness was also explored.

Results: Compared with community-dwelling older adults, institutionalized older adults had higher levels of loneliness and lower degrees of social support, social connection, trust, cohesion, and reciprocity. A further analysis of the social capital showed that low levels of social support, trust, and cohesion were related to high levels of loneliness among adults in both community dwellings and nursing homes. Social connection was negatively correlated with loneliness among older adults living in community dwellings. Institutionalization itself demonstrated a strong effect on loneliness.

Conclusion: Health-related policies should help older adults gain more social support, trust and cohesion to alleviate their loneliness. This is particularly crucial for older adults living in nursing homes, as they have higher levels of loneliness and lower levels of social capital than noninstitutionalized older adults.

KEYWORDS

social capital, loneliness, older adult, nursing home, community

Introduction

As a negative subjective emotional state, loneliness is an important and prevalent problem afflicting the health of older adults (1), and is prevalent among this population across countries. A US study found that 43% of older adults experienced loneliness (2). A research found that approximately 19.6–34.0% of older adults in Europe experienced loneliness (3). Data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) showed that about 53.5% of older adults suffered from a feeling of loneliness (4). Because loneliness can impair the physical and mental health of older adults to reduce their quality of life (5, 6). Advanced age (3), level of education (7), marital status (8), monthly income (9), and living environment (10) are the influencing factors of loneliness. Prevention strategies should be developed to recognize the risk factors of loneliness and deal with its adverse outcomes.

Social capital, as a social resource for mental health promotion (11, 12), can actually alleviate the levels of loneliness in older adults (10, 13). Social capital was first proposed by Bourdieu (14), who describes it as an ensemble of social network resources. According to Putnam (15) and Coleman (16), one of the most widely used definitions of described social capital as consisting of the features of social organizations, including social networks, norms, and trust, which can improve social efficiency by promoting coordinated actions. Typically, social capital is regarded as the quantity (frequency) and quality (perceived connections) of social networks (10, 17), including both structural social capital and cognitive social capital (18). Social participation, social support, and social connection can be categorized as dimensional components of structural social capital, while trust, cohesion, and reciprocity are dimensional components of cognitive social capital. The measurement of social capital has evolved from a single dimension (7, 10) in the past to a current tendency to measure multiple dimensions (17, 19, 20). In this study, we used a multidimensional social capital scale to examine the effects of structural social capital and cognitive social capital on loneliness in older adults, respectively.

As age and physical activity decline, social capital, as practical help and support for older people in their daily lives, has received more attention from researchers (17). Social capital theory can help researchers understand the impact of differences in place of residence on mental health and well-being (21). Most empirical studies concluded that social capital and loneliness are context dependent, such as geographical location or residential settings (10, 22). A study from the UK investigated the effects of housing with care on loneliness and found that those who lived in housing with care experienced lower levels of loneliness than would be expected if they lived in the general community (23). Another study in China compared social capital indicator factors on loneliness among widowed older adults between rural and urban areas. Compared to urban areas, widowed older adults in rural areas have lower social capital and higher levels of loneliness. It was found that social connection, trust, and cooperation were strongly associated with loneliness among widowed older adults in rural areas, but not among those in urban areas (24).

Similarly, institutions and non-institutions presented differences, with higher loneliness and lower social capital commonly found among institutionalized older adults (7, 10, 25, 26). Existing studies have analyzed the correlation between social connection and loneliness in older adults, presenting inconsistent results in institutionalized and noninstitutionalized living settings. A study from Norway reported that low levels of social connection (frequent contact with family members, friends, or neighbors) was associated with higher levels of loneliness among noninstitutionalized residents, but this association was not found among institutionalized residents (7). Differently, a study from Spain reported that social connection, like gathering with family members, friends, or neighbors, was associated with loneliness among residents in institutional settings, but not in noninstitutionalized settings (11, 12). However, a Finland study revealed that social connection was not linked with loneliness among older adults in both institutionalized and noninstitutionalized living settings (10). Maybe there are many reasons to explain this inconsistency, including different cultural background (7), and different scales used in different countries (20). Earlier research on the relationship between social capital and loneliness in institutionalized and noninstitutionalized older adults focused on western developed countries. Given the Eastern cultural background, it should be explored whether there are variations between China and western nations in the associations between them.

China has the largest aging population in the world (27), and aged care modes for older adults mainly include noninstitutionalized and institutionalized care. According to data from the Ministry of Civil Affairs of China (28), about 97% of Chinese older adults lived in communities for aging, and 3% lived in institutions for aging. According to the Chinese cultural background, the Chinese older adults prefer living in their homes, which enable them to easily connect with their family members, friends, and neighbors (29). Moving into a nursing home represents a departure from their familiar neighborhood and a disruption of the close social networks they had before (30, 31), which probably led to decreased social capital and an increased risk for loneliness. However, previous studies (7, 32, 33) in China mainly focused on the relationship between social capital and loneliness in noninstitutionalized older adults, with few concentrations on institutionalized older adults or comparative studies between both institutionalized and noninstitutionalized settings.

Considering that it is theoretically and practically important to explore the differences in social capital between both care modes, and the effect of social capital on loneliness among older adults, which is meaningful for improving nursing services, and developing health-related policies. The purpose of this study was to investigate the effects of institutionalization on loneliness among older adults and analyze the relationship between six components of social capital (social participation, social support, social connection, trust, cohesion, and reciprocity) and loneliness among institutionalized and noninstitutionalized older adults. Therefore, we proposed the following hypotheses: (i) Social capital is negatively associated with loneliness among older adults, and this applies to each dimension of social capital and for both institutionalized and noninstitutionalized older adults; (ii) Older adults living in nursing homes have higher levels of loneliness than those living in community dwellings; (iii) Social capital has a stronger effect on loneliness for older adults living in nursing homes than those living in community dwellings.

Materials and methods

Study design and data collection

We conducted a cross-sectional survey from July to October of 2021 in Zhejiang Province, China. According to China's seventh population census in 2021, 23.43% of the total population in Zhejiang Province is 60 years old or above (34), which is higher than the average

level of China (18.70%). A multi-stage stratified cluster sampling method was applied. First, we selected three cities based on economic level—Hangzhou (high economic level), Huzhou (middle economic level), and Lishui (low economic level); Second, three districts were randomly selected from each city based on a high, middle, or low level of urbanization; Third, one community dwelling and one nursing home were randomly selected from each district, resulting in a total of nine nursing homes and nine communities chosen for the survey.

A total of 1,440 respondents (about 80 older adults from each community and each nursing home) were enrolled in the survey and accepted a face-to-face interview by convenience sampling with the help of leaders in charge of the community and institutions. A team of eight college students from the School of Public Health, Hangzhou Normal University conducted face-to-face interviews after receiving training. The criteria for including participants were as follows: (1) age ≥ 60 years, (2) lucidity, and (3) adequate capabilities of comprehension and communication with the investigators. When the surveys were finished, gifts (approximately 1.5 US dollars) were rewarded for the respondents. Finally, a total of 1,278 questionnaires (670 from nine nursing homes and 608 from nine community dwellings) were acquired, of which 162 were incomplete due to temporary health conditions (45), unwillingness to invest time in the interview (78), and other unspecified reasons (39). The valid acceptance rate of the questionnaire was 88.75%.

Measures

Measurement of loneliness

Loneliness was measured by the short-form UCLA Loneliness Scale (ULS-8) as adapted by Hays et al. (35). ULS-8 contains eight items, each of which is scored on a four-point Likert scale (1 = never, 2 = seldom, 3 = usually, 4 = always), and two items were reverse-coded prior to analyses. The total score ranged from eight to 32 points, and a higher score indicated greater feeling of loneliness experienced by the relevant respondent. The value of Cronbach'α on ULS-8 among older adults was 0.831 (36), and its internal reliability in our study was 0.913. Details about the measurement of loneliness please refer to Supplementary Table S1.

Measurement of social capital

Based on the World Bank's Social Capital Assessment Tool and the related literature (37, 38), we included cognitive social capital (trust, cohesion, and reciprocity) and structural social capital (social participation, social support, and social connection) in this study. We used an adapted Chinese version of this assessment tool containing 22 items (Supplementary Table S2). The items were scored using a five-point Likert scale (1 = never, 2 = seldom, 3 = usually, 4 = often, 5 = more often). The value of Cronbach's α for the scale was 0.919 in the previous study (39), and was 0.879 in our study.

The score for each dimension was calculated as the sum of the scores of each item along that dimension. Binary variables (high and low levels) were generated, and categorized into two groups for each dimension according to their relative median values for analysis (40, 41). They included social participation [high (≥6) and low (<6)], social support [high (≥13) and low (<13)], social connection [high (≥12) and low (<12)], trust [high (≥13) and low (<13)], cohesion [high (≥20), and low (<20)], and reciprocity [high (≥11) and low (<11)].

Covariates

Sociodemographic and health-related variables, including age, gender, level of education, marital status, monthly income, whether or not the subject had chronic diseases, and number of children, were collected through standardized questionnaires. The level of education was defined as 1–6 years if the subject had attended primary school, 7–9 years for secondary school, and 10–12 years for high school. Marital status included married and others (single, widowed, and divorced). Chronic diseases were measured according to whether the subject had ever been diagnosed with diseases of this kind by a healthcare professional or had a record of taking medication for them. Monthly income was the ratio of total monthly household income to the population of the household. The variables were coded as follows: age (70–79 and 80+ each coded 1 vs. 60–79 = 0), sex (female = 1 vs. male = 0), education (middle and high or above each coded 1 vs. primary or below = 0), marital status (others = 1 vs. married = 0), monthly income (RMB) (3000–4,999 and 5,000–9,999 and 10,000+ each coded 1 vs. 0–2,999 = 0), number of children (1–2 and 3+ children each coded 1 vs. none), number of chronic conditions (1 and 2+ each coded 1 vs. none), care mode (living in nursing home = 1 vs. living in the community = 0).

Statistical analysis

The categorical variables were expressed in numbers (%) and the continuous variables were expressed as mean ± standard deviation. The differences between older adults living in nursing homes and those living in community dwellings were compared by using the chi-square test for categorical variables and *T*-test for continuous variables. Hierarchical multiple regression was applied to analyze the influence of institutionalization, social capital, and the interaction of social capital and institutionalization on loneliness among older adults. Variables such as their age, level of education, marital status, number of chronic diseases, and monthly income were adjusted in the regression model. All analyses were processed by using SPSS 23.0 statistical software (IBM Corp., Armonk, NY, United States). $p < 0.05$ was taken as representative of statistical significance.

Results

Results of descriptive analysis

Descriptive information of the studied population is presented according to sociodemographic, diseases, social capital, and loneliness (Table 1). In terms of sociodemographic, age, education, monthly income, and marital status were statistically different between residents in community dwellings and nursing homes ($p < 0.001$). Regarding diseases, seniors living in nursing homes had significantly higher rates of chronic diseases than those living in community dwellings (85.8% vs. 64.8%, $p < 0.001$).

Moreover, the ratio of residents with low social capital in nursing homes was greater than those in community dwellings: social support (64.5% vs. 32.4%), and social connection (95.52% vs. 86.68%), trust (80.3% vs. 52%), cohesion (74.3% vs. 41.4%), reciprocity (56.9% vs. 27.6%). There were no statistical differences in social participation (50.5% vs. 50.4%, $p > 0.05$) between two groups. Finally, a significant difference in loneliness was found between both groups: older adults

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TABLE 1 Characteristics of the study participants.

Variable	Total n =1,278	Older adults in community dwellings n =608	Older adults in nursing homes n =670	χ^2 or t	p
Age				136.025	<0.001
60–69	491 (38.4)	307 (50.5)	184 (27.5)		
70–79	445 (34.8)	226 (37.2)	219 (32.7)		
80-	342 (26.8)	75 (12.3)	267 (39.9)		
Sex				0.378	0.539
Male	554 (43.3)	269 (44.2)	285 (42.5)		
Female	724 (56.7)	339 (55.8)	385 (57.5)		
Education				19.688	<0.001
Primary or below	687 (53.8)	292 (48.0)	395 (59.0)		
Middle	308 (24.1)	152 (25.0)	156 (23.3)		
High or above	283 (22.1)	164 (27.0)	119 (17.7)		
Marital status				123.843	<0.001
Married	762 (59.6)	460 (75.7)	302 (45.1)		
Others	516 (40.4)	148 (24.3)	368 (54.9)		
Monthly income (RMB)				167.588	<0.001
0–2,999	376 (29.4)	135 (22.2)	241 (36.0)		
3,000–4,999	468 (36.6)	162 (26.6)	306 (45.7)		
5,000–9,999	323 (25.3)	219 (36.0)	104 (15.5)		
10,000-	111 (8.7)	92 (15.1)	19 (2.8)		
Number of children				0.350	0.983
0	23 (1.8)	11 (1.8)	12 (1.8)		
1–2	1,057 (82.7)	499 (82.1)	558 (83.3)		
3-	198 (15.5)	98 (16.1)	100 (14.9)		
Having chronic diseases				76.811	<0.001
No	309 (24.2)	214 (35.2)	95 (14.2)		
Yes	969 (75.8)	394 (64.8)	575 (85.8)		
Structural social capital					
Social participation				0.000	0.987
Low	645 (50.5)	307 (50.5)	338 (50.4)		
High	633 (49.5)	301 (49.5)	332 (49.6)		
Social support				131.215	<0.001
Low	629 (49.2)	197 (32.4)	432 (64.5)		
High	649 (50.8)	411 (67.6)	238 (35.5)		
Social connection				31.440	<0.001
Low	1,167 (91.3)	527 (86.68)	640 (95.52)		
High	111 (8.7)	81 (13.32)	30 (4.48)		
Cognitive social capital					
Trust				115.351	<0.001
Low	854 (66.8)	316 (52.0)	538 (80.3)		
High	424 (33.2)	292 (48.0)	132 (19.7)		
Cohesion				142.136	<0.001
Low	750 (58.7)	252 (41.4)	498 (74.3)		
High	528 (41.3)	356 (58.6)	172 (25.7)		

(Continued)

TABLE 1 (Continued)

Variable	Total n =1,278	Older adults in community dwellings n =608	Older adults in nursing homes n =670	χ^2 or t	p
Reciprocity				111.170	<0.001
Low	548 (43.0)	168 (27.6)	381 (56.9)		
High	729 (57.0)	440 (72.4)	289 (43.1)		
Loneliness	15.67 ± 5.69	13.78 ± 5.38	17.40 ± 5.40	−11.982	<0.001

living in nursing homes experienced loneliness more frequently than those living in community dwellings (17.40 and 13.78, respectively, $p<0.001$).

The influence of social capital and institutionalization on loneliness

Hierarchical multiple regression was used to analyze the effects of social capital and institutionalization on loneliness among older adults in model 1, model 2, model 3, and model 4 (Table 2). In model 1 (unadjusted), loneliness among the participants was significantly associated with social support ($\beta=-1.120$, $p<0.001$), social connection ($\beta=-2.716$, $p<0.001$), trust ($\beta=-3.456$, $p<0.001$), cohesion ($\beta=-2.112$, $p<0.001$), reciprocity ($\beta=-1.117$, $p<0.001$), and social participation ($\beta=0.788$, $p<0.01$). After adjusting for sociodemographic covariates in model 2, loneliness was still significantly associated with social participation ($\beta=0.658$, $p<0.05$), social support ($\beta=-1.081$, $p<0.001$), social connection ($\beta=-2.394$, $p<0.001$), trust ($\beta=-3.143$, $p<0.001$), and cohesion ($\beta=-1.879$, $p<0.001$). After adjusting for both sociodemographic covariates and institutionalization in model 3, social participation ($\beta=0.599$, $p<0.05$), social support ($\beta=-0.913$, $p<0.01$), social connection ($\beta=-2.376$, $p<0.001$), trust ($\beta=-3.054$, $p<0.001$), and cohesion ($\beta=-1.765$, $p<0.001$) were survived in the loneliness. As shown in model 3, institutionalization also significantly influenced loneliness. After adjusting for sociodemographic covariates, institutionalization, and social capital in model 4, we found that only the interaction of cohesion and institutionalization had a significant effect on loneliness ($\beta=-1.999$, $p<0.01$).

The influence of sociodemographic factors and social capital on loneliness among older adults living in community dwellings and nursing homes

Hierarchical regression models were applied to investigate sociodemographic factors and social capital of loneliness in each studied group (Table 3). For sociodemographic factors, age, monthly income, and marital status were associated with loneliness among older adults living in community dwellings, while age and education were associated with loneliness among older adults living in nursing homes. Social capital was strongly associated with loneliness in both groups. As is clear from model 1 (unadjusted), social participation ($\beta=0.778$, $p<0.05$), social support ($\beta=-1.079$, $p<0.05$), social connection ($\beta=-2.890$, $p<0.001$), trust ($\beta=-3.671$, $p<0.001$), and reciprocity ($\beta=-0.962$, $p<0.05$) were negatively associated with loneliness in older adults living in community dwellings. For nursing home residents, trust ($\beta=-2.766$, $p<0.001$), cohesion ($\beta=-3.274$, $p<0.001$), and reciprocity ($\beta=-0.904$, $p<0.05$) were negatively associated with loneliness. After controlling for the covariates in model 2, loneliness among older adults living in community dwellings came to be associated with social support ($\beta=-0.953$, $p<0.05$), and social connection ($\beta=-2.390$, $p<0.001$), trust ($\beta=-3.283$, $p<0.001$), cohesion ($\beta=-0.941$, $p<0.05$). Among older adults in nursing homes, social support ($\beta=-0.805$, $p<0.05$), trust ($\beta=-2.212$, $p<0.001$), and cohesion ($\beta=-2.982$, $p<0.001$) were associated with loneliness.

Discussion

In this study, we observed differences in the associations between social capital and loneliness for the older adults living in community dwellings and nursing homes, and demonstrated that social capital had great impact on older adults' loneliness in both living settings, indicating the role of social capital in protecting the mental health of older adults. These imply that relevant social capital plays an important role in protecting the mental health of older adults.

Generally, older adults living in nursing homes were more likely to feel lonely than those living in community dwellings, and institutionalization significantly contributed to their level of loneliness, after controlling for sociodemographic and social capital variables. This finding is consistent with previous literature (9, 42, 43). Most older adults are willing to live in the community for aging, which allows them to maintain a sense of autonomy, independence, security, familiarity, and connection (29, 44, 45). Chinese society is a collectivist, and acquaintance-based society (46), in which older adults value social relationships and prefer to live with families, relatives, and friends (29). When older adults move to nursing homes, they are usually at high risk of losing close ties (partners, other relationships, friends, and neighbors) and are more likely to experience loneliness (7).

Another finding of this study was that sociodemographic factors also contributed to loneliness among older adults in two different residential settings. Older adults living in community dwellings without a partner and with low income tended to feel more loneliness, as was observed in previous studies (30, 47). However, a finding that differs from previous studies is that institutionalized older adults with a middle level of education experienced higher degrees of loneliness compared to those with less than primary school or education, while this was not found among those with a high level of education. One possible explanation is that older adults with middle education degrees lack peers with a common language in institutions (7), but older adults with higher educational attainment have more opportunities to extend their social relationships and have more social contacts (48).

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TABLE 2 Regression analysis of the effect of social capital and institutionalization on loneliness among older adults.

Variable	Model 1 β (*SE*)	Model 2 β (*SE*)	Model 3 β (*SE*)	Model 4 β (*SE*)
Structural social capital				
Social participation (ref: low)				
High	0.788 (0.265)**	0.658 (0.268)*	0.599 (0.268)*	1.028 (0.848)
Social support (ref: low)				
High	−1.120 (0.298)***	−1.081 (0.295)***	−0.913 (0.298)**	−1.247 (0.975)
Social connection (ref: low)				
High	−2.716 (0.487)***	−2.394 (0.496)***	−2.376 (0.494)***	−4.134 (1.451)**
Cognitive social capital				
Trust (ref: low)				
High	−3.456 (0.326)***	−3.143 (0.326)***	−3.054 (0.326)***	−4.613 (1.001)***
Cohesion (ref: low)				
High	−2.112 (0.345)***	−1.879 (0.344)***	−1.765 (0.345)***	1.076 (1.065)
Reciprocity (ref: low)				
High	−1.117 (0.332)***	−0.654 (0.338)	−0.651 (0.337)	−1.188 (1.077)
Age (ref: 60–69)				
70–79		−0.357 (0.322)	−0.413 (0.321)	−0.410 (0.325)
80-		0.418 (0.394)	0.172 (0.400)	0.178 (0.409)
Sex (ref: male)				
Female		−0.108 (0.266)	−0.116 (0.265)	−0.090 (0.266)
Education (ref: primary or below)				
Middle		1.197 (0.340)***	1.246 (0.339)***	1.273 (0.340)***
High or above		0.852 (0.387)*	0.820 (0.386)*	0.787 (0.387)*
Marital status (ref: married)				
Others		0.784 (0.311)*	0.676 (0.312)*	0.658 (0.312)*
Monthly income (RMB) (ref: 0–2,999)				
3,000–4,999		−0.695 (0.343)*	−0.795 (0.343)*	−0.673 (0.346)
5,000–9,999		−1.796 (0.427)***	−1.678 (0.427)***	−1.608 (0.428)***
10,000-		−1.381 (0.567)*	−1.112 (0.571)	−1.002 (0.574)
Number of children (ref: no)				
1–2		0.379 (0.980)	0.320 (0.977)	0.129 (0.980)
3-		1.311 (1.031)	1.414 (1.027)	1.182 (1.031)
Having chronic diseases (ref: no)				
Yes		0.088 (0.323)	−0.028 (0.324)	0.055 (0.326)
Place of residence (ref: living in community dwellings)				
Living in nursing homes			0.992 (0.312)**	1.173 (0.567)*
Interactions				
Social participation*institution				−0.320 (0.528)
Social support*institution				0.208 (0.598)
Social connection*institution				1.423 (1.067)
Trust *institution				1.103 (0.667)
Cohesion*institution				−1.999 (0.697)**
Reciprocity*institution				0.358 (0.669)
R^2	0.318	0.348	0.353	0.359
Adjusted R^2	0.315	0.339	0.344	0.346

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Ref., reference group.

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TABLE 3 Regression analysis of social capital and loneliness among older adults living in community dwellings and nursing homes.

Variable	Older adults in community dwellings		Older adults in nursing homes	
	Model 1 β (*SE*)	Model 2 β (*SE*)	Model 1 β (*SE*)	Model 2 β (*SE*)
Structural social capital				
Social participation (ref: low)				
High	0.778 (0.381)*	0.671 (0.379)	0.546 (0.367)	0.351 (0.378)
Social support (ref: low)				
High	−1.079 (0.443)*	−0.953 (0.437)*	−0.798 (0.407)	−0.805 (0.403)*
Social connection (ref: low)				
High	−2.890 (0.563)***	−2.390 (0.573)***	−1.625 (0.922)	−1.535 (0.943)
Cognitive social capital				
Trust (ref: low)				
High	−3.671 (0.421)***	−3.283 (0.425)***	−2.766 (0.513)***	−2.212 (0.515)***
Cohesion (ref: low)				
High	−0.886 (0.460)	−0.941 (0.456)*	−3.274 (0.523)***	−2.982 (0.528)***
Reciprocity (ref: low)				
High	−0.962 (0.486)*	−0.902 (0.482)	−0.904 (0.457)*	−0.465 (0.473)
Age (ref: 60–69)				
70–79		−0.761 (0.409)		0.702 (0.534)
80-		−1.248 (0.630)*		1.868 (0.591)**
Sex (ref: male)				
Female		−0.633 (0.382)		0.393 (0.369)
Education (ref: primary or below)				
Middle		0.964 (0.502)		1.660 (0.465)***
High or above		0.368 (0.505)		0.754 (0.228)
Marital status (ref: married)				
Others		1.628 (0.445)***		−0.436 (0.455)
Monthly income (RMB) (ref: 0–2,999)				
3,000–4,999		−1.663 (0.562)**		0.197 (0.445)
5,000–9,999		−2.241 (0.564)***		−0.715 (0.718)
10,000-		−1.785 (0.681)**		1.237 (1.263)
Having children (ref: no)				
1–2		−0.203 (1.395)		0.579 (1.355)
3-		0.199 (1.465)		2.160 (1.431)
Having chronic diseases (ref: no)				
Yes		−0.049 (0.398)		0.862 (0.558)
R^2	0.279	0.323	0.245	0.294
Adjusted R^2	0.272	0.303	0.238	0.274

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Ref., reference group.

Our study examined the differences between institutionalized and noninstitutionalized older adults on six components of social capital. Compared with community-dwelling older adults, institutionalized older adults had lower degrees of social support, social connection, trust, cohesion, and reciprocity. Social capital, often defined as socially supportive resources embedded in social systems, can be considered a protective factor for older adults. Most urban Chinese older adults were willing to live in community for aging as they can obtain high levels of family and community capital there (29). Institutionalized older adults generally have lower social capital. Hence, social capital enhancement measures should be better integrated into health-related policies for them.

Specifically, for various indicators of social capital, our study revealed that social support, trust, and cohesion were negatively related to loneliness in both groups of older adults.

Social support, defined as the frequency with which older adults receive assistance from other people or groups during difficult times

(39), represents older adults' beliefs about the possible help their relationship networks may provide as well as the quantity and quality of this help (49). Social support can help the older adults obtain material and spiritual support, feel love and care, reduce the occurrence of psychological problems, and improve their quality of life (50). Among older adults in the community, the family and kinship system is the most important source of social support. Family members provide food, care and financial assistance to older people. Close interpersonal relationships are very important for the long-term development of a sense of familiarity and security (29). In addition, friends and neighborhood committees are important support resources (51), and they can provide the older adults with necessary financial and psychological support to reduce loneliness. Older adults who move into nursing homes have new social opportunities, and the social support provided by peers and staff within the institution is just as important as that provided by family and friends in community (52). Long-term friendships are very important for the well-being of old adults living in nursing homes, and close friends are irreplaceable (53). Because it is quite difficult to develop new friendships within the institution (10). Older adults may benefit from actively seeking social support (54), such as through the expansion of social networks (55, 56), which protect themselves from occurrence of psychological problems.

Trust refers to the degree of belief in family, friends, and neighbors which acts as lubricants in interpersonal interactions (57), as spouses and close friends can evoke feelings of intimacy, security and peace. Trust can bring people together, increase their attention to others (58), promote information exchange and knowledge dissemination, and help establish a good interpersonal relationship (59) to reduce loneliness. Trust in older adults can come not only from relatives or confidants, but also from people who can connect with their feelings and emotions to provide security (60). For the older adults in institutions, caregivers are daily service providers, who have regular contact and close relationship with them (42). Emotional connection with a trusted caregiver can reduce the loneliness of older adults to some extent (61). For older adults in the community, informal care is the main source of nursing, and most caregivers are their close relatives (7). Having a trusted family member provide care may prevent loneliness. Higher levels of trust in the community may promote information dissemination, service utilization, and healthy behaviors (62, 63), and reduce loneliness among the older adults.

Cohesion is the feeling that an individual derives strength from the group to which they belong (64), and it is an intrinsic link between the individual and the group. With the growth of age and the decline of mobility, older adults prefer to belong to a certain group and be recognized and accepted by the group, which has important implications for their quality of life and happiness (10). Within a well-established group, the older adults can share information and exchange views with each other, participate in collective social activities, play similar roles, and receive love and help in this process, thereby generating and sharing collective interests (29, 59), counteracting social loneliness and adjusting negative psychology (42). Cohesion is also capable of spawning positive mental states, increasing feelings of acceptance (65), security or self-efficacy (66), motivating individuals to improve their behavior (67, 68), and to help reduce loneliness. It is much easier for older adults who live in community to integrate into their community groups and create a sense of acceptance via interacting with neighbors and caring for community affairs (65). In our study, the interaction of cohesion and institutionalization was significantly associated with loneliness. We speculated that older adults are more eager to integrate because they are in an institutional group that is far from their families. If older adults have a sense of belonging and familiarity with the institution (12), the atmosphere within the institution is harmonious, and there is a greater sense of security and trust among the members (69), which reduces the feeling of loneliness.

In addition, social connection influenced loneliness among older adults living in community dwellings other than in nursing homes. Social connection indicates the degree of communication between older adults and their family members, friends, and neighbors. Older adults can improve their social adaptation by establishing contacts and acquiring more information through communication (70), which helps enhance their sense of self-worth. This can, in turn, promote their health and reduce their feelings of loneliness. Conversely, a lack of interpersonal interactions and social activities can lead to psychological problems and a feeling of emotional loss (71, 72). Building connections, especially face-to-face connections, can provide a sense of security to older people (42), regulate their physiological responses, and mitigate their negative emotions (73). The decline of physical and cognitive functions in older adults may cause them to become more dependent on their social contacts (74). Individuals who engage more frequently with members of their social relationship networks can improve the quantity and quality of their interactions, and are more likely to experience less loneliness (75). However, social connection was not found to be associated with loneliness among older adults living in nursing homes. We inferred that most of older adults living in nursing homes investigated may generally have low levels of social connection, because of their limited mobility and reduced contact with others after living in nursing homes (42). Moreover, measures for the prevention and control of the COVID-19 pandemic further limited their social interaction and activities.

In this study, reciprocity and social participation were not significantly related to older adults' loneliness.Generalized reciprocity refers to an ongoing exchange relationship that is unreciprocated or unbalanced at any given time, but where both parties expect that benefits given now should be reciprocated in the future (76). In particular, reciprocity was not observed in the adjusted regression models, and its role may depend on presence of other dimensions of social capital, as well as the covariates involved. Reciprocity refers to mutual help between individuals. That is, anyone who receives help should return it to the helper or another person (77). Research has pointed out that reciprocity indirectly influences health by helping maintain social networks and social participation. If people believe there is no loss in doing so, they are more likely to contribute to the group and subsequently obtain health benefits (76). Social participation was not found to be associated with loneliness in this study, which is inconsistent with the results of a previous study (19). Social participation is a set of social activities performed voluntarily by an individual to interact with others, and these activities include participation in sports, recreation, cultural programs, and neighborhood associations (78). The non-significant results of social participation in our study may be due to its generally low levels of all participants. As the survey for this study was conducted during the COVID-19 pandemic, epidemic prevention measures restricted older adults from participating in such organized activities (79, 80), and this might have led to a low, or even no, association between reciprocity and loneliness.

In summary, our results indicated that the difference in the sociodemographic characteristics as well as the levels of social capital between older adults living in nursing homes and those in community dwellings could be introduced to explain the difference in the levels of loneliness between them.

Future implication

According to our research, social capital and institutionalization were the main determinants of loneliness among older adults. Thus, to alleviate loneliness among the older adults in community dwellings and in nursing homes, relevant measures should be taken to improve social capital of the old adults, particularly focusing on social support, trust, and cohesion. In the community, the following actions can be taken: (i) strengthen social support for older adults by providing regular contact, care, and companionship from family and social workers; (ii) promote intergenerational integration by providing opportunities for older adults to participate in recreational activities with different age groups, especially by maintaining close relationships with the younger generation (81), in order to cultivate trust and social connections; (iii) communication social skills training (e.g., telephone or internet use). While, the following solutions are available in nursing homes: (i) provide care services based on the needs of older adults; (ii) enhance emotional communication between older adults and caregivers; (iii) facilitate meaningful social interaction, especially between people with common interests (e.g., set up book clubs, offer trips to senior centers).

Limitations

This study has a few limitations. First, the data were collected from three cities in Zhejiang Province, and this may limit the generalizability of the findings. Second, this was a cross-sectional study that did not clarify the causal relationship between social capital and loneliness. Longitudinal or controlled randomized trials should be considered in future studies to address this. Third, part of the data in the study was based on self-reports, which might cause bias in the responses. Fourth, in our analysis, we converted social capital scores into dichotomous variables, which may led to a loss of information. Fifth, the present study used convenient sampling, which may introduce selection bias and limit the representativeness of the sample. Future studies with expanded investigative sites and large sample sizes are needed.

Conclusion

This study indicated that components of social capital, particularly social support, trust, and cohesion, were significantly associated with loneliness among institutionalized and noninstitutionalized older adults. In addition, institutionalization itself and the interaction of cohesion and institutionalization also had an impact on loneliness among older adults. Health-related policies should help older adults gain more social capital to reduce their loneliness. This is particularly critical for older adults living in nursing homes, who have higher levels of loneliness and lower social capital than noninstitutionalized older adults.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Hangzhou Normal University (No. 20210002). The patients/participants provided their written informed consent to participate in this study.

Author contributions

YC and DW contributed to conception and design of the study. ML organized the database. YCZ, YH, and HC performed the statistical analysis. YCZ, YC, and SZ wrote the first draft of the manuscript. YYZ, SY, and XW wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1150310/full#supplementary-material

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Ernawati Ernawati,
Airlangga University, Indonesia
Erkan Oktay,
Atatürk University, Türkiye
Murat Gündüz,
Uşak University, Türkiye
Aşır Genç,
Necmettin Erbakan University, Türkiye

*CORRESPONDENCE
Ömer Alkan
✉ oalkan@atauni.edu.tr

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Passive smoking as a risk factor among older adults: an ordered probability approach for Türkiye

Şeyda Ünver[1], Hasan Hüseyin Tekmanli[1] and Ömer Alkan[1,2]*

[1]Department of Econometrics, Faculty of Economics and Administrative Sciences, Ataturk University, Erzurum, Türkiye, [2]Master Araştırma Eğitim ve Danışmanlık Hizmetleri Ltd. Şti., Ata Teknokent, Erzurum, Türkiye

Background/aim: Older adults represent a significant proportion of the population of many societies, and being one of the disadvantaged groups, they struggle with various difficulties in their social lives. Undoubtedly, passive smoking is one of these difficulties. Passive smoking among older adults, which is an important public health problem, is an issue that needs to be investigated. The aim of this study is to determine the relationship between the demographic and socio-economic characteristics of adults aged 60 and older in Türkiye and their exposure to secondhand smoke (SHS).

Methods: In this study, a microdata set of the 2016 and 2019 Turkey Health Survey conducted by the Turkish Statistical Institute (TUIK) was used. This survey was conducted by TUIK in the relevant years using a stratified sampling method to best represent the whole of Turkey. The study considered only demographic and socio-economic characteristics to investigate passive smoking. Since all the variables used in the study were categorical, the relationship between the dependent variable and the independent variables was first investigated using chi-square tests. In addition, since the dependent variable has an ordered-categorical probability form, the generalized ordinal logit model was used for the analysis of passive smoking and related factors.

Results: The rate of exposure to tobacco smoke of older adults who participated in the study in 2016 was 16%, while the rate of those who participated in the study in 2019 was 21%.

Conclusion: According to the findings of the study, older, uneducated, and uninsured smokers carry a more serious SHS risk. It may be beneficial for society for policy makers to carry out studies by considering these features a priority and focusing on policies in this context. Expanding smoke-free areas to cover older adult, increasing penalties as a deterrent, facilitating education, increasing state support for education, increasing education and public service announcements about tobacco harms, and facilitating social security are the main examples. This study's findings are crucial as a source of information for the development of policies and programs aimed at preventing the exposure of older adults to tobacco smoke.

KEYWORDS

disadvantaged groups, older adults, secondhand smoke, ordered choice models, Türkiye

1. Introduction

Tobacco usage is a severe threat to global health (1). More than 8 million individuals die annually from tobacco usage, and more than 7 million of these deaths are caused by direct tobacco use, while approximately 1.2 million are the result of secondhand smoke (SHS) (2). While active smoking is a voluntary behavior, SHS exposure occurs passively and can also affect non-smokers (3).

SHS exposure, which poses significant threats to human health, is the third leading cause of preventable deaths in the world (4). Similar to active smoking, passive smoking is a severe risk factor for many health morbidities (5). Various studies have found a relationship between SHS and cognitive impairment, dementia, and other neurodegenerative diseases (6–8). Exposure to SHS not only results in serious illness, but also imposes a significant economic and societal burden (3). SHS imposes direct and indirect expenses on national economies in addition to its ever-increasing health burden. Each year, billions of dollars are spent owing to this health issue (9). A review of the relevant literature has been examined, and it has been discovered that demographic and socio-economic factors significantly affect SHS. It has also been identified in previous studies that SHS is potentially associated with adverse health effects (9–11).

Exposure to tobacco smoke is an important public health problem. In addition, it has been discussed in the scientific world with different methods and perspectives for decades. The topic of infant and adolescent tobacco smoke exposure has also been investigated (12–15). Studies that make no distinction based on age are also relatively available (16–19), but there are very few adult-focused studies (20). Some studies have also addressed women's exposure to tobacco smoke (21–25). However, there is a very serious gap in the exposure of older adults to tobacco smoke. Undoubtedly, older adults are also one of the disadvantaged groups.

Aging is a physiological process that results in death and is affected by genetic factors, lifestyle choices, and environmental exposures. The effects of aging, which include changes in health requirements, last a long time in a person's life (26). The global population is rapidly aging, particularly in low- and middle-income countries (27). The older population (those aged 60 and over) is expanding more quickly than the general population worldwide. This situation has been attributed to increasing life expectancy and decreasing birth rates (28). Globally, the proportion of older adults (60 years and older) is expected to reach 21% by 2050 (29). Successful aging has developed into a critical term for defining the standard of aging. The definition evolved from a biomedical perspective to include a broader view of late-life cultural and mental adjustment mechanisms (30).

SHS exposure among older adults is a significant and potentially preventable public health issue (31). On the other hand, mental health entails a positive relationship with people and the pursuit of a productive and fulfilling existence (32). Due to age-related physiological changes and the development of severe health conditions, older adults may be particularly sensitive to the effects of SHS. In addition, older adults may be at a higher risk of involuntary exposure to SHS. This is because these people spend most of their time indoors and are at a greater risk of economic dependency (33). Various studies have found that exposure to SHS is a well-known risk factor for cardiovascular disorders (such as stroke, angina, and hypertension) and lung cancer in adults who do not smoke (6, 34–37). However, few studies have examined the effects of SHS exposure on the health of older adults (33).

In a study conducted in Italy, 33% of the older population was found to be exposed to SHS indoors (38). Another study conducted among nonsmokers over 60 years of age that aimed to evaluate the relationship between SHS and frailty syndrome in older nonsmokers found that exposure to SHS was associated with an increased frequency of frailty (33). In addition, it was stated in a study that the mental health and suicidal tendencies of older adults attracted a lot of attention due to their fragility. As a result of the study, it was determined that older men who had sex with men had higher depression and suicidality scores (39). Passive smoking was found to be significantly associated with an increased prevalence of hypertension and a lower control rate in the older population in a study conducted in Beijing, China (40). As a result of a study conducted to investigate the effects of passive smoking exposure on cognitive function in older adults, it was determined that passive smoking exposure is associated with an increased risk of cognitive impairment (6).

The concept of "old age" encompasses various dimensions, including chronological, biological, psychological, and social age. The United Nations defines "older adults" as those aged 60 and above (41). Previous studies have categorized individuals in this age group as "older adults" but little is known about their exposure to tobacco smoke in Türkiye (6, 28, 29, 31, 33, 42). This study aims to fill this gap by identifying factors associated with tobacco exposure in adults aged 60 and above in Türkiye, which can help identify those at higher risk. Overall, the language could be made more concise and easier to follow with clearer phrasing.

2. Methods

2.1. Data

In this study, a microdata set obtained from the Turkey Health Survey conducted by TURKSTAT in 2016 and 2019 was used. The Turkey Health Survey was conducted for the first time in 2008. This research has been applied to households by the face-to-face interview method, every 2 years until 2016, and every 3 years as of 2019. The latest data for 2019 have been shared by TURKSTAT (43, 44).

All cities, towns, and villages within the borders of the Republic of Türkiye were included in the populations for the stratified two-stage cluster sampling method used to obtain data. Rural–urban distinction was used as an external stratifying criterion (areas with population under and equal to 20,000 were considered rural, while areas with population equal to and above 20,001 were considered urban). The first-stage sampling unit comprised blocks selected from groups (blocks) consisting of an average of 100 house addresses, and the second-stage sampling unit consisted of systematically selected households from each selected group. Cross-sectional data on individuals above the age of 15 were used in this study for sample selection (43, 44). The scope of the study included older adults over 60 years of age in Turkey (45). There are 3,657 observations for 2016 and 3,595 observations for 2019 in the data set.

2.2. Outcome variables

The dependent variable of the study was the exposure of older adults to tobacco smoke. The dependent variable of the model consists of three categories in terms of the frequency of exposure to tobacco: exposure more than 1 hour per day, exposure less than 1 hour per day, and no exposure at all.

2.3. Independent variables

The independent variables included in the study were those from the Turkey Health Survey. The independent variables of the study are as follows: year (2016, 2019), gender (male, female), age (60–64, 65 and older), ability to afford treatment (yes, no), education (illiterate or did not complete primary school, primary school, high school, university), health problems (yes, no), tobacco use (yes, no), and reliable relatives (none, 1–2 people, 3 or more people).

Ordinal and nominal variables were defined as dummy variables so that the effects of the categories of all variables included in the binary logistic regression model could be observed (46, 47).

2.4. Analysis method

The statistical analysis in this study utilized Stata 15 software (Stata Corporation) to account for the complex sampling design and weighting. To obtain a more accurate representation of the population, a weighted analysis was conducted, as described by Coşkun et al. (48). First, the tobacco exposure status of the research participants was determined, along with the frequency and proportions of the independent variables. Subsequently, a generalized ordered logistic regression model was employed to investigate the factors associated with tobacco exposure among older adults.

3. Results

3.1. Descriptive statistics and crosstabs

Tables 1, 2 provide descriptive statistics and chi-square independence test results for the variables used in the study. According to the descriptive statistics of the study, the rate of exposure to tobacco smoke of older adults who participated in the study in 2016 was 16%, while the rate of those who participated in the study in 2019 was 21%.

Table 1 presents the findings on the factors affecting the exposure of older adults to tobacco smoke for 2016. The data includes the number and percentage of research participants based on their tobacco exposure status and various independent variables.

The *p*-values in the table show the significance of the association between each independent variable and tobacco exposure. A, b, and c show the statistical significance of the coefficients at the 1, 5, and 10% significance levels, respectively. For example, a *p*-value of less than 0.05 (indicated by "b") indicates a statistically significant association.

According to the significant findings, males have significantly higher tobacco exposure than females. The research participants aged 60–64 have significantly higher tobacco exposure than those aged 65 and above. The participants whose treatment costs are covered by the social security institution have significantly higher tobacco exposure than those who are not. The research participants who have faced payment difficulties have significantly higher tobacco exposure than those who have not. Smokers have significantly higher tobacco exposure than non-smokers.

Table 2 presents the findings on the factors affecting the exposure of older adults to tobacco smoke for 2019. According to the significant findings; males have significantly higher tobacco exposure than females. The research participants aged 60–64 have significantly higher tobacco exposure than those aged 65 and above. Illiterate participants have significantly lower tobacco exposure than those with primary education. The research participants who have faced payment difficulties have significantly higher tobacco exposure than those who have not. Smokers have a significantly higher tobacco exposure than non-smokers.

3.2. Econometric estimation

As with the independent variables, the generalized ordered logit model generates separate equations for each remaining category by using one category of the dependent variable as a reference (49, 50). Here, the category "no exposure" is mentioned. Tables 3, 4 provide the estimation results and marginal effects of the model. The fact that all the variance inflation factor values related to the independent variables are less than 5 indicates that there is no multicollinearity problem (51, 52). Tables 3, 4 display the model estimation results and marginal effects. The marginal effects will be interpreted for the exposure categories "more than 1 hour per day" and "less than 1 hour per day" respectively.

According to Table 3, women are 2.1% more likely than men to be exposed to tobacco smoke for more than 1 hour a day. Compared to individuals aged 60 to 64, those aged 65 and over are 3.1% less likely to be exposed to tobacco smoke for less than 1 hour a day. Primary school graduates are 2.7% less likely than illiterates to be exposed to tobacco smoke for less than 1 hour a day. Elementary school graduates are 3.7% less likely than illiterates to be exposed to tobacco smoke for more than 1 hour a day. University graduates are 4.9% less likely than illiterates to be exposed to tobacco smoke for less than 1 hour a day. Those whose treatment expenses are paid by a social security institution are 3.9% less likely to be exposed to tobacco smoke for more than 1 hour a day. Tobacco smokers are 23.3% more likely than nonsmokers to be exposed to tobacco smoke for more than an hour a day. Tobacco users are 10.5% more likely than nonsmokers to be exposed to tobacco smoke for less than 1 hour a day. Individuals who can rely on one or two people in an emergency are 3.6% more likely to be exposed to tobacco smoke for more than an hour a day compared to those who cannot.

Table 4 indicates that women are 1.4% less likely than men to be exposed to tobacco smoke for less than 1 hour a day. Graduates of primary school are 3.5% less likely than illiterates to be exposed to tobacco smoke for more than an hour every day. Graduates of elementary school are 2.1% less likely than illiterates to be exposed to tobacco smoke for less than an hour every day. Graduates of high school are 3.6% less likely than illiterates to be exposed to tobacco smoke for more than an hour a day. University graduates are 4.1% less likely than illiterates to be exposed to tobacco smoke for more than 1 hour a day. Individuals with problems affording health care are 2.4%

TABLE 1 Findings on the factors affecting the exposure of older adults to tobacco smoke for 2016 (n = 3,657).

Variables	n (%)	Tobacco exposure (%)			p
		Exposure more than one hour per day	Exposure less than one hour per day	No exposure at all	
Gender					
Male	1,617 (44.22)	8.09	11.04	80.87	0.004[a]
Female	2,040 (55.78)	5.82	8.91	85.27	
Age					
60–64	1,145 (31.31)	8.81	12.27	78.92	0.000[a]
65+	2,512 (68.69)	5.87	8.68	85.46	
Education					
Illiterate	1,487 (40.66)	6.51	9.62	83.87	0.398
Primary school	1,591 (41.54)	7.57	9.5	82.93	
Middle school	209 (5.72)	4.16	12.77	83.07	
High school	215 (5.88)	8.15	13.65	78.19	
University	227 (6.21)	5.34	7.8	86.86	
Are your treatment costs covered by the social security institution?					
No	433 (11.84)	10.98	10.68	78.34	0.000[a]
Yes	3,224 (88.16)	6.27	9.77	83.96	
Have you ever been unable to make health expenses due to payment difficulties?					
No	3,329 (91.03)	6.39	9.86	83.75	0.017[b]
Yes	328 (8.97)	11.36	10.06	78.59	
Do you smoke?					
No	3,145 (86)	3.8	8.07	88.13	0.000[a]
Yes	512 (14)	24.32	20.23	55.45	
How many people close to you can you trust if you have a serious personal problem?					
None	219 (5.99)	6.09	8.14	85.77	0.126
1–2	1,453 (39.73)	7.72	10.31	81.97	
3+	1,985 (54.28)	6.29	9.76	83.96	

[a]$p < 0.01$.
[b]$p < 0.05$.

more likely to be exposed to cigarette smoke for less than an hour each day than those without such difficulties. Nonsmokers are 26.2% less likely than smokers to be exposed to tobacco smoke for more than 1 hour every day.

4. Discussion

According to the descriptive statistics of the study, the rate of exposure to tobacco smoke of older adults who participated in the study in 2016 was 16%, while the rate of those who participated in the study in 2019 was 21%. This rate is quite low compared to other countries. According to a study conducted in Egypt, 37.1% of older adults were exposed to tobacco smoke (53). In a study conducted in China, the exposure rate for those aged 40 and older to tobacco smoke was found to be 21.35% (54), and in another study, it was found to be 24.8% for those aged 55 and older (31). In a study conducted in the United States, the proportion of older adults exposed to tobacco smoke was found to be 25.2% (55). According to a study conducted in eight sub-Saharan countries, the rates of exposure to tobacco smoke among those aged 65 and older are 20% in Cameroon, 17.5% in Kenya, 17.2% in Uganda, 9.5% in Nigeria, 18% in Senegal, 4% in Ethiopia, 21% in Botswana, and 13.5% in Tanzania (56).

According to a study conducted in Beijing, 40.5 and 41.1% of women aged 60–70 were exposed to tobacco smoke in 2001 and 2010, respectively. In the aforementioned study, it was determined that the prevalence of passive smoking was much lower among individuals with higher levels of education. In addition, according to the study, intense physical activity was associated with the greatest increase in the prevalence of passive smoking among males (15.2%), whereas light labor was associated with the highest decrease (7.3%) among women (31). In another study conducted on Chinese women, the rate of exposure to tobacco smoke was found to be 32.51% among women between the ages of 30 and 40 and 17.77% among women older than 40 (54). In a study conducted on individuals over the age of 60 in Zhejiang province, it was determined that the rate of exposure to

TABLE 2 Findings on the factors affecting the exposure of older adults to tobacco smoke for 2019 (n = 3,595).

Variables	n (%)	Tobacco exposure (%)			p
		Exposure more than one hour per day	Exposure less than one hour per day	No exposure at all	
Gender					
Male	1,633 (45.42)	10.2	4.78	85.02	0.000[a]
Female	1,962 (54.58)	6.53	3.13	90.34	
Age					
60–64	1,137 (31.63)	10.65	4.74	84.61	0.000[a]
65+	2,458 (68.37)	7.09	3.49	89.42	
Education					
Illiterate	1,211 (33.69)	8.11	2.59	8.93	0.025[b]
Primary school	1,642 (45.67)	7.5	4.78	87.71	
Middle school	190 (5.29)	10.15	1.71	88.13	
High school	289 (8.04)	10.6	5.96	83.44	
University	263 (7.32)	9.5	4.42	86.08	
Are your treatment costs covered by the social security institution?					
No	89 (2.48)	7.75	1.75	90.5	0.473
Yes	3,506 (97.52)	8.24	3.95	87.82	
Have you ever been unable to make health expenses due to payment difficulties?					
No	3,282 (91.29)	7.88	3.67	88.46	0.000[a]
Yes	313 (8.71)	11.89	6.2	81.9	
Do you smoke?					
No	2,984 (83)	4.22	3.3	92.48	0.000[a]
Yes	611 (17)	28.77	6.91	64.32	
How many people close to you can you trust if you have a serious personal problem?					
None	1,96 (5.45)	7.76	4.66	87.57	0.384
1–2	1,366 (38)	8.84	4.26	56.9	
3+	2,033 (56.55)	7.85	3.55	8.86	

[a]$p < 0.01$.
[b]$p < 0.05$.

tobacco smoke was 15.4% among married individuals and 16.7% among unmarried individuals. In the aforementioned study, it was determined that nonworking individuals were exposed to tobacco smoke at a rate of 19.2%, while working individuals were exposed at a rate of 15.5%. In addition, the rate of exposure to tobacco smoke among alcohol consumers in the study was reported to be 13.9% (6).

According to the findings of this study, women are more likely than men to be exposed to tobacco smoke. Similarly, according to a study conducted in India, rural women are more likely than men to be exposed to tobacco smoke (57). In a study conducted in Northern China, it was found that women were less likely to be exposed to tobacco smoke in cities (58). The findings of the study indicated that those aged 65 and older were less likely to be exposed to tobacco smoke than those aged 60 to 64. In a study conducted on women in Türkiye, it was determined that other age groups were more likely to be exposed to tobacco smoke than those aged 65 and older (21). Again, in a study examining the likelihood of exposure to tobacco smoke by education level in Türkiye, it was determined that those aged 55 and older were less likely to be exposed to tobacco smoke than younger age groups (4). In a study for Greece, age groups 25–39, 40–54, and 55–64 were found to be more likely to be exposed to tobacco smoke than age group 65+ (59). Similarly, according to the findings of a study conducted in China, tobacco smoke exposure decreases with age (60). In a study conducted in the United States, it was determined that the age groups 40–59 and 60+ were less likely to be exposed to tobacco smoke than the age group 20–39 (61). This group's withdrawal from the workforce may be a contributing factor to the low rate and probability of tobacco smoke exposure among older adults. In fact, a study conducted in China found that retirees were less likely to be exposed to tobacco smoke, supporting our finding because these individuals are no longer employed and are not frequently in places where tobacco is used (31). The decreasing possibilities with increasing age show the necessity of focusing on the youth in the policies to be followed. In addition to tobacco bans, it may be advantageous to emphasize tobacco's negative effects more frequently in educational programs. Furthermore, more emphasis on

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TABLE 3 Estimated model results and marginal effects of factors associated with older adults' exposure to tobacco smoke for 2016.

Variables	Exposure more than one hour per day				Exposure less than one hour per day				1/VIF
	COR	AOR	dy/dx	Std. Err.	COR	AOR	dy/dx	Std. Err.	
Gender (Ref: Male)									
Female	0.846	0.688[c]	0.021[c]	0.011	0.971	0.921	−0.011	0.014	0.803
Age (Ref: 60–64)									
65+	1.308[c]	1.296	−0.015	0.011	1.372[a]	1.427[a]	−0.031[b]	0.014	0.941
Education (Ref: Illiterate)									
Primary school	1.025	0.928	0.004	0.014	1.304[b]	1.196	−0.027[c]	0.016	0.695
Middle school	1.585	2.379[b]	−0.037[b]	0.015	1.201	1.374	−0.001	0.025	0.859
High school	1.066	0.999	$6*10^{-5}$	0.021	1.312	1.019	−0.003	0.031	0.836
University	2.164[c]	1.596	−0.023	0.021	1.881[a]	1.928[b]	−0.049[b]	0.02	0.827
Are your treatment costs covered by the social security institution? (Ref: No)									
Yes	1.962[a]	1.800[b]	−0.039[b]	0.0184	1.361[b]	1.453[b]	−0.011	0.023	0.908
Have you ever been unable to make health expenses due to payment difficulties? (Ref: No)									
Yes	0.696	0.711	0.021	0.019	0.903	0.846	0.0001	0.022	0.953
Do you smoke? (Ref: No)									
Yes	0.133[a]	0.099[a]	0.233[a]	0.029	0.149[a]	0.154[a]	0.105[a]	0.025	0.914
How many people close to you can you trust if you have a serious personal problem? (Ref: None)									
1–2	0.804	0.497[b]	0.036[b]	0.015	0.743	0.571[b]	0.027	0.021	0.216
3+	1.094	0.654	0.019	0.014	0.957	0.649[c]	0.027	0.021	0.213
Constant	14.395[a]	28.879[a]			5.669[a]	6.509[a]			

[a]$p < 0.01$.
[b]$p < 0.05$.
[c]$p < 0.10$.
COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio.

healthy lives in public service announcements, TV, and radio programs may also be effective.

Graduates of primary, middle, high school, and university are less likely to be exposed to tobacco smoke than illiterates. Higher education level refers to higher income levels at both state and private institutions, and individuals are more conscious of their health (62). A study conducted on different education levels in Türkiye, it was determined that those with a higher level of education were less likely to be exposed to tobacco smoke than illiterates (4). Similar to this study's findings, studies conducted in China, India, and Bangladesh found that exposure to tobacco smoke increased with decreasing levels of education (60, 63, 64). This demonstrates that the uneducated population faces greater risk and underlines the necessity of targeted education programs. Educating tobacco users about smoke-free homes and the dangers of tobacco is an essential element in reversing this situation and can reduce tobacco use and exposure (65). In contrast to the findings of this study, a study conducted in the United States found that those with a higher level of education were more exposed to tobacco smoke than those with a lower level of education (61).

Those whose medical expenses are covered by the social security institution are less likely to be exposed to SHS. In a study conducted in Türkiye, it was determined that men whose medical expenses were covered by social security institutions were less likely to use tobacco (66). Today, the use of preventive health services in the fight against health problems is becoming common. With preventive health services, individuals can be protected against diseases. They also reduce health care costs and prevent workforce loss. Unquestionably, preventive health services are crucial for reducing tobacco use and exposure, which is an important public health problem (67).

Tobacco users are more likely than others to be exposed to tobacco smoke. Studies conducted in the United States and India have also found that tobacco users are more likely to be exposed to tobacco smoke (64, 68). The low exposure probability of non-smokers is an expected outcome. This may highlight the need for population-based education campaigns that provide smoking cessation advice or information on how to assist a smoking friend or family member in quitting. Such campaigns may also be opportunities to encourage nonsmokers to become active participants in the enforcement of the smoke-free law, for instance, by contacting the relevant authorities when the indoor smoking ban is violated. Such concerted efforts by nonsmoking individuals and law enforcement can help normalize smoking in public places and promote smoke-free environments (16).

Those who have a number of close contacts to trust in the event of a serious personal problem are more likely than those who have no exposure to tobacco smoke. In a study conducted on infants in Türkiye, extended families were found to have a higher risk of exposure to tobacco smoke (69).

5. Strengths and limitations of this study

This study was conducted using data obtained from the official statistical institution of Türkiye, TurkStat. To the best of our

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TABLE 4 Estimated model results and marginal effects of factors associated with older adults' exposure to tobacco smoke for 2019.

Variables	Exposure more than one hour per day				Exposure less than one hour per day				1/VIF
	COR	AOR	dy/dx	Std. Err.	COR	AOR	dy/dx	Std. Err.	
Gender (Ref: Male)									
Female	1.015	0.998	0.0001	0.009	1.175	1.155	−0.014[c]	0.008	0.825
Age (Ref: 60–64)									
65+	1.162	1.109	−0.007	0.010	1.290[b]	1.206	−0.011	0.008	0.940
Education (Ref: Illiterate)									
Primary school	1.532[a]	1.657[a]	−0.035[a]	0.013	1.220	1.263	0.013	0.008	0.680
Middle school	1.278	1.402	−0.025	0.020	1.485	1.653[c]	−0.021[b]	0.008	0.853
High school	1.685[b]	1.673[c]	−0.036[b]	0.018	1.356	1.370	0.006	0.013	0.773
University	1.761[b]	1.835[b]	−0.041[b]	0.016	1.284	1.309	0.015	0.012	0.805
Are your treatment costs covered by the social security institution? (Ref: No)									
Yes	0.721	1.016	−0.001	0.033	0.706	0.834	0.017	0.016	0.979
Have you ever been unable to make health expenses due to payment difficulties? (Ref: No)									
Yes	0.652[b]	0.677[c]	0.029	0.019	0.539[a]	0.610[b]	0.024[c]	0.014	0.979
Do you smoke? (Ref: No)									
Yes	0.110[a]	0.098[a]	0.262[a]	0.024	0.149[a]	0.147[a]	0.015	0.012	0.907
How many people close to you can you trust if you have a serious personal problem? (Ref: None)									
1–2	0.657	0.709	0.022	0.019	0.767	0.787	0.001	0.014	0.201
3+	0.832	0.794	0.014	0.018	0.922	0.883	−0.003	0.013	0.199
Constant	28.368[a]	21.299[a]			14.682[a]	12.591[a]			

[a]$p < 0.01$.
[b]$p < 0.05$.
[c]$p < 0.10$.
COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio.

knowledge, this is the first known study to determine the factors associated with exposure to tobacco smoke in adults aged 60 and older in Türkiye. The study's findings are applicable to Turkish society in 2016 and 2019, but cannot be generalized to other years or societies. The aim of this study is to shed light on the policies to be developed by competent authorities. In the future, multivariate probability approaches, in which infants or adolescents, who are also disadvantaged segments of society, can be discussed together with older adults to obtain more detailed findings.

This study is not without limitations. To begin, the study relies on secondary data. The variables required for statistical analysis are those found in the data-set (70). Additionally, some variables, such as individuals' occupations, home ownership status, and levels of exposure to tobacco smoke by parents, siblings, and other household members and friends were not included in the analysis. Because the data are cross-sectional, the definite causal relationship between verbal violations and related socio-economic factors cannot be inferred (71). Furthermore, because the dataset did not include information about the location of tobacco smoke exposure, this study focused on general SHS exposure. The distinction between SHS-exposed locations, such as homes, public places, workplaces, restaurants, and bars, was omitted. Because tests to determine individuals' exposure to tobacco smoke could not be conducted in a laboratory setting, the study relied on individuals' own responses. The data obtained might be biased as a result of this data collection method.

6. Conclusion

Tobacco use causes significant health problems not only for tobacco users, but also for people who do not use tobacco, due to environmental tobacco smoke spreading to the environment. Each year, new evidence emerges regarding the health risks associated with tobacco smoke exposure. To reduce the prevalence of SHS, it is essential to understand the factors that determine tobacco use.

In this study, the data of older adults who participated in the 2016 and 2019 Turkey Health Survey conducted by the Turkish Statistical Institute were used. In this study, using a generalized ordinal logistic regression model, factors related to the exposure of older adults to tobacco smoke in Türkiye were identified.

Tobacco smoke exposure results in disease, death, loss of the workforce, etc. for society. In recent years, the Turkish government has taken serious measures to combat the damage caused by tobacco. However, the majority of the measures taken are for public areas, and there is little intervention in homes where older adults spend the majority of their time. The research shows that smoke-free laws have a positive relationship with smoke-free house rules. This suggests that prohibiting smoking in public places could have far-reaching effects on reducing exposure to SHS in other settings (72). The public should be made aware of the dangers of SHS, particularly in private areas, and awareness studies should be conducted. Through channels such as social media, the positive effects of a smoke-free home environment

on a healthy life should frequently be publicized (73). It has been shown that comprehensive smoke-free laws are significantly associated with fewer hospitalizations, deaths from coronary events, and other heart diseases (74). Therefore, strengthening SHS policies will reduce deaths from SHS exposure and the associated economic burden (75). In addition, smoking cessation efforts are a cornerstone in the prevention of tobacco harm, and this issue should be addressed separately as part of organized tobacco-control efforts (76).

Therefore, it is assumed that the sample in question best represents society. The study's findings are applicable to Turkish society in 2016 and 2019, but cannot be generalized to other years or societies. The aim of this study is to shed light on the policies to be developed by competent authorities. In the future, multivariate probability approaches in which infants or adolescents, who are also disadvantaged segments of society, can be discussed together with older adults to obtain more detailed findings.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data underlying this study is subject to third-party restrictions by the Turkey Statistical Institute. Data are available from the Turkish Statistical Institute (bilgi@tuik.gov.tr) for researchers who meet the criteria for access to confidential data. The authors of the study did not receive any special privileges in accessing the data. Requests to access these datasets should be directed to bilgi@tuik.gov.tr.

Author contributions

ÖA: conceptualization, methodology, software, data curation, writing - original draft, writing-review and editing, formal analysis, and visualization. HT: conceptualization, methodology, formal analysis, data curation, supervision, writing- original draft, and editing. ŞÜ: conceptualization, supervision, and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

ÖA was employed by Master Araştırma Eğitim ve Danışmanlık Hizmetleri Ltd. Şti., Ata Teknokent.

The remaining 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 reviewer EO declared a shared affiliation with the author(s) to the handling editor at the time of review.

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EDITED BY
Alex Siu-Wing Chan,
Hong Kong Polytechnic University,
Hong Kong SAR, China

REVIEWED BY
Hon Lon Tam,
The Chinese University of Hong Kong, China
Caress Alithia Dean,
Oakland University, United States

*CORRESPONDENCE
Change Zhu
✉ change.zhu@ucalgary.ca

†These authors have contributed equally to this work

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Assessing the effect of health status on multidimensional poverty among older adults: the Chinese longitudinal healthy longevity survey

Lulin Zhou[1†], Change Zhu[1,2*†], Christine A. Walsh[2] and Xinjie Zhang[1]

[1]Department of Management, Jiangsu University, Zhenjiang, China, [2]Faculty of Social Work, University of Calgary, Calgary, AB, Canada

Background: This study aimed to explore the association between health status (physical, mental, and self-rated health) and multidimensional poverty (subjective and objective poverty) in older adults.

Method: A panel binary logit regression approach was applied to four waves of CLHLS data (2008, 2011, 2014, and 2018). In total,1,445 individuals were included after data cleaning.

Results: The mean values and proportion of physical, mental, and self-rated health were 5.73 (87.42%), 0.93 (93.06%), and 3.46 (86.7%), respectively, and mean values and proportion of subjective and objective poverty were 0.19 (18.51%) and 0.21(21.4%). In addition, physical, mental, and self-rated health were all found to be associated with subjective poverty among older adults (r =−0.181, r =−0.630, r =−0.321, p <0.05), that is, the better the physical, mental, and self-rated health, the lower the probability of subjective poverty. A comparable connection between self-rated health and objective poverty also exists (r =−0.157, p <0.05). Furthermore, medical expenditure played a mediation role in the association between the health status and poverty of older adults.

Conclusion: In order to effectively alleviate the poverty of older adults, strategies should be taken to improve the health level of older adults, especially the physical and mental health of high-aged older adults, and the self-rated health of middle-aged older adults. Furthermore, social security and pensions should be further developed to adequately reimburse medical expenditures.

KEYWORDS

multidimensional health, multidimensional poverty, older adults, medical expenditure, China, CLHLS

1. Research background

Older adults are a vulnerable group in society in relation to poverty (1). Based on the poverty cycle theory, poverty is more likely to occur in older adults (2). As the world's population ages, the issue of poverty among older adults has become increasingly prominent. China has the largest aging population in the world, as noted in previous studies (3, 4). It is estimated that

China will have the largest older population in the world by 2050, with a projected number of 488 million older adults, comprising 35.5% of the total population.[1] Hence, it is imperative to accord significant attention to the issue of poverty among older adults in China.

Poverty not only imposes a significant burden on society, but also leads to a wide range of negative outcomes, including reduced access to healthcare (5), inadequate nutrition, and limited opportunities for social engagement. Under the circumstances, the high poverty rate of older adults is serious and needs to be addressed urgently (6, 7).

The multifaceted nature of poverty is widely acknowledged, as it can be defined and measured using a variety of dimensions (8). To our knowledge, economic poverty is a common experience for the older population (9). The comprehensive rollout of basic medical insurance plans in China has effectively addressed objective poverty concerns, however, due to the persistence of wealth inequality, the perception of poverty remains a primary issue. As such, it is necessary to conduct a comprehensive analysis of both objective and subjective poverty, that is, multidimensional poverty, among older adults (8).

Available studies have shown that older adults' poverty is related to individual-level, community-level, and policy-level factors such as age (10), gender (11), education (12, 13), marital status (14, 15), occupation (16), and place of residence (17). Furthermore, neighborhood service and community service are factors affecting poverty (18). Also, deficiency of government support and social security (19) are found to be closely related to poverty.

In recent years, there are an increasing number of researchers that are focusing on the impact of poverty on the health of older adults. However, few studies are concerned about the effect of health on poverty among older adults. The theory of poverty raised by Sen proposed that capability deprivation is the main cause of poverty (20). It was suggested that the ability of older adults typically decreases with aging due to the degradation of physical and cognitive function (21), thus resulting in a deficiency in income (22). Additionally, income level is normally found to be related to poverty among older adults (23). Thus, it can be supposed that improving health is one of the key initiatives to reduce poverty. Having good health is the basis and premise for individuals to participate in the labor market. It is well acknowledged that the health status of older adults is multidimensional, including not only physical health but also psychological and self-rated health. Therefore, it is necessary to conduct research that enriches our understanding of the multidimensional relationship between the health status of older adults and their poverty status.

In addition, some scholars have shown that the worse a population's health status, the more morbidities, and the heavier the medical expenditure, thus resulting in an economic burden (24, 25). In China, poverty related to disease is prevalent, particularly among older adults (26). According to statistics, the number of households returning to poverty as a result of the disease fell from 7.269 million at the end of 2015 to 3.882 million in 2017 in China.[2] Although the proportion of poverty caused by disease has decreased, the phenomenon of poverty caused by medical expenses remains severe.

Thus, the primary objective of this study was to examine the health status (including physical, mental, and self-rated health) and poverty (subjective and objective poverty) among older adults in China. Moreover, it aimed to investigate the impact of health status on poverty and explore the role of medical expenses in influencing this relationship.

2. Methods

2.1. Data and sample

Data were derived from the 2008, 2011, 2014, and 2018 Chinese Longitudinal Healthy Longevity Surveys (CLHLS). The survey was organized by the Research Center of Healthy Aging and Development of Peking University/National Development Institute. This survey is a comprehensive longitudinal study conducted across 23 provinces/autonomous regions in China. The regions were selected randomly for in-person household interviews. This survey mainly focuses on older adults. The respondents in this article were the older adults who participated in the research in 2008, 2011, 2014, and 2018. The survey groups were mainly older people aged 60 and older. In total, 1,445 individuals were investigated after data cleaning.

2.2. Variable definitions

2.2.1. Poverty (dependent variable)

The poverty of older adults was the dependent variable in this research. Different from the solo measure of economic poverty studied by previous research (27), the poverty of older adults in this article included both subjective and objective poverty. Subjective poverty was reflected by "whether all your sources of living are sufficient," with answers of 0 identified as non-subjective poverty and 1 identified as subjective poverty. Similarly, objective poverty was reflected by whether the *per capita* total income of residents reached the *per capita* annual income standard of 1,196 RMB in 2008, 2,300 RMB in 2011, 2,800 RMB in 2014, and 3,535 RMB in 2018. If the *per capita* annual income exceeded the criteria, it was determined as non-objective poverty, coded as 0; otherwise, it was identified as objective poverty, coded as 1.

2.2.2. Health status (independent variable)

The health status of older adults was the independent variable in this article. According to the extant research, health is not only physical function without disease but also good mental condition (28). In addition, self-rated health is found to be valid for people's assessments of their general health (29). Therefore, physical, mental, and self-rated health were utilized to measure the multidimensional health status of older adults in this research. Specifically, physical health refers to the unimpaired body function of the individual, which can ensure the normal progress of daily activities. The physical health of older adults is reflected by six activities of daily living (ADL) of "bathing, dressing, going to the toilet, indoor activities, and fecal control and eating" (30) and if the participants were able to perform the ADL independently, it was recorded as 1; otherwise, it was

1 United Nations (2012). World Population Prospects: The 2012 Revision. New York, NY: United Nations Department of Economic and Social Affairs. Available online at: http://esa.un.org/unpd/wpp/index.htm.

2 http://www.xinhuanet.com/politics/2018-07/03/c_1123069056.htm

recorded as 0. The total score of these six activities is used as an indicator of physical health for older adults. Thus, the score range was 0–6. In addition, they were considered to be physically healthy if the six routine activities were completed independently. If not, they were considered to be physically unhealthy.

Furthermore, the World Health Organization (WHO) defines mental health as a condition of overall wellness in which individuals can recognize and use their own abilities, manage typical life stressors, perform effectively and efficiently, and add value to their community (31). Mental health in this study was expressed by the personality, emotional characteristics, and depression of older adults, through the following six questions: "Do you always look on the bright side of things?," "Do you often feel fearful or anxious?," "Do you often feel lonely and isolated?," "Can you make your own decisions concerning your personal affairs?," "Do you feel the older you get, the more useless you are?," and "Are you as happy as when you were younger?" All the items were a five-level Likert scale; negative scoring items were transferred into positive ones (1 = very unhealthy, 2 = relatively unhealthy, 3 = average, 4 = relatively healthy, and 5 = very healthy). Specifically, if the total score for mental health was greater than 18 or equal to 18, it was identified as mentally healthy and coded as 1. Otherwise, if the score is less than 18, it was identified as mentally unhealthy and coded as 0.

Self-rated health is a comprehensive variable widely used in health status measurement. It is a general comprehensive evaluation made by the respondents based on their subjective cognition of their own health status (32, 33). Thus, in this article, self-rated health was reflected by older adults' assessment of their own health status, measured by the item, "How do you rate your health at present." Respondents' answers ranged from "very unhealthy"(=1), "relatively unhealthy"(=2), "average"(=3), "relatively healthy"(=4), and "very healthy"(=5). In addition, if the score of self-rated health was less than 3, it was considered to be self-rated unhealthy, otherwise, it was considered to be self-rated healthy.

2.2.3. Covariates

According to the existing research, individual characteristics that affect the poverty of older adults were used as control variables. Consideration was also given to the health behaviors of older adults, such as smoking and drinking alcohol. In addition, environmental level factors were also taken into account, such as community services and social security. Details are shown in Table 1.

2.3. Method of data analysis

The dependent variable of this study was multidimensional poverty, a binary variable, so this article used panel binary logit regression analysis to create the function $\text{logit}(Y) = a + \sum_{i=1}^{k}\beta_i x_i + \varepsilon$. Therefore, the analysis model of influencing factors of poverty of older adults is as follows:

$$P(Y_j = 1) = \frac{\exp\left(\hat{a} + \sum_{i=1}^{k}\beta_i x_i\right)}{1 + \exp\left(\hat{a} + \sum_{i=1}^{k}\beta_i x_i\right)} \quad (1)$$

Specifically, $P(Y_j = 1)$ is the probability of poverty of older adults; β_i is the regression coefficient of each independent variable (including the covariates); x_i is the independent variable (including the control

TABLE 1 The definition of variables and descriptive statistics.

	Variable	Variable definition	Mean (Proportion)	SD
Independent variable	Physical health	Total score of ADL ability (1–6)	5.73 (87.42%)	0.92
	Mental health	Healthy = 1, Unhealthy = 0	0.93 (93.06%)	0.25
	Self-rated health	Total score of self-rated health (1–5)	3.46 (86.7%)	0.89
Dependent variable	Subjective poverty	Poverty = 1, Non poverty = 0	0.19 (18.51%)	0.39
	Objective poverty	Poverty = 1, Non poverty = 0	0.21 (21.4%)	0.41
Mediator variable	Medical fee	Ln (medical fee)	5.74	3.38
Control variables	Age	The age of older adults (61–106)	78.97	8.83
	Gender	Male = 1, Female = 0	0.51 (51.09%)	0.50
	Residence	City = 1, Rural = 0	0.08 (8.44%)	0.28
	Living arrangement	living with family = 1; living alone = 2; living in an institution = 3	1.03	0.19
	Education	Years of schooling (0–20)	2.82	3.74
	Marital status	Currently married =1, Unmarried = 0	0.66 (66.02%)	0.47
	Smoking	Smoked = 1, never smoked = 0	0.37 (37.27%)	0.48
	Alcohol drinking	Drunk = 1, never drunk = 0	0.33 (32.75%)	0.47
	Community services	The total kinds of community service (0–8)	1.31	1.78
	Social security	The total kinds of social security (0–7)	1.34	0.79

SD denotes standard deviation.

variable), and α is the intercept term. The poverty of older adults included subjective poverty and objective poverty. Therefore, a regression model is constructed as follows:

$$P_i\left(SP_i, OP_i\right) = \delta_1 HS_i + \delta_2 IF_i + \varepsilon \quad (2)$$

Among them, P_i represents the probability of poverty of older adults; SP_i and OP_i represent the probability of subjective poverty and objective poverty, respectively; HS_i is the health status matrix that affects the poverty of older adults and δ_1 is its regression coefficient; $IF_i$is the personal characteristic matrix and δ_2 is its regression coefficient; ε is random disturbance term.

3. Results

3.1. Descriptive statistical analysis of the sample

From Table 1, it can be seen that the average score for physical health among older adults was 5.73, the average score for mental health was 0.93, and the average score for self-rated health was 3.46. In addition, the mean score for subjective poverty was 0.19, accounting for 18.51%, and the mean score for objective poverty was 0.21, accounting for 21.4%. In addition, the average age of older adults in this study was 78.97, with slightly more males than females, with males accounting for 51%. They mostly lived in rural areas, accounting for 91.56%, and had a generally low educational level with an average of 2.82 years of education. Regarding marital status, the majority of older adults (66%) were married at present, and the percentage of smokers and drinkers was relatively low, accounting for 37 and 33%, respectively. Furthermore, around half of the older adults (50.6%) received at least one community service. Finally, the majority of the older adults enjoyed some level of social security, accounting for 91.16%.

3.2. Analysis of the effect of multidimensional health status on multidimensional poverty

Table 2 shows the influence of health status and covariates on subjective and objective poverty of older adults. To control for errors and endogeneity issues, this study utilized panel data and employs fixed effects to examine the impact of health status on poverty. To be specific, Models 1 and 3 mainly investigate the effect of covariates on subjective poverty and objective poverty, respectively. Models 2 and 4 investigate the effect of health status on subjective poverty and objective poverty of older adults on the basis of covariates, respectively.

Table 2 shows that age had a significant negative impact on the subjective poverty of older adults, and a significant positive impact on objective poverty, that is, the older the individual, the lower the probability of subjective poverty and the higher the probability of objective poverty. The place of residence of older adults had a significant positive impact on their subjective poverty, indicating that the probability of subjective poverty among older people living in urban areas was significantly higher than that of those living in rural areas. In contrast, the place of residence had no significant negative impact on the objective poverty of older adults. Education had a significant negative relationship with the subjective poverty of older adults, that is, the higher the education level, the lower the probability of subjective poverty. The marital status of older adults was positively correlated with subjective poverty, indicating that the subjective poverty rate of older people with spouses was significantly higher than that of those without spouses, which is contrary to previous research (34). Smoking and drinking had no significant impact on subjective and objective poverty. In addition, community services had a significant negative impact on subjective poverty, suggesting that older people who enjoy community services had a lower prevalence of subjective poverty. Social security had no significant impact on subjective poverty but had a significant negative impact on objective poverty, that is, social security

TABLE 2 The effect of health status on the poverty of older adults.

	(1)*SP*	(2)*SP*	(3)*OP*	(4)*OP*
Age	−0.043***(0.012)	−0.059*** (0.013)	0.082*** (0.012)	0.075*** (0.012)
Residence	0.685* (0.306)	0.759* (0.312)	−0.065 (0.303)	−0.066 (0.304)
Living arrangement	−0.095 (0.234)	−0.04 (0.239)	−0.115 (0.204)	−0.109 (0.204)
Education	−0.069* (0.027)	−0.058* (0.028)	−0.038 (0.024)	−0.037 (0.024)
Marriage	0.371* (0.178)	0.496** (0.183)	0.289 (0.182)	0.327 (0.184)
Smoking	−0232 (0.197)	−0.256 (0.200)	0.049 (0.173)	0.037 (0.173)
Alcohol drinking	0.234 (0.161)	0.265 (0.164)	0.091 (0.151)	0.096 (0.152)
Community services	−0.166***(0.032)	−0.157*** (0.033)	−0.017 (0.029)	−0.012 (0.029)
Social security	−0.024(0.076)	−0.017 (0.077)	−0.185* (0.074)	−0.178* (0.075)
Medical fee	0.063***(0.015)	0.048** (0.016)	−0.030* (0.014)	−0.037** (0.014)
Physical health		−0.181*** (0.051)		−0.076 (0.050)
Mental health		−0.630*** (0.164)		−0.302 (0.170)
Self-rated health		−0.321*** (0.059)		−0.157** (0.056)

Standard errors in parentheses; *$p < 0.5$, **$p < 0.01$, ***$p < 0.001$; SP indicates subjective poverty; OP indicates objective poverty; The same below.

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significantly reduced the probability of objective poverty among older adults. Furthermore, medical expenses had a significant positive impact on subjective poverty, but a significant negative impact on objective poverty, indicating that the higher the medical expenses, the higher the probability of subjective poverty among older adults, but the lower the probability of objective poverty. Finally, the levels of physical and mental health both had a significant negative impact on subjective poverty and no significant impact on objective poverty. Self-rated health had a significant negative impact on both subjective and objective poverty, indicating that the higher the self-rated health level, the lower the probability of subjective and objective poverty among older adults.

3.3. Analysis of the differences in health and poverty among older adults of different age groups

In order to investigate whether age affects the health and poverty status of older adults, individuals were categorized into a low-aged group, a middle-aged group, and a high-aged group according to WHO standards. To be specific, the low-aged group included older individuals aged 60–74, the middle-aged group included those aged 75–89, and the high-aged group included individuals who were 90 years or older (35).

Table 3 presents the analysis of the health status and poverty of older adults in different age groups. The prevalence of physical and mental health problems in older adults exhibits a gradual upward trend, with a successive rise observed in the low-aged, middle-aged, and high-aged groups. Notably, the observed differences have been confirmed to be statistically significant ($p < 0.05$). The self-rated unhealthy proportion across different age groups was not found to be statistically significant ($p > 0.05$). In addition, there was a statistically significant difference in the subjective poverty proportion observed among different age groups. Specifically, a higher proportion of low-aged older adults reported subjective poverty compared to middle-aged older adults, and a higher proportion of middle-aged older adults reported subjective poverty compared to high-aged older adults ($p < 0.05$). Also, a statistically significant difference was observed in the objective poverty proportion among different age groups. Specifically, the high-aged older adults had a higher proportion of objective poverty compared to the middle-aged older adults, and the middle-aged older adults had a higher proportion of objective poverty compared to the low-aged older adults ($p < 0.05$). Thus, the poverty status of older adults varied significantly across different age groups.

3.4. Robust test

In order to enhance the reliability of the research conclusion, the standard of data classification was modified, by transferring the physical health from numerical variables to binary variables and if the total score of the six activities was not equal to 6, it will be classified as physically unhealthy, coded as 0. Conversely, if the total score was equal to 6, it will be classified as physically healthy and coded as 1. Furthermore, the measurement of mental health was converted from a binary variable to a continuous variable, and therefore, the total scores of mental health were considered. Furthermore, to supplement the analysis, self-rated health variation was used as a substitute for self-rated health status. The self-rated health variation score ranged from 1 to 5, with a score of 1 indicating very poor health, and a score of 5 indicating very good health. The impact of the health status of older adults on poverty was re-estimated using the panel binary logit regression method. The findings indicate that the initial results remain valid, thus supporting the overall conclusion. More detailed information can be found in Table 4.

3.5. Analysis of the impact mechanism of health status on poverty

Based on the above analysis, it is concluded that the physical, mental, and self-rated health of older adults is associated with both subjective and objective poverty, but the influence mechanism of older adults' health status on their poverty has not been clarified. It has been suggested that older adults are normally accompanied by multiple morbidities (36, 37), which increases the economic burden of older adults (24, 38). Thus, this ultimately increases the probability of poverty. Therefore, it is assumed that the expenditure of medical expenses is the mediating variable of the influence of health status on subjective and objective poverty in older adults. In this research, the sum of outpatient expenses and hospitalization expenses was taken as the total medical expenses, and then its logarithm was taken as the mediating variable. On the basis of the above discussion, the following research model was constructed (see Figure 1). Logit (Y) represents the probability of poverty of older adults. M is the logarithm of the medical expenses of older adults and X indicates the health status of older adults.

$$Logit(Y) = cX + e_1 \tag{3}$$

$$M = aX + e_2 \tag{4}$$

TABLE 3 Health and poverty analysis of different age groups.

		High-aged (>=90)	Middle-aged (75–89)	Low-aged (60–74)	Chi-square	*p* value
Health status	Physical unhealthy	259 (35.14%)	374 (12.19%)	94 (4.76%)	451.4787	0.000
	Mental unhealthy	73 (9.91%)	229 (7.46%)	99 (5.01%)	22.704	0.000
	Self-rated unhealthy	81 (10.99%)	427 (13.92%)	261 (13.22%)	4.4357	0.109
Poverty status	Subjective poverty	124 (16.82%)	546 (17.80%)	400 (20.25%)	6.4005	0.041
	Objective poverty	173 (23.47%)	686 (22.36%)	378 (19.14%)	9.5651	0.008

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TABLE 4 The robustness test.

	SP	OP
Physical health	−0.251(0.150)	−0.061(0.141)
Mental health	−0.091***(0.015)	−0.028*(0.014)
Self-rated health	−0.310***(0.062)	−0.068(0.059)

Due to space limitations, this article only presents regression coefficients of independent variables. *denotes $p < 0.05$; ***denotes $p < 0.001$.

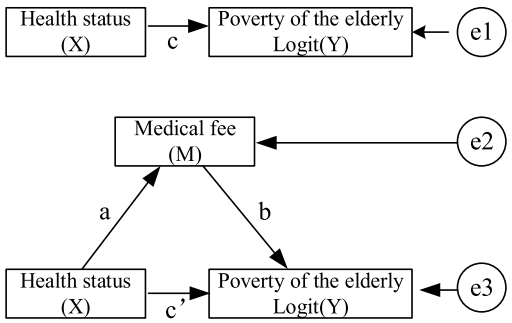

FIGURE 1
The mediating effect of medical expenses on the relationship between health status and poverty.

$$Logit(Y) = c'X + bM + e_3 \quad (5)$$

This study employed Stata software and stepwise regression analysis to confirm the mediating effect of medical expenses on the relationship between health status and poverty in older adults. Based on the findings from Table 5 for physical health, it can be concluded that the coefficient of c, a, b, and c' were all statistically significant, indicating that medical expenses act as a mediator in the relationship between physical health and subjective poverty. In other words, poor physical health in older adults may lead to higher medical expenses, which in turn, increases the probability of experiencing subjective poverty. For mental health, the coefficient of regression (a) was not significant, indicating that there was no intermediary effect between medical expenses and subjective poverty. Similarly, for self-rated health, the statistically significant coefficients of variables c, a, b, and c' suggest that medical expenses played a mediating role in the relationship between self-rated health and subjective poverty. Stated differently, older adults with poor self-rated health are more likely to incur higher medical expenses, which can ultimately contribute to a greater likelihood of experiencing subjective poverty.

Likewise, the results indicate that medical expenses served as a mediator in the relationship between self-rated health and objective poverty, as evidenced by the statistically significant coefficients of c, a, b, and c'. In other words, older adults with poor self-rated health are more likely to face higher medical costs, which in turn, can contribute to a decreased probability of experiencing objective poverty.

4. Discussion

The primary aim of this study was to empirically examine the impact of health status on poverty among older adults, using three

TABLE 5 The mediating effect of medical expenses on the relationship between health and poverty.

	Coefficient	Subjective poverty	Objective poverty
Physical health	c	−0.204***(0.053)	NA
	a	−0.120* (0.056)	
	c'	−0.203*** (0.053)	
	b	0.046**(0.016)	
Mental health	c	−0.670*** (0.165)	
	a	0.017 (0.195)	
	c'	−0.675*** (0.165)	
	b	0.046** (0.016)	
Self-rated health	c	−0.333***(0.059)	−0.127* (0.057)
	a	−0.593*** (0.061)	−0.593*** (0.061)
	c'	−0.308***(0.060)	−0.147* (0.057)
	b	0.046** (0.016)	−0.040**(0.014)

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

dimensions of health status (physical, mental, and self-rated health) and two dimensions of poverty (subjective and objective). Previous research on the relationship between health status and poverty among older adults has generally been limited to a single dimension.

Based on the analysis results, the following insight can be derived: the health status of older adults, specifically their physical, mental, and self-rated health, has a significant effect on subjective poverty, with higher levels of physical, mental, and self-rated health being associated with lower probabilities of subjective poverty. When older adults are in good physical, mental, and self-rated health, their quality of life and life satisfaction tend to be higher (39). Also, it has been suggested that subjective well-being can be reflected by the so-called subjective poverty concept (40), thus the better one's health status, the lower the likelihood of experiencing subjective poverty. Furthermore, higher levels of self-rated health were associated with a lower prevalence of objective poverty. One plausible explanation is that self-rated health is a comprehensive indicator of health status, which indicates the true health status, the healthier, the lower frailty, and thus the lower prevalence of absolute poverty (41). However, the analysis did not reveal any significant association between physical health, mental health, and objective poverty. One possible explanation is that when people rate their own health, it gives us a good idea of how healthy they actually are. The better their self-rated health, the less likely they are to suffer from physical frailty, and therefore less likely to experience extreme poverty. This age group of older adults often have savings from their working years (42), or receive pensions or financial support from their children (43), which means that even if they are not healthy, they may not fall into the category of objective poverty. In addition, the most important thing is that due to the existence of social security, older adults have received some economic security (44). Therefore, even if the physical or mental condition of older adults is not good, they will not fall into objective poverty.

We can conclude that there is a correlation between age and both subjective and objective poverty among older adults. As people age, the probability of experiencing subjective poverty tends to decrease, likely due to a decrease in life expectations and an increase in satisfaction with current circumstances (45), which is consistent with a previous study (8). On the other hand, the probability of objective

poverty tends to increase with age due to exclusion from the labor market, and thus a decrease in earning capacity, which may increase the odds of living in poverty for older adults (46). Despite experiencing less subjective poverty, older adults remain vulnerable to objective poverty as they age (10).

The residential location has a notable effect on the subjective poverty experienced by older adults. To be more specific, older adults residing in urban areas had a higher likelihood of experiencing subjective poverty than their counterparts in rural areas, which is consistent with a previous study (47). This difference may be attributed to the higher cost of living and increased financial stress in urban areas, while rural areas tend to have lower levels of consumption and less emphasis on material possessions. Additionally, according to an existing study, medication usage is lower among rural individuals compared to those in urban areas (48). As a result, the cost of medication is higher for urban individuals. Consequently, the probability of subjective poverty among older adults living in urban areas is greater.

Furthermore, the marital status of older adults was associated with subjective poverty, with a notably higher incidence of subjective poverty among those with a spouse compared to those without a spouse. This finding contradicts previous research (34). Generally, this may be due to the physical decline that often accompanies aging, which may result in a loss of stable income and increased reliance on adult children for financial support. In societies where being an older adult is viewed as hindering one's ability to earn money, having an older spouse may be seen as exacerbating poverty. Consequently, the subjective poverty rate among older adults with a spouse is higher than that among those without a spouse.

Furthermore, education was linked to a lower likelihood of subjective poverty among older adults. This may be due to the positive impact of education on self-perception and confidence, leading to a reduced probability of experiencing subjective poverty. In addition, according to the theory of human capital, the early education experience of older adults is the key way to accumulate human capital, which will have a continuous impact on the life of the individual. Previous studies have found that education has a significant positive effect on poverty reduction (49), quality of life (50), and health status (51). On the whole, the higher the education level of older adults, the higher the quality of life and the lower the probability of subjective poverty, which also has been verified in this study.

Smoking and alcohol consumption were found to be unrelated to both subjective poverty and objective poverty among older adults. There was a link between community services and subjective poverty in older adults, possibly due to the provision of services such as personal care, psychological counseling, and home visits. These services, similar to neighborhood services, can give older individuals a feeling of care and support from their community, which can compensate for the inadequacy of individual or household resources and decrease the likelihood of experiencing subjective poverty (18).

In addition, the study found that there was a significant correlation between medical expenses and both subjective and objective poverty among older adults. Specifically, as medical expenses increase, there was a higher probability of experiencing subjective poverty and a lower probability of experiencing objective poverty. High medical expenses can create an economic burden, and subjectively, it may be believed that high medical expenses can lead to poverty (8). However, currently, most people in China have medical insurance, which helps to alleviate the economic pressure of expensive medical expenses. In addition, rapid economic development in China has greatly reduced the incidence of absolute poverty (52), so expensive medical expenses are unlikely to increase the possibility of objective poverty. Moreover, many older people not only participate in basic insurance but may also participate in commercial insurance. Social insurance (a pension) has been found to be a protective factor in alleviating poverty (53, 54). It was found that older persons who have more than one health insurance spent less than those who had coverage only by one health insurance program (44). That is to say, when older adults incur high medical expenses due to illness, they could receive medical compensation from multiple sources, and the amount of compensation received may even exceed the amount paid for medical expenses. This is why medical expenses may sometimes reduce the possibility of objective poverty.

5. Contribution and limitations

This article utilizes four waves of longitudinal data to study the impact of the health status of older adults on poverty, and the use of longitudinal data ensures the scientific rigor of the study. Furthermore, this research enriches the relationship research between health and poverty, as previous research mainly focused on the effect of poverty on health. However, this study also has some limitations. Although the latest CLHLS public data were used, the data from 2018 were slightly outdated and did not reflect the most current health and poverty status of older adults. Additionally, this study does not consider debts, which could potentially result in an underestimation of the poverty levels of older adults. Moreover, while the use of mobile communication technology, such as mHealth and eHealth, has been suggested as a means of improving the health status of this population (55), no specific interventions were proposed to address health issues among older adults in this research.

6. Implications

Based on the analysis above, the issues of health and poverty among older adults require urgent attention, and in order to effectively alleviate the poverty of older adults, strategies should be taken to improve the health levels of older adults, especially the physical and mental health of high-aged older adults, and the self-rated health of middle-aged older adults. Furthermore, social security and pensions should be further developed to adequately reimburse medical expenditures.

7. Conclusion

The primary objective of this study was to empirically analyze the impact of multidimensional health on the multidimensional poverty of older adults using the panel binary logit regression method, with data sourced from the 2008, 2011, 2014, and 2018 CLHLS. Based on the above analysis, the following conclusions can be drawn.

① The findings of this study indicated that the physical, mental, and self-rated health of older adults had a significant positive impact

on subjective poverty, while self-rated health also played a critical role in objective poverty.

② There were significant differences in the physical and mental health status among older individuals in different age groups. Specifically, the prevalence of unhealthy physical and mental conditions among older adults was significantly higher in the oldest age group than in both the middle-aged and low-aged groups. Additionally, there are notable disparities in the subjective and objective poverty rates among older individuals in different age groups. In particular, the objective poverty rate in the oldest age group was significantly higher than that observed in the middle-aged and low-aged groups, while the subjective poverty rate in the oldest age group was significantly lower than that observed in the middle-aged and low-aged groups.

③ Finally, medical expenditure played a mediation role in the association between health status and poverty of older adults. Specifically, medical expenses mediated the relationship between physical health and subjective poverty, as well as between self-rated health and subjective poverty. Additionally, medical expenses also mediated the relationship between self-rated health and objective poverty.

Data availability statement

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

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

LZ: data curation. CZ: formal analysis, methodology, and resources. CW: language modification. XZ and LZ: funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

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EDITED BY
Elsie Yan,
Hong Kong Polytechnic University, Hong Kong SAR, China

REVIEWED BY
Seyedmohammad Mirhosseini,
Shahroud University of Medical Sciences, Iran
Hon Lon Tam,
The Chinese University of Hong Kong, China

*CORRESPONDENCE
Leilei Guo
✉ guoleilei@jzmu.edu.cn

†These authors have contributed equally to this work

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Mediating effect of successful aging on the relationship between psychological resilience and death anxiety among middle-aged and older adults with hypertension

Meiding Wang[1†], Lin Zhang[2†], Jianing Ma[1], Hong Sun[1], Ziyun Gao[1], Mengya Hu[1], Haiyang Liu[3] and Leilei Guo[1*]

[1]School of Nursing, Jinzhou Medical University, Jinzhou, Liaoning, China, [2]Department of Internal Medicine Nursing, School of Nursing, Wannan Medical College, Wuhu, Anhui, China, [3]Student Health Center, Wannan Medical College, Wuhu, Anhui, China

Objective: The aging trend of China's population is severe and successful aging (SA) is imminent. Aging can lead to various chronic diseases, with hypertension being the most common. Due to this lifelong disease, patients suffer from many anxieties, as death anxiety (DA) can be the most prevalent. Studies have exhibited that middle-aged adults approaching the transition to an older state show more pronounced DA than the more senior. It has been suggested that psychological resilience (PR) can reduce DA. Therefore, this study aimed to analyze the mediating effect of SA between PR and DA in middle-aged and older adults with hypertension.

Methods: A cross-sectional survey was designed. From August to December 2021, 298 middle-aged and older adults with hypertension were selected by multistage cluster random sampling in three districts (Ling he District, Gu ta District, and Tai He District) of Jinzhou City, Liaoning Province. They were surveyed using the demographic questionnaires, the Conner-Davidson Resilience Scale, the Successful Aging Inventory, and the Chinese version of a Likert-type Templer-Death Anxiety Scale. Descriptive analyses, independent sample *T*-test, and one-way analysis of variance (ANOVA) were used to describe demographic characteristics among hypertensive patients with different characteristics, respectively. Statistics were considered significant when $P < 0.05$. Pearson correlation coefficients describe the relationship between PR, SA, and DA. The research model was shaped through Structural Equation Modeling (SEM). SPSS PROCESS macro was used to verify the mediation model. A binary logistic regression model was used with DA as the dependent variable.

Results: The scores for PR, SA, and DA in hypertensive patients are (49.52 ± 14.38) points, (51.22 ± 7.63) points, and (46.67 ± 9.03) points. PR was negatively correlated with DA ($r = -0.307$, $P < 0.01$). Moreover, incorporating SA as a mediating variable in PR and DA, SA was positively correlated with PR ($r = 0.335$, $P < 0.01$) and DA ($r = 0.085$, $P > 0.05$). The direct effect is opposite to the sign of the indirect effect. There is a suppression between PR and DA with a percentage of 20.7%. Good self-assessed health status [0.057 (0.018, 0.183)] may be a protective factor for DA.

Conclusion: Healthcare providers should improve the PR of middle-aged and older adults with hypertension through interventions that reduce DA and increase the likelihood of SA.

KEYWORDS

psychological resilience, successful aging, death anxiety, middle-aged and older adults, hypertension

1. Introduction

China, the second-largest economy in the world, is quickly becoming an aging country (1). China is a country with not only the world's largest population but also the largest aging population; by 2050, the proportion of older people within the total national population is projected to be around 25% (2, 3). Accelerating population aging reports significant impacts on human wellbeing (4). Successful aging (SA) may answer the significant challenges that population aging poses to the health care system, financial security, and labor supply (5). So, SA is an indispensable part of development programs (6). SA is not just about extending life but more about increased awareness, active participation in society, and a proper perspective on aging. Numerous academics have defined SA. Rowe JW and Khan RL proposed the most influential SA concept in 1987, including three major components: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement with life (7). In subsequent studies, Crowther et al. (8) thought that this concept missed an important factor-positive spirituality and linked positivity with health. From then on, the definition of SA was expanded to four aspects. SA not only leads to longer life spans compared to normal aging but also improves people's quality of life through the positive effects of physical and psychological factors. Frailty and SA represent the opposite sides of the same coin (5). Improving the SA status of the older adults and transforming the adverse effects of aging on society into positive factors are the current focused topics in the field of aging research.

Aging is the primary driver of most chronic diseases (9). Chronic disease can lead to estimated 80% of deaths in China (10), with hypertension leading the way (11). Untreated and improperly managed hypertension can hasten the disease's progression, resulting in serious organ problems and possibly raising the risk of death (12–14). Patients typically die from hypertension's devastating consequences, such as strokes and heart diseases, rather than the condition itself. It is difficult to avoid death anxiety in patients suffering from hypertension. Among these anxiety, death anxiety (DA) is one of the most common. Death is described as an extraordinary fear of death, accompanied by feelings of dread or anxiety when a person considers the process of dying or what happens after death (15). DA is a persistent, abnormal, pathological fear of death. It is not an innate or inherent quality; instead, it is an acquired trait that is impacted by the immediate culture and context (16). It is found that hypertension is the most common complication and risk factor among patients with coronavirus disease 2019 (COVID-19) (17). DA increased significantly during the COVID-19 pandemic (18, 19). Since the beginning of the epidemic, people's lives have been turned upside down. "Death" was one of the most searched terms in the world during the year, it has become commonplace. Delayed access to care and drug scarcity has created panic among the sick, and their awareness and exploration of death have never been that profound. DA refers to anxiety experienced in daily life instead of how a person feels in an emergency, where fear is the feeling that life will end as opposed to the belief that life will go on (20). Throughout the life cycle, we tend to think about how much longer we can exist as independently conscious living beings. Considering the shortening of life span and the approach to death, it is inevitable that people suffer from DA. Guiding patients to express their views on death can help them reduce their anxiety (21). Death is an inevitable outcome of life's journey, and we live in an environment of death denial that leads many people to have more profound anxiety about it. Iverach et al. (22) argues that DA may become lingering stress that endangers personal health. Various factors affect DA, such as age, physical health, and quality of life (23). Research has been done to show that middle-aged adults have higher DA levels than older adults (24). Middle-aged people face the first signs of the aging process. They believe they are so old that they cannot accomplish things well and are gradually being abandoned by society. In the long run, they will develop severe anxiety and depression, also a negative attitude toward aging, and see it as an obstacle to achieving their goals. Therefore, it makes sense that beliefs about aging and old age are thought to affect DA (25).

Previous studies have demonstrated that improving psychological resilience (PR) helps reduce the patient's DA (26). PR, which is defined as the positive function of individual differences in people's response to stress and adversity, was proposed in 1987 by Rutter (27). PR may directly affect an individual's emotions or affect the individual's feelings indirectly by responding. In today's emotional life, DA is anticipated to be the most efficacious unconscious psychodynamic dynamism (28). Higher DA has also been associated with poorer overall mental health and co-occurring mental health conditions (22). DA

Abbreviations: CD-RISC, the Connor-Davidson Resilience Scale; SAI, Successful Aging Inventory; T-DAS, Templer-Death Anxiety Scale; CT-DAS, Chinese Version of Templer's Death Anxiety Scale; CL-TDAS, the Chinese version of a Likert-type Templer death anxiety scale; PR, psychological resilience; SA, successful aging; DA, death anxiety; PSU, primary sampling unit; SSU, secondary sampling units; χ^2/df, Chi-square and degree of freedom ratio; CFI, Comparative Fit Index; GFI, Goodness of Fit Index; AGFI, Adjust Goodness of Fit Index; RMSEA, Root-mean Square Error for Approximation.

increases with declining mental health, making it imperative to improve PR.

Current studies have explored the relationship between PR and DA (29), but there are few studies on the relationship between PR, SA, and DA in middle-aged and older adults with hypertension. Therefore, the purpose of this study is to explore the relationship between PR, SA, and DA in hypertensive patients, to provide a reference for formulating effective intervention measures to reduce the level of DA in hypertensive patients.

2. Methods

2.1. Aim

This study aimed to investigate the mediating effect of SA between PR and DA in middle-aged and older adults with hypertension after considering confounding factors. We hypothesized that SA plays a role between PR and DA in middle-aged and older hypertensive patients.

2.2. Study design

A cross-sectional survey of middle-aged and older adults with hypertension was conducted in three districts (Ling he District, Gu ta District, and Tai he District) of Jinzhou City, Liaoning Province, China, from August to December 2021.

2.3. Participants

A multistage cluster random sampling was used to conduct this study. In the first stage, two streets in each of the 3 districts (Ling he District, Gu ta District, and Tai he District) were randomly selected as primary sampling units (PSU). Then, two community was randomly selected from each primary sampling unit (PSU) as a secondary sampling unit (SSU). In the third stage, one community health service center was randomly selected from each secondary sampling unit (SSU) to set up a survey site, and 28 middle-aged and older adults with hypertension were randomly selected from each. Finally, 336 middle-aged and older adults with hypertension who met the inclusion criteria were surveyed. To guarantee the required sample size, 311 questionnaires were distributed in this study. Two hundred ninety-eight valid questionnaires were recovered, with an effective rate of 95.8% (Figure 1). The following inclusion criteria were used to choose the participants: (I) diagnosed as hypertension by clinical and pathological diagnosis; (II) conscious, able to communicate normally, and understand the survey content accurately; (III) aged $\geq$45. Exclusion criteria: Combined with other life-threatening severe diseases.

2.4. Study instruments

The questionnaire series consists of demographic questionnaires (i.e., gender, age, educational level, et al.) and three well-established instruments for collecting data on PR, SA, and DA.

2.4.1. Socio-demographic characteristics questionnaire

After a comprehensive literature review and rigorous group discussions, a questionnaire on socio-demographic characteristics, including gender, age, education level, place of residence, health behavior (smoking habits, alcohol habits, and physical activity), and self-assessed health status was finally developed.

2.4.2. Psychological resilience

Psychological resilience was assessed with the 25 items Conner-Davidson Resilience Scale (CD-RISC) was compiled by Connor and Davidson (30), which includes five dimensions, including "competency and tenacity," "tolerance of negative affect," "positive acceptance of change," "control," and "spiritual influences." The scale uses a 5-point Likert-type scale with the values 0 (strongly disagree) to 4 (strongly agree) to rate a person's psychological resilience. The total score ranges between 0 and 100, and the score positively correlates with the degree of PR felt by individuals; that is, the higher the score, the better the psychological resilience. The Cronbach's Alpha for the CD-RISC was 0.865 in the current study.

2.4.3. Successful aging

The Successful Aging Inventory (SAI) was compiled by Troutman et al. (31). This study takes a brief version of successful aging by Lee et al. (32), which is valid and reliable for detecting SA. Such a scale is made up of 16 items and four dimensions, including "proactive engagement," "wellness resources," "positive spirit," and "valued relationships," the answers to each item encompassed four levels, including not at all, sometimes, usually, and critical, for which scores were 1, 2, 3, and 4, respectively. The total score ranges from 16 to 64 points. Greater scores indicate better SA. The Cronbach's α-value of the scale was 0.862 in this study.

2.4.4. Death anxiety

The Templer's Death Anxiety Scale (T-DAS) was developed by Templer (33). This study adopts the Chinese version translated and revised by Yang et al. (34) composed of 15 items, namely the Chinese version of the Templer death anxiety scale (CT-DAS). The CT-DAS consists of 15 questions with a true or false answer. A 5-point Likert-type of CT-DAS was evaluated and validated in patients with colorectal cancer. The scale includes 15 items and four dimensions, including "Emotion," "stress and pain," "Time consciousness," and "Cognition," scoring on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Among them, nine items are positive scoring; in contrast, the other six items are scored in reverse. The total score on the Likert scale can range from 15 to 75. The higher the score, the higher the individuals' DA level. The Cronbach's Alpha for the CL-TDAS was 0.798 in the current study.

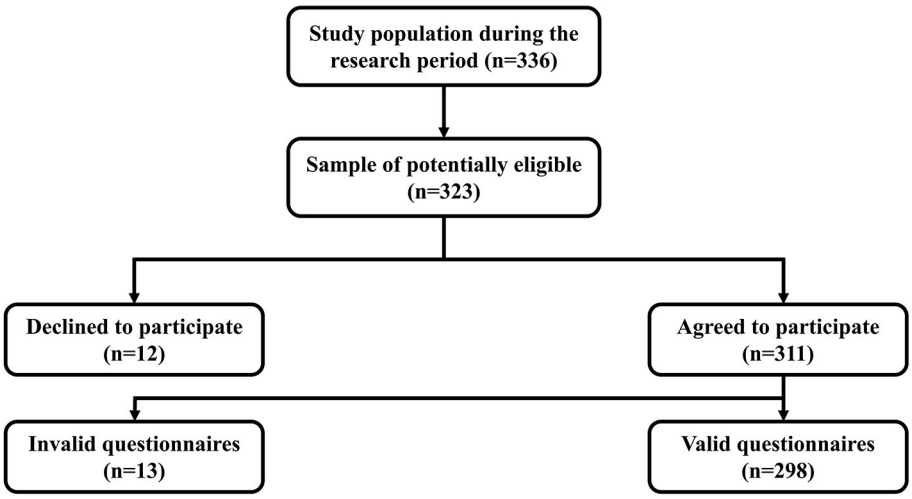

FIGURE 1
Population flow diagram.

2.5. Covariates

Age, gender, and self-assessed health status were used as covariates in this study. Gender is divided into male and female. Self-assessed health status includes poor, common, and good.

2.6. Data collection

To reduce errors, relevant research staff were trained before the survey, and uniform instructional language was used to clarify the purpose of the survey and scoring criteria. Before this interview, each participant was told that the survey was anonymous and credible to eliminate the concerns of patients and answer truthfully. Informed consent forms were signed, and paper questionnaires were distributed to patients who met the inclusion criteria after explaining the survey's purpose and questionnaire requirements. The subjects answered the questionnaires themselves. The questionnaires were returned on the spot after completion. The investigators asked the subjects face-to-face to illiterate adults and then filled in the questionnaires.

Sample sizes were determined to be 5–10 times the number of scale items with the most items using Kendall's sample calculation method (35). In this study, the scale with the highest number of entries was the Conner-Davidson Resilience Scale, which consisted of 25. Also, a 20% sample loss was considered, so the sample size for this study was at least 150–300. To secure the sample size requirements, 311 questionnaires were disseminated in this study. Two hundred ninety-eight valid questionnaires were recovered, with an effective rate of 95.8%.

2.7. Data analysis

The SPSS 26.0 software was used for data input and analysis. Descriptive analyses, independent sample *T*-test, and one-way analysis of variance (ANOVA) were used to describe demographic characteristics among hypertensive patients with different characteristics, respectively. Binary variables such as gender were compared by independent samples *t*-test; polytomous variables such as education levels and place of residence were compared by one-way analysis of variance (ANOVA). $P < 0.05$ was considered statistically significant. Pearson correlation coefficients described the relationship between the three variables (PR, SA, DA). Furthermore, a mediation model with PR as the independent variable, SA as the mediating variable, and DA as the dependent variable was set up. The SPSS PROCESS 3.5 macro (Model 4) was utilized to examine the mediating function of SA (36). Ninety-five percent confidence intervals (CIs) were calculated using the bias-corrected non-parametric percentile bootstrapping method with 5,000 samples. If the confidence interval includes zero, it means that there is no significant mediating (indirect) effect at the significance level of 5%.

2.8. Ethical consideration

All individuals have provided informed consent before the data collection. Approval for this study was given by the Medical Ethics Committee of Wannan Medical College (approval number: 2021-3), and all participants provided informed consent. All methods were performed in accordance with the Declaration of Helsinki.

3. Results

3.1. Descriptive statistic

Table 1 shows the demographic characteristics of the 298 study objects. Among them, 190 (63.8%) were male, and 108 (36.2%) were female. The age range of the middle-aged and older adults with hypertension was 45–96 years. Most of the study participants (69.4%) reported Junior high school education or

TABLE 1 Demographic characteristics of middle-aged and older adults with hypertension ($N = 298$).

Characteristic		Frequency (n)	Rate (%)
Gender	Male	190	63.8
	Female	108	36.2
Age (years)	45–54	59	19.8
	55–64	90	30.2
	65–74	109	36.6
	75–84	33	11.1
	≥85	7	2.3
Educational level	Primary school or less	116	38.9
	Junior high school	91	30.5
	Senior high school or above	91	30.5
Place of residence	City	144	48.3
	Suburban	31	10.4
	Countryside	123	41.3
Smoking habits	No	160	53.7
	Ever smoke	99	33.2
	Current smoke	39	13.1
Alcohol habits	No	167	56.0
	Ever drink	62	20.8
	Current drink	69	23.2
Physical activity	No	48	16.1
	Irregular physical activity	175	58.7
	Regular physical activity	75	25.2
Self-assessed health status	Poor	134	45.0
	Common	133	44.6
	Good	31	10.4

less. The proportion of patients living in city and Countryside is basically the same. The number of non-smokers and non-drinkers was both over half. Only 10.4% of the patients considered themselves in good health.

3.2. The scores of psychological resilience, successful aging, and death anxiety with different characteristics

Table 2 demonstrates the comparison of PR, SA, and DA scores of hypertensive patients with different characteristics. The scores for PR, SA, and DA in hypertensive patients are (49.52 ± 14.38) points (51.22 ± 7.63) points, and (46.67 ± 9.03) points. Education level, alcohol habits, physical activity, and self-assessed health status were factors that significantly affected the PR of hypertensive patients ($P < 0.05$). Age, place of residence, and self-assessed health status are factors that significantly influence SA in hypertensive patients ($P < 0.05$). There were differences between the DA in physical activity and self-assessed health status ($P < 0.05$).

3.3. Bivariate correlation analyses

Table 3 displays the correlational analysis between the study variables. DA was found to be negatively correlated with PR ($r = -0.307$, $P < 0.01$). SA was positively correlated with PR ($r = 0.335$, $P < 0.01$) and DA ($r = 0.085$, $P > 0.05$).

3.4. Model fitness indices

The value of the model fit indicators used in this study is displayed in Table 4. The model fitting results show that, CFI = 0.949; GFI = 0.920; AGFI = 0.880; RMSEA = 0.081, the judgment value is well-fitted, and the model is acceptable.

3.5. Relationship between psychological resilience, successful aging, and death anxiety assessed by the SEM

The relationship between PR, SA, and DA of the middle-aged and aged patients with hypertension is shown in Figure 2. There were three unobserved variables in this study: PR, SA, and DA. Among them, SA and DA were both represented by four observation variables, and PR was represented by five observation variables.

As illustrated in Figure 2, PR exerted a negative effect on DA (the standardized effect = −0.44, $P < 0.001$). Moreover, PR exerted a positive effect on SA (the standardized effect = 0.37, $P < 0.001$), SA also exerted a positive effect on DA (the standardized effect = 0.32, $P < 0.001$).

3.6. The mediating effect of successful aging on the association between psychological resilience and death anxiety

Table 5 shows the standardized total effect, direct effect, indirect effects, as well as the results of the mediating effect. With DA as the dependent variable, SA as the mediating variable, and PR as the independent variable, a structural equation model was constructed. Using the PROCESS 3.3 macro (Model 4) proposed by Hayes (36) to examine the mediating effect of SA in the relationship between PR and DA, the results showed that the Bootstrap 95% confidence intervals for the direct and indirect effects of PR on DA did not include 0. The results showed direct effect [B = −0.179, SE = 0.037, 95% CI = (−0.251, −0.107)] and indirect effects [B = 0.037, SE = 0.017, 95% CI = (0.006, 0.072)] of PR on DA by testing 95% confidence intervals (CIs) based on 5,000 bootstrapped samples, indicating SA partially mediated the relationship between PR and

TABLE 2 Comparison of the score of psychology resilience, successful aging, and death anxiety in different social-demographic subgroups ($N = 298$).

Variables	N	CD-RISC		F/t	P	SAI		F/t	P	CL-TDAS		F/t	P
		M	SD			M	SD			M	SD		
Gender				1.108	0.269			0.804	0.422			−1.164	0.245
Male	190	50.22	14.44			51.49	7.31			46.21	8.74		
Female	108	48.30	14.27			50.75	8.18			47.48	9.50		
Age (years)				0.496	0.739			2.869	0.023			0.551	0.699
45–54	59	51.29	15.44			50.85	8.54			47.45	8.32		
55–64	90	48.73	15.45			49.38	8.20			45.76	10.13		
65–74	109	49.59	14.23			52.75	6.88			46.55	8.41		
75–84	33	49.33	10.75			52.36	5.43			48.12	9.76		
≥85	7	44.57	8.12			48.86	7.99			46.94	5.84		
Educational level				9.508	<0.001			1.940	0.145			1.028	0.359
Primary school or less	116	47.46	13.55			51.38	6.72			46.54	9.24		
Junior high school	91	46.84	12.55			50.02	7.76			47.71	9.43		
Senior high school or above	91	54.84	15.79			52.22	8.47			45.81	8.32		
Residence				2.374	0.095			4.116	0.017			0.968	0.381
City	144	51.33	14.50			52.38	7.51			46.55	8.73		
Suburban	31	46.61	16.00			48.55	5.57			48.78	8.66		
Countryside	123	48.13	13.64			50.54	8.01			46.29	9.46		
Smoking habits				0.837	0.434			0.527	0.591			0.850	0.428
No	160	48.52	14.05			50.81	8.16			47.23	9.22		
Ever smoke	99	50.67	15.63			51.78	7.04			46.33	9.00		
Current Smoke	39	50.72	12.34			51.51	6.87			45.26	8.31		
Alcohol habits				3.367	0.036			1.156	0.316			2.866	0.059
No	167	48.44	13.74			50.77	7.68			47.44	9.26		
Ever drink	62	48.10	15.85			51.11	8.90			44.27	8.98		
Current drink	69	53.42	14.02			52.42	6.11			46.97	8.23		
Physical activity				5.871	0.003			0.052	0.949			3.856	0.022
No	48	44.40	13.64			50.90	7.13			47.25	9.46		
Irregular physical activity	175	49.30	14.10			51.29	7.38			47.58	8.90		
Regular physical activity	75	53.32	14.59			51.27	8.55			44.20	8.71		
Self-assessed health status				9.754	<0.001			3.451	0.033			25.503	<0.001
Poor	134	45.66	12.65			52.11	7.06			49.45	7.60		
Common	133	52.15	14.95			51.03	8.25			45.96	8.72		
Good	31	54.90	15.12			48.19	6.57			37.74	9.89		

CD-RISC, measurement of psychological resilience; SAI, measurement of successful aging; CL-TDAS: measurement of death anxiety.

DA. The direct effect is opposite to the sign of the indirect effect. Therefore, SA has a suppression effect rather than a mediating effect between PR and DA with a percentage of $|ab/c'| = |0.037/-0.179| = 20.7\%$.

As shown in Table 6, we examined the suppression role of SA on the relationship between PR and DA with the linear regression analysis after controlling for the demographic variables of gender, age, and self-assessed health status. Model 1 showed that PR was negatively associated with DA ($B = -0.143$, $p < 0.001$), and PR explained the total of 17.7% of the DA ($F = 16.986$, $P < 0.001$). Model 2 showed that PR was positively associated with SA ($B = 0.210$, $p < 0.001$), and PR explained the total of 16.5% of the SA ($F = 15.644$, $P < 0.001$). Model 3 showed that SA was positively associated with DA ($B = 0.172$, $p < 0.001$),

TABLE 3 Correlation between the study variables ($N = 298$).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. CD-RISC	1	0.928**	0.931**	0.817**	0.862**	0.662**	0.335**	0.381**	0.233**	0.287**	0.218**	−0.307**	−0.271**	−0.253**	−0.294**	−0.230**
2. Compentency and tenacity		1	0.805**	0.653**	0.780**	0.574**	0.254**	0.297**	0.168**	0.235**	0.145*	−0.322**	−0.304**	−0.250**	−0.279**	−0.241**
3. Tolerance of negative effect			1	0.693**	0.793**	0.550**	0.364**	0.424**	0.242**	0.325**	0.222**	−0.225**	−0.183**	−0.198**	−0.210**	−0.198**
4. Positive acceptance of change				1	0.627**	0.523**	0.296**	0.272**	0.246**	0.210**	0.270**	−0.258**	−0.235**	−0.217**	−0.286**	−0.141*
5. Control					1	0.459**	0.327**	0.383**	0.196**	0.293**	0.214**	−0.293**	−0.247**	−0.248**	−0.284**	−0.235**
6. Spiritual influences						1	0.147*	0.228**	0.127*	0.094	0.044	−0.209**	−0.166**	−0.171**	−0.239**	−0.160**
7. SAI							1	0.831**	0.839**	0.885**	0.832**	0.085	0.062	−0.056	0.087	0.177**
8. Proactive engagement								1	0.627**	0.651**	0.503**	−0.023	−0.030	−0.160**	0.008	0.079
9. Wellness resources									1	0.659**	0.624**	0.095	0.058	−0.010	0.103	0.176**
10. Positive spirit										1	0.678**	0.130*	0.102	0.010	0.144*	0.178**
11. Valued relationships											1	0.098	0.088	−0.015	0.052	0.177**
12. CL-TDAS												1	0.936**	0.817**	0.722*	0.859**
13. Emotion													1	0.702**	0.530**	0.729**
14. Stress and pain														1	0.523**	0.642**
15. Time consciousness															1	0.540**
16. Cognition																1

CD-RISC, Conner-Davidson resilience scale; SAI, Successful Aging Inventory; CL-TDAS, the 5-point Likert-type CT-DAS.

Competency and tenacity ~ Spiritual influences are items of CD-RISC; Proactive engagement ~ Valued relationships are items of SAI; Emotion ~ Cognition are items of CL-TDAS.

*$P < 0.05$.

**$P < 0.01$.

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and the explanation of PR for DA increased from 17.7 to 19.2% ($F = 15.125$, $P < 0.001$).

3.7. Logistic regression analysis with death anxiety screening results as the dependent variable

A binary logistic regression was performed with DA as the dependent variable and statistically significant in the univariate analysis as the independent variable. DA was defined as a cut-off score of 35, with a score below 35 representing low DA and a score ≥35 representing high DA. Good self-assessed health status ($P < 0.05$) was associated with low DA, and the higher the level, the more significant the protective effect (Figure 3).

TABLE 4 The model fit index ($N = 298$).

Index	*P*	CFI	GFI	AGFI	RMSEA
Change range	-	0–1	0–1	-	-
Reference standard	<0.05	>0.90	>0.90	>0.90	<0.080
Actual value	<0.001	0.949	0.920	0.880	0.081

4. Discussion

The study, conducted in three districts in Jinzhou, Liaoning Province, constructs a mediating model to explore whether PR is indirectly associated with DA through SA. The results suggest that the effect of PR on DA can be partially explained by SA. This study is the first to explore the mediating effect of SA and provides a theoretical basis and direction for reducing DA and increase the possibility of SA in middle-aged and aged hypertensive patients.

4.1. Death anxiety of middle-aged and older adults with hypertension

Older and middle-aged hypertensive patients in this study have a relatively high state of DA, which is slightly higher than that in previous studies (37). The reasons why they are prone to DA include the following. Firstly, most patients are unaware of the process and improvement options for the onset and progression of hypertension. It must be recognized that several factors, including economic status and a lack of resources, make it difficult for Chinese patients with hypertension to obtain health information from healthcare providers (38, 39). The high risk of complications from poorly controlled hypertension is one of the leading causes of anxiety and dread among middle-aged and older adults with hypertension, in addition to the fear of the likelihood of getting various diseases rising with age. A person's health depends on access to and utilizing public health information. Healthcare providers ought to utilize both online and offline tools to broadly disseminate health information and emphasize the importance of timely blood pressure regulation in order to increase public awareness of hypertension. Secondly, the process of hypertension is irreversible and progressive. The disease always chronically afflicts the patients. The inevitability of death is reminded almost every day, which makes them feel the threat of death deep inside. Thirdly, poor health is a significant factor influencing DA in this study, mainly because the changes in lifestyle and the lifelong medication disrupt the life balance of the patients.

Lonette classifies four common patterns of DA as the following: (a) cognitive-emotional problems, (b) concerns about physical changes, (c) concerns about the passage of time, and (d) concerns about stressors and pain concerns (40). The fear of death and the uncertainty about what would happen after death seems to be essential parts of the human mind. Previous studies have proven that physical health was negatively associated with DA (41). It means that the worse the physical condition is, the higher the level of DA is. When the physical state and the quality of the life are seriously reduced, the patients will feel no dignity, which undoubtedly causes a significant blow to the patient, seriously affects the patient's psychological state, and even aggravates the patient's psychological burden. DA can create negative emotions that are detrimental to the treatment of the disease and effective communication between the doctor and the patient. Furthermore, it may even lead to more serious psychological or physical problems. DA may be closer to a depressive defense mechanism rather than anxiety (42). Like earlier studies (43–45), physical exercise was a key influence in our research. In middle-aged and older adults with hypertension, physical activity reduces high mortality concerns and improves the quality of life, and it is safe and inexpensive. That is possible at any time and wherever. It is a cornerstone medication for preventing and treating hypertension and is considered a psychotropic treatment (46, 47). A considerable risk factor for increased cardiovascular disease mortality has been identified as little physical exercise (48, 49). Regular exercise is one of the most critical aspects in enhancing the existing state of hypertension. It is a good adjunct therapy that can be used in addition to medicine. The guidelines suggest 75 min of vigorous or 150 min of moderate exercise per week (50). However, the fact is that physical activity in hypertensive patients is not ideal, they were less physically taking part than the non-hypertensive individuals (51). Even more, the results from studies have demonstrated that the probability of hypertension increases with age. The risk of getting hypertension rises roughly 20-fold in individuals 65 and older (52). In the long run, a situation like that could lead to a vicious cycle. Therefore, regular physical exercise is more crucial for middle-aged and older adults with hypertension.

Healthcare providers ought to render exercise more enjoyable, encourage patients to work out on schedule, warn them about the seriousness of uncontrolled hypertension, and follow up frequently. Exercise interventions usually require individualized exercise prescriptions by health care providers for each patient. When exercise programs are adequately customized, patients can gain from lower blood pressure, body mechanism regulation, overall quality of life and health improvement. When creating and implementing an exercise program, several safety considerations should be made due to the poor health status of individuals with hypertension. Both the regularity and the intensity of the exercise are essential. Besides, exercise therapy should also be carried out with consideration for the patient's spiritual and

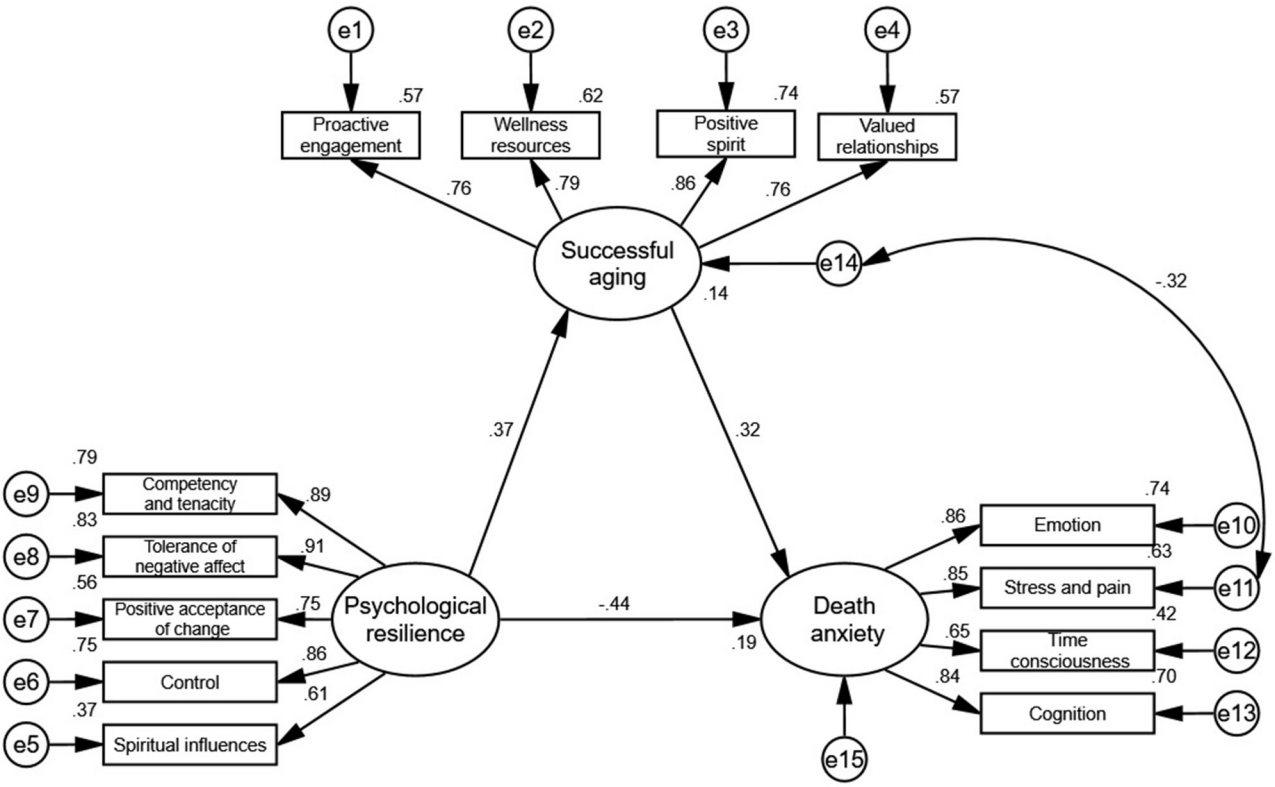

FIGURE 2
SEM of the mediating role of successful aging between psychological resilience and death anxiety.

TABLE 5 The standardized total, direct, and indirect effects of psychological resilience on death anxiety with successful aging as mediators ($N = 298$).

Path	Effect	SE	95% CI	
			LLCL	ULCL
Direct effect	−0.179	0.037	−0.251	−0.107
Psychological resilience→ Death anxiety				
Indirect effect	0.037	0.017	0.006	0.072
Psychological resilience→ Successful aging				
Successful aging→ Death anxiety				
Total effect	−0.142	0.034	−0.210	−0.075

psychological state. Low, moderate, vigorous, and strenuous intensity are the broad categories used to classify exercise training. There are plenty of distinct exercise rehabilitation techniques for hypertension. Western doctors frequently use aerobic and anaerobic exercises, while Chinese doctors select exercises that integrate traditional Chinese culture. Usually, aerobic exercise primarily consists of strolling, cycling, and jogging. Dumbbells and weight training are frequently used in anaerobic exercise. Exercise, both aerobic and anaerobic, has been displayed through investigations to substantially lower blood pressure levels in people with hypertension (53–55). Baduanjin exercise and Tai Chi are the two most widely practiced Chinese forms of exercise. Bajuanjin exercise, which derives from the martial arts of ancient Eastern cultures, is a gentle exercise combining breathing and meditative training to improve balance and awaken bodily consciousness. This is why it has always been well-liked. Numerous studies prove that Baduanjin exercise successfully reduces blood pressure (56, 57). Tai Chi has its origins in ancient traditional Chinese martial sports. The activity has been used for both bodily and psychological healing for several generations (58). The kind, as mentioned earlier, of conventional Chinese exercise successfully decreases blood pressure (59). Even patients' quality of life, anxiety, and cognitive function can be enhanced by Tai chi (60). Human beings dramatically benefit from this activity. In addition, in today's technologically advanced age, medical practitioners have developed tools to assist and monitor patients in their exercise (61, 62). These e-health program help patients improve their physical activity, help healthcare providers disseminate health information broadly, and facilitate regular follow-up.

In summary, the effect of exercise on people's health is receiving more and more attention in the structure of physical medicine integration; regular physical activity of any kind can help hypertensive patients recover more quickly by lowering blood pressure and defending target organs.

TABLE 6 Linear regression of hypothesized relationships ($N = 298$).

Predictors	Model 1 (DA)				Model 2 (SA)				Model 3 (DA)			
	B	SE	*T*	95% CI	B	SE	*t*	95% CI	B	SE	*t*	95% CI
Gender	1.128	0.997	1.132	−0.834, 3.090	−0.057	0.849	−0.067	−1.727, 1.614	1.138	0.988	1.152	−0.806, 3.082
Age	−0.036	0.477	−0.075	−0.975, 0.903	0.775	0.406	1.908	−0.024, 1.575	−0.169	0.476	−0.356	−1.106, 0.767
Self–assessed health status	−4.280	0.743	−5.759***	−5.743, −2.818	−2.700	0.633	−4.267***	−3.946, −1.455	−3.815	0.759	−5.026***	−5.309, −2.321
PR	−0.143	0.034	−4.171***	−0.210, −0.075	0.210	0.029	7.228***	0.153, 0.268	−0.179	0.037	−4.863***	−0.251, −0.106
SA									0.172	0.068	2.534***	0.039, 0.306
Adjusted R^2			0.177				0.165				0.192	
F			16.986***				15.644***				15.125***	

*** $P < 0.001$.

4.2. Psychological resilience and death anxiety

Our study's correlation analysis revealed that PR was negatively associated with DA in middle-aged and older hypertensive patients. In other words, higher PR can help reduce DA in hypertensive patients. This result is in line with findings from earlier research (63). The PR level among hypertensive patients was in the middle level in our study, slightly lower than previous studies of cancer patients (64, 65). The possible explanation is that hypertension is a lifelong disease, and its intractability and recurrence increase the psychological burden of patients, leading to lower PR level. In turn, patients with lower PR are more likely to experience psychological distress (66). Therefore, medical staff should intervene when they detect a decrease in patients' PR levels. Besides, this result also suggests to medical professionals that there is room to improve the current level of PR in middle-aged and older adults with hypertension.

People with high blood pressure are reportedly under tremendous stress, which makes them relatively less resilient (67). PR is a crucial protective factor for patients with hypertension as their condition worsens, which may considerably impact people's ability to adapt to severe sickness (68). Patients with high PR show more significant improvements in social functioning, mood, and mental health than those with low PR (69). This means that PR is dynamic and can be improved through acquired training. Improving PR can help patients develop or promote resistance to illness and stress, stimulate their potential, and prevent them from developing more serious psychological problems. Attitude toward death affects patients' PR level, and negative death attitudes such as DA are detrimental to older adults' physical and mental health. In addition, family as an essential social component has a positive effect on improving PR and reducing DA. A good family atmosphere, care, and support from family members can provide mental state support for middle-aged and older adults with hypertension. Educational attainment is a significant factor influencing PR in our study, consistent with previous findings (70). Higher educational attainment somehow increases patients' perceptions. Patients with higher levels of education may be more likely to access relevant information about hypertensive disorders through various sources. As a result, they better understand the disease and gain greater control over the treatment process. Therefore, when DA is prevalent in hypertensive patients, health care professionals should activate protective mechanisms for their PR and develop appropriate interventions to reduce DA in patients.

4.3. Psychological resilience and successful aging

This study shows a significant positive relationship between PR and SA. Such a result illustrates that PR can effectively mitigate mental deterioration. When confronted with aging difficulties, individuals with high resilience generally redirect their attention to what they can still do rather than what they cannot (71). This may be because they have summed up a lot of life experience from past setbacks and tribulations and are able to adjust

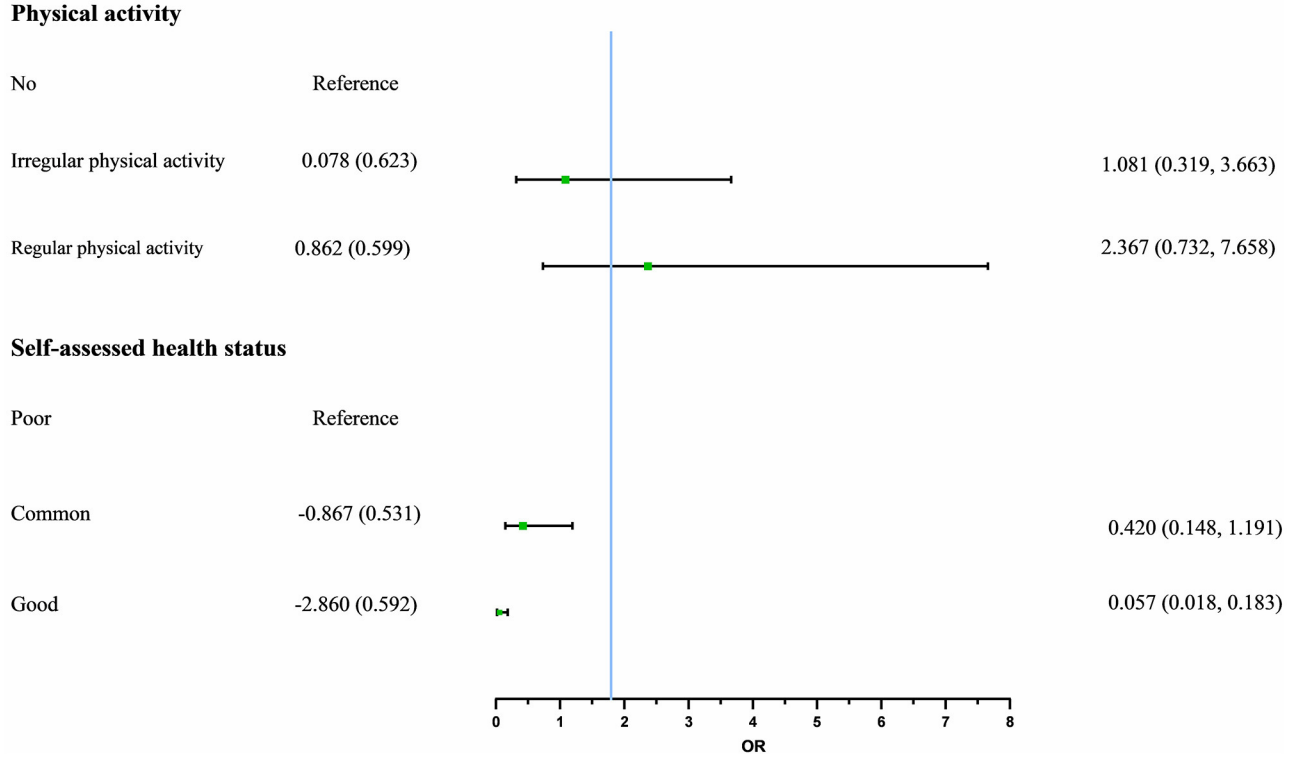

FIGURE 3
Effects of different types of physical activity and self-assessed health status on death anxiety (using the low level and no exercise as the reference).

their mindset and maintain a stable emotion in a timely and effective manner. It is crucial to distinguish PR from physical resilience (health) because many adults will encounter health issues (72). Health status is the most critical factor affecting SA (73). Health status includes physical health and mental health. Most traditional definitions of SA are based on the absence of somatic disorders and less often include psychological factors (74). However, psychological factors are an essential part of achieving SA. It is thought to be significantly related to SA (75). SA maximizes one's psychological resources, namely self-efficacy and resilience (76). In situations involving anxiety and the psychological issues brought on by long-term conditions, PR reduces the detrimental impacts of adversity on mental health (77). High PR can alter how stressful situations are perceived by an individual, which in turn reduces physiological reactions to stressful conditions, especially when reinforced by favorable environmental factors and positive social relationships (78). Although chronic diseases are not easily ameliorated, psychological conditions can be changed through intervention and treatment. Additionally, once sufficiently developed and continuously managed, PR can be long-lasting for a person (79). Therefore, when middle-aged and older adults with hypertension have decreased PR due to aging, medical professionals should promptly correct their perceptions of aging to improve the likelihood of SA.

4.4. Successful aging and death anxiety and the suppression effect of successful aging

A situation where the magnitude of the relationship between an independent and dependent variable becomes more prominent when a third variable is included would indicate suppression (80). This study showed a significant negative association between PR and DA. At the same time, when SA was included as a third variable, PR positively influenced DA through SA, suggesting that SA plays a masking role in this study. That is, undesirable SA increases the negative association between PR and DA. It is worth noting that studies show that the SA of our country is not optimistic. This may be due to several reasons. For one thing, aging implies the aging of organs, physical deterioration, and chronic diseases, which are contrary to the concept of SA and are all detrimental to achieving SA. This is precisely why the SA scores of those over 85 years old in this study were the lowest. Also, this study's SA of middle-aged adults was relatively poor. This is because middle-aged people need to face tremendous life stress and feel uneasy and anxious about the impending aging state. In another, place of residence significantly influences SA, which may be due to firstly, the risk of hypertension is more remarkable in rural than in urban areas (81), which may be related to the different dietary habits

and living habits between the two regions. Secondly, the healthcare conditions in rural areas are relatively poor. Thirdly, the lack of transportation in rural areas may prevent patients from delaying access to medical care. Fourth, rural patients may have a lower level of education, which leads to a lack of awareness of hypertension and is more prone to panic and possible inappropriate medication use. Fifth, patients in rural areas are relatively less aware of medical examinations. What's more, China's public health system is in its infancy, and its healthcare system and pension mechanism are still underdeveloped. In addition, the late start of compulsory education in China has indirectly led to the low literacy level of some Chinese people and their inability to view aging correctly, leading to the inability to achieve SA. In the end, a taboo culture of death prevails in China, and discussing death is rarely allowed in China. In this case, achieving SA is tough.

In our study, the SA of middle-aged and older hypertensive patients was not ideal. This is because hypertension is an important stress factor. Meanwhile, aging itself is a powerful risk factor for the development of hypertension (82). Patients with hypertension are concerned about their survival time, quality of life, and treatment outcome. However, as a lifelong disease, patients who suffer so much need not only long-term medication, functional exercise, and dietary changes but also frequent hospital checkups, which cause a lot of inconvenience and physical and mental exhaustion to middle-aged and older adults with hypertension. As the old Chinese saying goes, every medicament has its side-effect. The lifelong nature of hypertension treatment with medication will inevitably lead to different degrees of damage to patients' tissues, organs, and body functions. Patients with hypertension suffer from a decline in health, and those with severe conditions even develop related complications, which is hugely detrimental to achieving SA.

Death can happen at any age, as is well-known, yet it has often been accepted that getting older portends death. As people move into old age, their physical functions decline, and various diseases follow. They no longer think death is out of reach. Individuals routinely suffer DA when they recognize their own death (25). Everyone has DA because everyone will eventually experience death. It is a natural and normal feeling that continues throughout our lives. It is rooted in the uncertainty of the afterlife and the painful process of dying. Mild DA is necessary to help us cope positively with what is going on in our lives, but high DA can disrupt people's lives and become a worm in their minds. If DA is ignored, it may lead to an increasing lack of the individual's ability to perceive aging and be far removed from SA. Even though it is well-recognized that death is a remarkable fact of human life, people never feel entirely prepared for such a reality.

Therefore, first, medical staff should conduct regular lectures on hypertension to achieve early screening, diagnosis, and intervention, change their poor lifestyle and dietary habits, develop disease treatment plans, and follow up with them on time. Caregivers can improve patients' PR and reduce disease-related stress through mental health training, information support, and intensive training. Second, healthcare workers should promote proper attitudes toward aging patients; aging is not an irreversible stage of life but an age of infinite possibilities. Again, medical workers and the media should break the traditional culture of keeping their mouths shut about death and educate the public about it. Finally, it is urgent to improve the healthcare system promptly and strengthen the construction and services of aged institutions.

4.5. Implications

Recently, SA has become a significant issue due to the increase in the aging population. This study is the first to explore the mediating relationship between SA in PR and DA, which contributes to a deeper understanding of the mechanisms underlying the onset of DA among middle-aged and older adults with hypertension. Practically speaking, this study might offer hypertension patients a new strategy for achieving SA, something the medical staff should take note of. In addition, declining health status due to aging may hurt acquiring SA. We should focus on patients with irreversible diseases and intervene in their mental health to reduce their DA level in time to increase the likelihood of achieving SA.

4.6. Limitations

There are some limitations to our research. First, our study was merely cross-sectional; further longitudinal studies are required to ascertain the findings. Second, DA of hypertensive patients is affected by various factors. This study only includes SA as an intermediary variable to explore the relationship between PR and DA among hypertensive patients. In the future, more variables need to be added under the guidance of theory and professionals to explore the mechanism of DA deeply. Third, this study exclusively looked at middle-aged and older hypertension patients in Jinzhou City because of the COVID-19 epidemic. This result cannot represent more middle-aged and older adults with hypertension in China. A more in-depth study is expected to be conducted in the follow-up survey to analyze the influencing factors and related indicators further to improve the study.

5. Conclusion

The study showed that SA played a suppression role in the association of PR and DA. DA was at a high level in middle-aged and older adults with hypertension. Medical professionals should improve patients' PR through interventions to reduce DA, increase the likelihood of SA, and promote patient recovery.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

All individuals have provided informed consent before the data collection. Approval for this study was given by

the Medical Ethics Committee of Wannan Medical College (approval number: 2021-3) and all participants provided informed consent. All methods were performed in accordance with the Declaration of Helsinki. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LZ: designed the research, supervised the data collection, and collected the data. MW: analyzed the data and drafted the paper. MW, LZ, LG, HL, JM, HS, ZG, and MH: revised the paper. All authors read and approved the final manuscript.

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Conflict of interest

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

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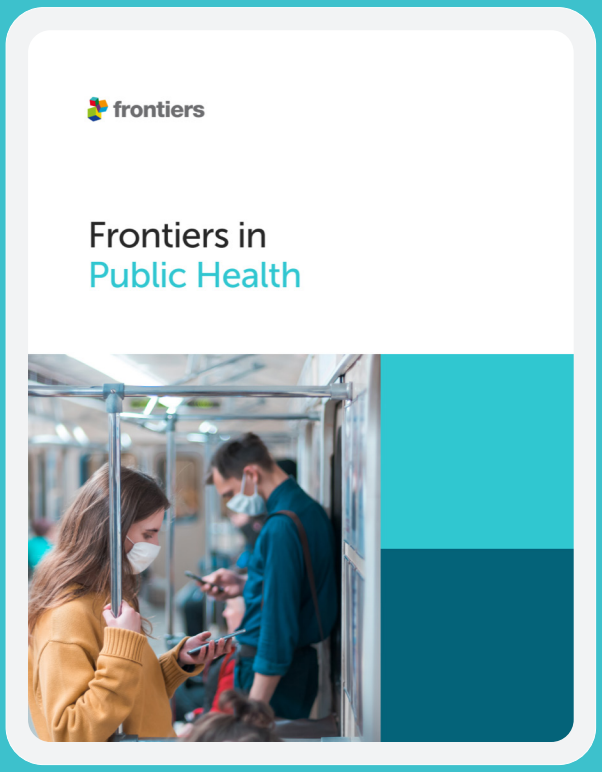

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