

Aging and work

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Aging and work

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Editorial: Aging and work

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aging, work, healthy aging, cognitive reserve, occupational health, ageism

Editorial on the Research Topic

Aging and work

1 Introduction

Population aging represents one of the most profound demographic transformations of the 21st century, with far-reaching implications for global labor markets. As working lives extend and workplaces become increasingly multigenerational, it is critical to understand how older adults adapt to evolving occupational demands. This Research Topic seeks to address these challenges through a multidisciplinary perspective, aiming to promote inclusive, sustainable, and meaningful career trajectories for aging populations.

The Aging and Work Research Topic brings together 14 original contributions that examine these challenges from psychological, organizational, sociological, and public health perspectives. These studies provide robust evidence on how aging intersects with work engagement, health, learning, and quality of life in later adulthood from a multidisciplinary perspective on healthy and sustainable working lives. The findings are organized into four key thematic areas: (1) mental health and emotional wellbeing; (2) workplace design and organizational practices; (3) learning, cognitive function, and career longevity, and (4) social and cultural perspectives on aging and work.

2 Mental health and emotional wellbeing

The studies under this theme highlight the multifaceted nature of emotional health in later life. Wang et al. explore longitudinal trajectories of subjective wellbeing, showing how emotional pathways in older adults are linked to anxiety and depression. Lv et al. examine the role of psychological flourishing in the context of mild cognitive impairment, suggesting emotional wellbeing as a protective factor. Onal et al. discuss the impact of nostalgia during leisure time on wellbeing, while Du et al. analyse fatalistic beliefs in disabled elderly populations, highlighting barriers to proactive engagement. Together, these studies underscore the complexity of emotional health in later life and the need for tailored mental health interventions.

3 Workplace design and organizational practices

This section emphasizes the strategic role of organizations in supporting longer and healthier careers. Hou et al. demonstrate that age-inclusive Human Resources

(HR) practices can enhance career sustainability, with mechanisms such as work–family enrichment and protean career orientation playing a critical role. [Hlado et al.](#) propose a model linking perceived work ability among teachers to work-life balance, emphasizing holistic support. [Maldonado-Macías et al.](#) explore burnout syndrome among manufacturing workers in Mexico, advocating for ergonomic interventions sensitive to age-related changes. These insights highlight the strategic role of organizations in enabling longer, healthier careers.

4 Learning, cognitive function, and career longevity

Lifelong learning emerges as a key factor in prolonging productive working lives. [Seeberg et al.](#) find that participation in skills development correlates with improved work ability and delayed retirement, supporting lifelong learning as a key to extended careers. [Feng et al.](#) investigate how chronic illnesses interact with cognitive function, emphasizing integrated health monitoring. [Zeng et al.](#) report that learning engagement significantly enhances subjective wellbeing among rural “empty nest” elders. [Sun et al.](#) add a technological dimension, showing how behavioral factors influence older adults’ adoption of smart devices, and calling for initiatives to promote digital inclusion.

5 Social and cultural perspectives on aging and work

This theme underscores the impact of cultural and social contexts on older adults’ work experiences. [Mei et al.](#) study the effects of multidimensional frailty on quality of life among older adults with coronary heart disease, emphasizing the need for functional accommodations. [Igreja et al.](#) reveal how older artisans in a UNESCO Creative City report high levels of life satisfaction, suggesting that creative work supports positive aging. [Li et al.](#) identify gender disparities in self-rated health among older Chinese workers, advocating for gender-sensitive workforce policies.

6 Toward a holistic model of healthy work and aging

Drawing on the insights provided by the contributions in this Research Topic, we propose a holistic model of healthy work and aging, structured around four interdependent pillars. This model integrates and illustrates the key findings across the collected works, offering a comprehensive framework for understanding and supporting aging in the workplace (see [Figure 1](#)):

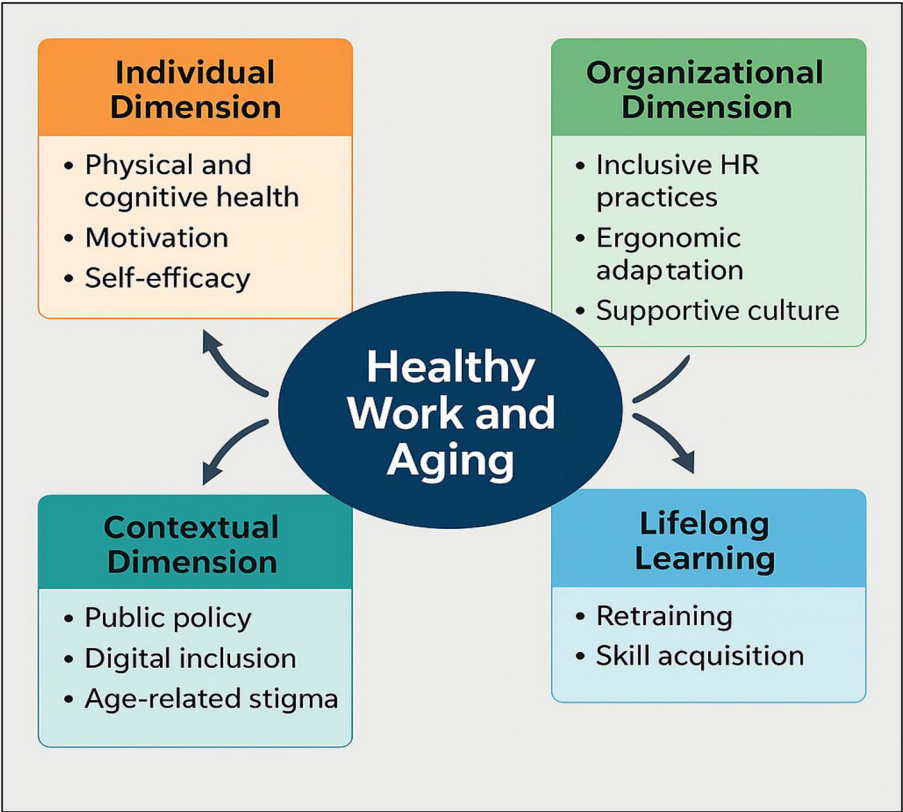


FIGURE 1
Holistic model of healthy work and aging.

- Individual dimension: encompasses physical and cognitive health, motivation, and self-efficacy.
- Organizational dimension: focuses on inclusive HR practices, ergonomic adaptation, and age-friendly workplace culture.
- Contextual dimension: includes public policy support, efforts to combat ageism, and initiatives for digital inclusion.
- Lifelong learning: emphasizes ongoing opportunities for retraining, skill renewal, and intellectual engagement at any age.

The figure illustrates a holistic model that integrates four interconnected dimensions essential for promoting healthy and sustainable working lives in the context of aging. At the core lies the Individual Dimension, which encompasses physical health, cognitive functioning, motivation, and self-efficacy—critical personal resources that support work ability in later life. Surrounding this are the Organizational Dimension, which includes age-inclusive human resource practices, ergonomic adaptations, and a workplace culture that values age diversity, and the Contextual Dimension, which involves broader societal and policy-level factors such as public support systems, anti-ageism efforts, and digital inclusion. Finally, the model emphasizes Lifelong Learning as a transversal element that enables older workers to continuously update skills, remain engaged, and adapt to changing work demands. The dynamic interaction among these four dimensions offers a comprehensive framework for understanding and supporting aging workers across diverse occupational and cultural settings.

This model may serve as a strategic guide for organizations, policymakers, and researchers seeking to implement age-inclusive practices and promote wellbeing across the working lifespan.

7 Final reflections

The diverse and rich contributions in this *Research Topic* reflect a growing interdisciplinary commitment to reimagining work in the context of aging. Far from viewing age as a limitation, the evidence presented here encourages a redefinition of later-life work as a stage full of potential, personal growth, and meaningful societal contributions.

As we face the demographic challenges of our time, this Research Topic offers both solid empirical foundations and a

transformative vision. It calls on researchers, practitioners, and policymakers to design work environments that recognize and value the dignity, capacity, and aspirations of older adults, ultimately fostering a more inclusive, cohesive, and resilient society.

We extend our deepest gratitude to all authors and reviewers for their valuable contributions. Their insights constitute a critical foundation for building healthier, more inclusive, and sustainable workplaces for today's and tomorrow's aging workforce.

Author contributions

SR-V: Writing – original draft, Writing – review & editing. RL-H: Writing – review & editing. PR: Writing – review & editing. SF: Writing – review & editing.

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Golden years happiness: analyzing the nostalgic aspect of leisure

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Retirees face numerous challenges, particularly in countries with lower socio-economic conditions. Perceived social isolation and happiness levels are seen as significant factors that significantly affect the quality of life in old age. Perceived social happiness levels can disrupt the quality of life in old age and contribute to mental disorders. Recent studies on leisure have suggested a direct impact of individuals' leisure attitudes on happiness. In this context, leisure nostalgia stands out in the relationship between leisure attitude and happiness levels among retirees. In this study, structural equation modeling (SEM) was employed to examine the relationship between leisure attitude, leisure nostalgia, and happiness levels in a sample of 210 retirees. The findings revealed that leisure nostalgia fully mediated the relationship between leisure attitude and happiness. It was concluded that previous experiences significantly shape retirement, and leisure attitude offers valuable opportunities for enhancing happiness through effective leisure utilization.

KEYWORDS

older adults, retirement, leisure attitude, nostalgia, happiness

Introduction

Retirement represents a significant life transition, marking the withdrawal from active employment and the conclusion of one's career (Coe and Zamarro, 2011; Kolodziej and García-Gómez, 2019). This period, often coinciding with old age, offers individuals the opportunity to relax and dedicate more time to leisure activities after years of work (Genoe et al., 2022; Henning et al., 2021). However, retirement introduces new challenges as individuals transition from a structured work routine to a more flexible lifestyle (Beutell and Schneer, 2021). While retirement provides more leisure time (Eismann et al., 2019), it can may disrupt well-being (Asebedo et al., 2019; Cai et al., 2020; Fleischmann et al., 2020).

Retirement is a distinct life stage during which individuals often set new goals and seek novel experiences (Stara et al., 2020). Nevertheless, it can also be a period marked by feelings of emptiness, purposelessness, or social isolation for some retirees (Guo et al., 2021). Therefore, maintaining a fulfilling lifestyle during retirement involves preserving social connections, staying physically active, making informed lifestyle choices, and optimizing leisure time. Indeed, leisure activities play a crucial role during this phase, allowing retirees to explore their interests, engage in hobbies, travel, partake in artistic or athletic pursuits, volunteer, or acquire new skills (Alwajud-Adewusi, 2021; Carney et al., 2021). These leisure pursuits have the potential to significantly enhance retirees' overall quality of life, increase their levels of happiness, and strengthen their social bonds.

In this context, the concept of leisure attitude assumes paramount importance. Leisure attitude encompasses individuals' perceptions of their leisure time, their approach to leisure activities, and the significance they attribute to these activities (Belo et al., 2020; Fan and Luo, 2021; Ragheb and Beard, 1982; Önal and Bedir, 2023). It reflects individuals' attitudes and behaviors toward their leisure time, how they organize and engage in activities, and their overall disposition toward leisure (Kim et al., 2022; Nootens et al., 2019). Allocating time to a hobby or activity that is important to an individual can help them spend their leisure time in a more positive and meaningful way. Additionally, maintaining a balance across various domains of life and engaging in diverse activities also influences leisure attitude (Yoon et al., 2020). It has been stated that the attitude toward leisure time is manifested in three dimensions: cognitive, affective (emotional) and behavioral. The cognitive dimension refers to the stage where individuals' thought structures are formed, the emotional dimension to the stage where these cognitive structures are transformed into emotions, and the behavioral dimension to the stage where the actions are performed (Kaya et al., 2015). There are many factors that could potentially interact with attitudes toward participation in leisure activities, and it is believed that leisure nostalgia May have a significant impact (Cho, 2020).

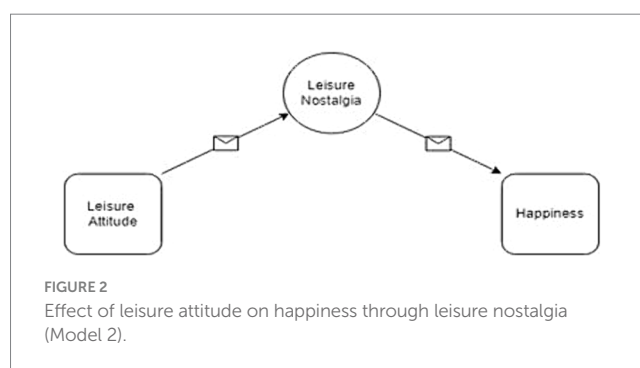
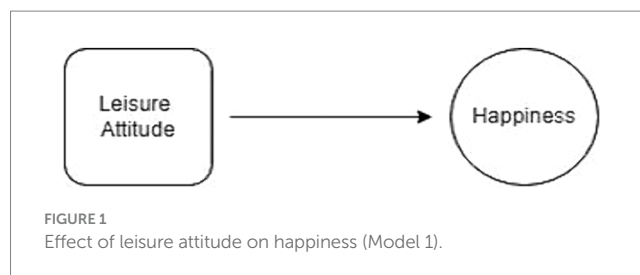
Hypothesis 1 (H1): It is hypothesized that individuals with a positive leisure attitude, characterized by a propensity for engaging in active and meaningful leisure activities, will report higher levels of happiness during retirement (Figure 1).

Leisure attitude is influenced by various factors, including the alignment of activities with personal interests and values, maintaining balance across multiple life domains, effective time management, and active engagement and mindfulness during leisure experiences (Stebbins, 2020; Yoon et al., 2020; Wang, 2019). However, one noteworthy factor, particularly prominent among retirees, is leisure nostalgia—the longing individuals feel for their past leisure experiences (Choi and Yoo, 2017).

Leisure nostalgia, characterized by the emotional connection with positive memories of past leisure activities and experiences, becomes more pronounced during the retirement phase (Gammon and Ramshaw, 2021; Cho, 2021; Wang and Xia, 2021). It holds the potential to not only evoke fond memories of past leisure engagements but also to enhance retirees' perceptions of their current leisure pursuits. Leisure nostalgia has been addressed in the literature in different dimensions 'experience, socialization, personal identity and group identity' (Cho et al., 2014). However, Balci and Yavaş Tez (2019) stated that leisure nostalgia May vary depending on cultural differences and can be addressed in different dimensions.

Hypothesis 2 (H2): It is further hypothesized that leisure nostalgia mediates the relationship between leisure attitude and happiness among retirees (Figure 2). Specifically, individuals with a positive leisure attitude who also experience leisure nostalgia are expected to report higher levels of happiness.

Consistent with the hypotheses, there are studies in the literature that support the potential mediating role of leisure nostalgia. FioRito and Routledge (2020) suggest that nostalgia is fundamentally an emotional experience oriented toward the future, enhancing well-being, fostering social connectedness, and deepening perceptions of life's



meaning. Additionally, a good event experience can be associated with greater optimism in the future while creating nostalgic memories (Biskas et al., 2019). Nostalgia has been shown to enhance psychological health and well-being, promoting adaptive functioning, particularly among individuals vulnerable to poor mental health. Compared to merely imagining a desired future experience, nostalgia not only increases well-being but also deepens one's perception of life's meaning (Routledge et al., 2012; Routledge et al., 2013).

This study aims to delve deeper into the intricate interplay of leisure attitude and nostalgia, shedding light on their combined impact on happiness and leisure engagement during retirement.

The impact of leisure nostalgia on the attitudes of retirees toward leisure activities cannot be understated (Cho, 2023; Cho et al., 2019). By fostering recollections of past leisure experiences, leisure nostalgia assumes a pivotal role in enhancing the nexus between happiness and one's outlook on leisure pursuits (Hepper and Dennis, 2022; Layouts and Kurtz, 2022; Li et al., 2023; Luo et al., 2022; Zhou et al., 2022). This intricate interplay permits retirees to not only reminisce about their former leisure engagements but also to assess their present leisure pursuits in a more favorable light (Wilson, 2015; Routledge et al., 2013). While the current investigation sheds preliminary light on these dynamics, it is important to emphasize that further comprehensive exploration is indispensable for a deeper comprehension of this intricate relationship. As such, this study endeavors to delve into the ramifications of yearning for past leisure endeavors on both happiness and the disposition toward leisure activities. This avenue of inquiry holds promise in furnishing invaluable insights for the effective harnessing of leisure during the retirement phase.

Research model

The hypothesized impact of leisure attitudes on happiness in Figure 1 is grounded in the Leisure Motivation Theory (Iso-Ahola, 1980). This theory posits that individuals are motivated to engage in leisure activities

due to various intrinsic and extrinsic factors, which fulfill psychological needs and, in turn, contribute to well-being. Positive attitudes toward leisure can lead to greater participation in these activities, thereby enhancing happiness through the satisfaction of personal motivations and the promotion of psychological well-being (Wolfe and Hsu, 2004).

The model presented in Figure 2 hypothesizes that leisure nostalgia may mediate the relationship between leisure attitudes and happiness. This proposition is supported by the Nostalgia Theory, which suggests that recalling positive past experiences, such as satisfying leisure activities, can enhance psychological well-being by fostering feelings of happiness, social connectedness, and a sense of belonging (Routledge et al., 2013). Additionally, grounded in Leisure Motivation Theory (Iso-Ahola, 1980), the model posits that positive leisure attitudes lead to greater participation in leisure activities, which is further amplified through the mediating effect of leisure nostalgia, thereby enhancing overall happiness.

Materials and methods

The study followed a relational screening model to investigate the relationship between leisure attitude and happiness and leisure nostalgia among retirees at Türkiye. The objective of this study was to investigate the potential mediating role of leisure nostalgia in the relationship under examination. Structural Equation Modeling (SEM) was employed as the statistical technique to analyze the collected data and examine the predictive associations among the variables under investigation (Fraenkel et al., 2012).

Sample group and data collection process

The universe of this research; retired population living in Erzurum. According to Türkiye İstatistik Kurumu [TÜİK] (2016) data for January 2022, this population constitutes a total of 24 thousand people. The sample of the study was selected by convenient sampling method, which is one of the non-random sampling methods (Gravetter and Forzano, 2015). The sample group consisted of retired individuals residing in the province of Erzurum, Turkey. The questionnaires were administered to retired individuals who spend their time in coffeehouses, cafes, parks, and recreational areas created for community service purposes, representing the sample group. In order to obtain more accurate data, the surveys were completed through face-to-face interviews and on a voluntary basis by the participants (Eysenbach, 2004). In the study, ethical principles outlined in the Helsinki Declaration regarding research involving human subjects, including informed consent, privacy, and procedures, were followed. Prior to answering the questionnaire, participants were provided with information about the purpose of the research (research article) and gave their consent. A total of 210 data were collected without any errors through face-to-face interviews. Of the participants, 71 were female and 139 were male. The completion time for the surveys filled out through the interview method ranged from 6 to 9 min.

Research model

This study was designed using a correlational research model to examine the effects of leisure attitude and nostalgia on happiness among

retired individuals. In this context, the Structural Equation Model (SEM) was utilized to explain the predictive correlations between the variables.

Data collection instruments

The data collection instruments in the study consist of four sections: a personal information form, “Oxford Happiness Scale,” “Leisure Nostalgia Scale” and “Leisure Attitude Scale.”

Personal information form

The personal information form, prepared by the researchers, includes questions about participants’ gender, age, marital status, retirement age, and educational background.

Oxford Happiness Scale

The scale, originally developed by Argyle et al. (1989) and later revised by Hills and Argyle (2002) to create a short form, consists of 29 items. The Turkish adaptation of the scale was conducted by Doğan and Akıncı Çötök (2011). The self-report scale is a five-point Likert-type scale and consists of 7 items. The scale is rated on a scale from “1-Strongly Disagree” to “5-Strongly Agree.” The lowest score is 7, and the highest score is 35. Increasing scores indicate higher levels of happiness. The reliability coefficient of the scale was found 0.74, according to Doğan and Akıncı Çötök (2011). The reliability of the scale used in the study was determined using Cronbach’s Alpha, and the coefficient was calculated to be 0.79.

Leisure Attitude Scale – short form

The scale, originally developed by Teixeira and Freire (2013) with 18 items and 3 subdimensions (cognitive: 1–6, affective: 7–12, behavioral: 13–18), has been adapted into Turkish by Önal and Bedir (2023). The scale utilizes a 5-point Likert rating. The lowest score is 18, and the highest score is 90. Increasing scores on the scale indicate a higher level of leisure attitude. The reliability coefficient of the scale was found 0.88, according to Önal and Bedir (2023). The reliability of the scale used in the study was determined using Cronbach’s Alpha, and the coefficient was calculated to be 0.84.

Leisure Nostalgia Scale

Another data collection instrument used in this study is the “Leisure Nostalgia Scale” developed by Cho et al. (2019). The scale consists of 15 items and 3 subdimensions. The Turkish validation and reliability study of the scale was conducted by Balci and Tez (2019). As a result of the study, the scale was confirmed to consist of 3 subscales and 15 items. The scale utilizes a 7-point Likert rating. The lowest score is 15, and the highest score is 105. The subscales of the scale include spatial memories (5 items), social memories (6 items), and group rituals (4 items). The increase in the scores obtained from the scale indicates that the nostalgic feelings are high. The reliability coefficient of the scale was found 0.78, according to Balci and Tez

(2019). The reliability of the scale used in the study was determined using Cronbach's Alpha, and the coefficient was calculated to be 0.76.

Data analysis

To test the hypotheses of the study, Structural Equation Modeling (SEM) was employed. SEM is a collection of statistical techniques that allow for the examination of a series of relationships between one or more independent variables (Ullman and Bentler, 2012). It provides a framework for assessing the relationships among observed variables and latent variables, allowing researchers to investigate complex relationships and evaluate the fit of a proposed model. By utilizing SEM, the study aimed to analyze the hypothesized relationships and gain a deeper understanding of the interrelationships between variables. SEM was chosen for the correlation analysis in this study because it allows for the estimation of parameters of correlation between latent variables and also enables the determination of error variances. The descriptive statistics of the variables were calculated using SPSS 24.0 software, while model testing was conducted using AMOS 24.0 software. The "Maximum Likelihood (ML)" and "Covariance Matrix" were used as parameter estimation methods. These methods are commonly employed in SEM to estimate the model parameters and assess the goodness of fit between the proposed model and the observed data.

First, the normality assumptions of the data was examined to determine whether they met the requirements for constructing the structural equation model. This was done by examining the kurtosis and skewness coefficients. The data set exhibited a normal distribution characteristic. The normality tests of the utilized scales yielded results within the range of values for Happiness (Skewness -1.5 and Kurtosis $+1.1$), Leisure Attitude (Skewness -1.4 and Kurtosis $+1.1$), and Leisure Nostalgia (Skewness -1.4 and Kurtosis $+1.1$), indicating a homogeneous distribution. After testing the normality assumptions, factors such as variance inflation factor and autocorrelation were examined before the analysis. It was found that there was no autocorrelation and the variance inflation factors were within the required limits. Subsequently, it was decided that the data set was suitable for parametric statistical analysis, and the data analysis process commenced.

Common method variance was analyzed with the Harman Single Factor test. According to the Harman test, there is no problem of common method variance when all the expressions are collected in a single factor and there is less than 40% of the variance explained (Podsakoff et al., 2003). The results showed that the factors had an eigenvalue of "LA" and "H," and the variances explained 33.86%, 29.62%, and 37.58% which were $<40\%$. According to the zero order correlation analysis, the correlation of the marker variable with both variables was found to be significant. Model 1 fit indices as follows: $\chi^2/df = 2.98$; RMSEA = 0.06; CFI = 0.97; GFI = 0.91 and Model 2 fit indices as follows: $\chi^2/df = 1.88$; CFI = 0.95; GFI = 0.91; RMSEA = 0.05. According to these results, it can be stated that common method variance is not a problem in the study.

Results

Descriptive statistics were examined for a group of 210 individuals in Table 1. Among this group, 139 individuals (66.2%) were male, and 71 individuals (33.8%) were female. Regarding educational

background, 45 individuals (21.4%) had completed primary education, 96 individuals (45.7%) had completed secondary education, 63 individuals (30%) had completed high school, and 6 individuals (2.9%) were university graduates. The majority of individuals in this group had received secondary education. Furthermore, among the participants, 80 individuals (38.1%) were employed in public service, 55 individuals (26.2%) were workers, and 75 individuals (35.7%) were self-employed and had retired. The retirement years ranged from 1 to 15, with an average retirement age of 6.7 years. The age range was between 57 and 80, with an average age of 66.8 years.

Table 2 presents the descriptive statistical results of all variables that showed significant correlation with each other in LA, H and LN, and the correlation coefficients between the variables ($p < 0.01$). Table 2 shows that the mean scores for Leisure Nostalgia (LN) at 2.75, Leisure Attitudes (LA) at 2.93, and Happiness (H) at 3.20 suggest moderate levels of nostalgia and positive attitudes toward leisure, with a relatively higher level of overall happiness among participants. These mean values complement the correlation coefficients by providing context to the relationships between these variables.

When assessing the goodness-of-fit measures for the structural model depicted in Figure 3, it becomes apparent that the latent variables in Model 1 demonstrate a statistically significant association with their corresponding observed variables ($p < 0.01$). Results suggest that the structural model exhibits a satisfactory fit in Table 3. Specifically, based on the results of Model 1, it was observed that Leisure Attitude exerted a positive and significant predictive impact on Happiness ($\beta = 0.11$, $p < 0.01$).

Upon assessing the fit indices of the model depicted in Figure 4, it becomes apparent that the latent variables in Model 2 demonstrate

TABLE 1 Descriptive of the participants.

| | N | % |
|---------------------------|-----|------|
| Gender | | |
| Male | 139 | 62.9 |
| Female | 71 | 37.1 |
| Education | | |
| Primary education | 45 | 21.4 |
| Secondary education | 96 | 45.7 |
| High school | 63 | 30.0 |
| Undergraduate | 6 | 2.9 |
| Institution of retirement | | |
| Public servant | 80 | 38.1 |
| Laborer | 55 | 26.2 |
| Self-employment | 75 | 35.7 |

TABLE 2 The examination of the Pearson product-moment correlation among variables.

| | LN | LA | H | \bar{X} | SS |
|----|----|---------|---------|-----------|------|
| LN | 1 | 0.177** | 0.408** | 2.75 | 0.82 |
| LA | | 1 | 0.683** | 2.93 | 1.08 |
| H | | | 1 | 3.20 | 1.20 |

** $p \leq 0.01$. LN, leisure nostalgia; LA, leisure attitude; H, happiness.

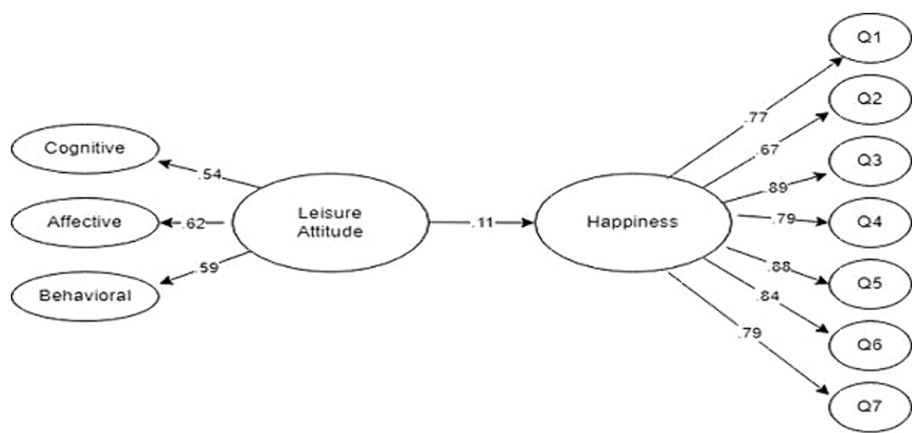


FIGURE 3
Standardized estimated results of the effect of leisure attitude on happiness (standardized SEM results for Model 1). “Q” represents the items related to the happiness scale.

TABLE 3 The fit index values of the model showing the effect of leisure attitude on happiness.

| Fit indexes | Acceptable limit | Excellent | Values in the model | Conformity |
|-------------|-------------------------|--------------------------|---------------------|------------|
| CMIN/df | Between 2 and 5 | ≤2 | 2.98 | Acceptable |
| RMSEA | Between 0.050 and 0.080 | Between 0.000 and <0.050 | 0.06 | Acceptable |
| GFI | 0.85 and above | =0.90 and above | 0.91 | Excellent |
| AGFI | 0.85 and above | =0.90 and above | 0.86 | Acceptable |
| CFI | 0.95 and above | 0.97 and above | 0.97 | Excellent |
| RMR | Between 0.050 and 0.080 | Between 0.000 and <0.050 | 0.07 | Acceptable |
| NFI | 0.90 and above | 0.95 and above | 0.92 | Acceptable |

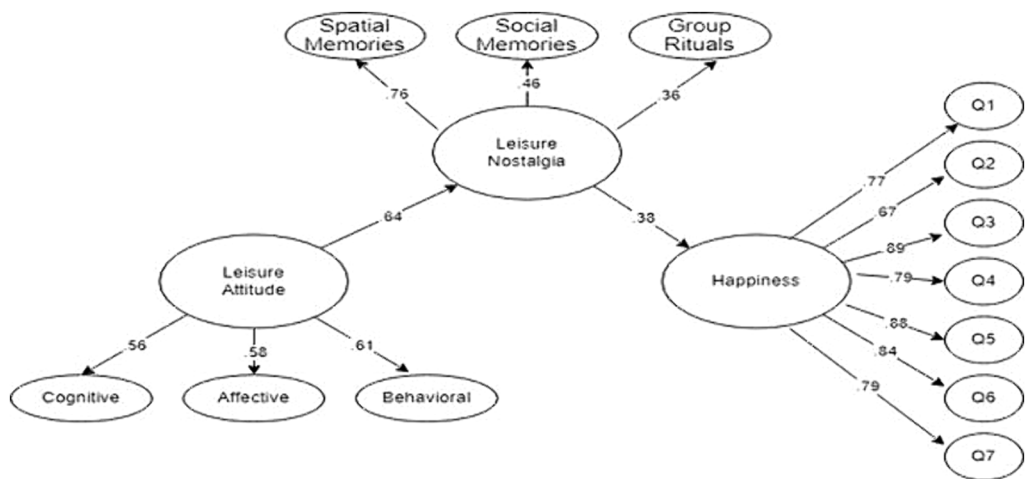


FIGURE 4
Standardized estimated results demonstrating the effect of leisure nostalgia its mediator role between leisure attitude and happiness (standardized SEM results for Model 2).

a statistically significant association with their corresponding observed variables ($p < 0.01$). These results suggest that the structural model exhibits a satisfactory fit in Table 4. Consequently, the hypothesis proposing that Leisure Nostalgia serves as a complete mediator in the link between Leisure Attitude and Happiness is supported by the empirical findings ($\beta = 0.38, p < 0.01$).

TABLE 4 The fit index values of the model showing the leisure nostalgia, happiness and leisure attitude.

| Fit indexes | Acceptable limit | Excellent | Values in the model | Conformity |
|-------------|-------------------------|--------------------------|---------------------|------------|
| CMIN/df | Between 2 and 5 | ≤ 2 | 1.88 | Excellent |
| RMSEA | Between 0.050 and 0.080 | Between 0.000 and <0.050 | 0.058 | Acceptable |
| GFI | 0.85 and above | ≥ 0.90 and above | 0.91 | Excellent |
| AGFI | 0.85 and above | ≥ 0.90 and above | 0.86 | Acceptable |
| CFI | 0.95 and above | 0.97 and above | 0.95 | Acceptable |
| RMR | Between 0.050 and 0.080 | Between 0.000 and <0.050 | 0.06 | Acceptable |
| NFI | 0.90 and above | 0.95 and above | 0.96 | Excellent |

Discussion

The phenomenon of increasing leisure in human life has been directly associated with individuals' happiness (Liu and Da, 2020; Nawijn and Veenhoven, 2012). The influence of past experiences on happiness and well-being is also significant (Leunissen et al., 2021). Previous studies in the literature have provided evidence that leisure activities enhance the happiness of retired individuals, and nostalgia for leisure also contributes to increased happiness (Cho, 2021; Cho, 2023; Fludernik, 2020; Lin et al., 2021). Carrasco et al. (2018) and Chaudhry et al. (2024) found that nostalgic ruminations on past roles and activities help individuals reconcile their current selves, expanding understanding of the role of nostalgia in everyday life. While previous research has focused on digital self-representation and its connection to past identities in older adults, our research expands the scope by examining how leisure nostalgia contributes to overall happiness and well-being. This highlights the potential for nostalgic elements to promote psychological health and life satisfaction not only in digital environments but also in leisure activities. These findings suggest that integrating nostalgia into leisure interventions may have broad benefits in both digital and real-world contexts. However, in this study, the mediating role of leisure nostalgia was examined, and the impact of leisure attitude on happiness was investigated.

The impact of nostalgia for past experiences during retirement on leisure attitude holds insights for younger individuals to feel good and happy in their old age. In this context, the research aims to determine the mediating role of leisure nostalgia in the relationship between leisure attitude and happiness. The influence of the predictor variables on the levels of happiness among retired individuals can be discussed in two ways. The direct effect of leisure attitude on happiness can be considered as one aspect (Model I), ($\beta = 0.11, p < 0.01$). The indirect effect, on the other hand, can be examined by considering the mediating role of leisure nostalgia in the relationship between leisure attitude and happiness (Model II), ($\beta = 0.38, p < 0.01$). Fit indices obtained as a result of testing measurement models indicate an adequate fit (Tabachnick and Fidel, 2007).

In psychology, attitude is expressed as a state of emotion, and a positive emotional state is important for achievement and happiness (Kamthan et al., 2019). Some studies in the literature have found that leisure activities enhance the happiness of retired individuals (Kim and Moen, 2002; Lachman and Agrigoroaei, 2010). In a study conducted by Lachman and Agrigoroaei (2010), it was found that individuals who engage in leisure activities have higher happiness.

Furthermore, in their study, Kim and Moen (2002) found a link between participation in leisure activities during retirement and individuals' increased sense of happiness. However, in a study conducted by Gorry et al. (2018), it was found that the impact of leisure activity participation on retired individuals' happiness was limited. This may be due to cultural and economic differences. This discrepancy in findings suggests the need for further research on how leisure activities affect the happiness of retired individuals.

Initially, we identified that the leisure attitude of retired individuals influenced their levels of happiness (0.11). However, when the mediating variable of leisure nostalgia was added to the model, it was observed that the effect of leisure attitude on happiness increased to 0.38. The findings indicate that leisure attitude is an important factor in determining the levels of happiness among retired individuals. Additionally, it has been determined that the emotion of nostalgia plays a mediating role in happiness and strengthens the relationship between leisure attitude and happiness. Similar studies can be found in the literature (Lu et al., 2022; Cho, 2023; Cho et al., 2021). In their study, Lu et al. (2022) found that leisure attitude has a positive impact on the happiness of retired individuals. The study also demonstrated that leisure nostalgia acts as a mediating variable, altering the influence of leisure attitude on happiness. Cho (2023) and Cho et al. (2021) have found significant results suggesting that leisure nostalgia can be a significant predictor of happiness, shedding light on future studies. In a study conducted by Zhang (2023), the relationship between leisure attitude, leisure nostalgia, and subjective well-being was examined. According to Stone and Mackie (2013), they stated that there is a close relationship between subjective well-being and happiness and can express a common point. Therefore, the findings revealed a positive relationship between leisure attitude, leisure nostalgia and happiness. Cho (2021) conducted a study focusing on older adults, investigating the relationship between leisure attitude, leisure nostalgia, and happiness. The findings indicated that leisure nostalgia mediated the relationship between leisure attitude and happiness. However, it is important to note that there are also studies with differing findings on this topic. Lee and Tideswell (2005) conducted a study among older adults in Korea to examine the effects of leisure attitude and leisure nostalgia on happiness. The findings revealed that leisure attitude had a positive impact on happiness, while the effect of leisure nostalgia was statistically insignificant. These results suggest that the influence of leisure nostalgia on happiness may vary in different contexts or populations. Spiers and Walker (2008)

conducted a study among retired individuals to examine the effects of leisure activities and leisure satisfaction on happiness. Riddick and Stewart (1994) investigated the impact of leisure attitudes on happiness among older adults and found that it was not directly related to happiness but was associated with social support. The findings of these studies revealed that leisure activities had a positive influence on happiness, while the effect of leisure satisfaction was statistically insignificant. The reasons for these differences may stem from various factors such as the methodologies employed in the studies, sample characteristics, measurement instruments, age ranges, socio-economic statuses, or cultural variations. Speculation about the underlying causes of these differences requires further research. Therefore, it is crucial for future studies to be designed in a more comprehensive manner, considering different factors. This would contribute to a better understanding of the topic and provide more insights into the relationship between leisure, nostalgia, and happiness among retired individuals.

Conclusion

In conclusion, the direct effect of leisure attitude on happiness was found to be 0.11 (Model 1), while examining the mediating role of leisure nostalgia in Model 2 revealed that the level of happiness increased to 0.38. This indicates that leisure nostalgia acts as an intermediary variable between leisure attitude and happiness. The findings suggest that leisure nostalgia enhances the impact of leisure attitude on happiness, especially in the retired population, and therefore plays a significant mediating role in happiness levels.

Beyond these findings, this research contributes to the theoretical understanding of how leisure nostalgia functions as a mechanism that bridges past experiences with present well-being. The study advances our knowledge of the psychological processes involved in leisure, highlighting the importance of integrating nostalgic elements in leisure activities for boosting psychological health and life satisfaction.

From a practical perspective, the results have implications for designing leisure programs and social interventions for both older and younger populations. For young individuals, actively engaging in enjoyable leisure activities not only enhances current happiness but also helps accumulate memories that could evoke nostalgia in later life, contributing to future happiness. For retirees, promoting activities that evoke leisure nostalgia can be a powerful tool to increase their overall life satisfaction and well-being. This emphasizes the importance of creating structured leisure environments that encourage reflection on positive past experiences as a means to improve emotional well-being.

Limitations and suggestions

To enhance the happiness levels of retired individuals, it is beneficial to provide tips on positively influencing their leisure attitudes and maintaining the feeling of nostalgia. Specifically, encouraging retired individuals to revive their past memories during their leisure, intensifying the nostalgic impact of those memories, and thereby increasing their happiness levels can be suggested. Exactly, preserving positive memories of past leisure experiences can be recommended as a means to increase happiness levels. Encouraging

retired individuals to actively reminisce about their past leisure activities and cherish the positive memories associated with them can contribute to their overall sense of well-being and happiness.

Indeed, implementing strategies that enhance the ability of retired individuals to remember and revive their past leisure experiences can leverage the impact of leisure attitude on happiness. By focusing on developing skills related to reminiscing and revitalizing past leisure activities, it is possible to enhance the influence of leisure nostalgia on happiness and ultimately increase the overall well-being of retired individuals.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found: <https://doi.org/10.48623/aperta.252437>.

Ethics statement

The studies involving humans were approved by Atatürk University Faculty of Sports Sciences Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LO: Writing – review & editing, Writing – original draft, Resources, Methodology, Data curation. FB: Writing – original draft, Software, Resources, Methodology, Formal analysis. MT: Writing – original draft, Formal analysis, Data curation. MM: Writing – original draft, Resources, Data curation. BS: Writing – original draft, Methodology, Data curation. FY: Writing – original draft, Methodology, Data curation.

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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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Gender differences in self-rated health among older adults in the Chinese workforce

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Introduction: This study investigates gender-based disparities in self-rated health among older individuals in the Chinese workforce, utilizing data from the China Health and Retirement Longitudinal Study (CHARLS). Understanding these health gaps is crucial for crafting effective health policies and interventions in light of the rapidly aging population.

Materials and methods: Data from the 2020 CHARLS survey, comprising Chinese individuals aged 45 and above, were analyzed, focusing on older adults actively employed. Descriptive statistics and regression analyses examined gender discrepancies in self-rated health, considering diverse sociodemographic, economic, and health-related factors.

Results: Gender disparities in demographics, work environments, and self-rated health were observable among male and female participants. Older males tended to have higher rates of smoking and alcohol consumption, coupled with lower incomes. In contrast, females exhibited healthier behaviors influenced by access to healthcare and lifestyle modifications. For males, economic stability and moderate alcohol use positively influenced self-rated health, while females benefited from healthcare coverage and healthy lifestyle choices. Tailored gender-specific health interventions should prioritize these unique factors to enhance overall well-being.

Discussion: Discussions highlighted the impact of demographic variables, including age, marital status, social security, and employment conditions, on self-rated health. The study emphasized the crucial role of marital relationships in the health outcomes of older adult workers.

Conclusion: This study underscores the pivotal role of gender in self-rated health variations and provides essential insights for targeted interventions. By considering both quantitative and qualitative determinants of well-being, focused health policies can effectively address the health and well-being of aging populations, especially older adult workers.

KEYWORDS

self-rated health, gender differences, older adult workforce, economic factors, lifestyle habits

Introduction

Population aging is a significant global challenge. According to the data from the United Nations, by 2050, one out of every six people in the world will be over 65 years old, which is three times higher than the proportion in 1990 (1). However, productive labour, instead of being a means of subjugating men, should become a means of their emancipation, by offering each individual the opportunity to develop all his faculties, physical and mental, in all directions and exercise them to the full—in which, therefore, productive labour should become a pleasure instead of being a burden (2). Instead of being seen as burdensome or irrelevant individuals, the social value of older adult workforce should be recognized. To achieve this, a thorough investigation of the health status of them is necessary. By addressing their specific health needs and challenges, policymakers can personalize interventions to promote their well-being and maximize their contribution to society, while also enabling the realization of their individual value in old age.

Previous studies (3–5) have not reached a consensus regarding gender differences in self-rated health, and research on the older adult workforce has also indicated the presence of gender discrimination in the labor market. Self-rated health serves as a vital marker, reflecting objective health conditions and correlating with long-term cardiovascular health. Research indicates that self-reporting health status is a critical indicator of cardiovascular health (6) and is closely associated with long-term physical morbidity and mortality (7). Based on data from China, this study aims to reveal gender disparities in self-rated health among the older adult workforce through empirical research. The findings will provide evidence-based interventions to enhance the health and well-being of older adult workforce, promote gender equality, and serve as a reference for policymakers seeking to fully utilize the social value of the older adults.

Literature context

Gender differences in self-rated health have been a topic of extensive research. However, the existing literature has yielded inconsistent findings regarding gender disparities in self-rated health. Some studies suggest no gender differences in self-rated health. Arber et al. (8) found that while older women had higher levels of functional impairment compared to men, there were no gender differences in self-rated health. Conversely, a study on self-rated health during adolescence indicated higher levels of self-rated health among females. Ostberg et al. (9) observed that adolescent girls scored higher on behavioral indicators, displayed greater interest in oral health, and perceived their oral health condition to be better than boys. D'Ambrosio et al. (10) also noted differences in self-regulatory behavioral patterns between males and females. Other research suggests that although women have longer lifespans, their self-rated health tends to be poorer than that of men. Knodel et al. (11) reported that despite higher survival rates among women, their self-rated health tends to be worse than that of men, with more health symptoms and physical functioning issues.

Scholars have demonstrated that gender differences in self-rated health diminish over time. Zajacova et al. (12) found that women generally rated their health lower than men, but this disparity

decreased in old age and disappeared after accounting for socioeconomic and health covariates. Other researchers have examined gender differences in self-rated health and other influencing factors among the aging population. Chen et al. (13) investigated the gender differences in the impact of parental bereavement on health outcomes, including self-rated health, among middle-aged and older adults. Sharma et al. (14) delved into the potential mechanisms of age and gender differences in self-rated risk tolerance among the aging population, focusing on cognitive functioning and emphasizing the importance of understanding cognitive function in mitigating low risk tolerance in older adults. Lastly, Qi et al. (15) emphasized the prevalence and risk factors of social frailty in older adult individuals with cardiovascular diseases in China, highlighting an understudied aspect of frailty within this population.

Previous studies in the context of older adult workforce have primarily focused on the economic benefits or have regarded older individuals as a societal burden or recipients of care. Johnson (16) argued that, apart from the interest in the impact of pay-as-you-go pension systems on future tax burdens, economists seem to have generally overlooked the issues of older individuals and population aging. Dhar et al. (17) highlighted that population aging is rapidly becoming a significant socio-economic concern in India, with the rising dependency ratio imposing economic burdens on families. Conrad et al. (18) emphasized that population aging in Japan not only increases the burden on the younger generation but also depletes the resources necessary for driving robust economic growth.

While some studies have mentioned gender differences in the older adult workforce, there is often an emphasis on older women as wives and family members when they become the focus of research. Marenzi et al. (19) analyzed the empirical relationship between female labor market participation and intergenerational family ties using data from the 2000 Bank of Italy's Survey on Household Income and Wealth (SHIW). Dempse et al. (20) noted that in Australia, retired men tend to assist rather than share the majority of traditional female household chores, with tasks requiring significantly less time and often of lower quality compared to the work of domestic helpers, while not significantly reducing their personal autonomy. Barone et al. (21) investigated whether and how the inflow of female immigrants specializing in household production affects the labor supply of Italian women.

Women are often studied as a specific labor force, namely caregivers. Finch et al. (22) found that care in residential institutions heavily relies on low-wage female labor. Ogawa et al. (23) examined the impact of providing care for older adult parents on the labor force participation of middle-aged women in Japan. The results indicated that regardless of the level of disability among older adult parents, the probability of daughters or daughters-in-law being employed is approximately 75%.

In summary, previous research has not yet reached a consensus on gender differences in self-rated health among the older adult workforce, and these findings have shown variation over time. Older adult workers are often viewed as a societal burden or recipients of care, with older adult women workers typically classified as caregivers, forming a distinct occupational group. Consequently, past studies have exhibited a pessimistic tendency, and older adult female workers also face tendencies of occupational discrimination.

Materials and methods

Source of data

This study utilized data from the China Health and Retirement Longitudinal Study (CHARLS).¹ CHARLS is a nationally representative, interdisciplinary public database aimed at understanding the health and well-being of individuals aged 45 and above in China (24). The present study utilized the 2020 wave of the CHARLS national baseline survey, covering 19,351 individuals and over 10,000 households. The selection of the CHARLS baseline survey was motivated by several factors: it provides detailed data on individuals' socioeconomic status, health conditions, and work situations, which are essential for exploring the health and well-being of China's older adult labor force. Moreover, this dataset offers an opportunity to investigate the impacts of delayed retirement and gender equality on the health and well-being of the older adult workforce. Since this study was a secondary analysis of CHARLS data, we did not require a separate ethical approval.

Model

This study utilized Stata 17.0 statistical software to conduct descriptive analysis and provide a detailed report on the differences in demographic characteristics, health conditions, and lifestyles between older adult individuals who are engaged in labor and those who are not. Additionally, chi-square tests are used to analyze the intergroup differences in various variables between these two groups. Logistic regression analysis is conducted to explore the correlations between the older adult workforce and various factors. All significant differences ($p < 0.05$) are included in the regression model. Results with a p -value less than 0.05 are considered statistically significant.

Dependent variables

The key variable of this study is gender, but specific selection criteria is required for the study population. Firstly, the selection of age range is crucial as there is a lack of clear age definition for the older adult workforce in research. Previous research (25) has suggested research should more broadly include employees aged 60 and above with the acceleration of population aging, so, we selected the older adult population aged 60 and above. Additionally, we determined individuals' retirement status by using the questionnaire item "Have you already retired?" (FH001), and we utilized the Xworking indicator in the questionnaire to determine whether individuals in the target age group were still engaged in labor activities. Based on the above considerations, the study population is defined as individuals aged 60 and above who are actively participating in labor activities.

In this study, the explanatory variables are analyzed from several aspects, including demographic information, social security, employment status, and individual habits. To provide a clearer representation of the data processing flow, we present a data filtering

flowchart (as shown in Figure 1). Demographic information encompasses age, Residence Location, Household registration type, and marital status. Social security includes pension insurance and medical insurance. Employment status includes type of employer, number of days worked per week in the past year, ways of receiving salary, and income level. Lifestyle habits include smoking and drinking habits, duration of sleep, and dietary intake. Detailed variable assignments are given in the [Supplementary material S1](#).

Results

Statistical analysis

| Items | Male | | Female | | p -value |
|---|---------|--------|----------|--------|---------------------|
| Age | 64.4385 | | 64.70385 | | <0.001 ^a |
| Residence location | | | | | 0.3143 ^b |
| Urban or town center | 123 | 21.93% | 46 | 17.69% | |
| Urban-rural or town-village junction area | 80 | 14.26% | 35 | 13.46% | |
| Rural area | 358 | 63.81% | 179 | 68.85% | |
| Type of household registration | | | | | 0.0551 ^b |
| Agricultural household registration | 455 | 81.11% | 224 | 86.15% | |
| Non-agricultural household registration | 56 | 9.98% | 13 | 5.00% | |
| Non-resident household registration | 50 | 8.91% | 23 | 8.85% | |
| Marital status | | | | | <0.001 ^b |
| Without spouse | 49 | 8.73% | 60 | 23.08% | |
| With spouse | 512 | 91.27% | 200 | 76.92% | |
| Pension insurance | | | | | |
| No | 0 | 0 | 0 | 0 | |
| Yes | 561 | 100% | 260 | 100% | |
| Medical insurance | | | | | 0.424 ^b |
| No | 18 | 3.21% | 12 | 4.62% | |
| Yes | 543 | 96.79% | 248 | 95.38% | |

(Continued)

¹ <http://charls.pku.edu.cn/>

| Items | Male | | Female | | p-value |
|---|----------|--------|----------|--------|---------------------|
| Information of employment | | | | | 0.005 ^b |
| Government | 73 | 13.01% | 20 | 7.69% | |
| Public institution | 26 | 4.63% | 7 | 2.69% | |
| Non-profit organization (NPO) | 4 | 0.71% | 2 | 0.77% | |
| Enterprise | 164 | 29.23% | 62 | 23.85% | |
| Self-employed household | 200 | 35.65% | 98 | 37.69% | |
| Farming household | 74 | 13.19% | 59 | 22.69% | |
| Resident household | 20 | 3.57% | 12 | 4.62% | |
| Whether you are a manager or not | | | | | <0.001 ^b |
| Non-supervisory position | 482 | 85.92% | 253 | 96.93% | |
| Management position | 79 | 14.08% | 8 | 3.07% | |
| Number of days worked per week in the past year | 5.308378 | | 5.161538 | | <0.001 ^a |
| Salary | | | | | 0.0945 ^b |
| Regular wage | 490 | 87.34% | 215 | 82.69% | |
| Performance-based wage | 71 | 12.66% | 45 | 17.31% | |
| Income | | | | | <0.001 ^b |
| Low wage level | 296 | 52.76% | 196 | 75.38% | |
| Medium-low wage level | 140 | 24.96% | 34 | 13.08% | |
| Medium wage level | 86 | 15.33% | 25 | 9.62% | |
| Medium-high wage level | 35 | 6.24% | 5 | 1.92% | |
| High wage level | 4 | 0.71% | 0 | 0 | |
| Cigarettes | | | | | <0.001 ^b |
| Non-smoker | 224 | 39.93% | 247 | 95% | |
| Smoker | 337 | 60.07% | 13 | 5% | |
| Alcohol | | | | | <0.001 ^b |
| Non-drinker | 202 | 36.01% | 221 | 85% | |
| Drinker | 359 | 63.99% | 39 | 15% | |
| Changes in sleep duration | | | | | 0.3536 ^b |

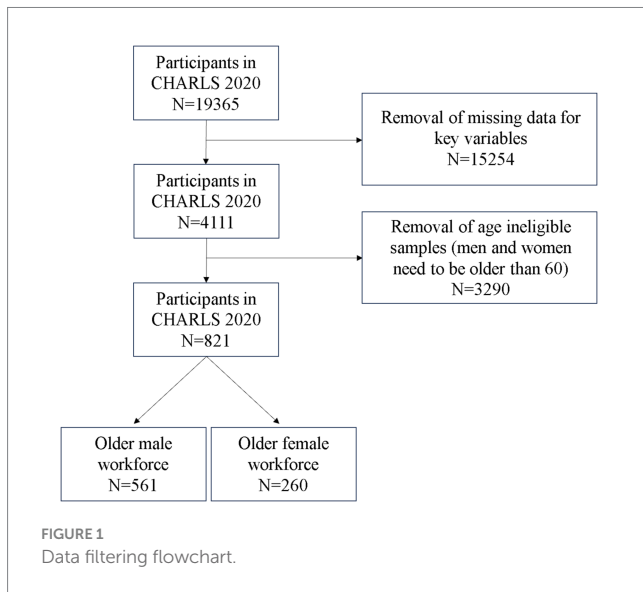
(Continued)

| Items | Male | | Female | | p-value |
|-------------------------|------|--------|--------|--------|---------------------|
| Decreased significantly | 18 | 3.21% | 11 | 4.23% | |
| Small decrease | 33 | 5.88% | 20 | 7.69% | |
| No change | 456 | 81.28% | 213 | 81.92% | |
| Small increase | 26 | 4.63% | 6 | 2.31% | |
| Significant increase | 28 | 4.99% | 10 | 3.85% | |
| Changes in food-intake | | | | | 0.3655 ^b |
| Decreased significantly | 22 | 3.92% | 9 | 3.46% | |
| Small decrease | 36 | 6.42% | 11 | 4.23% | |
| No change | 493 | 87.88% | 232 | 89.23% | |
| Small increase | 5 | 0.89% | 2 | 0.77% | |
| Significant increase | 5 | 0.89% | 6 | 2.31% | |
| Self-rated health | | | | | <0.001 ^b |
| Not at all satisfied | 10 | 1.78% | 15 | 5.79% | |
| Not very satisfied | 18 | 3.21% | 24 | 9.27% | |
| Quite satisfied | 323 | 57.58% | 123 | 47.49% | |
| Very satisfied | 188 | 33.51% | 87 | 33.59% | |
| Extremely satisfied | 22 | 3.92% | 10 | 3.86% | |

In this context, “a” represents the *t*-test, and “b” represents the chi-square test, where significance is defined as $p > 0.05$. Due to space constraints, the figures and tables presented here show the results after filtering for significant indicators. Please refer to the appendix for further details.

Analysis of the baseline statistical results

In this section, we conducted a comparative analysis of the demographics and working conditions between male and female respondents. Significant differences were observed: the average age of males was 64.44 years, while females averaged 64.70 years. Married males significantly outweighed females (91.27% vs. 76.92%). Notably, males were more likely to be self-employed or work in companies, and a higher proportion of males occupied managerial positions (14.08% vs. 3.07% for females). Income disparities were also evident, with 52.76% of males in the low-income bracket compared to 75.38% of females. Health habits revealed marked gender differences: 60.07% of males smoked, vastly exceeding the 5% of females who reported smoking. Similarly, alcohol consumption was much higher among males (63.99%) than females (15%). While self-rated health satisfaction was comparable, more females reported dissatisfaction. Males were more likely to work in government, institutions, and companies. They also had higher odds of being married, having pension and medical insurance, and earning more. Additionally, males predominated in smoking and alcohol consumption, and reported higher life and health satisfaction. No significant gender differences were noted in residential location, household registration, wage payment methods, or overall life



satisfaction. Furthermore, we also conducted a subgroup analysis, categorizing participants into two groups based on their self-perception of health (good or not), as detailed in [Supplementary material S2](#). These findings not only aid in our understanding of the role of gender in health inequality but also provide crucial insights for developing targeted health intervention measures.

Multivariate analysis of the self-rated health of the male and female respondents

Figure 2 illustrates the results of a multivariate analysis focusing on gender-specific factors influencing self-rated health. [Supplementary material S3](#) presents a detailed overview of these findings, highlighting the quantitative and qualitative aspects of gender disparities in self-rated health. The comprehensive analysis of our study reveals significant gender-specific factors influencing self-rated health, with both quantitative and qualitative aspects considered. Among males, economic indicators were paramount, particularly income level. Quantitatively, males with moderate-low (OR = 1.6730, 95% CI: 1.0852–2.5794, $p = 0.020$), moderate (OR = 2.0943, 95% CI: 1.2632–3.4723, $p = 0.004$), and moderate-high (OR = 4.2916, 95% CI: 2.0767–8.8687, $p < 0.001$) income levels exhibited significantly higher odds of better self-rated health compared to those with low income levels. Qualitatively, this suggests that economic stability plays a critical role in male self-perceived well-being. Additionally, alcohol consumption among males (OR = 1.9775, 95% CI: 1.3841–2.8251, $p < 0.001$) was positively associated with self-rated health, indicating a potential beneficial effect of moderate alcohol intake on male well-being.

For females, however, healthcare coverage and lifestyle factors emerged as significant predictors. Quantitatively, females with medical insurance coverage showed significantly better self-rated health (OR = 5.0955, 95% CI: 1.4181–10.0000, $p = 0.013$), underscoring the importance of accessible healthcare for female well-being. Furthermore, positive changes in sleep duration and food intake

among females were associated with improved self-rated health, indicating the beneficial impact of healthy lifestyle practices. Specifically, females reporting no change in sleep duration (OR not reported but positively correlated) and no change in food intake (OR = 2.2917, 95% CI: 0.8555–6.1386, $p = 0.099$ for trend) had better self-rated health compared to those experiencing significant decreases. Collectively, these findings highlight the need for gender-specific health policies and interventions that target the distinct quantitative factors influencing self-rated health among males and females, while also considering their qualitative implications for overall well-being.

Discussion

This study presents an empirical analysis of self-rated health among the older adult labor force in China, revealing significant gender differences in multiple dimensions. Univariate analysis provides rich background information for understanding these disparities, while multivariate regression analysis further elucidates the specific impacts of various factors on self-rated health for men and women. A detailed discussion of these findings follows.

Impact of demographic characteristics

There appears to be a positive correlation between age and self-rated health, although it is not statistically significant ($p = 0.1070$). This may suggest that as people age, their perception of health is influenced by various complex factors, including chronic diseases, physical functioning, and changes in social roles (26). Furthermore, marital status significantly affects self-rated health for both men and women, with married men tending to assess their health as good compared to unmarried men, while the opposite is true for unmarried women. This could be attributed to the social support, emotional solace, and coping abilities that marriage brings. Previous research (27) has also found that marriage indirectly influences health outcomes through emotions and lifestyle habits. Therefore, for the older adult labor force, a good marital relationship is crucial for health.

Social security and self-rated health

This study found that nearly all participants have access to pension and medical insurance, which to some extent safeguards their basic living and health needs. However, it is worth noting that although the coverage of medical insurance is high, its positive impact on women's self-rated health is more significant (OR = 5.0955, $p = 0.013$). This may be related to higher healthcare needs and expectations among women, and it could also reflect the greater responsibility women have in caring for family health within the context of gender role division. Research has shown (28) that older adult women in China have lower coverage under the basic medical insurance for urban employees, based on the labor market situation. Overall, women exhibit a more proactive demand for health beliefs and attention to medical insurance, preventive care, and regular check-ups compared to men (29).

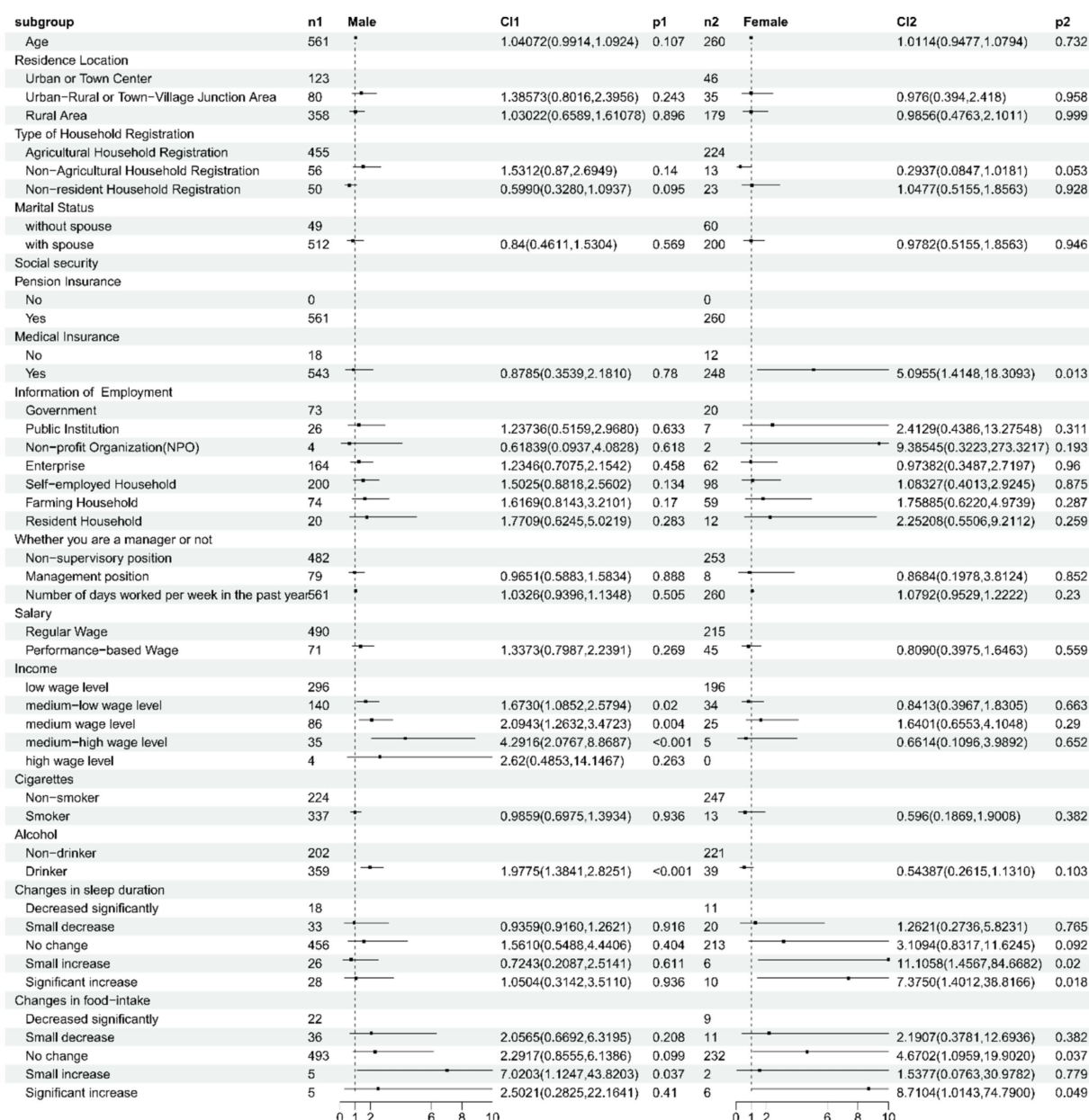


FIGURE 2

Gender-specific determinants of self-rated health among male and female older adult workers in China.

The impact of working conditions on self-rated health

Regarding working conditions, this study found that the proportion of men working in non-rural areas such as government and corporate sectors is higher than that of women, while women have a higher proportion of employment in rural and remote areas. This difference is particularly significant among men ($p = 0.045$) and may be attributed to factors such as the nature of work, work intensity, and income levels in different industries. Furthermore, the proportion of men holding managerial positions is significantly

higher than that of women ($p = 0.001$), which could be related to the manifestation of gender inequality in the occupational domain. The impact of income levels on self-rated health is particularly significant for men, as men with middle to high-income levels are more inclined to assess their health as good. This may reflect the importance of economic stability in men's perception of their own health. Research has found (30) that in relatively unequal societies, people generally perceive their health to be worse. Additionally, a study (31) has also found that income inequality significantly exacerbates subjective health disparities among older adult individuals in China, especially those with low incomes. Therefore,

targeted efforts should be made to improve the health and well-being of the older adult population.

Lifestyle habits and self-rated health

Lifestyle habits have a significant impact on the self-rated health of both men and women. Specifically, consumption of cigarettes and alcohol is more prevalent among men ($p < 0.001$), and moderate alcohol consumption is positively correlated with men's self-rated health (OR = 1.9775, $p < 0.001$). It should be noted that it may reflect the potential benefits of moderate alcohol intake or the consumption of alcoholic beverages on health (32). In contrast, women demonstrate a greater sensitivity to changes in sleep and dietary patterns. Specifically, the stability of sleep duration and dietary structure shows a significant positive correlation with women's self-rated health. This finding highlights the critical role of healthy lifestyle habits in women's health maintenance. Maintaining good sleep quality and a balanced dietary structure are of undeniable importance in promoting overall health among women. Therefore, encouraging women to pay attention to and improve their sleep and dietary habits would contribute to enhancing their quality of life and effectively preventing the occurrence of various health issues.

Gender-specific factors and self-rated health

An important finding of this study is the crucial role of gender-specific factors in self-rated health assessment. Economic factors and employment status have a more pronounced impact on men's self-rated health, while social security and lifestyle habits have a more pivotal influence on women's self-rated health. This finding emphasizes the importance of developing gender-specific health policies and interventions. For men, strengthening economic support and career development opportunities can enhance their perception of self-rated health. For women, enhancing the social security system and promoting the adoption of healthy lifestyle habits may be beneficial.

Limitations

Despite uncovering the significant role of gender-specific factors in self-rated health assessment, there are several limitations to this study. Firstly, the data used in this study are cross-sectional, which prevents establishing causal relationships. Future research can employ longitudinal designs to further explore the dynamic relationships among these factors. Secondly, this study did not consider other potential confounding factors such as genetics and psychological health status. Future research could control for these confounding factors to improve the accuracy of the results. Thirdly, the study sample primarily consists of a specific region or population, which may introduce certain regional and cultural differences. Future research can expand the sample size to enhance the generalizability of

the findings. The fourth limitation of this study is the lack of direct comparison with international data on older workforce health, which could provide valuable insights into how the findings and implications of this research in China align or diverge with experiences in other countries. Lastly, the study's reliance on single-year data limits its capacity to track longitudinal trends critical for comprehending temporal shifts in health outcomes. Additionally, the use of t-tests to evaluate gender disparities may fail to account for biases adequately. Future research should employ advanced statistical methods to establish causal relationships and mitigate omitted variable bias.

Conclusion

In conclusion, the study reveals significant gender disparities among China's older adult labor force in terms of occupation, marital status, insurance, income, health behaviors, and subjective well-being. Males are more likely to work in government, public institutions, and companies, indicating a gender imbalance in job distribution. The proportion of males with spouses is significantly higher, suggesting differences in marital status between genders. Males exhibit higher proportions of having pension insurance and medical insurance compared to females. Income disparities are observed, with higher proportions of males in low, medium, and medium-high income. Males also demonstrate higher rates of consuming cigarettes and alcohol. Moreover, males report higher levels of self-rated health compared to females. The findings highlight the need for targeted interventions to address these disparities and improve public health outcomes. For males, improving income levels and regulating and educating about consuming alcohol may enhance their self-rated health level. For females, promoting healthcare insurance coverage and encouraging healthy sleep duration and dietary habits may contribute to improving their self-rated health status.

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

WL: Conceptualization, Writing – original draft, Writing – review & editing. ZX: Writing – original draft, Writing – review & editing. WT: Conceptualization, Writing – review & editing.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1450045/full#supplementary-material>

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Study on the impact of learning engagement on the subjective wellbeing of empty nesters in rural China

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With the rapid development of China's socio-economic landscape and shifts in population structure, rural empty nesters have increasingly become a focal point of social concern. Compared to their urban counterparts, rural empty nesters face more life challenges and psychological stress, making their subjective wellbeing a significant issue. This study explores the impact of learning engagement on the subjective wellbeing of rural empty nesters in China, aiming to provide theoretical support and policy recommendations to enhance their wellbeing. Using a random sampling method, the study focused on elderly learners aged 50 and above from counties within Z Province, N City, where elderly learning is relatively concentrated. Data were processed using SPSS 27.0 software. The findings indicate that there is a significant difference in subjective wellbeing between rural empty nesters and rural non-empty nesters, with rural empty nesters exhibiting lower subjective wellbeing and more passive involvement in learning activities. Learning engagement has a significant effect on improving the subjective wellbeing of rural empty nesters, with a notable positive correlation between learning engagement dimensions and subjective wellbeing. Compared to rural non-empty nesters, learning engagement has a more pronounced positive effect on the subjective wellbeing of rural empty nesters.

KEYWORDS

learning engagement, rural empty nesters in China, subjective wellbeing, elderly education, social support

1 Introduction

The proportion of empty nesters among China's elderly population has now exceeded half, and in most urban and rural areas, this ratio surpasses 70%. A significant number of elderly individuals do not live with their children or other family members, facing numerous challenges related to aging at home ([Interface News, 2022](#)). The living conditions of rural empty nesters impact social harmony and stability; thus, helping them spend their later years peacefully and enhancing their wellbeing is essential for building a harmonious society. Subjective wellbeing refers to an individual's overall assessment of their quality of life based on internal standards, encompassing satisfaction with life and its various aspects, leading to a psychological state characterized by predominant positive emotions ([Diener et al., 1999](#)). It is also a key indicator of whether a country or region is experiencing positive aging ([Tovel and Carmel, 2014](#)). With the acceleration of urbanization and the migration of rural labor to cities, the proportion of left-behind elderly is gradually increasing ([Wei, 2024](#)).

Rural empty nesters often face issues such as inadequate social support systems and need to improve their quality of life and wellbeing through alternative means. Learning participation, as an active form of elderly engagement, can offer rural empty nesters new lifestyles and opportunities for social interaction. This study investigates the relationship between learning participation and the subjective wellbeing of rural empty nesters in China, as well as the differences in the impact of various types of learning participation on their wellbeing, aiming to provide theoretical support and policy recommendations for enhancing the subjective wellbeing of rural empty nesters.

2 Literature review

2.1 Research on rural empty nesters

The concept of “empty nest” was first introduced by Sorokin, Zimmerman, and Galipin in 1931, defining “empty nesters” as elderly individuals living either with their spouse or alone. In 1946, Duvall expanded this concept within the context of his well-known family life cycle model, which includes eight stages: the childless couple stage, the expanded family stage, the preschool family stage, the school-age family stage, the family with adolescent children stage, the middle-aged parents stage, and the elderly family stage (Duvall, 1988). Relevant scholars have defined the concept of empty nesters from various perspectives, such as the duration of separation from children (Lv and Feng, 2018) and whether children live with the elderly (Zong et al., 2018). Logan et al. (1998), from the perspective of living arrangements, defined “empty nesters” as elderly individuals living alone or with their spouse. In 1986, Reuben Hill further elaborated on the concept of “empty nesters” from the perspective of “empty nest families,” suggesting that “empty nest families” refer to the post-parental empty nest stage (Abdullah and Wolbring, 2013). Although scholars both domestically and internationally have different views on the definition of “empty nesters,” they share a common understanding: regardless of the stage, “empty nesters” refer to a state where the children are no longer living with the elderly, and the household consists only of the couple. In this study, “empty nesters” refers to elderly individuals aged 50 and above who have no children or whose children are not living with them, residing alone or with a spouse in rural areas. This specifically includes three types: living alone, living with a partner, and residing in a nursing home.

Rural empty nesters have attracted increasing research attention due to their unique social structure and living conditions, with studies focusing on their physical and mental health, quality of life, social support, and retirement models (Gao et al., 2022). Regarding the causes of empty nesting among the elderly, with economic development and frequent rural-to-urban migration, young family members leaving for work has led to changes in household decision-making power. This shift has gradually reduced the status and support of the elderly within the family, thereby contributing to the formation of empty nest elderly in rural areas (Giles and Mu, 2007). Survey results from van de Walle (2019) show that the quality of life of the elderly is significantly correlated with the financial support provided by their children. In other words, when children provide more financial assistance,

the quality of life of the elderly improves. However, a consequence of becoming an empty nester is the emergence of psychological health issues (Tomaka et al., 2006). Research has found that these empty nesters often face challenges such as health issues, psychological stress, and financial difficulties (Chen and Shen, 2020). In terms of physical health, the migration of rural children to cities significantly deteriorates the self-rated health of empty nesters and increases the likelihood of chronic diseases (Liu, 2022). Regarding mental health, a considerable number of rural elderly, especially empty nesters, are in a state of psychological deprivation, lacking companionship, and experiencing low self-efficacy, life satisfaction, and happiness (Wang and Wang, 2021). Sun et al. (2011) suggest that the long-term absence of children deepens empty nesters’ attachment to their children, which can adversely affect their mental state. Furthermore, the primary reason for the loneliness experienced by rural empty nesters is the lack of social support (Zhang, 2023; Dykstra, 2009). Kang and Luo (2022) found through visits to a typical “empty nest” rural area in central Sichuan that these elderly individuals are often in a disadvantaged position regarding social support, facing issues such as lack of care, emotional loneliness, and spiritual desolation. Consequently, some rural empty nesters are compelled to shift their retirement model from the traditional family care model to a primarily self-care model with supplementary family care (Guo and Liu, 2023), opting for community mutual aid retirement models. In summary, under the new demographic structure, with shrinking family sizes and social class differentiation, the disadvantaged position of rural empty nesters continues to strengthen.

Based on this, this study proposes Hypothesis 1: Compared to rural non-empty nesters, rural empty nesters have lower physical and mental health and wellbeing.

2.2 Research on the factors affecting the subjective wellbeing of rural empty nesters

The factors influencing the subjective wellbeing of rural empty nesters can be categorized into personal factors, family factors, and social factors. Firstly, personal factors include physical health, age, gender, economic income, and education level. Tobiasz-Adamczyk and Zawisza (2017) used a simplified version of the national happiness index (DRM) to study subjective wellbeing among rural empty nesters in Poland, finding that an increase in chronic diseases was associated with a decrease in subjective wellbeing. Wang et al. (2017) found that elderly individuals with good physical health scored significantly higher in positive emotions, overall happiness, and life satisfaction compared to those with chronic diseases, who scored higher in negative experiences. Additionally, rural empty nesters with religious beliefs reported lower levels of subjective wellbeing (Feng and Luo, 2015).

Secondly, from a family perspective, factors such as having a spouse and intergenerational support are crucial for subjective wellbeing. Family plays a vital role in providing emotional comfort to empty nesters (Stillwell and Warnes, 1995; Cloutier-Fisher et al., 2011). Barron et al. (1994) found that elderly individuals living alone generally feel more lonely due to the lack of warm family relationships. A complete family plays a significant role

in maintaining elderly individuals' mental health, while widowed elderly often experience severe negative emotions. Okun et al. (1990) noted that widowhood results in the loss of primary family care sources, exacerbating their economic, mental, and psychological conditions. Guo (2023), using the Logit model to analyze the factors affecting subjective wellbeing among 1,991 rural empty nesters, found that intergenerational support significantly affects the subjective wellbeing of those living alone. Moreover, excessive distance between children and parents negatively impacts the elderly's mental health (Benjamin et al., 2000).

Finally, social factors include living environment, interpersonal relationships, and social support. Long et al. (2022) found a positive correlation between subjective wellbeing and social support based on a survey of 494 rural empty nesters in Jiangxi Province, China. Xing et al. (2010) found a correlation between interpersonal relationships and elderly subjective wellbeing, noting that friendlier neighborhood relations are associated with higher life satisfaction (Li and Zhang, 2012). Research indicates that increasing peer interactions among empty nesters and enhancing social support from peers can alleviate feelings of loneliness (Andrews, 2020) and may even benefit disease recovery (Powell, 2012).

2.3 Study on the relationship between subjective wellbeing and learning participation among rural empty nesters

Research on the impact of learning participation on the wellbeing of rural empty nesters is limited both domestically and internationally, primarily consisting of descriptive studies showing its effects and a few empirical studies on specific activities (such as reading and sports). Firstly, Tong (2017) noted that attending elderly universities and taking courses based on actual needs can not only address the low cultural level of rural empty nesters but also fulfill many elderly individuals' "dreams of schooling." Research shows that guiding public platforms, people's groups, and social institutions to help rural empty nesters with learning plans and providing platforms for social activities can help them break out of isolation and alleviate feelings of loneliness, making their later years more meaningful (Zhang, 2023). Liu et al. (2024) studied the role of elderly community groups in enhancing the wellbeing of rural empty-nest elderly individuals. They pointed out that elderly education classes not only assist older adults in applying knowledge to improve their lives but also effectively increase their sense of happiness. In the study of the correlation between learning participation and subjective wellbeing, Fan (2009) further pointed out that the six internal elements of participating in learning activities—namely, the enjoyment of learning, achievement motivation, challenge and difficulty, level of engagement, self-actualization, and learning atmosphere—are significantly positively correlated with the overall score of subjective wellbeing. From an empirical research perspective, Bai (2017) explored the mediating role of aging attitudes. The study found that there are significant correlations among the three variables of participation in learning activities, aging attitudes, and subjective wellbeing. Additionally, social loss and psychological gains have a significant mediating effect between participation

in learning activities and subjective wellbeing. Dench and Regan (2000) showed that among 336 surveyed elderly learners, 80% experienced significant improvements in self-perception and life enjoyment and satisfaction. Du et al. (2016) investigated the impact of reading therapy on the subjective wellbeing of elderly individuals aged 75–80 residing in nursing homes in Tianjin. They conducted observations and recorded the scales used to assess the psychological and cognitive abilities of the elderly before and after the intervention. The results of the experiment indicated that reading therapy can enhance the subjective wellbeing of the elderly. Additionally, Yang and Xu (2024) found that participation in learning and other recreational activities can enhance elderly individuals' subjective wellbeing. However, excessively frequent participation in a single type of recreational activity may not improve subjective wellbeing as effectively as less frequent participation. For instance, rural elderly who engage in learning activities occasionally or regularly tend to have higher wellbeing compared to those who participate in such activities very frequently. Regarding specific learning activities, Kawakami et al. (2017) discovered that Japanese empty nesters experience improved positive emotions and subjective wellbeing when watching live sports events. Pan et al. (2018) suggested that indirect sports participation, such as watching matches, positively affects subjective wellbeing and is directly proportional. Escuder-Mollón et al. (2014) argued that engaging in learning activities can enhance the quality of life and increase happiness among the elderly. Su et al. (2022) found that the depression levels of empty-nest elderly individuals are higher than those of non-empty-nest elderly individuals. However, social participation can significantly reduce the depression of empty-nest elderly individuals, thereby enhancing their sense of wellbeing. For rural empty nesters, participating in learning activities helps reduce loneliness through social interaction, promotes physical and mental health, delays cognitive decline, boosts confidence and self-esteem through continuous learning opportunities, and ultimately enhances subjective wellbeing.

Boshier and Collins (1985) developed the Educational Participation Scale (EPS), which is widely used in adult learning surveys globally. The scale aims to systematically assess adult learners' motivation to learn, specifically including multiple aspects such as goal orientation, learning orientation, and activity orientation. It provides an important tool for researching adult learning, especially in evaluating the multidimensional characteristics of learning motivation, which has high scientific value. In addition, Fredricks et al. (2004) proposed a learning participation model based on three dimensions: behavior, cognition, and emotion. They argue that learning participation is not only reflected in the behavioral dimension, but also involves deep cognitive and emotional engagement, emphasizing the multidimensional interaction during the learning process. This model has provided a theoretical framework for subsequent research on learning participation and has influenced many scholars' research directions. Based on this theory, many researchers have designed self-developed questionnaires to measure different dimensions of learning participation. For example, Liu and Guo (2008), in her study, referred to Fredricks' model of learning participation and, combined with the actual situation of Chinese middle school students, created

a questionnaire to assess students' learning behaviors, cognitive engagement, and emotional participation. Her study provided a new perspective on measuring student learning participation, especially through an in-depth exploration of the mediating role of school climate and wellbeing. In empirical research, Fan (2009) explored the relationship between internal factors of learning participation and the subjective wellbeing of older adults, finding significant positive correlations between factors such as learning enjoyment, learning environment, learning investment, the level of challenge, achievement motivation experiences, and self-actualization. These findings further reveal the positive impact of learning participation on the wellbeing of adults, especially older individuals. Furthermore, Bru et al. (2019) developed the EVS D scale from the perspective of learning motivation. The scale includes four subscales: behavioral participation, behavioral dissatisfaction, emotional participation, and emotional dissatisfaction, aimed at measuring both behavioral and emotional participation in learning. This scale extends the measurement framework of learning participation, particularly in its dual dimensions of emotion and behavior, providing new methods for studying learners' emotional engagement. Based on the research findings of these previous studies, Li (2020) and Zhang (2022) further explored learning participation in older adults, proposing that learning participation can be categorized into three core dimensions: learning environment, learning experience, and learning investment. Their research, which integrates the multidimensional measurement framework of learning participation, expands the understanding of learning participation in different groups. This study will continue to use the classification proposed by Li and Zhang, taking learning environment, learning experience, and learning investment as the core dimensions of learning participation, in order to provide theoretical and empirical support for further exploring the relationship between learning participation and older adults' subjective wellbeing.

Based on this, the paper proposes Research Hypotheses 2 and 3:

Hypothesis 2: Learning participation can enhance the subjective wellbeing of rural empty nesters in China.

Hypothesis 3: The positive impact of learning participation on the subjective wellbeing of rural empty nesters in China is greater than that on non-empty nesters in rural areas.

3 Research design

3.1 Sample selection

To further reveal the mechanism through which learning participation affects the subjective wellbeing of rural empty-nester elderly, this study employed a random sampling method. The research focused on elderly individuals aged 50 and above who participate in senior learning programs in the districts and counties under Z Province, N City, where elderly learners are relatively concentrated. An electronic questionnaire was prepared, and prior to the survey, participants were informed about the purpose of the study and their consent was obtained before distribution. The electronic questionnaires were randomly distributed through educational institutions such

as senior universities, community colleges, and adult schools. A total of 1,350 questionnaires were collected, of which 1,234 were valid, resulting in a high valid response rate of 94.9%. The final sample composition was as follows: 792 responses from rural empty-nester elderly (64.20%) and 442 responses from rural non-empty-nester elderly (35.80%) (see Table 1).

3.2 Variable definitions and coding

Based on a comprehensive consideration of elderly learners' learning behaviors and engagement, the independent variable in this study is learning participation, which includes three dimensions: learning atmosphere, and learning experience, learning investment.

Learning Atmosphere includes elderly learners' perceptions and experiences regarding the teaching ability of senior university instructors, the teacher-student relationship, and the relationships among learners.

Learning Experience includes learning interest, learning initiative, learning concentration, and the importance of learning. These aspects are coded from "1—Strongly Disagree" to "6—Strongly Agree."

Learning Investment consists of time investment, number of courses, and monetary investment. Time investment is coded as 1–4, representing >1, 1–5, 6–10, and over 10 years, respectively. Monetary investment is coded as 1–5, representing 0, 1–50, 50–100, 100–200, and over 200 yuan, respectively. Number of courses is coded as 1–4, representing 1 course, 2 courses, 3 courses, and 4 or more courses, respectively.

After standardizing the above data, the reliability of the independent variable questionnaire was tested, with a Cronbach's α of 0.854, indicating good overall reliability with statistical significance. The results of the confirmatory factor analysis show a good model fit: $\chi^2/df = 1.762$, CFI = 0.99, TLI = 0.986, GFI = 0.972, and RMSEA = 0.041, indicating that the structural validity of the scale is satisfactory.

The dependent variable in this study is the subjective wellbeing of the elderly. The scale design was based on the "Subjective Wellbeing Scale for Urban Residents (Brief Version)" from China. While maintaining the original structure, dimensions, and scoring methods of the questionnaire, adjustments were made to some items based on field surveys. The elderly's subjective wellbeing was categorized into three dimensions: physical and mental health experience, adaptation and satisfaction experience, and self-development experience.

Physical and Mental Health Experience includes indicators such as psychological health experience, physical health experience, and emotional balance experience.

Self-Development Experience includes indicators such as goal value experience, growth and progress experience, and self-acceptance experience.

Adaptation and Satisfaction Experience primarily includes indicators such as interpersonal adaptation experience, family atmosphere experience, contentment and abundance experience, and social confidence experience.

TABLE 1 Demographic variables statistics.

| Variable | Empty-nester (<i>n</i> = 792) | Non-empty-nester (<i>n</i> = 442) | Total (<i>n</i> = 1,234) |
|------------------------------------|-----------------------------------|---------------------------------------|------------------------------|
| Total individuals | 792 (64.2%) | 442 (35.8%) | 1,234 |
| Age | | | |
| 50–59 | 259 (21.0%) | 225 (18.2%) | 484 (39.2%) |
| 60–69 | 378 (30.6%) | 178 (30.6%) | 556 (45.1%) |
| 70–79 | 146 (11.8%) | 39 (3.2%) | 185 (15.0%) |
| Over 80 | 9 (0.7%) | 0 (0.0%) | 9 (0.7%) |
| Gender | | | |
| Male | 117 (9.5%) | 52 (4.2%) | 169 (13.7%) |
| Female | 675 (54.7%) | 390 (31.6%) | 1,065 (86.3%) |
| Marital status | | | |
| With spouse | 718 (58.2%) | 395 (32.0%) | 1,113 (90.2%) |
| Without spouse | 74 (6.0%) | 47 (3.8%) | 121 (9.8%) |
| Monthly income | | | |
| Below 1,000 | 27 (2.2%) | 13 (1.1%) | 40 (3.2%) |
| 1,000–2,000 | 100 (8.1%) | 65 (5.3%) | 165 (13.4%) |
| 2,000–4,000 | 336 (27.2%) | 199 (16.1%) | 535 (43.4%) |
| Above 4,000 | 329 (26.7%) | 165 (13.4%) | 494 (40.0%) |
| Education level | | | |
| Elementary or below | 33 (2.7%) | 19 (2.7%) | 52 (4.2%) |
| Junior high | 284 (23.0%) | 131 (10.6%) | 415 (33.6%) |
| Senior high (including vocational) | 310 (25.1%) | 194 (15.7%) | 504 (40.8%) |
| Associate degree | 111 (9.0%) | 69 (5.6%) | 180 (14.6%) |
| Bachelor's or higher | 54 (4.4%) | 29 (2.4%) | 83 (6.7%) |
| Living situation | | | |
| Living alone | 90 (7.3%) | 0 (0.0%) | 90 (7.3%) |
| Living with spouse only | 702 (52.6%) | 0 (0.0%) | 702 (52.6%) |
| Living with children | 0 (0.0%) | 110 (8.9%) | 110 (8.9%) |
| Living with spouse and children | 0 (0.0%) | 331 (26.8%) | 331 (26.8%) |
| Living in care facility | 0 (0.0%) | 1 (0.1%) | 1 (0.1%) |

The scale consists of 10 measurement items, scored on a 6-point scale from “1—Strongly Disagree” to “6—Strongly Agree.” Higher scores indicate greater subjective wellbeing of the respondents.

After standardization, the reliability and validity testing results of the dependent variable questionnaire showed a Cronbach’s α of 0.882, indicating good overall reliability. The confirmatory factor analysis results demonstrated a good model fit: $\chi^2/df = 1.157$, CFI = 0.984, TLI = 0.997, GFI = 0.997, and RMSEA = 0.019, indicating that the structural validity of the scale is satisfactory.

The demographic variables in this study are divided into two parts: individual characteristics and family characteristics. Individual characteristics include variables such as age, gender, education level, and monthly income. Family characteristics include variables such as marital status and living conditions (specific values and coding details are provided in Table 2).

Finally, the overall homogeneity reliability of the questionnaire is $\alpha = 0.91$, with coefficients for each dimension and the total scale ranging from 0.80 to 0.93. The composite reliability for all variables is >0.7 , the Average Variance Extracted (AVE) is >0.5 , and the square root of the AVE is greater than the correlation coefficients between dimensions. This indicates that the reliability and validity of the overall scale meet the research requirements.

3.3 Research approach

This study uses SPSS 27.0 as the research tool. First, descriptive statistical analysis and difference tests are conducted to analyze the differences in subjective wellbeing and dimensions of learning participation among rural empty-nest elderly based on demographic variables. Next, an independent samples *T*-test is used to determine if there are significant differences in subjective wellbeing and learning participation dimensions between rural empty-nest elderly and rural non-empty-nest elderly. Subsequently, correlation analysis is employed to identify the relationship between learning participation and subjective wellbeing among rural empty-nest elderly. Finally, based on the correlation analysis, hierarchical regression is used to examine the mechanisms through which learning participation impacts the subjective wellbeing of rural empty-nest elderly and to identify specific differences in the impact of learning participation on the subjective wellbeing of both rural empty-nest and non-empty-nest elderly groups.

3.4 Analysis results

3.4.1 Descriptive statistical analysis and difference testing

Research data indicate (see Table 3) that there are significant differences in subjective wellbeing across different genders, age groups, and education levels. Specifically, female elderly individuals have higher levels of happiness than males. Among age groups, those aged 80 and above report the lowest subjective wellbeing. No significant differences in subjective wellbeing are found across different monthly income levels, suggesting that income does not affect elderly individuals’ subjective wellbeing. Additionally, subjective wellbeing does not differ significantly among elderly individuals with different marital statuses.

TABLE 2 Variable coding and explanation.

| Variable | | Value | Explanation |
|----------------------|--|-------|--|
| Age | | 1–4 | 1: 50–59 years old; 2: 60–69 years old; 3: 70–79 years old; 4: 80 years and above |
| Gender | | 1–2 | 1: male; 2: female |
| Marital status | | 1–2 | 1: with spouse; 2: without spouse |
| Living situation | | 1–5 | 1: living alone; 2: living only with spouse; 3: living with children; 4: living with spouse and children; 5: living in a care facility |
| Monthly income | | 1–4 | 1: below 1,000 RMB; 2: 1,000–2,000 RMB; 3: 2,000–4,000 RMB; 4: Above 4,000 yuan RMB |
| Education level | | 1–5 | 1: primary school and below; 2: junior high school; 3: high school (including technical secondary school, vocational high school); 4: associate degree; 5: bachelor's degree and above |
| Subjective wellbeing | Physical and mental health experience | 1–6 | From 1 “strongly disagree” to 6 “strongly agree”, with higher scores indicating greater subjective wellbeing. |
| | Adaptation and satisfaction experience | | |
| | Self-development experience | | |
| Learning engagement | Learning atmosphere | 1–6 | From 1 “strongly disagree” to 6 “strongly agree”, with higher scores indicating higher levels of learning Engagement among the elderly. |
| | Learning experience | | |
| | Learning investment | | |

In terms of elderly learning participation, there are significant differences in learning atmosphere, learning experience, and learning engagement across different education levels and age groups. However, no significant differences are found in learning engagement between different genders. Elderly individuals with varying monthly incomes show significant differences only in learning engagement, while no significant differences are observed in learning atmosphere, learning experience, or learning engagement among those with different marital statuses.

3.4.2 Independent sample t-test analysis of learning participation and subjective wellbeing in rural empty-nest and non-empty-nest elderly groups

To further clarify the differences between rural empty-nest and non-empty-nest elderly groups in terms of learning participation and subjective wellbeing, an independent samples *t*-test was conducted on the sample data using SPSS (as shown in Table 4). The study data indicate that, on average, the rural empty-nest elderly group scores lower than the rural non-empty-nest elderly group in the dimensions of learning atmosphere, learning experience, and learning investment. Additionally, there are significant differences between the two groups in all three dimensions of subjective wellbeing, with the rural empty-nest elderly group showing lower levels in each aspect compared to the rural non-empty-nest elderly group. Overall, there is a significant difference in subjective wellbeing between the rural empty-nest and non-empty-nest elderly groups, with the former exhibiting lower wellbeing and more passive engagement in learning activities. Hypothesis 1 is thus validated.

3.5 Correlation analysis of learning participation and subjective wellbeing among rural empty-nest elderly

To investigate the correlation between learning participation and subjective wellbeing among rural empty-nest elderly, Pearson correlation analysis was conducted using SPSS (see Table 5). The results indicate that all dimensions of learning participation among the rural empty-nest elderly are positively correlated with physical and mental health experience, self-development experience, adaptation and satisfaction experience, and overall subjective wellbeing, with the correlations being significant ($p < 0.01$). Specifically, learning engagement shows a low correlation with the subjective wellbeing of the rural empty-nest elderly, learning atmosphere shows a moderate correlation, and learning experience shows a high correlation. This suggests that participating in learning activities can significantly enhance the subjective wellbeing of rural empty-nest elderly.

3.6 Hierarchical regression analysis of the impact of learning participation on subjective wellbeing among rural empty-nest and non-empty-nest elderly

3.6.1 Multicollinearity test

To explore the impact of learning atmosphere, learning experience, and learning engagement on subjective wellbeing among rural empty-nest and non-empty-nest elderly groups,

TABLE 3 Descriptive statistics and difference testing results for variables.

| | Category | Subjective wellbeing | Learning atmosphere | Learning experience | Learning engagement |
|-----------------|---|----------------------|---------------------|---------------------|---------------------|
| Marital status | With spouse | 5.44 ± 0.83 | 5.45 ± 0.79 | 5.43 ± 0.82 | 3.89 ± 0.64 |
| | Without spouse | 5.46 ± 0.86 | 5.50 ± 0.83 | 5.50 ± 0.87 | 3.95 ± 0.76 |
| | <i>t</i> | −0.24 | −0.65 | −0.89 | −0.79 |
| Gender | Male | 5.16 ± 0.98 | 5.23 ± 0.87 | 5.23 ± 0.97 | 3.89 ± 0.68 |
| | Female | 5.48 ± 0.80 | 5.49 ± 0.77 | 5.47 ± 0.79 | 3.90 ± 0.64 |
| | <i>F</i> | 22.08*** | 15.13*** | 13.12*** | 0.01 |
| Age | 50–59 years | 5.45 ± 0.79 | 5.48 ± 0.72 | 5.44 ± 0.78 | 5.48 ± 0.72 |
| | 60–69 years | 5.44 ± 0.86 | 5.45 ± 0.81 | 5.46 ± 0.83 | 5.45 ± 0.81 |
| | 70–79 years | 5.45 ± 0.85 | 5.41 ± 0.84 | 5.44 ± 0.86 | 5.41 ± 0.84 |
| | 80 years and above | 4.46 ± 1.19 | 4.33 ± 1.55 | 4.27 ± 1.36 | 4.33 ± 1.55 |
| | <i>F</i> | 4.19** | 6.50*** | 6.28*** | 11.97*** |
| Monthly income | Below 1,000 RMB | 5.31 ± 0.95 | 5.30 ± 1.14 | 5.22 ± 1.09 | 3.50 ± 0.73 |
| | 1,000–2,000 RMB | 5.52 ± 0.82 | 5.48 ± 0.86 | 5.51 ± 0.84 | 3.67 ± 0.70 |
| | 2,000–4,000 RMB | 5.45 ± 0.83 | 5.48 ± 0.75 | 5.48 ± 0.80 | 3.85 ± 0.62 |
| | Above 4,000 RMB | 5.41 ± 0.83 | 5.42 ± 0.77 | 5.40 ± 0.82 | 4.05 ± 0.61 |
| | <i>F</i> | 1.14 | 1.02 | 2.13* | 23.66*** |
| Education level | Elementary school or below | 5.39 ± 1.05 | 5.33 ± 1.07 | 5.25 ± 1.18 | 3.51 ± 0.78 |
| | Junior high school or below | 5.53 ± 0.79 | 5.51 ± 0.79 | 5.52 ± 0.78 | 3.85 ± 0.68 |
| | High school (including secondary technical, vocational) | 5.50 ± 0.73 | 5.52 ± 0.70 | 5.51 ± 0.71 | 3.94 ± 0.62 |
| | Associate degree | 5.22 ± 0.96 | 5.25 ± 0.89 | 5.20 ± 0.93 | 3.98 ± 0.61 |
| | Bachelor's or higher | 5.12 ± 1.08 | 5.29 ± 0.89 | 5.22 ± 1.01 | 3.92 ± 0.53 |
| | <i>F</i> | 8.10*** | 5.59*** | 7.95*** | 6.46*** |

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

TABLE 4 Independent sample *T*-test.

| Variable | | Empty-nest | | Non-empty-nest | | <i>T</i> -value | Sig. |
|----------------------|--|------------|--------------------|----------------|--------------------|-----------------|------|
| | | Mean | Standard deviation | Mean | Standard deviation | | |
| Learning engagement | Learning atmosphere | 5.44 | 0.84 | 5.48 | 0.70 | 0.964 | 0.34 |
| | Learning experience | 5.42 | 0.86 | 5.45 | 0.76 | 1.198 | 0.23 |
| | Learning investment | 3.90 | 0.66 | 3.90 | 0.63 | −0.036 | 0.97 |
| Subjective wellbeing | Physical and mental health experience | 5.34 | 0.96 | 5.47 | 0.80 | 2.601 | 0.01 |
| | Self-development experience | 5.38 | 0.93 | 5.50 | 0.78 | 2.493 | 0.01 |
| | Adaptation and satisfaction experience | 5.47 | 0.85 | 5.57 | 0.70 | 2.200 | 0.03 |

hierarchical regression analysis is used. Before conducting the regression analysis, it is necessary to check for multicollinearity. Multicollinearity refers to the high correlation between variables that can affect the analysis results. The condition for multicollinearity is a Variance Inflation Factor (VIF) >10.00 and an average VIF >1.00. After standardizing the hierarchical independent variables, the average VIF was 1.03, slightly above 1.00, but all variable VIFs were below 5.00, indicating no severe multicollinearity issues and allowing for hierarchical regression analysis.

TABLE 5 Correlation analysis of learning participation and dimensions of subjective wellbeing among rural empty-nest elderly (n = 742).

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|----------|---------|---------|---------|---------|---------|---|
| 1. Learning experience | 1 | | | | | | |
| 2. Learning atmosphere | 0.867*** | 1 | | | | | |
| 3. Learning investment | 0.126** | 0.143** | 1 | | | | |
| 4. Physical and mental health experience | 0.746** | 0.807** | 0.152** | 1 | | | |
| 5. Self-development experience | 0.779** | 0.856** | 0.175** | 0.921** | 1 | | |
| 6. Adaptation and satisfaction experience | 0.803** | 0.866** | 0.163** | 0.890** | 0.930** | 1 | |
| 7. Subjective well-being | 0.798** | 0.867** | 0.168** | 0.967** | 0.979** | 0.966** | 1 |

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

3.6.2 Hierarchical regression model construction

Based on the descriptive statistics and correlation analysis mentioned above, hierarchical regression is conducted separately for the entire rural elderly population, the rural empty-nest elderly population, and the rural non-empty-nest elderly population. Model 1 includes only learning variables (learning atmosphere, learning experience, learning engagement). The regression results show that both the learning atmosphere and learning experience have a significant impact on the subjective wellbeing of elderly empty nesters in rural areas. Therefore, Hypothesis 2 is validated. Model 2 adds individual demographic factors (age, gender, education level, monthly income). Model 3 further incorporates family-related demographic factors (marital status) to provide a more comprehensive reflection of the impact and variation of learning participation on subjective wellbeing among rural empty-nest and non-empty-nest elderly groups. Let (Y) be the dependent variable (subjective wellbeing), and (X1, X2...Xk) be the independent variables (elderly learning participation and its factors). The multiple linear regression model is specified as: $(Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 \dots + \beta_iX_i + \epsilon)$ (see Table 6).

The regression analysis of the total elderly sample reveals that the standardized multiple linear regression equations for the entire sample, the empty-nest sample, and the non-empty-nest sample are as follows:

$$\begin{aligned} Y \text{ (Full sample)} &= 0.208 \times \text{Learning Atmosphere} + 0.692 \times \text{Learning Experience} + 0.023 \times \text{Learning Investment} \\ Y \text{ (Empty nest group sample)} &= 0.195 \times \text{Learning Atmosphere} + 0.723 \times \text{Learning Experience} + 0.060 \times \text{Learning Investment} \\ Y \text{ (Non-empty nest group sample)} &= 0.208 \times \text{Learning Atmosphere} + 0.644 \times \text{Learning Experience} - 0.050 \times \text{Learning Investment} \end{aligned}$$

The results of Model 1 show that both learning atmosphere and learning experience have a significant positive impact on the subjective wellbeing of the overall elderly population ($F = 1238.128, P < 0.001$), with an (R^2) of 0.735, indicating that 73.5% of the variance in subjective wellbeing can be explained. According to the regression results for the rural empty-nest elderly sample and the rural non-empty-nest elderly sample, the positive impact of learning experience and learning engagement on the subjective wellbeing of the empty-nest elderly is greater than that for non-empty-nest elderly learners. Conversely, only the learning atmosphere

factor has a more significant positive effect on the subjective wellbeing of the non-empty-nest elderly compared to the empty-nest elderly. In summary, learning participation has a more positive effect on the subjective wellbeing of rural empty-nest elderly individuals compared to rural non-empty-nest elderly individuals.

To further test the hypothesis, individual characteristics and family-related variables were sequentially added in Models 2 and 3. Learning engagement's impact on the overall elderly population's subjective wellbeing increased, while the effects of learning atmosphere and learning experience decreased, though they remained significantly positive. For the rural empty-nest elderly sample, the inclusion of individual factors such as age, gender, monthly income, and education level significantly enhanced the impact of learning engagement on subjective wellbeing, but reduced the impact of learning atmosphere and experience. With the addition of family factors, the effect of learning atmosphere improved, while the effects of learning experience and engagement declined. For the rural non-empty-nest elderly sample, after adding individual factors, the impact of all learning dimensions on subjective wellbeing decreased, with learning engagement having a negative effect. However, after incorporating family factors, the effects of learning atmosphere, learning experience, and learning engagement on subjective wellbeing increased. Despite the changes in the impact of learning participation on subjective wellbeing with the inclusion of individual and family factors, the positive effects of learning experience and learning atmosphere on the subjective wellbeing of rural empty-nest elderly remain higher than those for rural non-empty-nest elderly.

The results indicate that, both before and after accounting for individual and family factors, the positive effects of learning atmosphere and learning experience on the subjective wellbeing of rural empty-nest and rural non-empty-nest elderly populations are significant, with a high explanatory power for subjective wellbeing. Learning experience and learning engagement have higher coefficients for subjective wellbeing in vulnerable elderly groups compared to non-vulnerable elderly learners. Furthermore, learning engagement negatively impacts the subjective wellbeing of rural non-empty-nest elderly individuals. Overall, the analysis of Models 1, 1a, 1b; 2, 2a, 2b; and 3, 3a, 3b shows that the positive impact of learning participation on the subjective wellbeing of rural empty-nest elderly is more pronounced. Thus, Hypothesis 3 is supported.

TABLE 6 Regression results of the impact of learning participation on the subjective wellbeing of rural elderly ($n = 1,234$).

| Variables | All samples | | | Empty-nest elderly sample | | | Non-empty-nest elderly sample | | |
|---------------------|----------------------------|--------------------------|--------------------------|---------------------------|--------------------------|--------------------------|-------------------------------|-----------------------|--------------------------|
| | Model 1 | Model 1a | Model 1b | Model 2 | Model 2a | Model 2b | Model 3 | Model 3a | Model 3b |
| Learning atmosphere | 0.208*** (7.243) | 0.205*** (7.135) | 0.205*** (7.147) | 0.195*** (5.295) | 0.192*** (5.252) | 0.193*** (5.275) | 0.208*** (4.501) | 0.203*** (4.348) | 0.203*** (4.342) |
| Learning experience | 0.692*** (24.975) | 0.686*** (24.819) | 0.686*** (24.837) | 0.723*** (20.024) | 0.717*** (19.986) | 0.716*** (19.973) | 0.644*** (15.183) | 0.644*** (14.872) | 0.644*** (14.877) |
| Learning investment | 0.023 (1.182) | 0.029 (1.473) | 0.029 (1.484) | 0.060* (2.565) | 0.066** (2.674) | 0.065** (2.615) | −0.050 (−1.570) | −0.040 (−1.214) | −0.038 (−1.124) |
| Age | | −0.005 (−0.247) | 0.002 (0.095) | | 0.017 (0.777) | 0.023 (1.019) | | −0.017 (−0.508) | −0.011 (−0.308) |
| Gender | | 0.087** (2.325) | 0.095** (2.515) | | 0.080 (1.756) | 0.087 (1.906) | | 0.074 (1.108) | 0.081 (1.214) |
| Monthly income | | 0.00 (0.333) | 0.004 (0.249) | | −0.005 (−0.224) | −0.006 (−0.300) | | 0.013 (0.442) | 0.012 (0.431) |
| Education level | | −0.041** (−2.865) | −0.042** (−2.903) | | −0.051** (−2.865) | −0.051** (−2.866) | | −0.022 (−0.933) | −0.024 (−0.986) |
| Marital status | | | −0.065 (−1.532) | | | −0.063 (−1.151) | | | −0.933 (−0.820) |
| N | 1,234 | 1,234 | 1,234 | 792 | 792 | 792 | 442 | 442 | 442 |
| R ² | 0.735 | 0.737 | 0.738 | 0.762 | 0.767 | 0.767 | 0.676 | 0.673 | 0.673 |
| F | 1,138.128 (sig = 0.000) | 495.272 (sig = 0.000) | 434.132 (sig = 0.000) | 842.087 (sig = 0.000) | 368.781 (sig = 0.000) | 322.983 (sig = 0.000) | 304.792 (sig = 0.000) | 130.766 (sig = 0.000) | 114.418 (sig = 0.000) |

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

4 Research conclusions and discussion

First, there is a significant difference in subjective wellbeing between rural empty-nest elderly and non-empty-nest elderly, with the former experiencing lower levels of subjective wellbeing. Empty-nest elderly often face greater psychological and social pressures, which can impact their quality of life and attitude toward learning. Firstly, empty-nest elderly lack the companionship and support of family members, leading to feelings of loneliness and helplessness (Zhang, 2023). In rural areas, family relationships typically play a crucial role in social support (Wang, 2024). However, as children migrate and work elsewhere, the support network of empty-nest elderly deteriorates, leaving them without effective support and comfort during difficulties or emotional needs. In contrast, non-empty-nest elderly usually rely on family members' companionship and care, helping them maintain a more positive emotional state and higher subjective wellbeing. Secondly, empty-nest elderly are more prone to negative emotions such as loneliness, depression, and irritability, and have weaker emotional control, adversely affecting their mental health (Fung and Chan, 2008). Research shows that 60% of empty-nest elderly in rural China have psychological issues, with 20% developing conditions needing medical attention (Liang et al., 2020). Feelings of loneliness and helplessness exacerbate negative emotions and impact their subjective wellbeing. Additionally, psychological problems lead to reduced interest, decreased activity, and weakened sense of autonomy (McCusker et al., 2016). Therefore, mental health issues affect their attitude toward and participation in learning activities,

leading to a more negative mindset. Moreover, empty-nest elderly face issues of role degradation in social identity (Levy et al., 2002). The family plays a critical role in social life, and the empty-nest status causes elderly individuals to lose their central role within the family, affecting their self-identity and social role. In contrast, non-empty-nest elderly often play more active roles, such as caring for grandchildren or participating in family decisions, which helps them establish a more stable social identity and enhance their subjective wellbeing. Finally, empty-nest elderly face reduced social activities due to fewer family members or lack of a partner. Social activities are vital for maintaining social connections and receiving support; the empty-nest status limits their social range, leading to greater social isolation (Courtin and Knapp, 2017).

Second, participation in learning significantly enhances the subjective wellbeing of rural empty-nest elderly, with a notable positive correlation between various dimensions of learning participation and subjective wellbeing. The different dimensions of learning participation positively impact the subjective wellbeing of rural empty-nest elderly by offering social interaction and support, active engagement, and self-improvement opportunities, thereby improving life satisfaction and happiness. Firstly, the learning environment refers to the learning conditions and state of other members within the individual's learning context (Hou, 2021), directly affecting their learning experience. A positive learning environment includes support and encouragement, interaction, and communication with others, which boosts self-confidence and enhances happiness. Secondly, learning

experience involves the individual's perception, view, and understanding of the learning environment (Entwistle and Ramsden, 1982). The positive learning experience comes from the sense of achievement and self-fulfillment gained during learning. Social support theory suggests that perceived social support can mitigate the negative impacts of stress (Cohen and Kay, 1984). Positive learning experiences enhance self-awareness and self-esteem, leading to higher life satisfaction and happiness (Diener, 2000). Positive psychology focuses on individual strengths, happiness, and wellbeing, emphasizing the cultivation of positive emotions, personal traits, and life meaning to boost happiness. Overcoming learning challenges or acquiring new skills provides a sense of accomplishment that directly enhances happiness. Lastly, learning engagement refers to the effort, time, and energy invested in learning activities (Schaufeli et al., 2002). Research indicates that high learning engagement improves learning outcomes and sense of achievement, thus enhancing subjective wellbeing (Fredricks et al., 2004). The degree of engagement in learning is crucial for boosting subjective happiness. When elderly individuals are passionate about learning and actively participate, they generally feel more satisfied and happy. This engagement provides a sense of purpose and value, increasing their expectations and hopes for the future.

Third, compared to non-empty-nest elderly in rural areas, learning participation has a more pronounced positive effect on rural empty-nest elderly. After controlling for individual (gender, age, monthly income, education) and family (household registration, marital status, living conditions) factors, hierarchical regression analysis reveals that the two dimensions of learning participation—learning experience and learning engagement—explain a significant portion of the subjective wellbeing of rural empty-nest elderly. Learning experience and investment, as key dimensions of learning engagement, play a vital role in enhancing the subjective wellbeing of rural empty-nest elderly. Firstly, compared to non-empty-nest elderly, the migration of children, the death of spouses, or weakened community relationships often lead rural empty-nest elderly to feel loneliness and social deficiency, with limited resources in rural areas exacerbating this feeling. Thus, participation in educational activities helps empty-nest elderly establish new social connections and support networks. Through learning, they can build relationships with other learners and teachers, increasing social interaction and alleviating loneliness. This social interaction helps fill the social void created by their empty-nest status. In contrast, non-empty-nest elderly typically have more family members around, and their social needs may be relatively met, making the impact of learning participation on their subjective wellbeing less pronounced. Secondly, self-determination theory posits that autonomy and intrinsic motivation in one's actions are key to achieving happiness (Li, 2023). Compared to non-empty-nest elderly, empty-nest elderly, free from caregiving burdens, can devote more energy to learning, adjusting their lifestyle and finding new goals and pleasures in late life. Their efforts and engagement in learning satisfy intrinsic motivation, enhancing learning outcomes and enriching life experiences, which increases self-fulfillment and happiness.

5 Limitations and future directions

This study has certain limitations. Firstly, the scope is limited as it focuses only on elderly learners aged 50 and above in specific districts within Z Province's N City, which restricts the generalizability of the results. Future research should broaden the scope to include a wider geographical area, and samples from various socio-economic backgrounds to enhance the applicability and reliability of the findings. Secondly, the use of quantitative methods may overlook individual experiences, emotions, and perspectives, potentially affecting a comprehensive understanding of subjective wellbeing. Future studies should adopt a mixed-methods approach to gain a more thorough and nuanced understanding, including in-depth exploration of individual experiences and viewpoints. Lastly, using electronic questionnaires might exclude some rural empty-nesters who are unfamiliar with or unable to access electronic devices, potentially causing sample bias. Future research should employ diverse survey methods, such as face-to-face interviews or telephone surveys, to ensure sample diversity and representativeness and better capture the subjective wellbeing of rural empty-nesters.

6 Innovative evaluation

The study demonstrates innovation in three ways. First, the research employed a quantitative research method, utilizing random sampling and data analysis to systematically measure the impact of learning participation on the subjective wellbeing of rural empty-nest elderly. This approach provides new insights and a foundation for quantitative research in this field. Second, the research perspective is innovative. Traditionally, researchers are more inclined to explain the influencing factors of subjective wellbeing of the elderly from the aspects of economy, health, and social support, while relatively little attention has been paid to learning participation. Therefore, by introducing learning participation as an independent variable into the research framework, it provides new perspectives and ideas for exploring the influencing factors of subjective wellbeing of rural elderly groups. Finally, this study's content innovation lies in treating learning engagement as a variable and exploring its impact on the subjective wellbeing of rural empty-nest elderly. It proposes a new approach of enhancing learning engagement to improve elderly individuals' psychological wellbeing, social integration, and self-identity, emphasizing the potential role of learning activities in enhancing the quality of life and happiness of elderly people.

Data availability statement

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

Author contributions

RZ: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Conceptualization.

HS: Writing – review & editing, Project administration, Formal analysis, Data curation, Conceptualization. HW: Writing – review & editing. LS: Writing – review & editing, Visualization, Validation, Supervision, Resources, Funding acquisition.

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Latent profile analysis of fatalism and its influencing factors among community-dwelling disabled elderly individuals

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Objective: This study aims to explore the latent profiles of fatalism among community-dwelling disabled elderly individuals and identify the key factors influencing these profiles. The findings will provide valuable insights for formulating tailored care management strategies for this population.

Design: A cross-sectional survey study.

Methods: A random sampling approach was used to survey disabled elderly individuals residing in 109 communities across eight urban districts in Sichuan Province. Data were collected through a general information questionnaire and a Fatalism Scale. Latent profile analysis was performed to identify distinct fatalism profiles, and multivariate unordered regression analysis was conducted to assess their influencing factors.

Results: Three distinct latent profiles of fatalism were identified: high fatalism and pessimism tendency (35.6%), moderate fatalism and low optimism tendency (9.6%), and low fatalism with relative optimism tendency (54.8%). Multivariate analysis revealed that living arrangements, number of children, educational level, duration of disability, and self-reported economic stress were significant factors influencing these fatalism profiles.

Conclusion: There is significant heterogeneity in fatalism among community-dwelling disabled elderly individuals. Caregivers and healthcare managers can develop more precise and personalized management strategies by considering the different latent profiles and their associated influencing factors.

KEYWORDS

community, disabled elderly, fatalism, profile analysis, influence factor

1 Introduction

With the global aging population accelerating, the number of disabled elderly individuals is steadily increasing (Keshavarz et al., 2023). Current statistics indicate that there are over 100 million disabled elderly people worldwide, with more than 40 million residing in China, representing 18.3% of the total elderly population (Bao et al., 2022). As their ability to perform daily activities declines, disabled elderly individuals often face considerable physical and psychological challenges (Ma et al., 2022), resulting in negative emotions such as anxiety, depression, apathy, and pessimism, which severely diminish their quality of life. Fatalism, a common worldview characterized by the belief in the uncontrollability of fate, plays a significant role when individuals encounter major life changes and challenges (Keller et al.,

2024). However, an excessive sense of fatalism among disabled elderly individuals may lead to passive acceptance of adversity, exacerbating negative coping mechanisms (Sharrief et al., 2017).

The community serves not only as the primary living environment for elderly individuals but also as a vital source of social interaction, recreation, access to resources, and social support (Deardorff et al., 2022). Despite this, current psychological research on disabled elderly individuals in community settings predominantly focuses on assessing mental health through overall scale scores, often neglecting the nuanced differences within patient subgroups (Zivoder et al., 2019). Latent profile analysis (LPA), a person-centered approach, allows for the identification of underlying characteristics by analyzing individual responses across various dimensions of a scale (Bäjenaru et al., 2022). This method helps elucidate the distribution of distinct subgroups within a population.

Therefore, this study employs LPA to classify the fatalism characteristics among community-dwelling disabled elderly individuals and explore the differences across these latent types. The findings aim to assist clinical healthcare professionals in developing targeted intervention strategies tailored to the needs of different subgroups.

2 Subjects and methods

2.1 Study population

From July 10 to July 20, 2024, this study targeted disabled elderly residents from 109 communities across eight cities in Sichuan Province, namely Chengdu, Deyang, Zigong, Neijiang, Yibin, Luzhou, Leshan, and Nanchong. The required sample size was estimated using

the formula $N = \frac{(Z_{\alpha/2} \cdot \sigma)^2}{E^2}$, where $Z_{\alpha/2}$ represents the z-score for a

95% confidence interval (approximately 1.96), σ is the population standard deviation, and E is the desired width of the confidence interval. Based on a preliminary survey of 30 disabled elderly individuals in local communities, an estimated standard deviation $\sigma \approx 10$ was calculated. To achieve a high level of precision with a confidence interval width of ± 1 unit, indicating that actual scale scores would vary within ± 1 unit at a 95% confidence level, the required sample size was determined to be 385. Adjusting for a potential 10% rate of invalid questionnaires, the final sample size was set at 424 disabled elderly individuals.

To ensure sample representativeness and the scientific validity of the results, a random sampling approach was used. The number of participants selected from each community was dynamically adjusted based on community size and the number of disabled elderly residents. Each community selected between 3 and 10 individuals randomly, based on these factors.

Inclusion Criteria: Aged 60 years or older, Diagnosed with disability according to the Barthel Index (score less than 100), Normal communication ability with no impairment of consciousness, Voluntarily participated in the study with informed consent. **Exclusion Criteria:** Currently participating in other psychological-related surveys or studies.

2.2 Ethical approval

This study adheres to the National Code of Ethical Conduct for Human Research (2016) and has received approval from the Ethics

Committee of Zigong Fourth People's Hospital (Approval No: EC-2023-073). All procedures were conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants prior to their involvement in the study.

2.3 Survey instruments

2.3.1 General information questionnaire

The general information questionnaire was developed by the research team based on a comprehensive literature review and expert consultations. It includes demographic and disease-related data. Demographic information encompasses gender, age, marital status, and number of children. Age categories are defined as follows: 60–69 years as young-old, 70–79 years as middle-old, and 80 years and above as old-old, as per the China Population Science Dictionary. Marital status is categorized into married and non-married, with the non-married category including divorced, widowed, or never married individuals. The primary caregiver category includes options such as “others,” which typically refers to caregivers like nannies or fellow patients.

Disease-related data include the primary disabling condition, the number of comorbidities, and the degree of disability. Comorbidities refer to additional systemic diseases beyond the primary disabling condition. Disability degree is assessed using the Barthel Index rating scale.

2.3.2 Barthel index rating scale

The Barthel Index, developed by Mahoney in 1965, assesses 10 areas of daily living. A lower score indicates greater disability, with a total score of 100. Scores ≤ 40 indicate severe disability, 41–60 indicate moderate disability, 61–99 suggest mild disability, and 100 denotes full independence in daily living (Izumi et al., 2024).

2.3.3 Fatalism scale

The Fatalism Scale (Shen et al., 2009), developed by Shen and colleagues in 2009, includes three dimensions: Predetermination (items 1–10), Luck (items 11–14), and Pessimism (items 15–20). It employs a Likert 5-point scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”), with higher scores indicating stronger fatalistic beliefs. The scale demonstrates good reliability and validity, with a Cronbach's alpha coefficient of 0.88 and a content validity index of 0.89.

2.4 Data collection methods

Prior to the study, team members briefed community healthcare center staff on the study's background and methods. The principal investigator assigned unique identification numbers to each survey questionnaire based on study regions. Questionnaires were distributed via mail or delivery to community healthcare centers, where participants completed them independently and anonymously. Each participant could fill out the survey only once. Completed surveys were collected only if all sections were fully answered. After data collection, regional supervisors gathered the completed surveys and sent them to the central research team.

2.5 Quality control

To ensure data accuracy, a research team was formed before the study's initiation. Each healthcare institution appointed a survey supervisor who received standardized training and was responsible for quality control and data collection within their region. Two researchers reviewed all returned questionnaires, cross-checking them against the expected number for each region. Questionnaires with apparent biases or multiple corrections were excluded. The analysis and interpretation of data were reviewed by experts in statistics to ensure the results accurately reflected clinical significance.

2.6 Statistical methods

Exploratory latent profile analysis (LPA) was performed using Mplus 8.3 software to classify community-dwelling disabled elderly individuals based on their fatalism scores. Differences in social factors and demographic characteristics among fatalism categories were compared using chi-square tests, one-way ANOVA, or rank-sum tests.

Variables showing statistically significant differences in univariate analyses were included as independent variables in a multinomial logistic regression analysis, with fatalism categories as the dependent variable. This analysis aimed to explore factors influencing the categorization of fatalism among the elderly.

Model fit indices included the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Adjusted Bayesian Information Criterion (aBIC), and Entropy, along with the Lo-Mendell-Rubin (LMR) test and the bootstrapped likelihood ratio test (BLRT). Lower AIC, BIC, and aBIC values indicate better model fit, and an Entropy value close to 1.0 suggests better predictive accuracy. An Entropy value around 0.8 indicates classification accuracy exceeding 90% (Ford et al., 2022). Significant p -values for LMR and BLRT indicate that the model with k classes is significantly better than the model with $k - 1$ classes. Statistical significance was set at $p < 0.05$.

3 Results

3.1 General data of community-dwelling disabled elderly individuals

A total of 527 questionnaires were collected for this study. Of these, 480 were randomly selected, and 469 were valid, yielding an effective response rate of 97.70%. Among the 469 community-dwelling disabled elderly individuals, there were 226 males and 243

females. The distribution of disability severity was as follows: 185 individuals with mild disability, 186 with moderate disability, and 98 with severe disability. The mean score on the Fatalism Scale was 48.48 ± 10.23 . The dimension scores were: Predetermination 18.65 ± 4.77 , Luck 12.62 ± 3.46 , and Pessimism 17.20 ± 4.78 .

3.2 Latent profile analysis results of fatalism among community-dwelling disabled elderly individuals

Latent profile analysis (LPA) was conducted based on the Fatalism Scale scores. Five potential profile models were assessed using AIC, BIC, aBIC, Entropy, LMR, and BLRT to evaluate the heterogeneity of fatalism among community-dwelling disabled elderly individuals. The results of the LPA are summarized in Table 1. As the number of profiles increased, AIC, BIC, and aBIC showed a consistent decreasing trend. Among the tested models, the three-profile solution was identified as the optimal fit. Compared to Models 2, 4, and 5, the three-profile model not only achieved the highest Entropy value but also demonstrated statistical significance in both LMR and BLRT ($p < 0.05$). Additionally, although the four-class and five-class models exhibited lower AIC and BIC values, they resulted in smaller class sizes, which could undermine the interpretability and practical relevance of the latent profiles. Detailed information is provided in Table 1 and Figure 1.

The analysis identified three latent profiles:

Class 1: Comprising 167 individuals (35.6%). This group exhibited high scores on the Predetermination and Pessimism dimensions of the Fatalism Scale, reflecting a strong belief in the uncontrollability of fate and pronounced pessimism. Individuals in this class tend to perceive many events as predestined and maintain a generally negative outlook on the future. Their Luck dimension scores were moderately high, indicating some expectation of good fortune, but the overall impact of pessimism was significant. Thus, this group is named as “High Fatalism and Pessimistic Tendency.”

Class 2: Consisting of 45 individuals (9.6%). This group demonstrated moderately high scores on the Predetermination dimension, signifying a moderate level of fatalistic belief, though less intense than Class 1. The Luck dimension scores were low, indicating minimal expectation of good fortune and skepticism about luck. Pessimism scores were moderately low, suggesting some negative emotions but a less severe outlook overall. This group is named as “Moderate Fatalism and Low Optimism Tendency.”

Class 3: Including 257 individuals (54.8%). This class showed lower scores on the Predetermination dimension, reflecting greater

TABLE 1 Fit indices for different latent profile analysis models ($n = 469$).

| Model | AIC | BIC | aBIC | Entropy | P-value | | Class probability |
|-------|----------|----------|----------|---------|---------|--------|-------------------------------|
| | | | | | LMR | BLRT | |
| 1 | 8102.806 | 8127.709 | 8108.666 | – | – | – | |
| 2 | 7871.307 | 7912.813 | 7881.075 | 0.776 | <0.001 | <0.001 | 0.356/0.643 |
| 3 | 7736.048 | 7794.157 | 7849.724 | 0.872 | <0.001 | <0.001 | 0.356/0.096/0.548 |
| 4 | 7778.884 | 7853.595 | 7796.467 | 0.823 | 0.001 | <0.001 | 0.185/0.194/0.460/0.159 |
| 5 | 7760.541 | 7851.854 | 7782.030 | 0.792 | 0.229 | <0.001 | 0.166/0.104/0.198/0.462/0.068 |

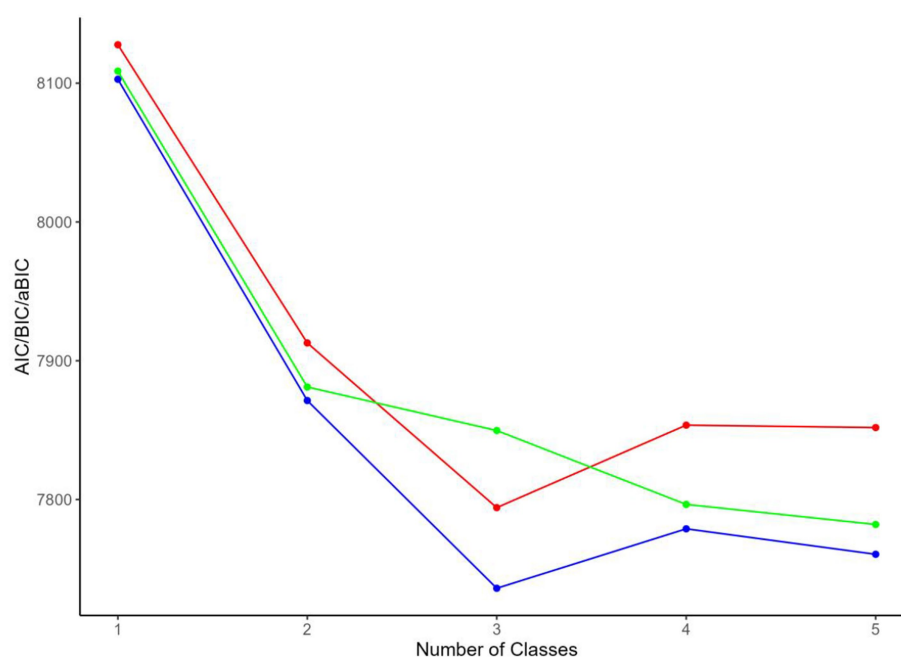


FIGURE 1
Elbow plot for model selection in latent profile analysis of fatalism in community-dwelling disabled elderly.

trust in personal control over fate and belief in the influence of choices and efforts on life outcomes. Luck dimension scores were moderate, suggesting an openness to good fortune. Pessimism scores were also moderate but lower compared to the other classes. This group is named as “Low Fatalism and Relatively Optimistic Tendency.”

The scores for each dimension of the Fatalism Scale for Class 1, Class 2, and Class 3 are illustrated in Figure 2.

3.3 Univariate analysis results

Univariate analysis was conducted with the three latent profiles of fatalism among community-dwelling disabled elderly individuals as dependent variables, and demographic and disease-related data as independent variables. The analysis revealed that several factors significantly influenced the differences in fatalism profiles. These factors include: Number of Children, Payment Method for Medical Expenses, Educational Level, Duration of Disability, Living Situation, Primary Caregiver, Self-Rated Family Harmony, Self-Rated Economic Pressure. Each of these factors was found to have a significant impact on the variation in fatalism profiles, indicating that they play a crucial role in shaping the fatalistic views of disabled elderly individuals living in the community. The detailed results are presented in Table 2.

3.4 Multivariate analysis results of fatalism profiles in community-dwelling disabled elderly individuals

Given that the latent profile analysis did not reveal significant ordinal relationships among dimensions, unordered multinomial logistic regression was employed to identify the influencing factors for

different fatalism profiles among community-dwelling disabled elderly individuals.

Before conducting the multivariate analysis, collinearity diagnostics were performed on the variables identified as statistically significant in the univariate analysis. The results of these diagnostics indicated that the tolerance for each variable was greater than 0.1, and the variance inflation factors (VIF) were below 10. These findings suggest that multicollinearity among the variables was not a concern in the analysis.

This study examined the factors influencing fatalism profiles among disabled elderly individuals. The results showed that compared to disabled elderly individuals living alone, those living with family (OR = 0.067, 95% CI [0.016–0.277]) or others (OR = 0.246, 95% CI [0.069–0.877]) were more likely to be classified as Class 3. Having two or more children was linked to a lower chance of being classified as Class 1 compared to having no child (OR = 0.380, 95% CI [0.223–0.648]). Individuals with a middle school education were more likely to be classified as Class 1 compared to those with higher education (OR = 2.670, 95% CI [1.015–7.024]). Those with a disability duration of 1 to 2 years had a higher likelihood of being classified as Class 1 compared to those with longer disability durations (OR = 2.958, 95% CI [1.313–6.666]). Finally, elderly individuals with no economic pressure were more likely to be classified as Class 3 compared to those with high economic pressure (OR = 0.415, 95% CI [0.213–0.810]).

In the study, only results with statistical significance are presented, while detailed regression analysis of the factors influencing fatalism profiles among community-dwelling disabled elderly individuals is provided in Table 3. This table includes the odds ratios (OR) along with their 95% confidence intervals (CIs) for each factor analyzed in relation to fatalism. The results are further visualized in the accompanying forest plot (Figure 3), offering an intuitive graphical representation of these findings.

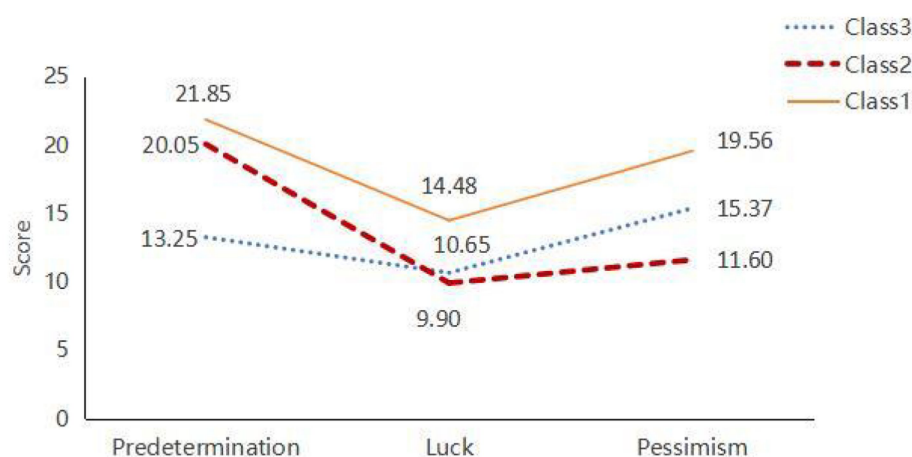


FIGURE 2
Latent profiles of fatalism in community-dwelling disabled elderly.

4 Discussion

4.1 Analysis of the potential profiles of fatalism in community-dwelling disabled elderly

Fatalism significantly influences the later stages of life for disabled elderly individuals, yet it remains underexplored in current research. Defined as a belief in the uncontrollability of fate, fatalism can adversely affect psychological well-being and quality of life, leading to diminished agency and increased emotional distress (Valenti and Faraci, 2022). Despite its potential impact, existing literature provides limited insights into this issue, highlighting the need for further investigation.

This study used latent profile analysis to identify three distinct symptom categories based on the fatalistic attitudes of community-dwelling disabled elderly individuals. These categories provide insights into how different groups cope with life's challenges and pressures, enriching the understanding of fatalism in elderly populations.

By identifying groups with distinct fatalistic traits, we can better address their psychological needs and design tailored interventions. For those with strong fatalistic attitudes, support should focus on improving perceptions of fate and reducing reliance on fatalism. Balanced groups may benefit from interventions that enhance their sense of control and foster positivity, while those with weaker fatalistic views can gain from strengthened social support networks. These classifications highlight the importance of addressing fatalism in elderly care to improve mental health and quality of life.

4.2 Analysis of factors shaping fatalism profiles in community-dwelling disabled elderly

4.2.1 The impact of living situation on fatalism

The results showed that disabled elderly individuals living alone were more likely to be classified as Class 2, while those cohabiting with family or others, such as colleagues or friends, tended to fall into

Class 3. This may be due to the greater daily and emotional support available to those living with others (Long et al., 2023). Cohabitants provide assistance with meals, hygiene, and daily activities, reducing stress and uncertainty while offering psychological support through regular interactions (Zheng et al., 2023). This stable support system enhances life satisfaction and resilience, fostering a more positive outlook and moderate fatalism, aligning their psychological state with Class 3.

In contrast, elderly individuals with disabilities living alone are more likely to be classified into Class 2, which may be related to their unique lifestyle and behavior patterns. Living alone and lacking assistance from others, these elderly individuals must handle many daily tasks on their own, such as shopping, cooking, and personal care. This self-care requirement encourages the development of some degree of independence but also brings greater life stress and physical and mental burdens (Gao et al., 2021). The lack of support from family members or others makes their anxiety more prominent in daily life, leading to higher anxiety and pessimism when facing difficulties. Additionally, elderly individuals living alone may be more inclined to reduce social interactions or outdoor activities, which increases their sense of loneliness and creates a more closed-off lifestyle (Scarantino et al., 2022; Zhang and Dong, 2022). Over time, the lack of social support and emotional interaction may further exacerbate their negative views on life, influencing their classification.

Based on the analysis of influencing factors, practical nursing interventions can be implemented for elderly individuals with disabilities in different living environments to improve their psychological health and quality of life. For elderly individuals living with family members or others, nursing interventions should focus on enhancing internal family interactions and support. Family members play a crucial role in the daily care of disabled elderly individuals (Li et al., 2023). Therefore, encouraging family members to participate more in daily tasks and psychological support for the elderly is vital. Nursing staff can facilitate regular family support group meetings or training to help family members understand the elderly individual's care needs, promote emotional communication, and reduce family conflict and stress caused by the elderly person's disability. At the same time, encouraging family members to provide more emotional

TABLE 2 Univariate analysis of fatalism profiles in community-dwelling disabled elderly individuals.

| Options | | Class 1 <i>n</i> = 167,35.6% | Class 2 <i>n</i> = 45,9.6% | Class 3 <i>n</i> = 257,54.8% | Statistics | <i>P</i> |
|---|----------------------------|------------------------------|----------------------------|------------------------------|----------------------|----------|
| Gender No (%) | Male | 81 (48.51) | 17 (37.77) | 128 (49.80) | 2.229 ^a | 0.328 |
| | Female | 86 (51.49) | 28 (62.23) | 129 (50.20) | | |
| Age No (%) | 60 ~ 69 years | 36 (21.55) | 10 (22.22) | 60 (23.34) | 1.265 ^b | 0.531 |
| | 70 ~ 79 years | 62 (37.12) | 20 (44.44) | 106 (41.24) | | |
| | ≥80 years | 69 (41.33) | 15 (33.34) | 91 (35.42) | | |
| Marital status No (%) | Married | 109 (65.29) | 31 (68.88) | 166 (64.59) | 5.201 ⁽¹⁾ | 0.267 |
| | Not Married | 58 (34.71) | 14 (31.12) | 91 (35.41) | | |
| Number of children No (%) | Two or more children | 102 (61.09) | 32 (71.12) | 203 (79.00) | 15.049 ^b | 0.001 |
| | One children | 5 (2.99) | 3 (6.66) | 7 (2.72) | | |
| | No children | 60 (35.92) | 10 (22.22) | 47 (18.28) | | |
| Medical expense payment method No (%) | Urban medical insurance | 45 (26.94) | 11 (24.44) | 104 (40.46) | 15.207 ^a | 0.019 |
| | Employee medical insurance | 54 (32.33) | 13 (28.88) | 71 (27.62) | | |
| | Out-of-Pocket | 60 (35.92) | 20 (44.44) | 79 (30.73) | | |
| | Other | 8 (4.81) | 1 (2.24) | 3 (1.19) | | |
| Occupation before disability No (%) | Farmer | 61 (36.52) | 13 (28.88) | 128 (49.80) | 12.473 ^a | 0.052 |
| | Self-employed | 67 (40.11) | 19 (42.22) | 73 (28.40) | | |
| | Public institution staff | 29 (17.39) | 10 (22.22) | 42 (16.34) | | |
| | Other | 10 (5.98) | 3 (6.68) | 14 (5.46) | | |
| Education Level No (%) | Elementary School | 83 (49.70) | 18 (40.00) | 85 (33.07) | 12.992 ^b | 0.002 |
| | Middle School | 49 (29.34) | 18 (40.00) | 75 (29.18) | | |
| | High School | 17 (10.17) | 5 (11.11) | 78 (30.35) | | |
| | College and Above | 18 (10.79) | 4 (8.89) | 19 (7.40) | | |
| Number of Diseases No (%) | 1 | 51 (30.53) | 18 (40.00) | 97 (37.74) | 0.123 ^b | 0.94 |
| | 2 | 52 (31.13) | 15 (33.33) | 79 (30.73) | | |
| | 3 | 21 (12.57) | 2 (4.44) | 30 (11.67) | | |
| | >3 | 32 (25.77) | 10 (22.23) | 51 (19.86) | | |
| Primary Disease Causing Disability No (%) | Respiratory System | 46 (27.54) | 16 (35.55) | 66 (25.68) | 12.343 ^a | 0.055 |
| | Circulatory System | 49 (29.34) | 3 (6.66) | 62 (24.12) | | |
| | Nervous System | 57 (34.13) | 18 (40.00) | 93 (36.18) | | |
| | Other Systems | 15 (8.99) | 8 (17.79) | 36 (14.02) | | |
| Barthel Index Score <i>m</i> ± <i>s</i> | | 59.37 ± 18.79 | 62.89 ± 19.55 | 58.07 ± 18.54 | 1.317 ^c | 0.269 |

(Continued)

TABLE 2 (Continued)

| Options | | Class 1 <i>n</i> = 167,35.6% | Class 2 <i>n</i> = 45,9.6% | Class 3 <i>n</i> = 257,54.8% | Statistics | <i>P</i> |
|--|---------------------|------------------------------|----------------------------|------------------------------|---------------------|----------|
| Degree of Disability No (%) | Mild disability | 68 (40.71) | 20 (44.44) | 97 (37.74) | 1.836 ^b | 0.399 |
| | Moderate disability | 62 (37.12) | 20 (44.44) | 104 (40.46) | | |
| | Severe disability | 37 (22.17) | 5 (11.12) | 56 (21.80) | | |
| Duration of Disability No (%) | <1 year | 120 (71.85) | 34 (75.55) | 139 (54.08) | 10.820 ^b | 0.004 |
| | 1 ~ 2 years | 19 (11.37) | 3 (6.66) | 99 (38.52) | | |
| | ≥3 years | 28 (16.78) | 8 (17.79) | 77 (7.40) | | |
| Monthly hospitalization frequency No (%) | 1 time | 40 (23.95) | 8 (17.77) | 72 (28.01) | 5.965 ^b | 0.051 |
| | 2 times | 38 (22.75) | 10 (22.22) | 50 (19.45) | | |
| | ≥3 times | 89 (53.30) | 27 (60.01) | 135 (52.54) | | |
| Understanding of disability No (%) | No | 25 (14.97) | 9 (20.00) | 36 (14.00) | 0.834 ^b | 0.659 |
| | Partial | 109 (65.26) | 27 (60.00) | 164 (63.81) | | |
| | Full | 33 (19.77) | 9 (20.00) | 57 (22.19) | | |
| Source of income No (%) | Pension | 107 (64.07) | 27 (60.00) | 138 (53.69) | 6.422 ^a | 0.17 |
| | Living with family | 41 (24.55) | 10 (22.22) | 69 (26.84) | | |
| | Other | 19 (11.38) | 8 (17.78) | 50 (19.47) | | |
| Monthly hospitalization days No (%) | <3 days | 32 (19.16) | 7 (15.55) | 57 (22.17) | 5.965 ^a | 0.051 |
| | 3-5 days | 57 (33.72) | 22 (48.88) | 116 (45.13) | | |
| | >5 days | 78 (46.68) | 16 (35.57) | 84 (32.70) | | |
| Living situation No (%) | Living with family | 88 (52.69) | 29 (64.44) | 173 (67.31) | 11.616 ^a | 0.002 |
| | Other | 21 (12.58) | 11 (24.45) | 25 (9.74) | | |
| | Living alone | 58 (34.73) | 5 (11.11) | 59 (22.95) | | |
| Primary caregiver No (%) | Spouse | 46 (27.54) | 16 (35.55) | 75 (29.18) | 16.012 ^a | 0.014 |
| | Children | 52 (31.13) | 11 (24.44) | 115 (44.74) | | |
| | Grandchildren | 68 (40.71) | 17 (37.77) | 64 (24.90) | | |
| | Other | 1 (6.20) | 1 (2.24) | 3 (1.18) | | |
| Frequency of visits from relatives or friends No (%) | 0times/week | 9 (5.38) | 4 (8.88) | 20 (7.78) | 5.471 ^b | 0.065 |
| | 1time/week | 30 (17.96) | 14 (31.11) | 36 (14.00) | | |
| | 2times/week | 33 (19.76) | 9 (20.00) | 61 (23.73) | | |
| | ≥3times/week | 95 (56.90) | 18 (40.01) | 140 (54.49) | | |

(Continued)

TABLE 2 (Continued)

| Options | | Class 1 <i>n</i> = 167,35.6% | Class 2 <i>n</i> = 45,9.6% | Class 3 <i>n</i> = 257,54.8% | Statistics | <i>P</i> |
|---|-------------------|------------------------------|----------------------------|------------------------------|---------------------|----------|
| Self-rated family harmony No (%) | Not harmonious | 15 (8.98) | 2 (4.44) | 10 (3.89) | 18.682 ^b | 0.001 |
| | Fairly harmonious | 56 (33.53) | 2 (4.44) | 70 (27.23) | | |
| | Harmonious | 96 (57.49) | 41 (91.12) | 177 (68.88) | | |
| Self-rated economic pressure No (%) | Not pressure | 69 (41.31) | 18 (40.00) | 75 (29.18) | 9.694 ^b | 0.008 |
| | Some pressure | 69 (41.31) | 22 (48.88) | 117 (45.52) | | |
| | High pressure | 29 (17.38) | 5 (11.12) | 65 (25.30) | | |
| Frequency of communication with family No (%) | 0 times/day | 11 (6.58) | 5 (11.11) | 23 (8.94) | 3.596 ^b | 0.385 |
| | 1 time/day | 25 (14.97) | 7 (15.55) | 41 (15.95) | | |
| | 2 times/day | 21 (12.57) | 11 (24.44) | 37 (14.39) | | |
| | ≥3 times/day | 110 (65.88) | 22 (48.90) | 156 (60.72) | | |
| Community support No (%) | Almost none | 116 (69.46) | 38 (84.44) | 187 (72.76) | 3.764 ^b | 0.152 |
| | Rarely | 27 (16.16) | 4 (8.88) | 33 (12.84) | | |
| | Sometimes | 17 (10.17) | 1 (2.96) | 32 (12.45) | | |
| | Often | 6 (3.59) | 1 (2.96) | 2 (0.78) | | |
| | Always | 1 (0.62) | 1 (2.96) | 3 (1.17) | | |

^aChi-square test.

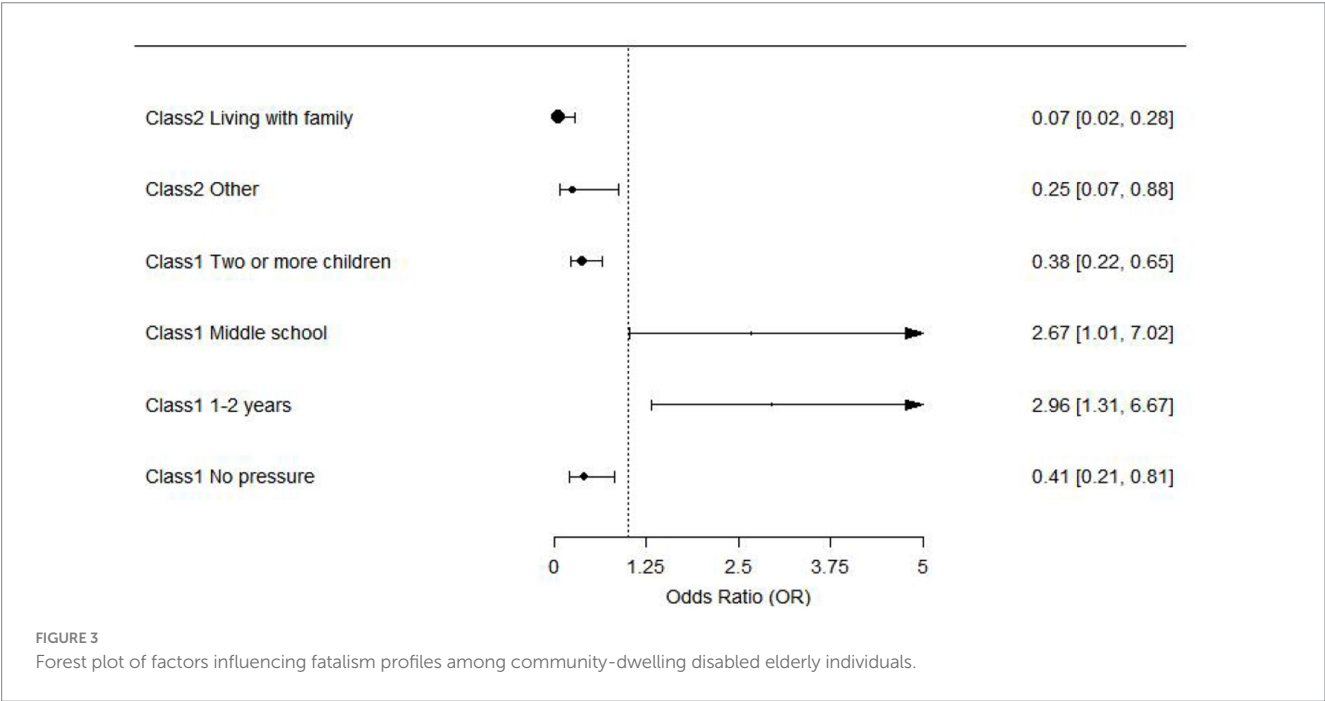
^bRank sum test.

^cAnalysis of variance.

TABLE 3 Regression analysis of the three latent categories of fatalism in community-dwelling elderly individuals with disabilities.

| Category | Variable | Item | B | Standard error of B | Wald chi-square value | P | OR | 95%CI |
|----------|------------------------------|----------------------|--------|---------------------|-----------------------|--------|-------|-------------|
| Class 2 | Living situation | Living with family | −2.699 | 0.722 | 13.973 | <0.001 | 0.067 | 0.016–0.277 |
| | | Other | −1.404 | 0.649 | 4.671 | 0.031 | 0.246 | 0.069–0.877 |
| Class 1 | Number of children | Two or more children | −0.968 | 0.273 | 12.627 | <0.001 | 0.380 | 0.223–0.648 |
| | Education level | Middle school | 0.982 | 0.493 | 3.961 | 0.047 | 2.670 | 1.015–7.024 |
| | Duration of disability | 1–2 years | 1.085 | 0.415 | 6.846 | 0.009 | 2.958 | 1.313–6.666 |
| | Self-rated economic pressure | No pressure | −0.880 | 0.341 | 6.650 | 0.010 | 0.415 | 0.213–0.810 |

Class 3 as the reference group.



companionship can help the elderly maintain a positive mindset and alleviate anxiety and depression (Yang et al., 2023).

4.2.2 Impact of the number of children on fatalism profiles

In this study, the number of children significantly affects the symptom characteristics of fatalism in disabled elderly individuals. Specifically, elderly individuals with two or more children are more likely to be classified into Class 3. The reasons for this can be analyzed as follows: for disabled elderly individuals with two or more children, mutual support and care among family members play a crucial role in their psychological well-being. These elderly individuals usually receive more comprehensive daily care, such as assistance with daily tasks, medical care, and emotional companionship from their children. The interactions and cooperation between children provide more emotional support, significantly reducing feelings of anxiety and loneliness in the elderly (Shulyaev et al., 2024). This emotional

connection helps them maintain a more positive attitude when facing the challenges of disability. This stable support system helps reduce fatalism and pessimism, making them more likely to be classified into Class 3, characterized by lower fatalism and higher optimism.

In contrast, disabled elderly individuals with no children or fewer children face a more difficult living situation (Du et al., 2024). First, the lack of direct care and companionship from children makes the emotional support sources for these elderly individuals relatively limited, leading to increased feelings of loneliness and pressure (Gan et al., 2023). Especially as the daily needs of disabled elderly individuals increase, the lack of children or having fewer children makes it difficult for them to receive timely and sufficient help and care. Moreover, without close family members to rely on, elderly individuals living alone or with non-immediate relatives often become more dependent on external services or social support. However, the lack of or instability in the social support system may not effectively replace the emotional support and daily care provided by the family

(Kobayashi et al., 2023). Therefore, these elderly individuals are more likely to experience stronger fatalism and pessimism when facing life pressures and are more likely to be classified into Class 1, characterized by higher fatalism and lower optimism.

To effectively improve the psychological health and quality of life of disabled elderly individuals in families with varying numbers of children, targeted intervention measures should include the following aspects: For elderly individuals with multiple children, it is essential to encourage cooperation and coordination among the children to ensure balanced distribution of daily care and emotional support. For disabled elderly individuals with no children or fewer children, greater focus should be placed on strengthening community support systems, providing regular home care, health check-ups, meal delivery services, and other services to relieve the elderly's daily pressures and ensure proper care (Fukumoto et al., 2023). At the same time, elderly individuals should be encouraged to engage in social interactions with other community members, participate in community activities and volunteer services, increase social opportunities, and establish external support networks.

4.2.3 Impact of educational level on fatalism profiles

In this study, elderly individuals with a middle school education were more likely to be classified into Class 1, reflecting the specific impact of education level on psychological health and life attitudes. Compared to elderly individuals with other levels of education, those with a middle school education tend to exhibit stronger fatalistic beliefs and more pessimistic emotions. This phenomenon may stem from the cognitive and social adaptation differences associated with the education level represented by a middle school education. Compared to individuals with higher education, those with a middle school education typically have fewer cognitive resources and problem-solving skills (Stephens et al., 2023). Therefore, when faced with life challenges such as disability, they may find it difficult to adopt effective coping strategies, leading to emotional distress and negative cognitions.

From a social support perspective, elderly individuals with a middle school education are often situated in more fragile social networks. While they may sometimes rely on relatives or neighbors, this support is often loose and unstable (Li et al., 2022). In contrast, individuals with elementary or lower education may depend more on family or long-term community care, which provides them with a greater degree of stability. Those with a high school education or above are more likely to rely on self-regulation and independent problem-solving abilities, as they possess stronger social interaction skills and resource access capabilities, enabling them to better cope with life challenges (Chen et al., 2020). Therefore, elderly individuals with a middle school education often lack both the support and capabilities needed to cope effectively, making them more prone to stronger fatalistic beliefs and pessimism (Mesas et al., 2020).

To address the needs of elderly individuals with a middle school education, community interventions should focus on enhancing their social support and life adaptation abilities. Services such as regular health check-ups, daily care, and psychological counseling can provide more support for this group. In particular, community efforts should strengthen attention to their emotional companionship and psychological guidance, offering personalized assistance to alleviate

feelings of loneliness and pessimism. Furthermore, community activities and social interactions should be promoted to encourage elderly individuals with a middle school education to participate, enhancing their social engagement and reducing feelings of isolation.

4.2.4 Impact of duration of disability on fatalism profiles

In this study, community-dwelling disabled elderly individuals with a disability duration of 1–2 years were more likely to be classified as Class 1, characterized by stronger fatalistic beliefs and pessimistic emotions. This finding underscores the unique psychological impact of disability duration. Compared to individuals with shorter disability durations (less than 1 year) or longer durations (more than 2 years), those in the 1–2 year range appear to be in a critical transitional phase of psychological adjustment, facing heightened emotional fluctuations and psychological distress.

From an adaptation perspective, individuals with a shorter duration of disability may still be in the “shock and denial” phase, where the full acknowledgment of their condition is incomplete, and psychological defense mechanisms mitigate some negative emotions (Pahor et al., 2020). Conversely, individuals with longer disability durations may have undergone prolonged psychological adjustment and lifestyle restructuring, allowing them to transition to the “acceptance and adaptation” phase, where they gradually accommodate the changes in their daily lives and find new life priorities. However, those with a disability duration of 1–2 years are often in a “midway dilemma” phase. At this stage, the decline in physical function has already caused significant disruptions to daily life, but psychological acceptance remains incomplete (Ogawa et al., 2021). This discordance between their psychological state and lived experience may lead to feelings of helplessness and pessimism.

From a social support perspective, individuals in this transitional phase may also encounter instability in their support systems. During the initial stages of disability, family members and community services typically provide substantial attention and assistance (Jadhav et al., 2021). However, over time, this support often diminishes, particularly during the 1–2 year “transition period,” when familial and community support tends to normalize, and the individual's adaptive capacity is not yet fully developed, potentially increasing feelings of isolation. Additionally, individuals in this phase may face challenges related to shifts in their social roles, such as losing work capacity or reducing social engagement, further exacerbating psychological stress (Putek et al., 2023).

To address the needs of community-dwelling disabled elderly individuals with a disability duration of 1–2 years, a comprehensive intervention approach integrating family support and professional medical care is essential. Families should encourage regular communication to monitor the elderly's psychological state, facilitate emotional expression, and alleviate negative feelings (Basoglu et al., 2022). Creating a positive atmosphere through effective communication and shared caregiving responsibilities, as well as engaging the elderly in household activities or interactions with grandchildren, can enhance their sense of participation and purpose.

From a medical perspective, healthcare providers should offer specialized psychological support, including mental health assessments, counseling referrals, and individualized rehabilitation

plans. These plans should include physical activity training, occupational therapy, and chronic disease management education to improve self-efficacy and reduce the psychological impact of health issues. Collaboration among general practitioners, nurses, rehabilitation therapists, and social workers is critical for ongoing support and regular follow-ups to monitor both physical and psychological well-being. By combining family support with professional care, psychological distress can be alleviated, quality of life improved, and the ability to cope with disability strengthened during this transitional phase (Kalnina et al., 2024).

4.2.5 Impact of self-rated economic pressure on fatalism profiles

The analysis revealed that disabled elderly individuals with significant economic pressure were more likely to be classified in Class 1 than those without economic pressure. This finding indicates that elderly individuals with better economic conditions are less likely to exhibit fatalism and are more likely to maintain an optimistic outlook on life. Conversely, those experiencing economic hardship are prone to negative emotions and stronger fatalistic beliefs. Economic challenges can exacerbate feelings of helplessness and pessimism, leading to a more fatalistic view of life (Sigurdardottir et al., 2019). This underscores the importance of economic support in enhancing the psychological well-being of disabled elderly individuals.

From a mechanistic perspective, elderly individuals under economic pressure often experience physical and mental exhaustion from the ongoing strain of daily expenses and medical costs (Li et al., 2024). When household income is insufficient to cover substantial medical and caregiving expenses, these individuals are more likely to feel pessimistic about the future, potentially abandoning active engagement with life (Rodriguez-Pereira et al., 2020). Economic constraints also limit participation in social activities, such as community events or educational programs, further reducing social support and emotional interactions, which exacerbates loneliness and psychological stress.

To address the needs of elderly individuals under economic pressure, a multi-faceted approach to intervention is essential. From a social support perspective, governments and communities should strengthen economic aid policies, such as increasing disability subsidies or expanding social security coverage for low-income groups, ensuring that basic living needs are met. Communities can also establish special assistance funds to provide temporary relief for individuals with urgent economic needs. Additionally, partnerships with non-governmental organizations and philanthropic initiatives can deliver medical subsidies, material support, and opportunities for free participation in community activities.

From a healthcare perspective, medical professionals should deliver targeted psychological support for elderly individuals facing economic pressure. This includes providing regular counseling to alleviate anxiety and assisting them in accessing medical aid programs through local governments or charitable organizations to ease the financial burden of health issues. By addressing economic stressors through comprehensive social, family, and healthcare interventions, it is possible to improve the mental health and overall well-being of elderly individuals experiencing economic hardship.

5 Conclusion

This study, through latent profile analysis, identified three distinct fatalism tendencies among community-dwelling disabled elderly individuals: high fatalism and pessimistic tendency, moderate fatalism and low optimism Tendency, low fatalism and relatively optimistic tendency. These classifications offer new perspectives for understanding and addressing the psychological states of disabled elderly individuals and lay a foundation for developing personalized intervention strategies.

The findings emphasize the heterogeneity of fatalism tendencies among disabled elderly individuals and highlight the associations between fatalism tendencies and their living conditions. These results provide important insights for designing targeted psychosocial interventions, particularly in enhancing the psychological well-being and quality of life of disabled elderly individuals.

Based on the results of this study, future intervention strategies should consider the specific needs of disabled elderly individuals with varying fatalism tendencies to achieve more precise care and management. Furthermore, the findings offer new directions for future research, particularly in exploring the influencing factors of fatalism tendencies and the effectiveness of interventions.

In conclusion, this study not only advances the understanding of fatalism tendencies among community-dwelling disabled elderly individuals but also provides an empirical foundation for the development of effective health promotion and psychological support strategies.

6 Limitations

This study was limited to examining the fatalism profiles of disabled elderly individuals within different regions of Sichuan Province, which may introduce a risk of regional bias. Future research should aim to expand the geographical scope and sample size to achieve a more comprehensive understanding of fatalism among disabled elderly populations. Additionally, this study was limited by its cross-sectional design, which restricts the ability to establish causal relationships between the variables. The findings are correlational and should not be interpreted as causal. Future research with longitudinal designs is recommended to validate the temporal relationships between the variables and better understand their causal pathways.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Ethics Committee of Zigong Fourth People's Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The animal study was approved by Ethics

Committee of Zigong Fourth People's Hospital. The study was conducted in accordance with the local legislation and institutional requirements. 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

JD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Resources. XW: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – original draft. QZ: Data curation, Investigation, Methodology, Resources, Writing – original draft. YW: Data curation, Investigation, Methodology, Software, Writing – original draft. YC: Data curation, Investigation, Supervision, Validation, Writing – original draft. CN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Project administration, Resources, Software, Supervision, Writing – review & editing.

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Conflict of interest

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

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Participation in and use of skills development for work ability and expected retirement age: a cross-sectional study among senior workers

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Introduction: Europe's aging population calls for ways to prolong working life. Skills development initiatives could potentially improve work ability and extend working lives and may thus be key to address this challenge. However, the role of skills development in relation to work ability and retirement age is still not fully understood.

Aim: This study aims to investigate the association of skills development with work ability and expected retirement age among senior workers.

Methods: In 2022, all State employees in Denmark aged 55 years or above ($n = 53,673$) received a web-based questionnaire, of which 42% were included in the analyses ($n = 22,544$). The questionnaire included questions about participation in skills development initiatives over the past 2 years, lifestyle and work environment, including work ability and expected retirement age. We employed Generalized Linear Models (GLMs), weighted for Union, sex and age, with multivariate adjustment to examine associations of participation in (1) courses, (2) formal education, and (3) other forms of skills development on work ability and expected retirement age.

Results: Formal education showed associations with expected retirement age with a between-group difference of 0.68 years Confidence Interval (CI) (0.54 to 0.82). Conversely, other forms of skills development (peer-to-peer training or self-study) were most positively associated with work ability in specific models with a between-group difference of 0.20 years CI (0.16 to 0.24).

Conclusion: Our findings suggest that participation in skills development is positively associated with work ability and expected retirement age. These findings underscore the need for targeted skills development programs, which may enhance workforce sustainability and help workers prolong their working life.

KEYWORDS

adult education, senior workers, human capital theory, age dependency ratio, job supply, gerontology

1 Introduction

Europe faces important changes in demographics, characterized by a growing proportion of older adult citizens (1, 2). This shift is leading to an increased age dependency ratio, where fewer younger individuals are available to support and finance welfare systems (3). As more citizens approach retirement age, increasing focus on ensuring an adequate labor supply becomes crucial. This demographic shift, combined with the rapid evolution of work requirements, underscores the necessity of retaining older workers and expanding workforce participation. Several strategies have been proposed and implemented to deal with these potential challenges to societies (4), including raising the retirement age (5) and enhancing workforce productivity. A key area of focus is ensuring a high level of employment and productivity across all age groups to sustain economic stability and social welfare systems.

A potential solution to maintain workers in the workforce is skills development. Skills development initiatives can play a role in enhancing work ability, which in turn may influence retirement patterns. Moreover, such initiatives may result in better opportunities for work tasks that are more suited to the aging worker, allowing them to continue contributing effectively in roles that align with their evolving capabilities (6, 7). Studies suggest that by improving workers' skills, particularly those of older workers, it is possible to prolong their working lives and delay retirement (8, 9).

Previous research has indicated a link between skills development initiatives and extended working lives (8–13). However, the existing literature pertaining to the relationship between different forms of skills development, work ability, and expected retirement age remains highly limited and not fully understood. It is unclear whether all forms of skills development are equally effective in achieving this outcome. Such knowledge is warranted by politicians and workplaces and could help them design effective initiatives potentially leading to more sustainable working lives.

This study aims to investigate the influence of skills development on work ability and expected retirement age among senior workers aged 55 and above. By examining various forms of skills development, including courses, formal education and other forms of skills development, we seek to provide new knowledge into their association with work ability and expected retirement age.

2 Methods

2.1 Study design

This is a cross-sectional study using self-reported questionnaire data on both the explanatory and outcome variables. We followed the recommendations from The STROBE reporting guideline for transparency (14).

2.2 Settings and population

This cross-sectional study was conducted among Danish State employees aged ≥ 55 years. Currently employed workers from five different Unions—this includes professionals, administrative staff,

service workers, educators, and individuals in specialized public service roles. By incorporating diverse job categories, the study captures a broad sample, enabling a comprehensive understanding of work conditions and experiences across various professions and organizational levels. The participants received a questionnaire survey designed about the participants' experiences with skills development initiatives as well as lifestyle, health, and work environment factors. Participation in the study was voluntary, and the sample is therefore non-random, as it depends on individuals' willingness to respond to the questionnaire. As we did not have access to data on non-respondents, it was not possible to conduct a non-response analysis to determine whether the characteristics of the study sample differ significantly from those of the full sample.

2.3 Data collection

Data collection was conducted in 2022 using a questionnaire. The Danish Agency for the Modernization of Public Administration (MEDST) identified and drew all Civil Registration Numbers (CPR), which is a unique personal identification number assigned to all residents of Denmark, used for official identification and public services such as healthcare, taxation, and social security, for Danish State employees aged 55 years and above. These individuals were then contacted via a secure digital mail system, e-Boks used in Denmark to send official correspondence from both public institutions and private companies which is widely. The e-Boks system is linked to the CPR number assigned to each citizen, ensuring the secure and personalized distribution of the questionnaire.

The data collection spanned approximately 3 months. In case of non-response, reminders were sent to 2,929 individuals on October 25, 2022 to encourage participation. These reminders were disseminated through the same secure e-Boks system. The flow of participants throughout the data collection process is illustrated in Figure 1.

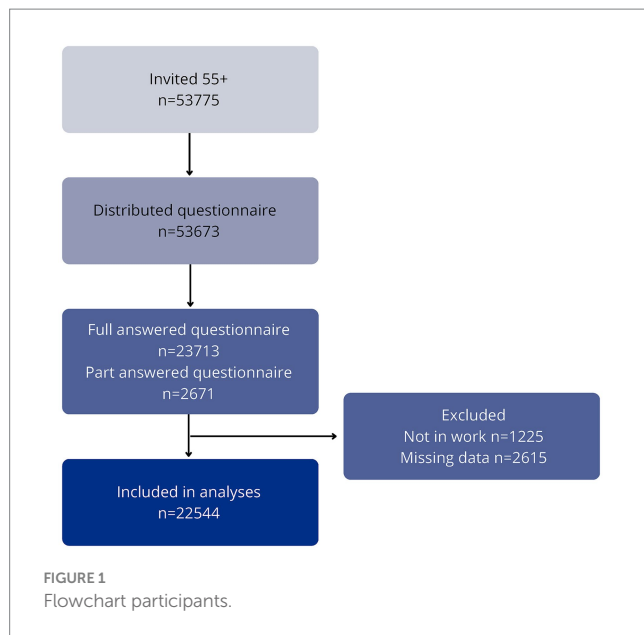
2.4 Measures

2.4.1 Explanatory variables

2.4.1.1 Skills development

The skills development measures were developed through a collaborative process involving The Secretariat for Competence Development (Kompetencesekretariatet) and representatives from both employer and employee organizations. The categories were specifically designed to reflect the complete range of skills development opportunities available within the Danish state sector, ensuring content validity for this specific context. The three distinct categories—courses, formal education, and other forms of skills development—were created to encompass both traditional and contemporary approaches to professional development, allowing for a comprehensive assessment of skills development participation among state employees.

Data on skills development were collected using the question: "Have you participated in or completed any of the following forms of skills development within the last 2 years?" The participants were



provided with detailed explanations in each category of skill development, clarifying what was meant by courses, formal education, and other forms of skill development, from which they could choose. This includes both in-person and online activities, and participants could select multiple categories of skills development:

2.4.1.1.1 Courses

This includes short or long-duration courses, whether conducted online or in-person.

2.4.1.1.2 Formal education

Encompasses formal educational programs ranging from individual modules to full degrees (e.g., bachelor's, master's, Ph.D., vocational training).

2.4.1.1.3 Other forms of skills development

This includes informal learning activities such as mentoring, peer learning, conferences, seminars, self-study, and other non-traditional educational experiences.

2.4.2 Outcomes

2.4.2.1 Expected retirement age

The expected retirement age was assessed using the following question: "At what age do you expect to permanently leave the labor market?" This single-item measure provided a direct estimate of each participant's anticipated age of retirement. We have utilized this question in previous research (15, 16).

2.4.2.2 Work ability

Work ability was assessed using a single-item question from the Work Ability Index (WAI): "Please rate your current work ability on a scale of 0–10, where 0 is unable to work and 10 is lifetime best work ability." The Work Ability Index (WAI) scale ranged from 0 to 10 and was treated as a discrete variable. For descriptive purposes in Table 1, we categorized the WAI scores into three groups: poor (0–5), moderate

(6–7), and good/excellent (8–10), to provide an overview of the distribution among participants (17, 18).

Although the full WAI index includes multiple items, previous studies have also used this single item to assess work ability effectively (19). Using a single-item approach simplifies the data collection process, which can be advantageous in large-scale studies by reducing respondent burden and potentially increasing response rates.

The Work Ability Index (WAI) was chosen for its ability to measure work ability comprehensively by considering various dimensions, including physical health, mental well-being, and alignment between work demands and individual capacity (20).

2.4.3 Potential confounding factors

2.4.3.1 Age and sex

Age and sex were determined using participants' CPR numbers. Evidence indicates that work ability tends to decline with age, with older workers potentially adjusting their expected retirement age due to declining health or reduced job satisfaction (21, 22). Age also influences opportunities for skill development, with younger workers often having greater access compared to their older counterparts. Similarly, sex plays a significant role in work ability and retirement expectations. Women, for instance, may retire earlier due to caregiving responsibilities, lower lifetime earnings, and sex-based wage gaps (23). These factors can limit professional growth opportunities for women, further influencing retirement expectations (23).

2.4.3.2 Health/general health

Health data were collected by asking participants about their height, weight and smoking habits smoking (yes/no). Physical activity during leisure time was assessed with the question; "In the past year, which of the following best describes your physical activity during your leisure time?" The response options were: (1) Reading, watching television, or engages in other sedentary activities, (2) Walking, cycling, or performing other light physical activities for at least 4 h per week, (3) Participates in structured exercise or performs heavy gardening or similar activities for at least 4 h per week, or (4) Participating in intense training or competitive sports several times a week. Self-rated health was determined by using a 5-point scale; poor, fair, good to excellent from the COPSOQ II questionnaire (24). Poor health is linked to earlier retirement, as chronic conditions or functional limitations make work more difficult (25). Those in better health are more likely to engage in skill development, which can enhance employability and extend working life (26).

2.4.3.3 Physical demands at work

Physical demands at work were assessed using the question: "how will you describe your general physical activity at work? Mostly sedentary work that does not require physical exertion, mostly standing or walking work that otherwise does not require physical exertion, standing or walking work with a fair amount of lifting and carrying, or heavy or fast-paced work that requires physical exertion. Physically demanding jobs were considered a potential confounder, as they are linked to reduced work ability, especially in older workers (27). These jobs can lead to earlier retirement due to physical strain (25, 28) and offer fewer opportunities for skill development, which can reduce the ability to prolong working life.

TABLE 1 Characteristics of the included sample.¹

| Variable | <i>n</i> | Percent (%) |
|---|----------|-------------|
| Age | | |
| 55–59 | 11,129 | 49.4 |
| 60–64 | 8,455 | 37.5 |
| 65+ | 2,960 | 13.1 |
| Sex | | |
| Male | 11,543 | 51.2 |
| Female | 11,001 | 48.8 |
| Workplace location (demographics) | | |
| Capital Region | 8,409 | 37.39 |
| Central Denmark Region | 4,757 | 21.15 |
| North Denmark Region | 2,178 | 9.68 |
| Region Zealand | 2,911 | 12.94 |
| Region of Southern Denmark | 4,237 | 18.84 |
| Smoking | | |
| Yes | 2090 | 9.3 |
| No | 20,326 | 90.7 |
| BMI | | |
| Underweight (< 18.5) | 217 | 1.0 |
| Normal weight (18.5–24.9) | 8,873 | 41.2 |
| Overweight (25–29.9) | 8,745 | 40.6 |
| Obesity (30 and above) | 3,682 | 17.1 |
| Physical activity in leisure time | | |
| Reads, watches television, or engages in other sedentary activities | 1863 | 8.3 |
| Takes walks, cycles, or engages in other light physical activities for at least 4 h per week | 14,440 | 64.4 |
| Participates in structured exercise or performs heavy gardening or similar activities for at least 4 h per week | 5,636 | 25.1 |
| Engages in intense training and regularly participates in competitive sports several times a week. | 501 | 2.2 |
| Physical activity at work | | |
| Most sedentary work, which does not require physical exertion | 14,079 | 62.5 |
| Mostly standing or walking work, which otherwise does not require physical exertion | 6,336 | 28.1 |
| Standing or walking work involving some lifting or carrying. | 1832 | 8.1 |
| Heavy or fast-paced work that is physically demanding. | 297 | 1.3 |
| Unions² | | |
| AC | 7,697 | 34.1 |
| CO10 | 4,377 | 19.4 |
| LC | 2,968 | 13.2 |
| OAO | 7,021 | 31.1 |
| Others | 481 | 2.1 |
| Health | | |
| Good to Excellent | 20,077 | 89.3 |
| Poor to Fair | 2,409 | 10.7 |
| Do you know exactly what your work tasks are? | | |
| 1. Always or often | 20,166 | 89.45 |
| 2. Sometimes | 1877 | 8.33 |
| 3. Never or rarely | 501 | 2.22 |

(Continued)

TABLE 1 (Continued)

| Variable | <i>n</i> | Percent (%) |
|--|----------|-------------|
| Do you and your colleagues recognize each other at work? | | |
| 1. Always or often | 16,705 | 74.1 |
| 2. Sometimes | 4,402 | 19.53 |
| 3. Never or rarely | 1,437 | 6.37 |
| Do you have influence on how you perform your work tasks? | | |
| 1. Always or often | 19,607 | 86.97 |
| 2. Sometimes | 2,213 | 9.82 |
| 3. Never or rarely | 724 | 3.21 |
| Do you have influence on when you perform your work tasks? | | |
| 1. Always or often | 15,833 | 70.23 |
| 2. Sometimes | 4,394 | 19.49 |
| 3. Never or rarely | 2,317 | 10.28 |
| Does your job give you confidence and job satisfaction? | | |
| 1. To a high degree | 14,606 | 64.79 |
| 2. To some degree | 6,171 | 27.37 |
| 3. To a lesser degree | 1,767 | 7.84 |
| Participated in or completed any of the following forms of skills development | | |
| Courses | 10,522 | 46.7 |
| Formal education | 1,803 | 8.0 |
| Other forms of skills development | 10,532 | 46.7 |
| Not participated in any form of skills development | 6,470 | 28.7 |
| At what age do you expect to leave the workforce completely? | | |
| 65 years or younger | 7,363 | 33.4 |
| 66–67 years | 6,168 | 28.0 |
| 68–69 years | 4,050 | 18.4 |
| 70 years or older | 4,482 | 20.3 |
| Work ability | | |
| Good work ability (8–10) | 16,330 | 72.4 |
| Moderate work ability (6–7) | 4,728 | 21.0 |
| Poor work ability (0–5) | 1,486 | 6.6 |

¹The total number of participants included in the sample is 22,544, which represents 42% of the initial sample. The remaining participants did not respond.

²AC: Academic Central Organization—Represents professionals with higher academic qualifications in various sectors. OAO: Public Employees' Organization—Represents unions for public sector employees. LC: Teachers' Central Organization—Represents teachers and educational staff in Denmark. CO10: Central Organization 2010—Represents civil servants in various administrative roles within the public sector.

2.4.3.4 Psychosocial work factors including role clarity, influence at work, recognition and job satisfaction

Participants provided information on psychosocial work factors such as role clarity, influence at work, recognition, and job satisfaction, in part through the COPSOQ II questionnaire (24). To assess role clarity, we asked participants the following question: “Do you have a clear understanding of your work tasks?” with response options ranging from “always,” “often,” “sometimes,” “rarely,” to “never.” Recognition was measured by asking: “Do you and your colleagues acknowledge each other's work?” using the same response scale. Influence at work was assessed with the question: “Do you have influence on how you perform your tasks?” with possible responses ranging from “always” to “never.” We also asked: “Do you feel that your work is recognized and appreciated by management?” with similar response options. Finally, job satisfaction was evaluated by asking: “Does your work give you confidence and job

satisfaction?” with responses ranging from “to a very high degree,” “to a high degree,” “to some degree,” “to a lesser degree,” to “not at all.

Poor psychosocial working conditions, such as low recognition and job satisfaction, can push individuals toward early retirement by reducing work ability and increasing job strain (29). In contrast, a positive work environment can support skill development and prolong working life. Research shows that improving these factors can enhance work ability and delay retirement (30, 31).

2.5 Statistical analyses

SAS version 9.4 (SAS Institute, Cary, North Carolina, USA) were used for statistical analysis. We used the GLM (General Linear Model) procedure to calculate least squares mean differences between skills

development vs. no skill development and work ability or expected retirement age. Model-assisted weights were used for the SurveyFreq and SurveyLogistic procedures to produce representative estimates and 95% confidence intervals. These weights were based on age, sex, unions.

“We assessed the normal distribution of our continuous variables and verified the assumptions of the Generalized Linear Model (GLM) by evaluating residuals using histograms, residual plots, and Q-Q plots.”

We controlled for age, sex, BMI, physical demands at work, smoking, physical activity in leisure time, general health and psychosocial work factors including role clarity, influence at work, recognition and job satisfaction, in our main analysis. These confounders were selected based on Spearman correlation and previously demonstrated associations between these factors and skill development (23, 30, 31), work ability (21, 27, 29–31), and/or expected retirement age (22, 26, 28–31) are discussed in the section above.

We conducted a stratified analysis to examine subgroup differences. The analysis was stratified by age and sex, guided by existing literature, and adjusted for organizational affiliation, smoking, leisure-time physical activity, and BMI. Age was divided into two groups: 55–59 years and 60 years and older, reflecting key differences in labor market participation and life stages. The 55–59 age group typically includes individuals who are still active in the workforce but may start considering retirement. In contrast, the 60+ group represents a transition phase where many either retire or significantly reduce their workforce participation (23, 32). Within age groups we additionally, controlled for age as a continuous variable.

2.5.1 Sensitivity analyses

We conduct sensitivity analyses based on existing literature to assess the robustness of our findings regarding sedentary work as a predictor of educational attainment and our outcomes. Specifically, these sensitivity analyses explore whether variations in the sedentary work variable influence the relationships observed with educational level and self-reported health.

3 Results

We analyzed data from 22,544 participants. Table 1 presents the characteristics of the included participants. It shows a nearly equal representation of male and female participants (51.2 and 48.8%, respectively). The majority (49.4%) of participants were within the 55–59 age group. Additionally, 89.3% perceived their health as good or excellent. Our findings indicated that our included sample predominantly has sedentary jobs as less than 10% stated that they had either Standing or walking work involving some lifting or carrying or heavy or fast-paced work that is physically demanding.

A large proportion of participants had engaged in some form of skills development, with only 28.7% reporting no participation. Courses and other skills development activities were particularly favored or offered to the participants. In total, 33.4% of workers expected to retire before the official retirement (67 years) age, while 38.7% of workers expected to continue working beyond the statutory retirement age. Moreover, 72.4% perceived their work ability as good or moderate, while 6.6% perceived their work ability as poor.

3.1 Skills development and work ability

Table 2 presents the results of the GLM assessing the association of skills development with work ability. The fully adjusted model shows a statistically significant association between all three forms of skills development and a higher level of work ability: courses 0.12 (95% CI 0.08 to 0.16), formal education 0.18 CI (0.11 to 0.26) and other forms of skills development 0.14 CI (0.10 to 0.18).

3.1.1 Skills development and work ability stratified analysis on age and sex

We performed stratified analyses to investigate the relationship between age, sex, skills development and work ability. Due to the risk of over-adjustment in Model 3, where psychosocial work factors could act as either a mediator or a collider, we chose to use Model 2.

TABLE 2 Main GLM analysis of courses, formal education and other forms of skills development on work ability and expected retirement age cumulative modeling adjustment.

| Outcomes | Exposure | Model 1 ^A | | | Model 2 ^B | | | Model 3 ^C | | |
|--|-----------------------------------|-----------------------------------|----------------|--|-----------------------------------|----------------|--|-----------------------------------|----------------|--|
| | | Between-group mean diff. (95% CI) | <i>p</i> value | | Between-group mean diff. (95% CI) | <i>p</i> value | | Between-group mean diff. (95% CI) | <i>p</i> value | |
| Work ability (0–10) | Courses | 0.17 (0.13 to 0.21) | <0.0001 | | 0.15 (0.11 to 0.19) | <0.0001 | | 0.12 (0.08 to 0.16) | <0.0001 | |
| | Formal education | 0.20 (0.13 to 0.28) | <0.0001 | | 0.19 (0.12 to 0.26) | <0.0001 | | 0.18 (0.11 to 0.26) | <0.0001 | |
| | Other forms of skills development | 0.25 (0.21 to 0.29) | <0.0001 | | 0.20 (0.16 to 0.24) | <0.0001 | | 0.14 (0.10 to 0.18) | <0.0001 | |
| Expected retirement age (unit: years)* | Courses | 0.12 (0.04 to 0.19) | 0.002 | | 0.11 (0.03 to 0.18) | 0.006 | | 0.09 (0.01 to 0.17) | 0.020 | |
| | Formal education | 0.69 (0.55 to 0.83) | <0.0001 | | 0.68 (0.54 to 0.82) | <0.0001 | | 0.68 (0.54 to 0.82) | <0.0001 | |
| | Other forms of skills development | 0.26 (0.18 to 0.33) | <0.0001 | | 0.26 (0.18 to 0.34) | <0.0001 | | 0.22 (0.14 to 0.30) | <0.0001 | |

^AAdjusted for sex, age and organizations.

^BFurther adjusted for smoking, physical activity in leisure time, physical demands at work, and BMI.

^CFurther adjusted for demographics, psychosocial work factors and health*.

Psychosocial factors might mediate the associations of skills development on work ability by improving aspects like job satisfaction and stress levels, which in turn enhance work ability. Alternatively, if these factors influence both skills development and work ability, adjusting for them could distort the true relationship. Thus, we opted for Model 2 to provide a more accurate assessment of the link between skills development and work ability. Skills development remained associated with work ability for all stratified groups, except for older men and formal education. Significant associations were found for formal education among younger men 0.26 (CI 0.13 to 0.40) and older women 0.28 (CI 0.09 to 0.47) and other forms of skills development among younger women 0.24 (CI 0.15 to 0.32) and older men 0.18 (CI 0.11 to 0.25) (see [Table 3](#)).

3.1.2 Skills development and work ability sensitivity analysis on sedentary workers and good health

We conducted a sensitivity analysis focusing on sedentary workers with good or excellent self-reported health. Statistically significant associations were observed for skill development and work ability, though the mean differences were minor (see [Table 4](#)).

3.2 Skills development and expected retirement age

In addition to exploring the association between skills development and work ability, we investigated the relationship between skills development and expected retirement age. Due to the varied plots observed regarding normal distribution, we opted to trim our data to focus solely on the expected retirement age between 55 and 80 years. This decision was informed by the plots demonstrating normal distribution within this age group.

We observed a significant positive association between skills development and expected retirement age across all models. The fully adjusted model shows a statistical significant association between course 0.09 years CI (0.01 to 0.17), formal education 0.68 years CI (0.54 to 0.82) and other forms of skills development 0.22 years CI (0.14 to 0.30) and higher expected retirement age (see [Table 2](#)).

3.2.1 Skills development and expected retirement age: stratified analysis on age and sex

We performed a stratified analysis to investigate the relationship between age and sex for skills development, and expected retirement age. The analysis was based on Model 2, as Model 3 was deemed at high risk of being over-adjusted as mentioned in the previous section regarding stratified analysis. For all stratified groups; younger men 0.14 years (−0.08 to 0.35), younger women 0.13 years (−0.04 to 0.31), older men −0.11 years (−0.29 to 0.08) and older women 0.15 years (−0.02 to 0.31), courses were not significant. For both younger (59 years old and below) 0.11 years (−0.06 to 0.29) and older women (60 years old and above) 0.02 years (−0.15 to 0.18), other forms of skills development were not significant as well. Formal education and expected retirement age were significantly positively associated, with a mean difference of younger men 0.57 years (CI 0.21 to 0.92), younger women 0.80 (CI 0.53 to 1.07), older men 0.67 years (CI 0.25 to 1.10) and older women 0.85 years (CI 0.49 to 1.20) (see [Table 3](#)).

TABLE 3 Stratified analysis of skills development stratified on sex and age (below and above 60 years old) on work ability and expected retirement age.

| Outcomes | Exposures | Model 2 stratified ^a | | | | | | | |
|---------------------------------------|-----------------------------------|-----------------------------------|---------|-----------------------------------|---------|-----------------------------------|---------|-----------------------------------|---------|
| | | Younger men | | Younger women | | Older men | | Older women | |
| | | Between-group mean diff. (95% CI) | p value | Between-group mean diff. (95% CI) | p value | Between-group mean diff. (95% CI) | p value | Between-group mean diff. (95% CI) | p value |
| Work ability (0–10) | Courses | 0.19 (0.11 to 0.27) | <0.0001 | 0.15 (0.07 to 0.24) | 0.0003 | 0.16 (0.09 to 0.23) | <0.0001 | 0.11 (0.02 to 0.19) | 0.0129 |
| | Formal education | 0.26 (0.13 to 0.40) | 0.0001 | 0.16 (0.03 to 0.29) | 0.0148 | 0.05 (−0.12 to 0.21) | 0.574 | 0.28 (0.09 to 0.47) | 0.0033 |
| | Other forms of skills development | 0.19 (0.10 to 0.27) | <0.0001 | 0.24 (0.15 to 0.32) | <0.0001 | 0.18 (0.11 to 0.25) | <0.0001 | 0.18 (0.09 to 0.27) | <0.0001 |
| Expected retirement age (Unit: years) | Courses | 0.14 (−0.08 to 0.35) | 0.205 | 0.13 (−0.04 to 0.31) | 0.127 | −0.11 (−0.29 to 0.08) | 0.255 | 0.15 (−0.02 to 0.31) | 0.077 |
| | Formal education | 0.57 (0.21 to 0.92) | 0.002 | 0.80 (0.53 to 1.07) | <0.0001 | 0.67 (0.25 to 1.10) | 0.002 | 0.85 (0.49 to 1.20) | <0.0001 |
| | Other forms of skills development | 0.43 (0.20 to 0.65) | 0.0002 | 0.11 (−0.06 to 0.29) | 0.206 | 0.23 (0.04 to 0.42) | 0.016 | 0.02 (−0.15 to 0.18) | 0.831 |

Adjusted for organizations, smoking, physical activity in leisure time, physical demands at work, and BMI.

TABLE 4 Sensitivity analysis on skills development and sedentary workers with good self-rated health on work ability and expected retirement age.

| Outcomes | Exposures | Model 2 ^A | | | Model 3 ^B | | |
|--|-----------------------------------|-----------------------------------|-----------------|---------|-----------------------------------|-----------------|---------|
| | | Between-group mean diff. (95% CI) | | p value | Between-group mean diff. (95% CI) | | p value |
| Work ability (0–10) | Courses | 0.07 | (0.02 to 0.11) | 0.002 | 0.05 | (0.01 to 0.09) | 0.020 |
| | Formal education | 0.10 | (0.02 to 0.18) | 0.013 | 0.09 | (0.01 to 0.17) | 0.024 |
| | Other forms of skills development | 0.11 | (0.07 to 0.16) | <0.0001 | 0.06 | (0.02 to 0.10) | 0.008 |
| Expected retirement age (Unit: years)* | Courses | 0.05 | (−0.05 to 0.16) | 0.297 | 0.06 | (−0.04 to 0.16) | 0.249 |
| | Formal education | 0.65 | (0.46 to 0.84) | <0.0001 | 0.67 | (0.48 to 0.86) | <0.0001 |
| | Other forms of skills development | 0.16 | (0.06 to 0.26) | 0.003 | 0.12 | (0.01 to 0.22) | 0.026 |

^AAdjusted for age, sex, organizations, smoking, physical activity in leisure time and BMI.

^BAdjusted for age, sex, organizations, smoking, physical activity in leisure time, BMI, demography, psychosocial work factors and health*.

3.2.2 Skills development and expected retirement age: sensitivity analysis

When the sensitivity analysis was focusing on sedentary workers with good self-reported health (good and excellent), courses were not significant in either models, while other forms of skills development revealed statistically significant. Formal education remained statistically significant, indicating robust findings [Model 2: 0.65 (CI 0.46 to 0.84), Model 3: 0.67 (CI 0.48 to 0.86)].

4 Discussion

4.1 Main results

Our study found that skills development is positively associated with both work ability and expected retirement age among state employees aged 55 and above. Notably, formal education was significantly associated with expected retirement age, see Table 2, while other forms of skills development were significantly linked to work ability see Table 2, model 1 and 2. These findings underscore the importance of targeted skills development programs as a means to potentially enhance work ability and extend working lives for senior workers. By focusing on improving specific types of skills, employers and policymakers could support older workers in maintaining their capacity to work and adjust their retirement expectations.

Although our study is cross-sectional, meaning causality cannot be established; our results are consistent with those of other cross-sectional and prospective studies, which have demonstrated positive relationships between skills development and work ability and expected retirement age. Previous cross-sectional research has shown that skills development is associated with higher work ability (33) and prospective studies further suggest that engaging in skills development may contribute to reduce early or delay retirement (8, 9, 13, 34).

4.2 Statistical significance vs. practical relevance

While many of our results were statistically significant, it is important to assess their practical relevance. For instance, the association of courses on expected retirement age was relatively modest compared to formal education. This underscores the need to prioritize the most beneficial forms of skills development in policies

and practices. The association of formal education on expected retirement age indicates that investing in higher-level training could be particularly beneficial for prolonging working lives.

Our results show that the difference in work ability remained within less than one point. To evaluate the practical relevance of between differences in work ability, it is essential to establish a threshold that signifies a meaningful difference. Minor changes, such as 0.1 points, are insufficient to meet practical relevance criteria. Evidence suggests that a minimum change of one point in the Work Ability scale is required to achieve practical relevant outcomes (19, 21, 35). A one-point reduction in the Work Ability scale increases the risk of long-term sickness absence by 15.1% and early retirement by 33%, while a one-point increase reduces the risk of mobility limitations among retirees (19, 21, 35). Consequently, for changes in work ability to be meaningful and clinically relevant, they must exceed one point. Even though we discuss the potential lack of clinical relevance in work ability, even small differences in expected retirement age could be significant when viewed from a broader social and economic perspective.

4.3 Job supply

Our main analysis revealed that receiving formal skills development is associated with a higher expected retirement age between 0.68–0.69 full-time equivalent (FTE) years depending on models. For those who have not received such training, this potential extension in work life could be significant. To illustrate the potential implications, if formal skills development were implemented across the sample, we could potentially increase the labor supply by a substantial number of FTE years. Specifically, this could result in an aggregate gain of $(6.470 \times 0.68) = 4,400 - (6,470 \times 0.69) = 4,464$ FTE years.

Considering other forms of skills development, we observed a higher expected retirement age in the main analysis between 0.22–0.26 years. This potentially translates to an increase in labor supply by 1,423–1,682 FTE years for those who have not received any form of skills development.

Our findings highlight the importance of implementing comprehensive skills development programs to extend working lives and enhance labor supply. This perspective shifts the focus from individual benefits to societal gains, demonstrating that offering skills development opportunities to those who currently

lack them could result in many additional years of work and productivity.

4.4 Theoretical perspective

Our research is informed by several theoretical frameworks, including Human Capital Theory and Social Exchange Theory in the form of Reciprocity Theory. Together these frameworks provide a comprehensive understanding of the interplay between motivations, work ability, expected retirement age, and skills development in older workers.

Human Capital Theory emphasizes the importance of investing in skills and knowledge to enhance productivity and job security (36). This concept is reflected in our findings, where increased skills development is linked to higher work ability. Public policies inspired by Human Capital Theory often focus on promoting workplace training, lifelong learning subsidies, and incentives for employers to support skill development among workers. These policies are particularly critical for older workers, as they help maintain employability, improve productivity, and potentially delay retirement (37, 38). Access to training improves not only professional skills but also overall well-being (37, 39). By equipping older workers with the skills needed to adapt to technological changes and evolving job demands, these initiatives may also contribute to sustainable labor market participation and reduce pressure on public pension systems.

Additionally, Reciprocity Theory, rooted in Social Exchange Theory, highlights the reciprocal relationship between workers and employers. When workers perceive that their employers invest in their development, they often feel an obligation to reciprocate through increased loyalty and extended tenure (40–42). Our data align with this, showing a positive association between skills development and a higher expected retirement age, suggesting that workers who perceive employer investment in their development are more likely to extend their tenure. Studies like Venneberg and Wilkinson (43) and Li et al. (11) further emphasize the importance of utilizing older workers' accumulated knowledge and fostering supportive organizational climates for skills development and retention. Integrating these perspectives underscores the mutual benefits of investing in older workers' skills: while workers improve their productivity and career stability, employers benefit from increased retention and engagement.

4.5 Practical recommendations

For a practical approach to addressing the challenges of an aging workforce, it is essential to consider the implementation of effective skills development programs. To improve work ability and potentially extend the expected retirement age, skills development programs for senior workers could include several suggested features. These might involve customized training content addressing both job-specific and transferable skills, flexible delivery methods to suit individual needs, and supportive organizational structures to facilitate the application of new skills. Additionally, integrating health-promoting elements and offering incentives for participation may enhance engagement and effectiveness. For

instance, workplace-based digital literacy training combined with peer mentoring could improve skills while fostering intergenerational collaboration and engagement. Based on our findings, we propose that employers and policymakers consider skills development, particularly formal education, as a potential strategy to extend working lives and improve work ability among older workers. However, it is important to recognize that our study only shows an association, not causation. The varying associations of different types of skills development suggest that a tailored approach may be beneficial. Workplaces could consider offering a mix of formal education and other skills development opportunities to maximize benefits for both work ability and extended working lives. Further research is needed to determine long-term outcomes and optimal implementation strategies, but our results provide a foundation for promoting skills development as a component of age management policies.

4.6 Strength and limitations

Our cross-sectional design provides valuable insights but also has limitations. The use of self-reported data may lead to recall bias in relation to participation in skills development and expectation bias in relation to expected retirement age. Additionally, the questions used to measure skills development were not validated, which may affect the results. Although the categories were developed in collaboration with relevant stakeholders, the lack of validation means we cannot fully confirm that the measures accurately capture the intended constructs of skills development in this specific context.

In terms of selection bias, while we were unable to perform a non-response analysis, our response rate of 42% is relatively reasonable, although it is somewhat lower than similar surveys of workers, such as the Work Environment and Health Study (AH study) (response rate of 60%) (44) and the Senior Working Life study (response rate of 62%) (16). We also applied weighting based on age, sex and organizations to account for non-respondents. Despite this, we cannot be certain of the characteristics of those who did not respond. Additionally, as participation in the study was voluntary, the sample is non-random and reflects only those who chose to participate. If, as studies suggest, non-respondents are primarily individuals with lower educational attainment, poorer work ability, and an earlier expected retirement age—those who may benefit most from skills development—this could further compromise the validity of our findings and restrict their generalizability to the broader population of Danish State employees aged 55 years and above.”

In our analysis, we considered the potential for over-adjustment in Model 3, particularly regarding psychosocial work factors and health. These variables could act as either colliders or mediators in the relationship between skills development and work ability or expected retirement age. If they are mediators, adjusting for them might obscure the true association of skills development. Conversely, if they are colliders, controlling for them could introduce bias and distort the observed relationship. Despite this, the results remain significant even when these variables are not adjusted for, suggesting that the potential influence of these factors as colliders or mediators may be less pronounced. Therefore, while Models 2 and 3 provide valuable insights, Model 2 may represent the most reliable approach given the potential complexities of over-adjustment in Model 3.

While we were unable to control for all relevant variables, such as educational level and socioeconomic status, we did account for union organizations, as described in the methods section. The anticipated variation in education levels among different employee groups—specifically AC (Academic Central Organization), CO10 (Central Organization 2010), LC (Teachers' Central Organization), and OAO (Public Employees' Organization)—reflects the unique requirements of each category. Typically, AC members hold advanced degrees, whereas CO10 and LC employees display a broader range of educational backgrounds, from secondary education to higher qualifications. OAO includes a diverse array of educational attainment levels, underscoring the varied nature of jobs and industries represented. This educational diversity can influence job responsibilities, career advancement opportunities, and overall job satisfaction across these groups. For instance, the significant association between formal education and expected retirement age may partially stem from existing differences in educational background and career opportunities.

Future studies with longitudinal designs and register-based measures could further strengthen our findings and help interpret these associations. While our study provides insights into workers' intentions regarding retirement, we acknowledge that expected retirement age does not necessarily reflect actual retirement behavior. To address this, future research could examine the prospective association between skills development and actual retirement age, using longitudinal data and register linkage to clarify whether the positive associations observed in our study translate into actual changes in retirement patterns. Longitudinal studies are essential for exploring how changes in skills and work ability influence retirement timing. Additionally, register-based measures and intervention-based studies would offer valuable insights into the impact of targeted skills development programs on retirement patterns. Replicating these findings across different occupational and national contexts would also enhance our understanding of the generalizability of these associations.

A key strength of our study was that we conducted sensitivity and stratified analyses to assess the consistency of our results. These analyses allowed us to test the stability of our findings under various conditions and explore differences within subgroups. While caution is needed regarding the error estimates due to the use of split subsamples, the significant associations observed remained consistent, which supports the reliability of our conclusions.

5 Conclusion

Our study demonstrates a positive association between skills development and both work ability and expected retirement age among our sample of Danish State employees aged 55 years and above. Specifically, formal education exhibits the significant association with extending the expected retirement age; while other forms of skills development most significantly showed a positive association with work ability. However, as participation in the study was voluntary and the sample is therefore non-random, the findings should be interpreted with caution and cannot be directly generalized to all Danish State employees aged 55 years or above. Further replication studies are needed to assess the stability and broader applicability of these results. Despite this limitation, these

findings highlight the potential of targeted skills development initiatives to enhance work ability and prolong working lives among older workers.

Data availability statement

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

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

KS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. SS: Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. ES: Conceptualization, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. OM: Conceptualization, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. LA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

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

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Antecedents of perceived teacher work ability: a comprehensive model across work and non-work domains

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Introduction: This study investigates the antecedents of perceived teacher work ability, a critical construct for addressing challenges associated with extending working lives and maintaining sustained professional engagement in the teaching profession. Grounded in the job demands-resources (JD-R) model, this cross-sectional study investigates the relationships between job demands (quantitative, cognitive, and emotional), job resources (supervisor support, coworker support, and autonomy), burnout, and work-life conflict in shaping perceived teacher work ability.

Methods: Data were obtained from 841 Czech primary and lower secondary school teachers (86.1% female) with a mean age of 45.9 years ($SD = 10.8$). The full SEM model was developed and estimated based on the proposed hypotheses.

Results: The findings suggest that burnout is the most significant antecedent of perceived teacher work ability, with quantitative and emotional job demands indirectly influencing it through burnout. While supervisor and coworker support directly enhance perceived teacher work ability, autonomy primarily alleviates quantitative and emotional job demands, thereby indirectly mitigating burnout. Work-life conflict partially mediates the relationship between job demands and burnout but does not directly impact perceived teacher work ability.

Discussion: These results contribute to a deeper understanding of the interplay between job demands, job resources, and burnout in enhancing teachers' capacity to meet the multifaceted demands of their profession effectively.

KEYWORDS

work ability, perceived teacher work ability, job demands, job resources, teacher burnout, work-life conflict

Introduction

In recent decades, the demographic composition of the teaching population has undergone significant changes. The aging of the teaching workforce is a widespread and critical phenomenon observed across North and Latin America, as well as in many European countries (European Commission, 2023a; UNESCO, 2024). The average age of Czech teachers in primary and lower secondary schools is 46 years, with over 65% aged 50 or older (Czech School Inspectorate, 2023). Due to an aging workforce, educational systems are either already facing or will soon encounter significant teacher shortages, which pose a range of challenges for both educational policies and systems (UNESCO, 2024). At the individual level, research indicates that such shortages can lead to a considerable increase in the workload of current teachers (European Commission, 2023c). In response to these demographic shifts, there is a need to develop and implement target support strategies that address the distinct needs of teachers across all age groups, aimed at enhancing their capacity to perform job tasks effectively and improving retention within the profession.

In efforts to extend working lives, growing attention has been directed toward the construct of work ability (WA), defined as an individual's ability or perception of their ability to meet job demands and complete required tasks (Ilmarinen et al., 1997). This construct was proposed in the 1980s by researchers at the Finnish Institute of Occupational Health to assess whether individuals can continue to meet the physical and psychosocial requirements of their profession (Ilmarinen et al., 1991). Ilmarinen et al. (2005) emphasizes that high WA is crucial for promoting longer work life and preventing early retirement. Conversely, low WA results in a range of unfavorable employment outcomes. For instance, it is linked to a decline in work performance and productivity (Van Den Berg et al., 2009), short-term and long-term absenteeism (Alavinia et al., 2009; Sell, 2009), low job satisfaction (Milosevic et al., 2011), the decision to leave the profession prematurely and early retirement (McCarthy et al., 2024; McGonagle et al., 2015; Vertanen-Greis et al., 2022).

Since its establishment, WA has primarily been assessed based on evaluations of an individual's health and functional capacity. However, recent critiques of this construct have led to a differentiation between objective and perceived WA (Brady et al., 2020; Cadiz et al., 2019; Freyer et al., 2019; McGonagle et al., 2015). Objective WA is based on assessing the employee's health and functional limitations (McGonagle et al., 2022). In contrast, perceived WA refers to the worker's self-perception or subjective assessment of their ability to continue working in their current job, considering the job characteristics and available resources (McGonagle et al., 2022). Despite substantial research focusing on objective WA (Cadiz et al., 2019), perceived WA has received considerably less attention (Guidetti et al., 2018; Hlado and Harvankova, 2024; Magnavita et al., 2024; McCarthy et al., 2024; McGonagle et al., 2015, 2022; Selander et al., 2023). Furthermore, research on perceived WA has predominantly focused on non-teaching professional populations, highlighting the need for more targeted studies on teachers' WA.

This study focuses on teachers' perceived work ability (PTWA), conceptualized as the subjective evaluation of their physical and mental capacity to meet job requirements and effectively navigate the diverse physical, cognitive, interpersonal, emotional, and organizational demands inherent in contemporary teaching roles (Hlado and Harvankova, 2024; McCarthy et al., 2024). The goal of this study is to provide a more nuanced understanding of the antecedents of PTWA while advancing theoretical frameworks, informing future research, and offering recommendations for planning and implementing PTWA interventions. We surveyed a large and diverse group of Czech primary and lower secondary school teachers to achieve this goal. The Czech Republic is particularly suited for this research because it is one of the OECD countries with a high proportion of aging teachers. Nearly one-third of teachers in the Czech Republic (30.5%) are aged 55 or older, considerably exceeding the EU average of 24.5% (European Commission, 2023b).

We contribute to the literature by comprehensively examining the antecedents of PTWA. The job demands-resources (JD-R) model and WA research (Bakker et al., 2005; Cadiz et al., 2019; Hlado and Harvankova, 2024) have identified three key categories that play a significant role in the depletion of perceived WA: job demands, job resources, and burnout. Therefore, we investigate

how job demands (quantitative, qualitative, and emotional), job resources (supervisor, coworker support, and autonomy), and teacher burnout interact to affect PTWA. In addition to replicating established predictors of perceived WA, we contribute to the literature by exploring an additional determinant—work-life conflict—which is not included in the JD-R model (Demerouti et al., 2001; Demerouti and Bakker, 2011) and remains underexplored. Thus, the present study empirically tests the underlying psychological processes captured in the JD-R model, which has been expanded to include a non-work domain. The contribution of our study lies in its holistic approach, investigating the effects of the model variables on PTWA and the complex interrelationships among them.

Theoretical background and hypotheses development

The construct of WA initially emerged without a theoretical grounding (Cadiz et al., 2019). A proper theoretical framework for investigating WA, particularly PTWA, is provided by the JD-R model (Cadiz et al., 2019; Demerouti et al., 2001; Demerouti and Bakker, 2011; Schaufeli, 2017; Schaufeli and Taris, 2014). Although the JD-R model was not designed initially to address WA, it has been effectively applied in this context. Perceived WA can be integrated into the JD-R model as an outcome that is positively influenced by job resources and negatively affected by job demands (Brady et al., 2020; Cadiz et al., 2019; Hlado and Harvankova, 2024; McGonagle et al., 2014, 2022; Schaufeli and Taris, 2014).

The JD-R model (Bakker and Demerouti, 2007) asserts that every job encompasses various types and levels of job demands that can impede employee functioning while also highlighting the role of job resources that can support and enhance employee performance and wellbeing. Job demands refer to the physical, psychological, social, or organizational characteristics of a job that require sustained physical or mental effort and are associated with physical and psychological costs (Demerouti et al., 2001). Examples of job demands in the teaching profession include work overload, administrative tasks, time pressure, multitasking, responsibility, disruptive student behavior and misbehavior, difficulties in communication and cooperating with parents (Hlado et al., 2020; Hlado and Harvankova, 2024; Schaufeli and Taris, 2014). Conversely, job resources are the physical, psychological, social, or organizational factors that can be functional in achieving work goals, reducing job demands and associated physiological and psychological costs, and encouraging personal growth and development (Schaufeli, 2017). In the context of teaching, job resources include job control, a supportive social climate, constructive feedback, supervisory coaching, student appreciation, and professional development opportunities (Hlado and Harvankova, 2024; Schaufeli and Taris, 2014).

The JD-R model delineates two independent psychological processes: health impairment and motivation (Bakker and Demerouti, 2007; Demerouti and Bakker, 2011; Schaufeli and Taris, 2014; Taris et al., 2017). First, the health impairment or energetic process posits that when job demands exceed individual capabilities and are accompanied by low levels of job resources, it can result in the depletion of mental and physical energy. This depletion, in turn,

may contribute to developing health-related issues and adverse job-related outcomes, including reduced WA. The JD-R model in the health impairment process suggests that the relationship between job demands and outcomes mediates burnout through the gradual depletion of mental resources. Second, the motivational process posits that job resources have motivational potential, fostering high work engagement and positive job-related outcomes (e.g., work performance, innovativeness, organizational commitment, service quality, and intention to stay).

Alongside the main effects of job demands and resources, the JD-R model specifies how job demands and job resources interact and predict important outcomes (Bakker et al., 2005, 2007; Bakker and Demerouti, 2007; Demerouti and Bakker, 2011). More specifically, the buffering hypothesis postulates that high levels of job resources can mitigate the adverse effects of job demands on job strain, including burnout and other outcomes.

The effect of job demands

Job demands were linked to physical and psychological costs incurred by teachers in meeting job tasks and challenges (Hlado and Harvankova, 2024). Job demands are recognized as crucial determinants affecting WA (Brady et al., 2020; Kunz and Millhoff, 2023). Prior research has shown that various physical, mental, psychosocial, and emotional job demands negatively impact WA across general adult populations as well as perceived WA in the teaching profession (Cadiz et al., 2019; Hlado and Harvankova, 2024; Truxillo et al., 2020). Among teachers, the job demands affecting WA include aspects like a poor indoor environment, workplace noise, high workload (which involves administrative tasks and supervision of students during breaks), homeroom teacher duties, and coping with challenging interactions with students such as student misbehavior, lack of discipline in the classroom, and instances of violence and aggression. Additionally, interactions with parents represent an important job demand (Alcantara et al., 2019; De Ceballos and Carvalho, 2021; Hlado et al., 2020; Hlado and Harvankova, 2024; Sottimano et al., 2017; Vertanen-Greis et al., 2022).

In the qualitative study conducted among upper secondary school teachers (Hlado and Harvankova, 2024), prolonged exposure to job demands was associated not only with a decline in PTWA but also with the occurrence of burnout—a work-related psychological syndrome characterized by physical and emotional exhaustion, depersonalization, reduced personal accomplishment, and diminished professional efficacy (Maslach et al., 2001). Numerous studies, including those focused on teachers (Hakanen et al., 2006; Skaalvik and Skaalvik, 2020; Xanthopoulou et al., 2007), have established this link between job demands and burnout. However, the JD-R model and related research (Hlado et al., 2020) suggest that burnout may also operate as a mediator between job demands and perceived WA. The aforementioned study (Hlado and Harvankova, 2024), in line with the health impairment process (Taris et al., 2017), found that when teachers perceived job demands as excessively high or burdensome or when they encountered obstacles in meeting these demands, their job stress increased. Job-related distress, if not effectively managed, led among the teachers

in this study to fatigue, exhaustion, and subsequently, physical and mental health issues, as well as a decline in PTWA (Hlado and Harvankova, 2024). In this light, we hypothesize:

- **Hypothesis 1:** Higher quantitative, cognitive, and emotional job demands are associated with (a) lower PTWA and (b) higher teacher burnout.
- **Hypothesis 2:** Burnout mediates the associations between quantitative, cognitive, and emotional job demands and PTWA.

Studies evaluating the limitations of the JD-R model highlight that this theory focuses exclusively on job-related aspects, neglecting the non-work domain (McGonagle et al., 2022). However, empirical evidence indicates that work and family are essential life domains, and achieving a balance between these two domains is crucial for teacher burnout and PTWA (Hlado et al., 2020; Hlado and Harvankova, 2024). The interconnection between work and family is supported by studies indicating that challenging job demands may lead to work-life conflicts on the one hand (Gu and Wang, 2021), while increased work-life conflicts are associated with higher levels of burnout and lower WA on the other (Abdelrehim et al., 2023; Bacci et al., 2024; Shields and Chen, 2021). However, generalizable findings regarding teachers are currently lacking. Drawing on the findings from a qualitative study among teachers (Hlado and Harvankova, 2024), work-life conflict may play a mediating role between job demands and burnout as well as perceived WA. Hlado and Harvankova's (2024) study revealed that teachers outside standard working hours frequently complete numerous tasks inherent to the teaching profession. As a result, this can contribute to work-life conflict, which may cause exhaustion and decrease their capacity to meet work requirements. Considering previous findings and the understanding that work and non-work domains are intricately intertwined and cannot be examined separately, we hypothesize that:

- **Hypothesis 3:** Higher levels of quantitative, cognitive, and emotional job demands are positively associated with increased teacher work-life conflict.
- **Hypothesis 4:** Work-life conflict is (a) positively associated with teacher burnout and (b) negatively associated with PTWA.
- **Hypothesis 5:** Work-life conflict mediates the relationships between quantitative, cognitive, and emotional job demands and (a) teacher burnout and (b) PTWA.

The effect of job resources

In the present study, we examined three of the seven categories identified as job resources positively related to WA (Brady et al., 2020): supervisor support, coworker support, and job control, represented by autonomy. Social support at work, provided by supervisors and coworkers, encompasses various forms of assistance, including instrumental, informational, emotional, and appraisal support, that employees receive within organizational settings (Jolly et al., 2021). Such support can directly reduce job

demands or make them seem less overwhelming, as evidenced by findings within the JD-R model (Demerouti et al., 2001; Schaufeli and Taris, 2014).

Research on diverse populations suggests that supportive organizational climates, positive supervisory and interpersonal relationships, constructive feedback, and both supervisor and coworker support can enhance WA (Ahlstrom et al., 2013; Airila et al., 2014; Bethge and Radoschewski, 2010; Boelhouwer et al., 2020; Feldt et al., 2009; Leijon et al., 2017; McGonagle et al., 2014). A study examining specific sources of social support among healthcare workers in Australia revealed that support provided by supervisors and coworkers significantly influences perceived WA (McGonagle et al., 2014). However, detailed insights into such effects among lower and upper secondary school teachers are lacking. The only available study, which focused on preschool teachers, revealed that coworker support alone has a significant positive impact on WA (Sottimano et al., 2017).

Research consistently highlights that supervisor and coworker support serve as vital resources that can alleviate the adverse effects of job demands. Specifically, supervisor and coworker support are associated with lower levels of burnout, particularly emotional exhaustion and depersonalization (Afota et al., 2024). Support from supervisors is recognized as a crucial resource for mitigating burnout across various professions, including the teaching profession (Leung and Lee, 2006).

In summary, support from supervisors and coworkers may play a crucial role in influencing teachers' levels of burnout and perceived WA, as well as their perceptions of job demands. Research findings, consistent with the JD-R model, suggest that social support at work serves as a job resource that may mitigate the negative effects of job demands while enhancing the capacity to meet these demands. Building on the theoretical and empirical arguments presented above, we propose the following hypotheses:

- **Hypothesis 6:** Higher levels of (a) supervisor support and (b) coworker support are associated with lower perceptions of quantitative, cognitive, and emotional job demands among teachers.
- **Hypothesis 7:** Higher levels of (a) supervisor support and (b) coworker support are associated with lower levels of teacher burnout.
- **Hypothesis 8:** Higher levels of (a) supervisor support and (b) coworker support are associated with higher levels of PTWA.
- **Hypothesis 9:** Quantitative, cognitive, and emotional job demands mediate the relationships between (a) supervisor support and PTWA and (b) coworker support and PTWA.

Autonomy, as a form of job control, refers to the extent to which individuals possess freedom, independence, and discretion in performing their work assignments (Morgeson and Humphrey, 2006). Although autonomy may present challenges related to responsibility for some teachers, thereby functioning as a job demand, research utilizing the JD-R model has previously recognized autonomy as a job resource (Taris et al., 2017). This construct includes the ability to schedule work, make decisions, and choose the methods and procedures used to perform tasks. Thus, autonomy can influence job demands by allowing teachers to tailor their job tasks and work plans to align with their strengths

and abilities. When teachers have the autonomy to determine the content of their work, along with the methods and procedures they employ, it can either directly reduce job demands or lead them to perceive these demands as more manageable and less challenging. This perception, in turn, may help mitigate the adverse effect of job demands on burnout and PTWA.

Conceptually, autonomy empowers teachers to determine the most effective way to align their available job resources with current demands. Accordingly, a lack of autonomy has been found to be adversely related to burnout and WA (Boelhouwer et al., 2020; Guo et al., 2023; Tuomi, 2001; Van Den Berg et al., 2009). Furthermore, autonomy is considered a preventing factor concerning work-life conflict (Brauchli et al., 2014; Thompson and Protas, 2006). Overall, autonomy may serve as a protective factor against work-life conflict, teacher burnout, and low PTWA, both directly and indirectly, through the management of job demands. Building on the theoretical and empirical arguments, we formulate the following hypotheses:

- **Hypothesis 10:** Autonomy in the teaching profession is negatively associated with (a) perceptions of quantitative, cognitive, and emotional job demands, (b) work-life conflict, and (c) burnout, while being positively associated with (d) PTWA.
- **Hypothesis 11:** Quantitative, cognitive, and emotional job demands mediate the relationship between autonomy and (a) work-life conflict, (b) burnout, and (c) PTWA.

The proposed research model, which conceptualizes the relationships among job demands, job resources, work-life conflict, burnout, and PTWA, is presented in Figure 1.

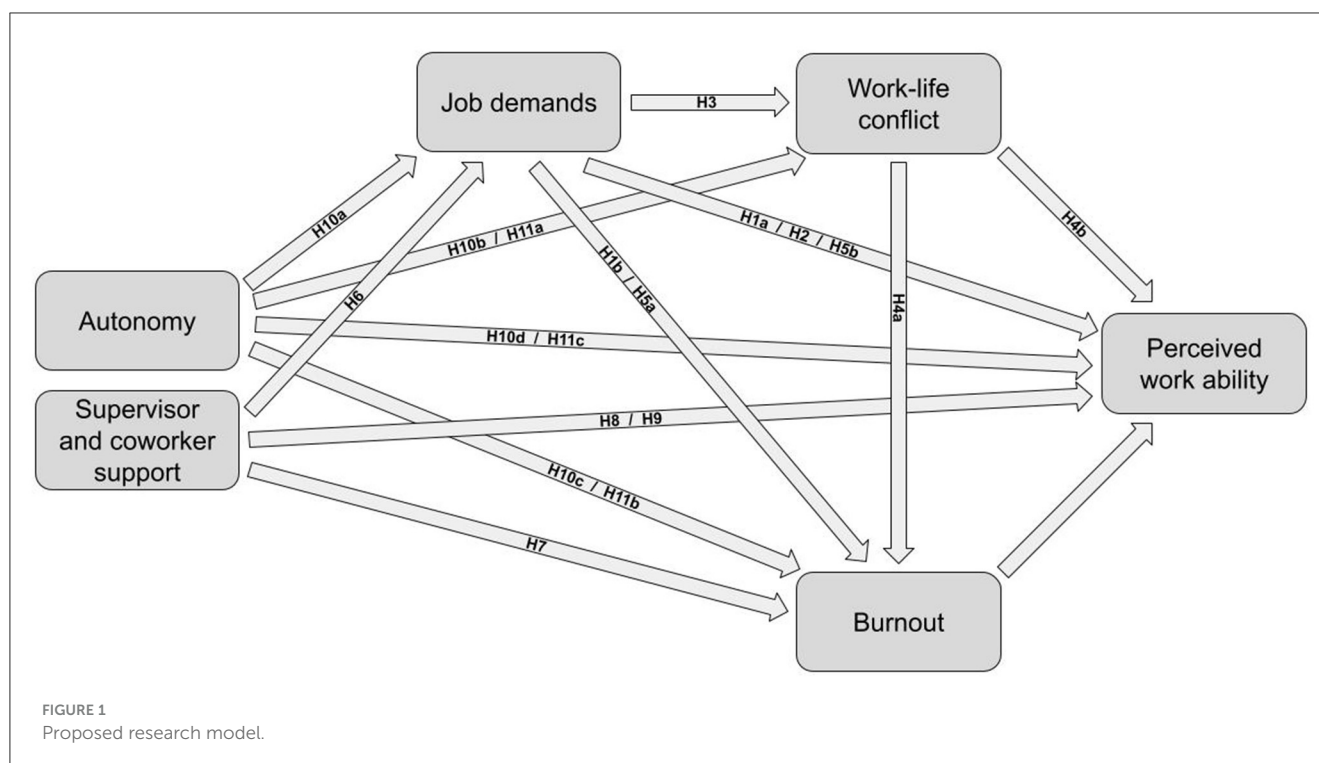
Methods

Participants and procedure

A total of 352 schools providing primary and lower secondary education in two regions of the Czech Republic—South Moravian Region and Vysočina Region—were contacted via email. The school administrations of these schools were invited to participate in a longitudinal mixed-methods study. The consent was granted by 44 schools, forming the basis for this study.

This study draws on quantitative data collected during the first wave of data collection involving teachers from participating schools. Teachers were invited to participate in the research through a letter from the researchers, which was distributed by headteachers. However, the participation of the teaching staff in the research was voluntary. The data collection took place from October and November 2023 using an online questionnaire.

The sample comprises 841 primary and lower secondary teachers (86.1% female). Participants' ages ranged from 22 to 76 years, with a mean age of 45.9 years ($SD = 10.8$). On average, the teachers had 19.3 years of experience in the teaching profession ($SD = 12.04$), and 42.2% of them were teachers at the level of primary education (ISCED 1), while 54.1% were teachers at the level of lower secondary education (ISCED 2). For the remaining 3.7% of teachers, it was not possible to distinguish between primary



and lower secondary education, or they worked at both levels. The participants taught various subjects, including biology, chemistry, languages, mathematics, physics, and physical education. The sample demonstrates the demographic representativeness of Czech teachers concerning age, years of teaching experience, and gender. Statistical data indicate that the average age of Czech teachers in primary and lower secondary education is 46 years, with an average teaching experience of 19 years (Czech School Inspectorate, 2023). Additionally, female teachers constitute a significant majority, representing 83% of the workforce (MEYS, 2024).

Measures

Perceived teacher work ability was assessed using the Teacher Work Ability Scale (TWAS), a tool designed to measure teachers' perceived physical and mental capacity to meet various job demands within the teaching profession. The Czech version used in this study measured the perceived WA of teachers using 21 items. Teachers were asked, "Considering all the requirements of your teaching job, how do you rate your physical and mental capacity to meet these demands?" Responses were given on a 7-point Likert scale ranging from 1 (*low*) to 7 (*high*). The TWAS has a 5-factor structure consisting of the following dimensions: instructional management (5 items, an example item: "Keep students' attention in lesson"), teaching organization (4 items, an example item: "Organize team group work of students"), teacher-staff interaction (4 items, an example item: "Receive feedback from superiors and colleagues"), navigating difficult situations (3 items, an example item: "Address problematic situations with students"), and non-teaching responsibilities (5 items, an example item: "Supervise students outside the classroom"). The Cronbach's

α for the TWAS in the sample was 0.95 for the whole scale, while the Cronbach's α for the individual dimensions were as follows: 0.88 for instructional management, 0.91 for teaching organization, 0.86 for teacher-staff interaction, 0.90 for navigating difficult situations, and 0.84 for non-teaching responsibilities. A second-order confirmatory factor analysis (CFA) was conducted to confirm the five-factor structure of the TWAS. The results of the CFA showed a good fit ($\chi^2 [177] = 796.9, p < 0.001, CFI = 0.951, TLI = 0.942, RMSEA = 0.065, SRMR = 0.042$), supporting the proposed five-factor structure of the TWAS.

Burnout was measured using the Czech version of the Shirom-Melamed Burnout Questionnaire (SMBQ; Ptáček et al., 2017). The SMBQ is a 14-item inventory consisting of three subscales that measure physical exhaustion (6 items), cognitive weariness (5 items), and emotional exhaustion (3 items), with high scores indicating high burnout. The SMBQ items were measured on a 7-point Likert-type scale with response options ranging from 1 (*never or almost never*) to 7 (*always or almost always*). In the present study, Cronbach's α of the total score was 0.93, and 0.92 for physical exhaustion, 0.88 for cognitive weariness, and 0.92 for emotional exhaustion subscales. A second-order CFA model with the presupposed three-factor structure showed a good fit ($\chi^2 [73] = 274.5, p < 0.001, CFI = 0.977, TLI = 0.971, RMSEA = 0.057, SRMR = 0.036$).

Job resources, job demands, and work-life conflict were assessed using the Czech version of the Copenhagen Psychosocial Questionnaire (COPSOQ-III; Burr et al., 2019), which is designed to assess various dimensions of the psychosocial factors at work. Job resources were measured by three different scales: social support from supervisor (3 items, an example item: "How often is your immediate superior willing to listen to your problems at work, if needed?," Cronbach's $\alpha = 0.82$), social support from colleagues (3 items, an example item: "How often are your colleagues willing

to listen to your problems at work, if needed?," Cronbach's $\alpha = 0.77$), and influence at work measuring autonomy at work (5 items, an example item: "Can you influence the amount of work assigned to you?," Cronbach's $\alpha = 0.75$). Within job demands, three different dimensions of demands were distinguished and measured: quantitative job demands (4 items, an example item: "Do you get behind with your work?," Cronbach's $\alpha = 0.77$), cognitive job demands (4 items, an example item: "Does your work require you to make difficult decisions?," Cronbach's $\alpha = 0.75$), emotional job demands (4 items, an example item: "Does your work put you in emotionally disturbing situations?," Cronbach's $\alpha = 0.76$). The work-life conflict was measured using the work-life conflict scale (3 items, an example item: "Do you feel that your work drains so much of your energy that it has a negative effect on your private life?," Cronbach's $\alpha = 0.82$). The long version of the COPSOQ-III scales was used to measure all variables. The questionnaire items were rated on Likert-type scales with five response options, ranging from 1 (*never*) to 5 (*always*). The CFA performed on all seven scales showed a good fit ($\chi^2 [250] = 832.5, p < 0.001$, CFI = 0.926, TLI = 0.911, RMSEA = 0.053, SRMR = 0.051), thus supporting the ability of the chosen instrument to discriminate and measure the individual dimensions of job resources, job demands, and work-related conflict.

Data analysis

Prior to the main analysis, a confirmatory factor analysis (CFA) was used to assess the psychometric properties of all measures used in this study and to confirm their expected factor structure. In addition, Cronbach's alpha was calculated for all measures to assess their reliability. In order to estimate the proposed model and test the above hypotheses, structural equation modeling (SEM) was used, applying the maximum likelihood estimation method. The analyses were carried out in the R statistical environment (R Core Team, 2023), relying particularly on the *lavaan* package (Rosseel, 2012). To test the full SEM model as well as to assess the goodness of fit of the CFA models, several measures of fit were used and reported in the study. Specifically, we used: χ^2 (chi-squared), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). However, as the χ^2 indicator is sensitive to sample size (Schumacker and Lomax, 2010), this indicator was not interpreted strictly, and we focused on the remaining indicators to evaluate the goodness of fit of the CFA models. The following recommendations were followed to assess the goodness of fit of the models: The measures of CFI and TLI indicated an acceptable fit with a threshold above 0.90 and a good fit above 0.95. The measures of RMSEA and SRMR value indicated an acceptable fit below 0.08 and a good fit below 0.05 (Hu and Bentler, 1999; Kline, 2016).

Results

We developed and estimated the full SEM model based on the proposed hypotheses. The structural model results yielded

the following goodness-of-fit indices: $\chi^2 [1,656] = 4,210.5, p < 0.001$, CFI = 0.918, TLI = 0.912, RMSEA = 0.043, SRMR = 0.050. Comparing these values to the critical thresholds outlined earlier, the CFI and TLI exceed the recommended cutoff of 0.90. Similarly, both the RMSEA and SRMR are below the acceptable threshold of 0.08, with the RMSEA even falling below the more stringent criterion of 0.05. These findings indicate that the proposed conceptual model demonstrates an acceptable fit to the empirical data. Regarding hypothesis testing, the main results are summarized in Table 1 (direct effect hypotheses) and Table 2 (indirect effect hypotheses). A detailed explanation of these findings is provided below.

Hypothesis 1 proposed that higher job demands would be associated with lower PTWA and, at the same time, with higher teacher burnout. The results of the SEM model only partially supported Hypothesis 1. Specifically, quantitative job demands were significantly associated with lower PTWA, while cognitive and emotional job demands showed no significant associations. Regarding the relationship with teacher burnout, all three job demands were significantly associated with burnout. However, contrary to expectations, higher cognitive job demands were linked to lower levels of teacher burnout rather than higher levels, as initially hypothesized. With respect to Hypothesis 2, we proposed that burnout mediates the relationship between job demands and PTWA. As shown in Table 2, Hypothesis 2 was fully supported. Specifically, a statistically significant indirect effect of burnout on PTWA was observed for all three types of job demands. These findings confirm that burnout plays a significant intermediary role in the relationship between job demands and PTWA. However, it is important to note that, in the case of cognitive job demands, the direction of the relationship differs from that of quantitative and emotional job demands. This result is also contrary to what would typically be expected based on existing research and theoretical frameworks in this area.

Hypothesis 3 posited that higher levels of job demands would be associated with an increased risk of work-life conflict among teachers. Hypothesis 3 was only partially supported by the results. Specifically, quantitative and emotional job demands were significantly and positively associated with work-life conflict, whereas cognitive job demands showed no significant relationship with work-life conflict. Hypothesis 4 examined the relationships between work-life conflict and teacher burnout, as well as between work-life conflict and PTWA. Specifically, the hypothesis posited a positive association in the case of teacher burnout and a negative association in the case of PTWA. The results of the estimated SEM model indicate that only the first part of Hypothesis 4 is supported by our data. Specifically, work-life conflict is significantly and positively associated with teacher burnout but shows no significant relationship with PTWA. Following on from the direct effects, Hypothesis 5 examined whether work-life conflict mediates the relationship between job demands and, respectively, teacher burnout and PTWA. The results provided partial support for the first part of Hypothesis 5, i.e., the indirect effect of job demands on burnout through work-life conflict. Work-life conflict significantly mediates the relationship between quantitative and emotional job demands and burnout. However, it does not mediate the relationship between cognitive job demands and burnout. Regarding the relationship between job demands and PTWA, no significant indirect effect of work-life conflict was observed.

TABLE 1 Direct effects for the proposed SEM model.

| | Est | CI | p |
|---|--------|------------------|------------------|
| Autonomy → Quantitative job demands | −0.131 | [−0.235; −0.028] | 0.013 |
| Supervisor support → Quantitative job demands | −0.123 | [−0.227; −0.019] | 0.020 |
| Coworker support → Quantitative job demands | −0.025 | [−0.125; 0.074] | 0.621 |
| Autonomy → Cognitive job demands | 0.154 | [0.052; 0.257] | 0.003 |
| Supervisor support → Cognitive job demands | −0.124 | [−0.228; −0.019] | 0.021 |
| Coworker support → Cognitive job demands | 0.096 | [−0.004; 0.196] | 0.059 |
| Autonomy → Emotional job demands | −0.110 | [−0.211; −0.010] | 0.031 |
| Supervisor support → Emotional job demands | −0.083 | [−0.185; 0.020] | 0.114 |
| Coworker support → Emotional job demands | 0.017 | [−0.081; 0.114] | 0.738 |
| Autonomy → Work–life conflict | −0.152 | [−0.226; −0.079] | <0.001 |
| Quantitative job demands → Work–life conflict | 0.493 | [0.422; 0.564] | <0.001 |
| Cognitive job demands → Work–life conflict | 0.047 | [−0.049; 0.143] | 0.334 |
| Emotional job demands → Work–life conflict | 0.252 | [0.156; 0.349] | <0.001 |
| Supervisor support → Burnout | −0.082 | [−0.166; 0.001] | 0.054 |
| Coworker support → Burnout | −0.099 | [−0.178; −0.019] | 0.015 |
| Autonomy → Burnout | −0.035 | [−0.124; 0.055] | 0.445 |
| Quantitative job demands → Burnout | 0.388 | [0.288; 0.488] | <0.001 |
| Cognitive job demands → Burnout | −0.138 | [−0.239; −0.037] | 0.007 |
| Emotional job demands → Burnout | 0.202 | [0.097; 0.307] | <0.001 |
| Work–life conflict → Burnout | 0.285 | [0.183; 0.387] | <0.001 |
| Work–life conflict → PTWA | 0.037 | [−0.073; 0.147] | 0.508 |
| Autonomy → PTWA | 0.053 | [−0.039; 0.146] | 0.258 |
| Quantitative job demands → PTWA | −0.179 | [−0.302; −0.057] | 0.004 |
| Cognitive job demands → PTWA | 0.105 | [−0.002; 0.212] | 0.054 |
| Emotional job demands → PTWA | 0.022 | [−0.092; 0.136] | 0.706 |
| Supervisor support → PTWA | 0.091 | [0.004; 0.178] | 0.041 |
| Coworker support → PTWA | 0.152 | [0.069; 0.235] | <0.001 |
| Burnout → PTWA | −0.368 | [−0.492; −0.244] | <0.001 |

Significant effects are shown in bold.

The remaining hypotheses examined the role of work resources in the relationships under investigation. Hypotheses 6 to 9 focused on support from supervisors and coworkers, while Hypotheses

TABLE 2 Indirect effects for the proposed SEM model.

| | Est | CI | p |
|---|--------|------------------|------------------|
| Work-life conflict as a dependent variable | | | |
| Autonomy → Quantitative job demands | −0.065 | [−0.116; −0.013] | 0.013 |
| Autonomy → Cognitive job demands | 0.007 | [−0.008; 0.023] | 0.366 |
| Autonomy → Emotional job demands | −0.028 | [−0.055; −0.001] | 0.043 |
| Burnout as a dependent variable | | | |
| Quantitative job demands → Work–life conflict | 0.140 | [0.089; 0.192] | <0.001 |
| Cognitive job demands → Work–life conflict | 0.013 | [−0.015; 0.042] | 0.350 |
| Emotional job demands → Work–life conflict | 0.072 | [0.035; 0.109] | <0.001 |
| Autonomy → Quantitative job demands | −0.051 | [−0.093; −0.009] | 0.018 |
| Autonomy → Cognitive job demands | −0.021 | [−0.042; −0.001] | 0.048 |
| Autonomy → Emotional job demands | −0.022 | [−0.046; 0.001] | 0.061 |
| PTWA as a dependent variable | | | |
| Quantitative job demands → Burnout | −0.143 | [−0.202; −0.083] | <0.001 |
| Cognitive job demands → Burnout | 0.051 | [0.010; 0.091] | 0.014 |
| Emotional job demands → Burnout | −0.074 | [−0.121; −0.028] | 0.002 |
| Quantitative job demands → Work–life conflict | 0.018 | [−0.036; 0.073] | 0.510 |
| Cognitive job demands → Work–life conflict | 0.002 | [−0.004; 0.008] | 0.579 |
| Emotional job demands → Work–life conflict | 0.009 | [−0.019; 0.037] | 0.511 |
| Supervisor support → Quantitative job demands | 0.022 | [−0.002; 0.046] | 0.073 |
| Supervisor support → Cognitive job demands | −0.013 | [−0.030; 0.004] | 0.139 |
| Supervisor support → Emotional job demands | −0.002 | [−0.011; 0.008] | 0.713 |
| Coworker support → Quantitative job demands | 0.004 | [−0.014; 0.023] | 0.625 |
| Coworker support → Cognitive job demands | 0.010 | [−0.006; 0.025] | 0.174 |
| Coworker support → Emotional job demands | <0.001 | [−0.002; 0.003] | 0.800 |
| Autonomy → Quantitative job demands | 0.024 | [−0.001; 0.048] | 0.060 |
| Autonomy → Cognitive job demands | 0.016 | [−0.003; 0.036] | 0.107 |
| Autonomy → Emotional job demands | −0.002 | [−0.015; 0.010] | 0.710 |

Significant effects are shown in bold.

10 and 11 addressed autonomy as a job resource. Hypothesis 6 examined whether higher levels of perceived supervisor and coworker support are associated with lower levels of perceived job demands. The results partially supported *Hypothesis 6*, as a statistically significant association was found only for supervisor support, with no such association observed for coworker support. This indicates that perceptions of coworker support were not related to perceptions of job demands. In addition, supervisor support was only significantly related to quantitative and cognitive job demands but not to emotional ones. Hypothesis 7 proposed that higher levels of supervisor and coworker support would be associated with lower levels of teacher burnout, while Hypothesis 8 posited that higher levels of supervisor and coworker support would be associated with higher levels of PTWA. *Hypothesis 7* was only partially supported, with support from coworkers showing a significant relationship. Although the *p*-value for supervisor support was relatively close to the 0.05 threshold, it suggests that supervisor support may still be an important factor in relation to teacher burnout. *Hypothesis 8* was fully supported, highlighting the positive impact of both types of support on teachers' perceptions of their WA. *Hypothesis 9*, which examined the potential mediating effect of job demands on the relationships between supervisor and coworker support and PTWA, was not supported. This indicates no significant indirect effects of supervisor and coworker support on PTWA through job demands.

Hypothesis 10 focused on teacher autonomy and examined its associations with four other variables. *Hypothesis 10a* proposed a negative association between autonomy and job demands and was partially supported. Specifically, autonomy was negatively associated with both quantitative and emotional job demands. However, contrary to the hypothesis, a positive association was found with cognitive job demands. Hypothesis 10b proposed a negative relationship between autonomy and work-life conflict. The results supported *Hypothesis 10b*, indicating that higher levels of teacher autonomy were associated with a lower risk of work-life conflict. Hypothesis 10c proposed a negative relationship between autonomy and burnout, while Hypothesis 10d posited a positive relationship between autonomy and PTWA. Neither *Hypothesis 10c* nor *Hypothesis 10d* was supported, indicating no significant direct link between autonomy and burnout or between autonomy and PTWA.

Finally, Hypothesis 11 examined whether the relationships between teacher autonomy and the other variables (i.e., work-life conflict, burnout, and PTWA) were mediated by job demands. This hypothesis was not supported in relation to the relationship between autonomy and PTWA, suggesting no significant mediating effects of job demands in this pathway, and therefore, *Hypothesis 11c* was not supported. However, partial support was found for the relationships between autonomy and work-life conflict (*Hypothesis 11a*) and between autonomy and burnout (*Hypothesis 11b*). In the first case, quantitative and emotional job demands significantly mediate the relationship between autonomy and work-life conflict. In the second case, quantitative and cognitive job demands significantly mediate the relationship between autonomy and burnout, with the *p*-value for emotional job demands being relatively close to the 0.05 threshold.

Discussion

This was the first study to comprehensively examine the antecedents of PTWA, including the relationships between teacher job demands (quantitative, qualitative, and emotional), job resources (supervisor support, coworker support, and autonomy), and burnout, using structural equation modeling. In contrast to the traditional JD-R model (Schaufeli and Taris, 2014), our research model was expanded to include the non-work domain to investigate PTWA. This expansion was informed by findings, which demonstrated that the work and non-work domains are intricately intertwined and cannot be examined separately, particularly when investigating perceived WA (Hlado and Harvankova, 2024; McGonagle et al., 2022). Our findings provided mixed support for WA literature (Brady et al., 2020; Cadiz et al., 2019; Hlado and Harvankova, 2024) and the JD-R model (Bakker and Demerouti, 2007; Demerouti and Bakker, 2011; Schaufeli and Taris, 2014; Taris et al., 2017) among a sample of Czech teachers, and they are further discussed with a particular emphasis on PTWA.

While our study did not explicitly formulate a hypothesis regarding the relationship between burnout and PTWA, burnout emerged as the most statistically significant antecedent of PTWA, demonstrating a strong negative effect. This outcome is consistent with prior research that has similarly recognized burnout as a key predictor among teachers (Hlado et al., 2020). Consequently, alongside PTWA, we will place increased emphasis on the findings related to teacher burnout.

The teaching profession is known for having many job demands. In line with expectations (Hakanen et al., 2006; Skaalvik and Skaalvik, 2020; Xanthopoulou et al., 2007), all three types of job demands had a direct effect on teacher burnout. However, an unexpected finding was that higher cognitive demands were linked to lower burnout levels. This result diverges from the general assumptions of the JD-R model (Taris et al., 2017), which posits that excessive job demands typically lead to adverse outcomes and deplete individuals' energy and psychological resources, thereby increasing the risk of burnout. However, cognitive demands likely function as a challenge rather than a hindrance stressors for teachers. Challenge stressors, such as solving problems, engaging in intellectually stimulating tasks, and adapting to diverse needs typical of the teaching profession, can serve as motivational factors and provide opportunities for personal growth, learning, and mastery (Podsakoff et al., 2007). Empirical studies have shown that when individuals perceive cognitive demands as meaningful and manageable, these demands can promote engagement and even reduce the risk of burnout by enhancing intrinsic motivation and fostering a sense of competence (Rodell and Judge, 2009).

Furthermore, only quantitative job demands were directly and negatively associated with PTWA. Regarding cognitive and emotional demands in the teaching profession, these were not linked to PTWA. Our results may be attributed to a professional effect; teachers who choose this career may expect to encounter cognitive and emotional demands as an inherent aspect of their work, which might prevent them from viewing these job demands as burdensome or exhausting (McGonagle et al., 2014). Based on research (Schaufeli and Taris, 2014), many teachers develop adaptive strategies to manage these job demands, potentially

reducing their impact on PTWA. Another possible explanation for the lack of a direct link between cognitive and emotional job demands in the teaching profession and reduced PTWA may lie in their dual nature, as described earlier. Our findings suggest that teachers might perceive cognitive and emotional job demands as challenges that provide opportunities for personal growth, learning, and development (Hlado and Harvankova, 2024; McGonagle et al., 2014), which could reduce the risk of a decline in PTWA. Additionally, teachers who lack the resources to manage cognitive and emotional job demands may leave the profession and thus were not represented in our study. However, these potential explanations highlight the need for further exploration.

Consistent with previous research (Hlado et al., 2020; Hlado and Harvankova, 2024), our results suggest that job demands indirectly affect PTWA. All three types of job demands—quantitative, cognitive, and emotional—exerted a mediating effect on PTWA through burnout. The present study extends the understanding of the health impairment process proposed in the JD-R model (Taris et al., 2017), emphasizing that high quantitative and emotional job demands in the teaching profession are associated with physical and psychological costs. These costs can deplete energy and lead to burnout, adversely affecting not only teachers' health, as shown in several studies (Hakanen et al., 2006) but also other work-related outcomes, such as reduced PTWA, as demonstrated in the present study. Our findings are important not only because cognitive job demands may play a protective role against burnout but also because they may indirectly enhance PTWA through their impact on burnout. From the perspective of the JD-R model (Taris et al., 2017), it seems that cognitive job demands may transform into job resources in the teaching profession, as they likely have inherent motivational qualities. These findings also require further research to uncover the underlying mechanism behind it.

The inclusive framework we proposed, encompassing work and non-work domains, revealed that high quantitative and emotional job demands may contribute to work-life conflict. Contrary to expectations (Gu and Wang, 2021; Hlado and Harvankova, 2024), the results show that cognitive job demands do not necessarily lead to work-life imbalance and related work-life conflict. This may suggest that teachers have adequate resources for managing cognitive job demands, unlike quantitative and emotional job demands, which disrupt their family life (Gu and Wang, 2021). One potential explanation is that, with increasing work experience, teachers may develop more effective strategies for managing cognitive job demands or perceive them as less intensive, thereby mitigating their impact on work-life conflict (Kubicek et al., 2022). Furthermore, our results support the previous findings that work-life conflict contributes to teacher burnout (Shields and Chen, 2021). In contrast to the previous findings (Abdelrehim et al., 2023; Bacci et al., 2024; Berglund et al., 2021), we did not find that work-life conflict directly affects PTWA. Despite this, work-life conflict remains an important variable in our model, as it influences burnout, a key antecedent of PTWA. In the present study, we did not examine the mediating effect of burnout in the relationship between work-life conflict and PTWA, which was suggested by a previous qualitative study on teachers (Hlado and Harvankova, 2024). We recommend that further research focus on this aspect.

Our expectation that work-life conflict mediates the relationship between quantitative, cognitive, and emotional job demands, and both burnout and PTWA was only partially supported. Specifically, work-life conflict acted as a mediator solely in the relationship between quantitative and emotional demands and burnout. Nevertheless, these findings extend existing literature which has mainly focused on the direct relationships between job demands and work-life conflict (Gu and Wang, 2021), as well as between work-life conflict and burnout (Shields and Chen, 2021) and between work-life conflict and WA (Abdelrehim et al., 2023; Bacci et al., 2024). As previous research on teachers has shown (Hlado and Harvankova, 2024), to manage quantitative job demands, teachers often extend their work beyond regular hours. Our study indicates that a similar mechanism could apply to the emotional demands teachers need to manage, which can also impact them beyond working hours. Overall, high quantitative and emotional job demands in the teaching profession can negatively affect family relationships, the fulfillment of non-work commitments, and active and passive rest. Our finding that quantitative and emotional job demands indirectly contribute to teacher burnout through work-life conflict suggests that if teachers cannot manage these demands effectively, it negatively demonstrates in work-life conflict which causes fatigue and consequently burnout. The present study, therefore, validates the qualitative findings obtained from in-depth interviews conducted with teachers (Hlado and Harvankova, 2024). In summary, the present findings indicate that work and life are essential for teachers, and maintaining a balance between these two is crucial for preventing burnout. However, this balance shows no significant effect on PTWA.

In line with the JD-R model (Demerouti et al., 2001; Schaufeli and Taris, 2014) and previous research across different professional groups (Afota et al., 2024; Alavinia et al., 2009; Brauchli et al., 2014; Guo et al., 2023; Leung and Lee, 2006; McGonagle et al., 2014; Sottimano et al., 2017), our study showed that job resources such as supervisor and coworker support, as well as autonomy, can not only alleviate teachers' perceptions of job demands and reduce the risk of burnout but also mitigate work-life conflict and improve PTWA. The present study contributes significantly to the literature by demonstrating how the influence of job resources on job demands, burnout, and PTWA differs depending on the resource type, thereby providing empirically grounded insights for potential interventions.

As anticipated, we found that supervisor support has a direct negative effect on quantitative and cognitive job demands among teachers and contributes to improving PTWA. The results of our study, which show that supervisor support leads to improved PTWA, align with previous research (Boelhauwer et al., 2020; McGonagle et al., 2014). Contrary to our expectations, the influence of supervisor support on emotional job demands and teacher burnout was not confirmed. This result differs from the assumptions of the JD-R model (Bakker et al., 2005) and prior research (Afota et al., 2024; Leung and Lee, 2006) that has demonstrated a negative association between supervisor support and burnout. Our findings related to the role of supervisor support in the teaching profession underscore the importance of enhancing supervisor support as a key resource, particularly for fostering

PTWA and shaping the perception of quantitative and cognitive job demands. A critical issue that emerged in our research is how headteachers, as school leaders, could contribute to preventing burnout and supporting the emotional job demands of teachers, which were in our research linked to work-life conflict and burnout.

According to the literature review, coworker support serves as another important job resource in the JD-R model (Demerouti et al., 2001; Schaufeli and Taris, 2014). Based on our results, coworker support helps mitigate the risk of burnout and enhances PTWA but does not have a direct effect on the perception of job demands. On the other hand, insufficient or lack of coworker support may thus negatively manifest in energy depletion and the development of burnout, as well as in reduced capacity to meet job demands. Our findings regarding the substantial influence of coworker support on burnout and PTWA are, to some extent, explainable by the specific nature of relationships within the teaching profession. In Czech schools, teachers share their workspaces daily with colleagues in staff rooms or common areas, which creates opportunities for building intense, deep, and often close relationships. Teachers have the chance to share their challenges at work and offer advice and support, which can manifest in lower burnout risk and higher PTWA. In light of this explanation, it is therefore surprising that instrumental and psychosocial support from colleagues does not manifest in the perception of quantitative, qualitative, and emotional job demands in our study.

Although supervisor support was associated with the perception of specific job demands, the findings related to coworker support raise concerns about the interaction effect between job demands and job resources, as introduced in the revised JD-R model in 2007 (Bakker and Demerouti, 2007). Nevertheless, our finding aligns with prior studies, where less than two-thirds of the 50 tested interactions between job demands and resources were significant (Taris et al., 2017). Further research appears essential to uncover the mechanisms underlying why some job resources interact with job demands among teachers, whereas others fail to, enabling the effective use of job resources to address the challenges of the teaching profession.

The third key job resource, autonomy, included in our investigation (Brady et al., 2020), has a direct negative effect on the perception of quantitative and emotional job demands. Therefore, promoting autonomy emerges as a potential strategy to support teachers in managing these job demands. On the other hand, our findings show that higher autonomy is linked to increased cognitive demands in the teaching profession. A potential reason is that cognitive demands promote professional growth (Clarà et al., 2022). Teachers with increased autonomy may place higher cognitive job demands on themselves to foster their professional development.

Additionally, we found that higher autonomy helps mitigate work-life conflict, which aligns with previous findings across various professions (Brauchli et al., 2014; Thompson and Prottas, 2006). Contrary to expectations (Boelhouwer et al., 2020; Guo et al., 2023; Tuomi, 2001; Van Den Berg et al., 2009), however, autonomy does not have a significant direct effect on teacher burnout or PTWA. Autonomy influences work-life conflict also indirectly through quantitative and emotional job demands. In line with expectations based on the literature and previous

research, a mediating role of quantitative and cognitive job demands in the relationship between autonomy and burnout was also demonstrated. This suggests that autonomy in the teaching profession can serve as a protective factor for work-life conflict and teacher burnout, as it allows for individual adjustment and management of these job demands.

In our study, we hypothesized that supervisor support, coworker support, and autonomy would reduce job demands and thereby indirectly support PTWA. However, our assumptions were not confirmed. Nevertheless, our findings clearly demonstrated that a supportive organizational climate, in the form of supervisor and coworker support, is significant and indispensable for PTWA.

Limitations and practical implications

First, this study employed a cross-sectional research design, which restricts the ability to draw causal inferences and assess long-term relationships. Second, our findings are based on self-reported scales, reflecting teachers' perceptions and evaluations of themselves, job demands, job resources, work-life conflict, burnout, and PTWA. As a result, the responses could be influenced by biases such as social desirability or inaccurate self-assessments, particularly when assessing variables like burnout, work-life conflict, and health status, which is an integral component of PTWA (Latkin et al., 2017). Moreover, self-reported data may not fully capture objective realities, as perceptions can differ significantly from observable behaviors or conditions. Third, the study was limited to a relatively homogeneous sample of Czech primary and lower secondary school teachers. This limits the generalizability of the findings to other groups, such as preschool and upper secondary school teachers, teaching assistants, and headteachers, as well as to different cultural contexts or professional populations. Our sample is also specific due to the significant proportion of female participants (86.1%), which aligns with the proportion of female teachers in the Czech education system (MEYS, 2024). However, women are also over-represented among primary and secondary education teachers in other OECD countries (OECD, 2021). This broader characteristic of educational systems implies that, with certain limitations, the findings may apply to the entire teacher population, including both men and women. As noted, perceived WA in teachers is associated with multiple aspects. Fourth, we focused only on selected job demands and job resources, work-life conflict, and burnout, which were highlighted in recent studies and found to be significant predictors of WA in teachers. It is also apparent that other risk factors may be associated with WA, such as physical and mental health. Another limitation is that our model did not include personal resources (e.g., self-esteem, self-efficacy, resilience, hope, and value orientation). Personal resources, which were more recently added to the JD-R model (Bakker and Demerouti, 2017), may also play a vital role in this dynamic. They can buffer the adverse effects of job demands and enhance the positive impact of job resources, thereby promoting higher levels of PTWA.

Despite these limitations, the present study has important practical implications. Several strategies can be employed to support PTWA. PTWA can be enhanced through strengthening

social support, which involves, for example, creating strong networks among teaching staff where teachers can share resources, advice, and best practices. An effective approach is, for example, teacher sharing. Headteachers themselves, as key resources, can play a significant role by providing constructive feedback, creating mentoring programs, and facilitating communication among staff members. Another potential approach to supporting work ability, arising from our findings, is adjusting quantitative job demands. This includes, for example, personalizing workloads through flexible scheduling and considering individual circumstances when setting performance targets. Headteachers can also assist by reducing administrative burdens and providing additional support to teachers facing high demands. Furthermore, proactive support for PTWA can involve offering professional development opportunities and ensuring teachers have access to mental health resources. The prevention of teacher burnout should also be considered. Our research highlights the complex interplay of antecedents and a range of hidden relationships between them. While we have suggested potential pathways for supporting PTWA, it is also essential to promote teacher autonomy and implement measures within schools to prevent the emergence of work-life conflict.

Conclusions

The present study examined the antecedents of PTWA within the framework of both work and non-work domains. The analysis identified quantitative job demands, supervisor and coworker support as job resources, and burnout as the most influential factors affecting PTWA. Among these, burnout was found to be the strongest negative predictor of PTWA. Furthermore, all examined job demands, along with work-life conflict, were significant predictors of burnout. While autonomy does not directly influence PTWA, it indirectly mitigates quantitative, cognitive, and emotional job demands, which in turn reduce burnout and enhance PTWA. Our findings emphasize the importance of a supportive and autonomous organizational climate, the management of job demands in accordance with individual capacities, and the implementation of targeted burnout prevention strategies to promote PTWA and maintain teachers' long-term professional engagement. Further research is needed to explore the dynamic interaction between work and non-work factors and to assess potential intervention strategies more comprehensively.

Data availability statement

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

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Ethics statement

The studies involving humans were approved by the Research Ethics Committee of Masaryk University under reference number EKV-2022-031 prior to data collection. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PH: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. LJ: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. KH: Methodology, Writing – original draft.

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Conflict of interest

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

Generative AI statement

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

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Number of chronic diseases and cognitive function among the elderly in China: a moderated mediation model

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Purpose: Despite the wealth of data on the role of chronic disease comorbidity in shaping cognitive dysfunction in older adults, a comprehensive view of this dynamic interplay remains a frontier. This study will reveal the intricate interactions between the number of chronic diseases and cognitive function in the elderly, based on the perspective of cognitive function in patients with multiple chronic diseases.

Methods: Our study was based on the data from the 2023 China Psychological Care for the Elderly Action Survey, and the SPSS 26.0 (IBM Corp., Armonk, NY, United States) software package was used for mediation model analysis. The approach encompassed descriptive analysis of variables, Spearman's correlation analyses to explore associations between variables, and a moderated mediation analysis.

Results: The study found that the number of chronic diseases ($r = 0.183$, $p < 0.001$) was positively correlated with cognitive function. Anxiety and depression partially mediated the relationship between the number of chronic diseases and cognitive function ($\beta = 0.227$, 0.235 , both $p < 0.001$). Age moderated the association between the number of chronic diseases and depression ($\beta = 0.010$, $p < 0.001$).

Conclusion: This study provides a comprehensive mediation model that establishes a new association between the number of chronic diseases and cognitive function in older adults. It suggests that we should pay attention to the negative impact of multiple chronic diseases on cognitive function of the elderly and improve their psychological coping ability, so as to ensure the stable development of healthy aging.

KEYWORDS

the elderly, chronic diseases, cognitive function, mental health, effect of mediation

Introduction

With the rapid aging of the global population, elderly health has become a key area of concern. Chronic diseases, such as cardiovascular disease, diabetes, and chronic respiratory disease, are the major factors affecting the physical health and quality of life of older people worldwide (Cong et al., 2024). According to the World Health Organization, the number of

people aged 60 years and older is expected to double by 2050, and a large proportion of them will experience multimorbidity, the coexistence of multiple chronic conditions (GBD 2021 Diseases and Injuries Collaborators, 2024). With the change of social economy and lifestyle, the prevalence of chronic diseases in the elderly in China has increased significantly, which has brought major challenges to the medical and health system (Xiang et al., 2024). Although the impact of a single chronic disease on cognitive function has been well documented, the impact of the coexistence of multiple chronic diseases on cognitive health in the elderly has not been fully explored (Ma et al., 2024). Multimorbidity complicates the relationship between chronic diseases and cognitive function, and the impact of multimorbidity on cognitive function may be more serious than that of single chronic disease.

Aging is a natural phase of life that brings about a series of physiological, psychological and social changes. As people age, it is important to take steps to maintain or improve their quality of life for active and healthy aging (Ye et al., 2024). Among the non-pharmacological strategies to improve the quality of life of the elderly, the most recommended is physical exercise, especially strength training, which is an effective intervention (Khodadad Kashi et al., 2023). It can not only improve muscle strength and balance ability, but also help to reduce the frequency of falls, improve the overall physical condition, and reduce the fear of falling, thus helping to improve the quality of life and autonomy of the elderly (Amiri and Sheikholeslami-Vatani, 2023).

In addition to physical health, mental health plays a crucial role in cognitive decline, which raises the question of anxiety and depression. Mental health conditions, particularly anxiety and depression, have been proposed as mediators between chronic diseases and cognitive functioning, but this area remains understudied. Although some studies have touched on the role of anxiety and depression in older people with chronic diseases, the mechanisms by which these mental health conditions affect cognitive function are not fully understood (Meng et al., 2024; Huang et al., 2023). This knowledge gap is significant because it hinders the development of comprehensive intervention strategies.

The present study aimed to address these gaps by examining the number of chronic conditions and how anxiety and depression affect cognitive functioning in older adults. We hypothesized that increasing numbers of chronic diseases would negatively affect cognitive function (Hypothesis H1). This hypothesis is based on the understanding that each additional chronic disease may increase the cumulative burden on the brain's cognitive reserve, possibly leading to a decline in cognitive performance (Valletta et al., 2023). Second, anxiety and depression could partially mediate this relationship (Hypothesis H2). This is supported by psychological models suggesting that mental health can affect cognitive processes through stress and emotion regulation pathways (Wu et al., 2024). In addition, we will explore whether age moderates the relationship between the number of chronic diseases and depressive status (Hypothesis H3). Age may play a role in this relationship because of age-related biological factors, different coping mechanisms in older versus younger adults, or other factors that influence the expression and impact of depression in the context of chronic disease (Brothers et al., 2021).

By testing these hypotheses, this study will deepen our understanding of the complex interactions between chronic disease,

mental health, and cognitive decline and will provide the basis for targeted intervention strategies.

Methods

Study participants

This study utilized data from the 2023 National Psychological Care for the Aged Initiative in Guangxi Province, China, aiming to understand the health status of the elderly and related social, behavioral, and biological factors. The study focused on individuals aged 65 and older, which aligns with the conventional definition of 'elderly' in China and many other countries. This age range corresponds to an increased prevalence of chronic diseases, marking it as a critical demographic for studying multimorbidity's impact on cognitive function. A multi-stage stratified sampling method was employed to select 35 districts/counties from 14 prefecture-level cities, ensuring a representative sample across different regions. The stratification was based on a combination of urban vs. rural areas and socioeconomic status, ensuring a representative sample across diverse regions. Within each district/county, the elderly aged 65 years and above were surveyed using a convenience sampling method, which was feasible given the study's scope and resources. A total of 10,693 interviewees were included, with 323 non-respondents, yielding a response rate of 97.0%.

Measures

Cognitive function

The cognitive function of the elderly was measured by the Cognitive Function Screening tool (AD8) (Galvin et al., 2006). The questionnaire contained 8 items, each of which contained 3 items: change, do not change and do not know. The score for the answer to any question "change" was 1, and the total score was 0–8. If the AD8 total score is ≥ 2 , the possibility of cognitive dysfunction is highly suspected. The Cronbach's α coefficient of the scale in this study was 0.89, which is usually used to screen for cognitive impairment in the elderly.

Number of chronic diseases

Information on chronic diseases was obtained by asking participants if they had ever been diagnosed with the following 20 chronic diseases and symptoms, as classified by the International Classification of Diseases, 10th Revision (ICD-10) (Aguado et al., 2020): hypertension, heart disease/coronary heart disease, diabetes mellitus, cerebrovascular disease, chronic bronchitis, cancer, kidney disease, liver disease, gastroenteritis or other gastrointestinal disease, tuberculosis, rheumatoid arthritis, cervical/lumbar disease, reproductive system disease, prostate disease, urinary system disease, glaucoma or cataract, osteoporosis, emotional and mental problems, neurological diseases, and deafness. Each disease was assigned a score of 1, and the total score was summed to quantify the burden of chronic disease per older person. The selection of these diseases was based on their prevalence in elderly populations and their known association with cognitive decline.

TABLE 1 Baseline data and univariate analysis of mental health status (N = 10, 370).

| Variable | n(%) | Depressive state | | Anxiety level | |
|--------------------|--------------|---------------------------|-----------|---------------------------|-----------|
| | | Score ($\bar{x} \pm s$) | T-value | Score ($\bar{x} \pm s$) | T-value |
| Gender | | | −9.528*** | | −6.787*** |
| Male | 4,590 (44.3) | 0.98 ± 2.058 | | 0.56 ± 1.708 | |
| Female | 5,780 (55.7) | 1.41 ± 2.461 | | 0.81 ± 2.007 | |
| Residence | | | −1.706 | | 1.338 |
| Town | 5,337 (51.5) | 1.18 ± 2.210 | | 0.73 ± 1.912 | |
| Rural area | 5,033 (48.5) | 1.26 ± 2.394 | | 0.68 ± 1.856 | |
| Mode of residence | | | 6.906*** | | 4.610*** |
| Live alone | 1,083 (10.4) | 1.67 ± 2.912 | | 0.95 ± 2.385 | |
| Non solitary | 9,287 (89.6) | 1.17 ± 2.213 | | 0.67 ± 1.815 | |
| Years of education | | | 41.790*** | | 93.909*** |
| <9 years | 8,034 (77.5) | 1.22 ± 2.301 | | 0.62 ± 1.347 | |
| ≥9 years | 2,336 (22.5) | 1.07 ± 2.265 | | 0.70 ± 1.885 | |
| Marital Status | | | −7.614*** | | −4.158*** |
| Have a spouse | 7,302 (70.4) | 1.11 ± 2.157 | | 0.65 ± 1.800 | |
| No spouse | 3,068 (29.6) | 1.48 ± 2.594 | | 0.82 ± 2.068 | |

***P < 0.001.

Level of anxiety

Generalized anxiety Disorder-7 (GAD-7) was used to investigate the subjective feelings of the subjects for 2 weeks, and their anxiety symptoms were scored (Spitzer et al., 2006). The scale had 7 items, each item was scored from 0 to 3, and the total score was from 0 to 21. The score of 0–4 was no anxiety, the score of 5–9 was mild anxiety, the score of 10–14 was moderate anxiety, and the score of 15–21 was severe anxiety. A total score ≥ 5 was considered anxiety symptoms. The Cronbach’s α coefficient of the scale in this study was 0.82, which proved the reliability in the elderly population.

State of depression

The Patient Health Questionnaire-9 (PHQ-9) was used to measure the depression status of the elderly (Kroenke et al., 2001). The PHQ-9 contains 9 items on a 4-point scale from 0(not at all) to 3(almost every day), with a total score of 0–27. A total score of ≥5 on the PHQ-9 indicates depressive symptoms, and higher scores indicate more severe depressive symptoms. The Cronbach’s α coefficient of the scale was 0.88, which was also scientifically applied in the elderly population.

Potential confounders

Sociodemographic covariates included sex, place of residence, living arrangements, years of education, and marital status.

Statistical analysis

Data analysis was performed using SPSS 26.0 (IBM Corp., Armonk, NY, United States) software package. T-test or analysis of variance was used for continuous variables. Correlation analysis was used to determine the potential correlation between the number of chronic diseases, anxiety, depression and cognitive function in the elderly. Subsequently, SPSS macro program PROCESS V3.5 (Igartua and Hayes, 2021) was used to verify the mediating effect of anxiety

and depression on the relationship between the number of chronic diseases and cognitive function and the moderating effect of age. All p-values are two-tailed, and p-values <0.05 were considered statistically significant.

Study outcomes

Common method deviation test

The Harman single factor test method was used to test (Podsakoff et al., 2003), and the results showed that there were 3 factors with eigenvalues greater than 1, and the first factor extracted accounted for 22.53% (<40%) of the variance, indicating that there was no serious common method deviation in this study.

Basic information of participants

Among the 10, 370 participants, 44.3% were males and 55.7% were females. 77.5% of the elderly had less than 9 years of education, and 22.5% of the elderly had more than 9 years of education. 51.5% of the elderly lived in urban areas and 48.5% in rural areas. In terms of marital status, most of the respondents had a spouse (70.4%), and those who were separated, divorced or widowed were regarded as having no spouse, accounting for 29.6%. 10.4% of the elderly lived alone, 89.6% of the elderly lived with others (including spouse, children, grandchildren, and other relatives) (Table 1).

Results of univariate analysis

The general influencing factors of depression and anxiety in 10, 370 elderly people were analyzed, which were gender, residence, living style, years of education, and marital status. The results showed that gender, living style, years of education and marital status were the

TABLE 2 Means, standard deviations and correlation coefficients of key variables.

| Variable | 1 | 2 | 3 | 4 | 5 |
|----------------------------|----------|---------|---------|---------|-------|
| Cognitive function | – | | | | |
| Depressive state | 0.361*** | – | | | |
| Anxiety level | 0.288** | 0.689** | – | | |
| Number of chronic diseases | 0.183** | 0.242** | 0.176** | – | |
| Age | 0.213** | 0.086** | 0.034** | 0.107** | – |
| Mean value | 1.05 | 1.22 | 0.70 | 1.15 | 73.41 |
| Standard deviation | 1.710 | 2.301 | 1.885 | 1.089 | 6.666 |

** $P < 0.01$, *** $P < 0.001$.

TABLE 3 The mediating effect of depression on the number of chronic diseases and cognitive function.

| Pathway | Effect value (β) | BootSE | BootLLCI | BootULCI | Effect size |
|------------------|--------------------------|--------|----------|----------|-------------|
| Anxiety level | | | | | |
| Direct effect | 0.1884 | 0.0145 | 0.1600 | 0.2167 | 73.39% |
| Indirect effect | 0.0683 | 0.0059 | 0.0569 | 0.0803 | 26.61% |
| Total effect | 0.2567 | 0.0147 | 0.2278 | 0.2856 | 100% |
| Depressive state | | | | | |
| Direct effect | 0.1423 | 0.0144 | 0.1140 | 0.1705 | 55.43% |
| Indirect effect | 0.1144 | 0.0076 | 0.1001 | 0.1301 | 44.57% |
| Total effect | 0.2567 | 0.0147 | 0.2278 | 0.2856 | 100% |

influencing factors of depression and anxiety in the elderly, and the differences in the scores were statistically significant ($p < 0.05$) (Table 2).

Descriptive statistics and correlation analysis

Correlation analysis was conducted for the key variables, including the number of chronic diseases, anxiety, depression, cognitive function, and age. The average scores of number of chronic diseases, anxiety and depression were (1.15 ± 1.089), (0.70 ± 1.885) and (1.22 ± 2.301) respectively. The number of chronic diseases ($r = 0.183$, $p < 0.01$), anxiety ($r = 0.288$, $p < 0.01$) and depression ($r = 0.361$, $p < 0.01$) were positively correlated with cognitive function. The number of chronic diseases was positively correlated with anxiety ($r = 0.176$, $p < 0.01$) and depression ($r = 0.242$, $p < 0.01$). Age was positively correlated with anxiety ($r = 0.034$, $p < 0.01$) and depression ($r = 0.086$, $p < 0.01$) (Table 2).

The mediating effect of anxiety and depression on the number of chronic diseases and cognitive function

First of all, Model 4 of SPSS Process was used to test the mediating effect of anxiety and depression between the number of chronic diseases and cognitive function in the elderly. The results showed that the number of chronic diseases had a significant positive effect on anxiety ($\beta = 0.301$, $p < 0.001$) and depression ($\beta = 0.491$, $p < 0.001$) in

the elderly. Anxiety ($\beta = 0.227$, $p < 0.001$) and depression ($\beta = 0.235$, $p < 0.001$) had a significant positive effect on cognitive function. The number of chronic diseases had a significant positive effect on cognitive function in the mediating model of anxiety and depression ($\beta = 0.188$, 0.015 , both $p < 0.001$). Anxiety and depression partially mediated the relationship between the number of chronic diseases and cognitive function. The results of the specific effect analysis are shown in Table 3, and the mediating effect of anxiety level as a mediating variable is shown in Figure 1.

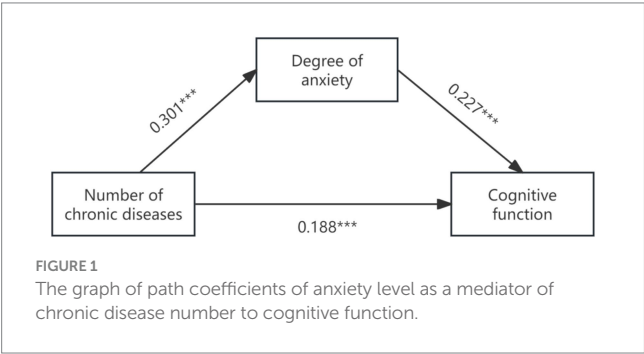
Moderating effect of age on the association between the number of chronic diseases and depressive status

Secondly, Model 7 in Process (Bootstrap sampling was 5,000) was used to construct a moderated mediation model with cognitive function as the dependent variable, depression as the mediating variable, and age as the moderating variable. After age was introduced into the model, the product term of the number of chronic diseases and age had a significant positive predictive effect on depression ($\beta = 0.010$, $p < 0.001$), indicating that age could play a moderating role in the indirect prediction of the number of chronic diseases and depression. The test results of the moderating mediating effect are shown in Table 4, and the moderating mediating effect is shown in Figure 2. Further simple slope analysis was carried out, as shown in Figure 3, in the younger age group, the number of chronic diseases positively predicted depression. In the older age group, the number of chronic diseases still significantly positively predicted depression, but the predictive effect was large, indicating that the predictive effect of

the number of chronic diseases on depression gradually increased with age.

Discussion

In this study, we focused specifically on several potential confounders, including gender, region of residence, lifestyle, years of education, and marital status, as these factors are widely recognized as important factors affecting the number of chronic diseases and cognitive function in older adults. Gender differences play a particular role in the experience of mental health and chronic illness, with studies suggesting that women may be more likely to report depressive symptoms than men (Moreno et al., 2022). This may be attributed to biological factors such as hormonal differences, social factors like gender roles and expectations, or cultural factors that influence help-seeking behavior. In addition, the area of residence is related to the access to health resources and the prevalence of diseases, with urban areas typically having better access to healthcare facilities and preventive services compared to rural areas (Su et al., 2024). Living style, especially living alone versus living with others, is associated with social support and mental health status (Li et al., 2023). Years of education are related to health literacy and disease prevention behaviors, while marital status is related to social support and perceived stress (Stewart et al., 2020; Zhang et al., 2024). By controlling for these confounding factors, we were able to more accurately assess the impact of the number of chronic conditions on cognitive function in older adults and provide more targeted recommendations for public health interventions.



The results of our study indicated that the mean number of chronic diseases among the elderly was 1.15 ± 1.089 , a figure that underscores the commonality of multimorbidity in this age group. This finding aligns with prior research, including Hu et al. (2024), which also highlighted the high prevalence of multiple chronic conditions among the elderly. Our data suggest that there is a notable presence of chronic diseases that could be further exacerbated by various stressors, including those related to health crises such as pandemics. However, it is important to note that the direct link between the number of chronic diseases and the pandemic's impact is beyond the scope of this study and warrants further investigation. The anxiety score of the elderly was (0.70 ± 1.885) points, the depression score was (1.22 ± 2.301) points, and the cognitive function score was (1.05 ± 1.710) points, which were higher than the research results of Peng et al. (2024). This discrepancy could be due to regional differences in mental health awareness and access to mental health services or methodological differences in how anxiety and depression were assessed. Understanding these differences will help the reader interpret our findings more critically.

This study investigated the relationship between the number of chronic diseases and cognitive function in the elderly, and the results showed that the number of chronic diseases significantly positively predicted the cognitive function of the elderly, which verified the hypothesis H1 and was consistent with the research results of Ren et al. (2024) and Lor et al. (2023). In recent years, studies have found that low-grade chronic inflammation, increased frequency of cerebrovascular problems, cumulative effect of disease, and insufficient cerebral oxygen supply may increase the risk of cognitive dysfunction in patients with multiple chronic diseases (Shabir et al., 2020; Burtcher et al., 2021). However, at present, domestic and foreign scholars' research on the potential mechanisms of cognitive dysfunction in patients with multiple chronic conditions is still in the initial stage of development, and the exact biological pathways of cognitive dysfunction in patients with multiple chronic conditions remain to be elucidated. Researchers need to continue to explore the mechanism of occurrence and development, so as to lay the foundation for clinical multidisciplinary intervention. In addition, the study of Sakakibara et al. (2019) highlighted that the more unhealthy lifestyle factors, the greater the degree of cognitive decline associated with chronic disease comorbidity, and the common pathogenic pathway plays a key role. Specifically, lack of physical activity may increase the vascular and

TABLE 4 Moderated mediation model testing.

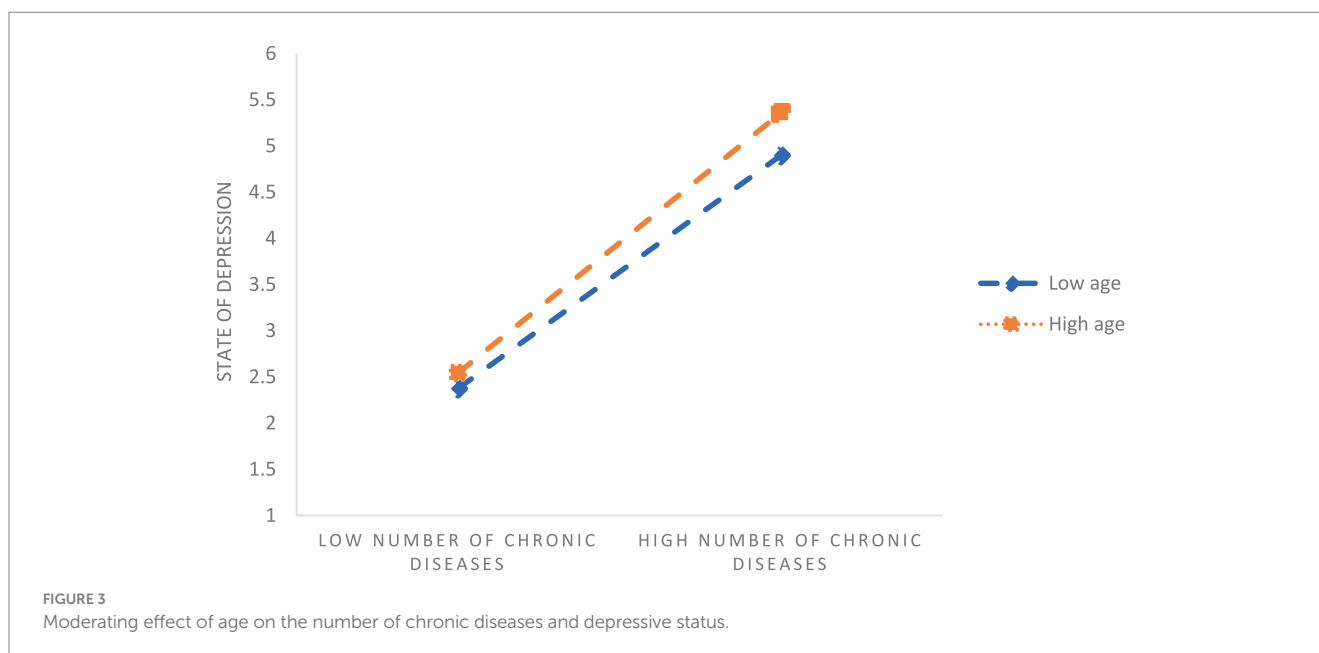
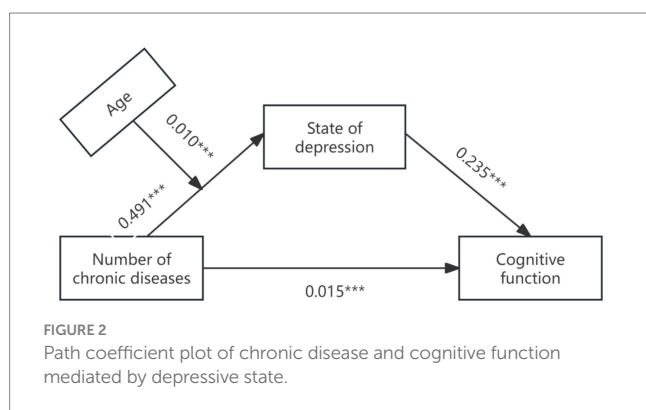
| Variable | Depressive state | | | | Cognitive function | | | |
|---|------------------|-------|----------|-------------|--------------------|-------|----------|--------------|
| | β | SE | <i>t</i> | 95%CI | β | SE | <i>t</i> | 95%CI |
| Constant | 1.503 | 0.189 | 7.956 | 1.133–1.873 | 0.220 | 0.133 | 1.647 | –0.042–0.481 |
| Number of chronic diseases | 0.491 | 0.020 | 24.373 | 0.452–0.530 | 0.164 | 0.015 | 11.321 | 0.136–0.193 |
| Age | 0.010 | 0.004 | 3.525 | 0.006–0.019 | | | | |
| Depressive state | | | | | 0.235 | 0.007 | 33.960 | 0.221–0.248 |
| Number of chronic diseases \times Age | 0.010 | 0.003 | 3.238 | 0.004–0.016 | | | | |
| R^2 | 0.076 | | | | 0.170 | | | |
| <i>F</i> | 121.664 | | | | 354.539 | | | |

metabolic burden, leading to an increased risk of cognitive dysfunction. Excessive alcohol and smoking can lead to brain damage by promoting vascular damage and inflammatory processes (Freisling et al., 2020), and inflammation may accelerate brain neurodegeneration and vascular pathological changes (Grande et al., 2021), thereby increasing the risk of cognitive dysfunction. Medical staff need to innovate a new self-management model combining self-health monitoring, chronic disease management, and cognitive function prevention according to the characteristics of patients with multiple chronic diseases, and encourage patients with multiple chronic diseases to establish active health thinking, in order to reduce the risk of cognitive dysfunction and improve the quality of life.

This study found that anxiety degree played a partial mediating role between the number of chronic diseases and cognitive function, which confirmed hypothesis H2 and supported the construction model of caring science resilience proposed by Wei et al. (2020). As a key influencing factor of cognitive function, the number of chronic diseases can significantly predict the risk of cognitive impairment in the elderly by affecting the degree of anxiety. This is consistent with previous studies (Teixeira et al., 2015). It can be seen that for the

elderly with multiple chronic diseases, it is necessary to pay attention to the change of their anxiety, which is also a favorable measure for the improvement of cognitive function. The results of this study showed that depression partially mediated the relationship between the number of chronic diseases and cognitive function, and age moderated the relationship between the number of chronic diseases and depression. Specifically, the number of chronic diseases in the elderly could significantly predict cognitive function. For older elderly individuals, the predictive effect of the number of chronic diseases on cognitive function was significantly enhanced, which verified hypotheses H2 and H3. In the younger age of the elderly, active prevention and treatment of the occurrence and development of chronic diseases can prevent or delay the risk of cognitive impairment to a certain extent. At the same time, for elderly patients with multiple chronic diseases, more attention should be paid to their mental health status to prevent psychological problems caused by diseases in the elderly (Zhang et al., 2021).

Some limitations of this study need to be addressed. First, only GAD-7, PHQ-9, and AD8 scales are used to measure anxiety, depression, and cognitive function without clinical diagnosis or other cognitive tests, which may not be comprehensive enough. The use of self-reported scales may introduce bias, and clinical diagnoses or other neuropsychological tests could provide more precise measures of cognitive decline. Second, although there is a psychosocial mechanism between chronic disease comorbidity and cognitive function, the mechanism of the vascular mechanism hypothesis has also been proposed (Biessels and Despa, 2018; Pase et al., 2012). However, our study only considered psychological mechanisms as potential mediators, and further research is needed to fully explain the relationship between the number of chronic diseases and cognitive function in older adults. In addition, we recognize that there are some limitations in using data from the Guangxi region to represent the national situation, which may mean that our findings are not fully applicable to all regions of China and need to be further validated with the support of broader national data.



Overall, our findings suggest that mental health should be prioritized in interventions aimed at preventing or managing cognitive decline in older adults with chronic diseases. Public health programs should consider incorporating mental health screenings and support services into chronic disease management plans. Future studies with larger, more diverse samples and longitudinal designs will be essential for further understanding the complex relationship between chronic diseases, mental health, and cognitive function 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 humans were approved by the Second Affiliated Hospital of Guangxi Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

XF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JP: Investigation, Methodology, Software, Visualization, Writing – review & editing. XC: Investigation,

Methodology, Software, Writing – review & editing. LL: Investigation, Methodology, Software, Writing – review & editing. DH: Investigation, Resources, Writing – review & editing. PT: Investigation, Supervision, Writing – review & editing. XP: Investigation, Resources, Writing – review & editing. QP: Investigation, Writing – review & editing. DF: Investigation, Writing – review & editing. SL: Investigation, Writing – review & editing. CL: Investigation, Writing – review & editing. YP: Investigation, Writing – review & editing. PD: Investigation, Writing – review & editing. HW: Investigation, Writing – review & editing. YC: Investigation, Writing – review & editing. PH: Investigation, Writing – review & editing. HH: Methodology, Project administration, Resources, Software, Supervision, Writing – review & editing.

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Conflict of interest

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

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Correlation between mild cognitive impairment and flourishing among Chinese residents: a cross-sectional study

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Objective: This study aimed to investigate the correlation between mild cognitive impairment and flourishing among Chinese residents.

Methods: A total of 527 community residents aged ≥ 18 years were recruited from December 2023 to April 2024. Based on the results of the Ascertain Dementia 8-Item Informant Questionnaire (AD8), participants were classified into a healthy group ($n = 356$) and a mild cognitive impairment (MCI) group ($n = 171$). General demographic data, including age, gender, height, weight, place of residence, education level, marital status, household composition, personal income, occupation, and the flourishing scale (FS) were collected for statistical analysis. The analysis was performed using Statistical Product and Service Solutions software. Chi-square test was used to compare differences between the groups, while Kendall's correlation analysis and multivariate logistic regression were applied to assess the relationship between flourishing and MCI.

Results: Comparisons between the healthy and MCI groups showed that the FS scores in the healthy group were significantly higher than those in the MCI group ($p < 0.01$). Kendall's correlation analysis revealed that the score of AD8 was negatively correlated with FS ($r = -0.237$, $p < 0.01$). Multivariate analysis indicated that age [odds ratio (OR) = 1.451, 95% confidence interval (CI): 1.107–1.902, $p = 0.007$], place of residence [OR = 5.523, 95% CI (3.572–8.539), $p < 0.001$], and FS [OR = 0.421, 95%CI (0.311–0.569), $p < 0.001$] were correlated with MCI.

Conclusion: Flourishing levels are negatively correlated with MCI, and higher levels of flourishing associated with a lower risk of MCI. This suggests that flourishing may serve as a protective factor against cognitive decline. Additionally, age and place of residence are identified as risk factors for MCI.

KEYWORDS

mild cognitive impairment, flourishing, correlation analysis, Chinese residents, AD8

Introduction

Dementia is a major cause of disability in individuals aged >65 years worldwide, including China, and presents significant challenges for policymakers, healthcare providers, and family members (Jia et al., 2020b). The onset and progression of Alzheimer's disease (AD), the leading cause of dementia, are gradual and span several years to decades before symptoms become evident (Jack et al., 2013; Villemagne et al., 2013). It is characterized by progressively worsening

cognitive and functional impairments. Mild cognitive impairment (MCI), considered the first clinical manifestation of AD, occurs when an individual exhibits below-average performance on standardized neuropsychological tests (Stuart and Nitrini, 2016). When cognitive impairment becomes significant enough to interfere with daily functioning, the diagnosis of AD is established (Albert et al., 2011). AD is irreversible and can only have its progression delayed. Therefore, paying attention to MCI in the early stages is crucial. Early diagnosis and timely intervention during this phase can help slow down the progression of AD.

MCI imposes a significant burden, affecting the quality of life and psychological well-being (Gates et al., 2014). Those with MCI exhibit lower levels of social support, self-esteem, life satisfaction, positive affect, optimism, and hope but higher levels of negative affect compared with healthy individuals (Dos Santos et al., 2018). Currently, the research on the psychological aspects of MCI is limited. However, some studies indicated that individuals with dementia exhibit a lack of recognition, assessment, and even the ability to feel negative emotions (Balconi et al., 2015; Oliver et al., 2015; Bora et al., 2016) and preserve the ability to recognize positive emotions (Dos Santos et al., 2018; Oliver et al., 2015; Bora et al., 2016; Goodkind et al., 2015; St. Jacques et al., 2015). The incidence of cognitive impairment was also associated with optimism in a study evaluating 4,624 elderly people over 4 years, which showed that high optimism was a protective factor against cognitive impairment and played an important role in maintaining cognitive functioning (Dos Santos et al., 2018; Gawronski et al., 2016). Thus, we should pay more attention to positive psychology. The mission of positive psychology is to understand and foster the factors that allow individuals, communities, and societies to flourish (Fredrickson, 2001).

The flourishing theory, an emerging field of well-being within positive psychology, was originally developed to operationalize mental health in response to the notion that well-being is not merely the absence of mental illness (Jahoda, 1959), but rather, it encompasses the cultivation of positive emotional experiences, eudaimonic well-being, and meaningful social engagement and contribution (Keyes, 2002; Mock and Smale, 2023). Keyes (2002) conceptualized flourishing within the Mental Health Continuum Model, which defines mental health as a spectrum ranging from languishing (a state of psychological distress and low well-being) to flourishing (optimal mental health with high levels of emotional, psychological, and social well-being). Similarly, Seligman's (2011) PERMA model identifies five core elements essential for flourishing: Positive Emotion, Engagement, Relationships, Meaning, and Accomplishment, each contributing to overall life satisfaction and psychological resilience.

Most research on flourishing focused on adolescents and the elderly (Parsons et al., 2022; Otgon et al., 2023), its relevance to individuals with MCI remains largely unexplored. Flourishing is the pinnacle of good mental health, and it is constituted by an affective state and psychological and social functioning (Mjøsund, 2021) — elements that have been associated with cognitive health (Rodrigues and Delerue-Matos, 2025; Yang et al., 2024) — understanding its relationship with MCI may provide insights into potential protective mechanisms against cognitive decline. Consequently, this study aims to explore the correlation between MCI and flourishing among Chinese residents.

Methods

Study design

This cross-sectional study recruited 527 Chinese residents using a convenience sampling between December 2023 and April 2024. Inclusion criteria for residents were (1) the age of ≥ 18 years and (2) Chinese citizenship. Exclusion criteria for residents comprised (1) individuals with mental illnesses or those unable to communicate and (2) a prior confirmed diagnosis of dementia, stroke, Parkinson's disease, or other conditions impacting cognitive function. The sample size was determined using Kendall's sample size estimation method (Stuart and Ord, 2010), which suggests that the sample size should be 5 to 10 times the number of variables. This study analyzed 26 variables, including 10 items from a self-made questionnaire and 16 items from two scales. Considering a 30% inefficiency rate of the questionnaire, the minimal sample size for this study was determined at 507, the final sample size was 527.

Data collection

Data were collected by nursing undergraduates who underwent standardized training. During their spare time, they collected data in their local communities through face-to-face interviews, during which residents were guided to independently complete the self-administered questionnaires. Before distributing the questionnaires, instructions for this study and informed consent forms were provided to the residents. Data collection commenced only after participants indicated their consent by selecting "yes."

Regarding demographic data, all residents provided their general data, including age, gender, height, weight, place of residence, education level, marital status, household composition, personal income, and occupation.

The ascertain dementia 8-item informant questionnaire

The self-reported AD8 has been shown to be effective in differentiating individuals with MCI from those without dementia, with its diagnostic performance also validated in studies primarily involving Chinese populations (Chin et al., 2013; Passler et al., 2021). And it created by the Alzheimer's Disease Research Center at Washington University in 2005, is an 8-item questionnaire based on informant responses, designed to detect changes within the individual in areas such as memory, orientation, judgment, and functional abilities (Galvin et al., 2005), which may coincide with MCI, in this study, a cut-off score of two or greater suggests that the individual may have MCI (Tanwani et al., 2023; Yin et al., 2020). The informant-rated AD8 demonstrated good internal consistency, with Cronbach's $\alpha = 0.84$ – 0.85 for the English version (Galvin et al., 2006; Shaik et al., 2016) and 0.78 for the Chinese version (Li et al., 2012). It also shows strong interrater reliability, with an intraclass correlation coefficient of 0.85 for the English version (Shaik et al., 2016), and solid test–retest reliability, with weighted κ values between 0.67 and 0.80 for the English version (Galvin et al., 2006; Shaik et al., 2016) and an intraclass correlation coefficient of 0.96 for the Chinese version (Li et al., 2012). The AD8 is less influenced by the

individual's educational background compared to other cognitive assessment tools such as the Mini-Mental State Examination and Montreal Cognitive Assessment (Chin et al., 2013). This feature makes the AD8 particularly useful for detecting cognitive changes across diverse populations without the confounding effect of educational attainment.

The flourishing scale

Flourishing scale (FS) is a brief 8-item summary measure of the respondent's self-perceived success in areas such as relationships, self-esteem, purpose, and optimism (Diener et al., 2010). Each item is rated by respondents on a 7-point Likert scale (1 indicates "strongly disagree" and 7 indicates "strongly agree"), with high scores indicating high flourishing, and the total score ranging from 7 to 56 (Cerezo et al., 2024). In this study, we utilized the simplified Chinese version of the FS introduced by Tang et al. (2016), the scale shows excellent reliability and validity, with Cronbach's $\alpha = 0.90$ – 0.93 (Keyes, 2002). And Xiao et al. (2021) further classified this scale into different levels, categorizing FS scores as follows: ≥ 5 points represented a high flourishing level, 4–4.99 was a medium flourishing level, and < 4 denoted a low flourishing level. The exploratory factor analysis identified a single factor that accounted for 75.03% of the total variance, and the confirmatory factor analysis indicated that all the goodness-of-fit indices were acceptable (Zhang, 2018).

Statistical analysis

All statistical analyses were conducted using Statistical Product and Service Solutions version 25.0 software (IBM, Armonk, NY, United States). Variables showing statistical differences in the univariate analysis were subsequently included in a multivariable logistic regression model to assess their net effects on cognitive function. Odds ratios (ORs) along with their 95% confidence intervals (CIs) were utilized to evaluate the independent impact of prognostic factors. The Chi-square test was used to assess the differences between groups with categorical variables. Kendall's correlation analysis was employed to identify associations of the Ascertain Dementia 8-Item Informant Questionnaire score with general information. All p -values were two-tailed, with $p < 0.05$ indicating statistical significance.

Quality control

The study was conducted anonymously to ensure the authenticity and validity of the data. Before the survey, the data collectors were trained uniformly and followed by a test after the training to ensure the accuracy and reliability of data collection. The data collectors, who were third-year nursing undergraduates from various locations, conducted the surveys in their communities therefore to reduce language barriers. Data were collected in real-time during the face-to-face interviews.

Results

The sample included 215 males and 312 females aged 18–94 years (average: 53.36 ± 18.06 years). The healthy group comprised 356

subjects aged 18–88 years (average: 49.93 ± 17.75 years), whereas the MCI group included 170 individuals. The Kendall sample estimation algorithm was used, which estimates the sample size 10–15 times the number of variables.

Comparing the healthy group and the MCI Group

A total of 527 participants were included in the cross-sectional study. The demographic characteristics of the residents are presented in Table 1. Based on the total AD8 scores, participants were grouped into two categories: the healthy group ($n = 356$) and the MCI group ($n = 171$), with those scoring ≥ 2 points on the AD8 classified as the MCI group. Compared with the healthy group, the MCI group had a higher proportion of older and overweight individuals ($p < 0.05$) but lower numbers of married, single, urban and high-income individuals, and lower FS scores ($p < 0.05$). However, no statistically significant differences were observed in gender, region, household composition, or occupation ($p > 0.05$).

Correlation analysis of MCI

Kendall's correlation analysis showed a negative correlation between FS ($b = -0.237$, $p < 0.001$), education level ($b = -0.187$, $p < 0.001$), personal income ($b = -0.191$, $p < 0.001$), and the AD8 score. Additionally, age ($b = 0.248$, $p < 0.001$) was positively correlated with the AD8 score (Table 2). The factor values are listed in Table 3.

Univariate logistic regression analysis revealed a statistically significant difference in age, place of residence, and FS level. Age [OR = 1.451, 95% CI (1.107–1.902), $p = 0.007$], FS [OR = 0.421, 95% CI (0.311–0.569), $p < 0.001$], and place of residence [OR = 5.523, 95% CI (3.572–8.539), $p < 0.001$] continued to be independently linked with MCI (Table 4).

Discussion

Influencing factors of MCI

Numerous conditions can cause a decline in cognitive function and dementia. This study indicated that MCI is associated with age, personal income, and especially FS scores.

Age and rural residency are the influencing factors

The risk of MCI increases with age and among rural residents, of which age is a nonmodifiable factor (Jia et al., 2020a; Alzheimer's Association, 2015). Age-related MCI is multifactorial, with numerous underlying and frequently co-morbid pathological correlates (McKenzie et al., 2022). Research indicated that various forms of brain pathology (such as cerebrovascular disease, neuritic plaques, neurofibrillary tangles, Lewy body disease, TDP-43 pathology, and hippocampal sclerosis) can be linked with an increased risk of age-related mild cognitive impairment (Kapasi et al., 2017; Power et al., 2018). Furthermore, living in rural areas is a major risk factor for mild cognitive impairment (Vega and

TABLE 1 Demographic characteristics of the residents.

| Variables | Group | Total <i>n</i> (%) | Health <i>n</i> (%) | Mild cognitive impairment <i>n</i> (%) | χ^2 | <i>p</i> |
|---------------------------|--|--------------------|---------------------|--|----------|----------|
| Gender | Male | 215 (40.80%) | 154 (43.30%) | 61 (35.7%) | 2.752 | 0.097 |
| | Female | 312 (59.20%) | 202 (56.70%) | 110 (64.3%) | | |
| Age | ≤59 | 319 (60.50%) | 247 (69.40%) | 72 (42.10%) | 36.718 | <0.001 |
| | 60–69 | 95 (18.00%) | 52 (14.60%) | 43 (25.10%) | | |
| | 70–79 | 91 (17.30%) | 47 (13.20%) | 44 (25.70%) | | |
| | ≥80 | 22 (4.20%) | 10 (2.80%) | 12 (7.00%) | | |
| Region | Inside Sichuan | 416 (78.90%) | 277 (77.80%) | 139 (81.30%) | 0.84 | 0.359 |
| | Outside Sichuan | 111 (21.10%) | 79 (22.20%) | 32 (18.70%) | | |
| Marital status | Married | 379 (71.90%) | 264 (74.20%) | 116 (67.30%) | 36.447 | <0.001 |
| | Divorced | 11 (2.10%) | 6 (1.70%) | 5 (2.90%) | | |
| | Widowed | 55 (10.40%) | 19 (5.30%) | 35 (21.10%) | | |
| | single | 82 (15.60%) | 67 (18.80%) | 15 (8.80%) | | |
| Household composition | Living alone | 45 (8.50%) | 25 (7.00%) | 20 (11.70%) | 3.696 | 0.158 |
| | Living with spouse | 209 (39.70%) | 147 (41.30%) | 62 (36.30%) | | |
| | Living with children or other family members | 273 (51.80%) | 184 (51.70%) | 89 (52.00%) | | |
| Occupation* | None | 132 (25.00%) | 87 (24.40%) | 45 (26.30%) | 0.369 | 0.832 |
| | Mental work | 83 (15.70%) | 58 (16.30%) | 25 (14.60%) | | |
| | Physical work | 312 (59.20%) | 211 (59.30%) | 102 (59.10%) | | |
| Education level | Primary school and below | 233 (44.20%) | 135 (37.90%) | 98 (57.30%) | 21.631 | <0.001 |
| | Junior high school | 125 (23.70%) | 86 (24.20%) | 39 (22.80%) | | |
| | High school and above | 169 (32.10%) | 135 (37.90%) | 34 (19.90%) | | |
| Personal income (monthly) | Less than 2000 RMB | 268 (50.90%) | 158 (44.40%) | 110 (64.30%) | 18.387 | <0.001 |
| | More than 2000 RMB | 259 (49.10%) | 198 (55.60%) | 61 (35.70%) | | |
| BMI | Underweight | 45 (8.50%) | 32 (9.00%) | 13 (7.60%) | 7.973 | 0.047 |
| | Normal | 361 (68.50%) | 246 (69.10%) | 115 (67.30%) | | |
| | Overweight | 101 (19.20%) | 60 (16.90%) | 41 (24.00%) | | |
| | Obese | 20 (3.80%) | 18 (5.10%) | 2 (1.20%) | | |
| FS level | Low level | 60 (11.40%) | 29 (8.10%) | 31 (18.10%) | 31.992 | <0.001 |
| | Medium level | 140 (26.60%) | 77 (21.60%) | 63 (36.80%) | | |
| | High level | 327 (62.00%) | 250 (70.20%) | 77 (45.30%) | | |
| Place of residence | Urban | 345 (65.50%) | 277 (77.80%) | 68 (39.80%) | 73.946 | <0.001 |
| | Rural | 182 (34.50%) | 79 (22.20%) | 103 (60.20%) | | |

*Using the Occupational Classification of the People's Republic of China (2015 edition) as a reference, we categorized occupations into two groups: mental work (e.g., professionals, government employees) and physical work (e.g., farmers, factory workers).
 FS, flourishing scale.

Newhouse, 2014). A study among older Indians demonstrated significant differences in cognitive impairment based on urban or rural residential status, with rural residence identified as a significant risk factor for cognitive impairment (Muhammad, 2023). Similarly, a cross-sectional survey of residents aged ≥65 years from 30 urban and 45 rural communities across China revealed that the prevalence of dementia and AD was notably higher in rural areas than in urban areas (Jia et al., 2014). Urban areas provide better transportation, healthcare access, health information, infrastructure, and educational opportunities, all of which contribute to improved health and quality of life for older

residents. In contrast, older adults in rural areas face limited and less adequate services in these areas, increasing the likelihood of developing MCI.

Flourishing is an important factor related to MCI

Our study found that flourishing is significantly associated with a lower risk of MCI. Specifically, participants with higher flourishing level had a reduced likelihood of MCI (OR = 0.421, 95%CI: 0.311–0.569, *p* < 0.001). This finding suggest that flourishing may have a protective effect on cognitive function, potentially by enhancing psychological resilience. Consistent with

TABLE 2 Kendall’s correlation analysis of Mild Cognitive Impairment with general information.

| | FS level | age | Education level | Personal income |
|----------------|------------------|------------------|------------------|------------------|
| AD8 score | | | | |
| <i>b</i> | −0.237 | 0.248 | −0.187 | −0.191 |
| <i>p</i> value | <i>p</i> < 0.001 | <i>p</i> < 0.001 | <i>p</i> < 0.001 | <i>p</i> < 0.001 |

FS, flourishing scale.

TABLE 3 Factor values of the independent variables.

| Values | Value |
|---------------------------|---|
| FS level | 1 = Low level, 2 = Medium level, 3 = High level |
| age | 1 = ≤59, 2 = 60 ~ 69, 3 = 70 ~ 79, 4 = ≥80 |
| Education level | 1 = Primary school and below, 2 = Junior high school, 3 = High school and above |
| Personal income (monthly) | 1 = Less than 2000 RMB, 2 = More than 2000 RMB |
| Marital status | 1 = Married, 2 = Divorced, 3 = Widowed, 4 = single |
| BMI | 1 = Underweight, 2 = Normal, 3 = Overweight, 4 = Obese |
| Place of residence | 1 = Urban, 2 = Rural |

prior research, our findings indicated that flourishing may protect against cognitive decline by fostering psychological resilience. Psychosocial resilience factors, such as positive emotional states and social support, may contribute more significantly to cognitive well-being than physical health alone (Reichstadt et al., 2007; Jeste et al., 2013; O'brien et al., 2023). Furthermore, psychological resilience and competence play a significant role in slowing down biological aging (Zábó et al., 2023), which aligns with our observation that individuals with higher flourishing scores exhibited better cognitive performance. These may help individuals more effectively cope with neuropathological changes, potentially delaying cognitive decline.

Correlation between flourishing and MCI

This study identified a correlation between flourishing and MCI. It indicated that individuals with higher flourishing levels have a significantly lower incidence of MCI, with a correlation coefficient of −0.237 (*p* < 0.001). This suggests that flourishing plays a meaningful role in reducing the risk of MCI and may serve as a protective factor in maintaining cognitive function. However, the research focusing on the relationship between MCI risk and flourishing is scarce. A randomized controlled trial involving 51 participants suggested that positive psychology interventions can enhance the subjective well-being of individuals diagnosed with amnesic MCI, with the benefits persisting for some time after the intervention ends (Tsiflikioti et al., 2023). The study also reflected that MCI may be related to the relatively intact emotional function in early AD (Bozeat et al., 2000). Flourishing may protect cognitive function through multiple pathways, including reducing stress-related neurotoxicity and enhancing emotional regulation. Chronic stress is known to elevate cortisol levels, which can accelerate hippocampal atrophy—a key

TABLE 4 Multivariate logistic regression analyses of factors affecting cognitive dysfunction.

| | Multivariate analysis | | |
|---------------------------|-----------------------|-------------|----------------|
| | OR | 95% CI | <i>p</i> value |
| Age | 1.451 | 1.107–1.902 | 0.007 |
| Education level | 0.784 | 0.574–1.069 | 0.124 |
| Personal income (monthly) | 0.625 | 0.387–1.008 | 0.054 |
| FS level | 0.421 | 0.311–0.569 | <0.001 |
| Marital status | 1.011 | 0.818–1.25 | 0.918 |
| BMI | 1.151 | 0.811–1.634 | 0.431 |
| Place of residence | 5.523 | 3.572–8.539 | <0.001 |

FS, flourishing scale.

brain region implicated in early AD (Wells et al., 2019; Hakeem et al., 2025; Sharan and Vellapandian, 2024). However, individuals with higher flourishing levels tend to exhibit greater psychological resilience, which has been linked to lower cortisol reactivity (Heller et al., 2013) and lower stress (Laakso et al., 2025). Additionally, flourishing fosters positive emotional states, which are associated with increased dopamine (Chopra, 2023) and serotonergic activity (Fan et al., 2023), both of which play crucial roles in cognitive processing and emotional regulation (Echouffo-Tcheugui et al., 2018; Ott and Nieder, 2019; Švob Štrac et al., 2016). By mitigating chronic stress and promoting emotional stability, flourishing may serve as a buffer against MCI risk and cognitive decline.

Chronic stress is a well-established risk factor for MCI and AD, primarily due to its impact on the hippocampus, a brain region highly susceptible to stress-induced atrophy (Kennedy et al., 2017; Hyer et al., 2021). Elevated stress levels lead to dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, resulting in prolonged cortisol exposure, which in turn accelerates neuronal damage and cognitive decline (Magri et al., 2006; Tsigos and Chrousos, 2002). However, increasing evidence suggests that positive psychology techniques, particularly those that foster flourishing, can effectively enhance subjective well-being and mitigate stress levels (Machado et al., 2019; Kinoshita et al., 2024). Flourishing has been linked to improved emotional regulation and lower cortisol reactivity (De Vries et al., 2022), potentially protecting the hippocampus from stress-induced damage. Therefore, flourishing may act as a protective factor against MCI, reducing the impact of stress and emotional disturbances on cognitive health.

Conclusively, in the future, greater attention should be given to the psychological aspects of patients with MCI. Instead of focusing solely on the negative aspects, more positive psychological interventions, such as psychological counseling, positive psychology training, and social support programs, should be implemented. These interventions can improve individuals’ flourishing levels, thereby enhancing their cognitive function.

Limitations

This study has some limitations, including the use of a non-random sampling method due to constraints in time and workforce, which may have affected generalizability. Future research should improve sampling methods and adopt longitudinal designs to

explore causal relationships between flourishing and MCI. Additionally, future studies need to investigate specific impacts of flourishing on various types of MCI.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Ethics Committee of the People's Hospital of Jinniu District in Chengdu, Sichuan, China. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

HL: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. XY: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. XG: Investigation, Writing – original draft, Writing – review & editing. ML: Investigation, Writing – original draft, Writing – review & editing. DB: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. XN: Investigation, Writing – original draft. XW: Investigation, Writing – original draft, Writing – review & editing. XL: Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Generative AI statement

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Association between multidimensional frailty and quality of life in older adults with coronary heart disease: a cross-sectional study

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Purpose: This study aims to investigate the relationship between multidimensional frailty and quality of life among older adults with coronary heart disease who are hospitalized.

Patients and methods: A convenience sampling approach was employed to select older adults with coronary heart disease admitted to the Cardiology Department of a tertiary hospital in Wuxi City between September 2023 and June 2024. The study utilized the General Information Questionnaire, the Tilburg Frailty Indicator (TFI), and the SF-12 Scale to gather data. To examine the relationship between multidimensional frailty and quality of life, Spearman correlation analysis was conducted. Additionally, stratified regression analysis was performed to identify factors associated with quality of life.

Results: Among 254 older adults with coronary heart disease, 135 (53.15%) exhibited multidimensional frailty. The physical health score of frail older patients with coronary heart disease (36.62 ± 6.51) was found to be lower than that of their non-frail counterparts (42.88 ± 6.91). A negative correlation was observed between multidimensional frailty and quality of life, encompassing both physical and mental health aspects ($r = -0.513, -0.428, p < 0.01$). Further analysis using stratified regression revealed that multidimensional frailty independently accounted for 9.1 and 11.3% of the variance in quality of life (physical health and mental health, respectively) among older adults with coronary heart disease.

Conclusion: Older adults with coronary heart disease often experience widespread frailty, which is linked to their quality of life. The presence of multifaceted weakness serves as a crucial indicator of life quality in these individuals.

KEYWORDS

multidimensional, frailty, quality of life, older adults, coronary heart disease

1 Introduction

The demographic composition of society has changed significantly. There is a notable increase in the aging population and a rise in chronic disease prevalence. Cardiovascular diseases have seen a continuous uptick in morbidity and mortality rates, with projections indicating that 330 million individuals in China are affected by these conditions. Among them,

the prevalence rate of CHD among older adults in China is approximately 27.8% aged 60 years and over (Wang, 2023), 11.4 million people are battling coronary heart disease (CHD) (Diseases NCfC, Health TWCotRoC, China Di, 2024) which stands as the primary cause of heart disease-related deaths and negatively impacts the older adult's quality of life. Research has indicated that various factors, including socio-demographic characteristics, lifestyle choices, and psychological well-being, play a role in influencing the quality of life experienced by older adults with CHD (Chu et al., 2019; Miao et al., 2019; Liu et al., 2023).

As the population ages, frailty has emerged as a common geriatric condition. A systematic review and meta-analysis of 64 studies involving 106,826 participants from 23 provinces in China reported that the prevalence of frailty among community-dwelling older adults was approximately 10.1% (95% CI: 8.5–11.7%) (Zhou et al., 2023). Research indicates that frailty affects 30% of older patients with CHD (Xiamin et al., 2023). Frailty older CHD adults face higher risks of unplanned readmission and all-cause mortality compared to their non-frail counterparts, with rates of 36.1 and 11.4%, respectively (Ning et al., 2021). Frailty status serves as a crucial indicator of adverse cardiovascular events and mortality in older CHD patients (Ning et al., 2021), significantly impacting patient outcomes and life quality. While existing studies have explored the relationship between frailty and both prognosis and quality of life, research specifically examining multidimensional frailty—including physical, cognitive, psychological, and social aspects—and its impact on quality of life in older patients with CHD, particularly within tertiary care settings, remains limited. A study focusing on hospitalized cardiac patients revealed a general decline in quality of life and an increase in psychological issues among these individuals (Tang et al., 2021). Unlike previous studies that predominantly addressed physical frailty, multidimensional frailty encompasses a broader range of factors. For instance, a five-year longitudinal study demonstrated that multidimensional frailty, assessed using the Multidimensional Prognostic Index (MPI), more accurately predicts mortality in community-dwelling older adults compared to physical frailty assessments like the Cardiovascular Health Study (CHS) index (Cella et al., 2021). Given the increasing prevalence of frailty in older CHD patients, understanding its multidimensional nature. Gobbens et al. (2015) introduced the concept of multidimensional frailty, proposing an integrated model where various factors contribute to a dynamic state of decline in one or more domains (physical, psychological, social), increasing the likelihood of negative outcomes. This integrated approach to frailty emphasizes treatment and prevention strategies, incorporating holistic care concepts and interdisciplinary collaboration. This aligns with the current 'biopsychosocial' model in modern medicine and resonates with China's promotion of healthy aging and wellness (Yuhui et al., 2024). Consequently, an increasing number of researchers are exploring the multidimensional nature of frailty (Xue et al., 2024), highlighting its complexity in older adults and advocating for a comprehensive management approach. This emphasis on frailty's impact on quality of life and prognosis in older CHD adults aims to raise awareness among clinical staff and ultimately enhance patient well-being.

The global population has experienced significant aging in recent times, prompting the World Health Organization to introduce the concept of active aging as a means to address this worldwide trend (Abdullah and Wolbring, 2013). Aging is a natural stage of life that entails physical, psychological, and social changes. As people age, it is

important to take measures to maintain or improve their quality of life in order to age actively and healthily. Among the most recommended non-pharmacological strategies for improving quality of life in old age is physical exercise (Parra-Rizo, 2020). Strength training is an effective intervention. It not only improves muscle strength and balance but also helps reduce fall frequency, improves overall physical condition, and decreases the fear of falling, which together improve the quality of life and autonomy of older adults (Rivera Miranda et al., 2024). Evidence suggests that active aging plays a pivotal role in safeguarding the physical and mental health of older adults, ensuring their quality of life, and slowing down the progression of frailty (Maidan et al., 2023). Currently, most studies concentrate on the physical frailty status and quality of life of older CHD adults, which does not align with the principles of active aging and the contemporary biopsychosocial medical model. Consequently, it is essential to examine the multidimensional frailty condition of older adults and its effects on their quality of life. This approach seeks to enhance clinical recognition of frailty's multidimensional aspects—physical, cognitive, psychological, and social—in hospitalized patients with CHD. It also aims to promote the implementation of targeted interventions by healthcare professionals. These interventions include structured exercise programmes, nutritional counseling, cognitive-behavioral strategies, and social support initiatives (Dent et al., 2019; Choi et al., 2023). By addressing the various dimensions of frailty, this method works to improve the overall quality of life for patients. This study investigated the relationship between multidimensional frailty and quality of life among older adults with CHD in Chinese hospitals. The goal was to provide guidance for clinical practice and contribute to improving patients' health management. Building on this background, the following section outlines the methods employed to investigate multidimensional frailty in older adults with CHD.

2 Materials and methods

2.1 Research population

A study was conducted using convenience sampling to recruit older patients with CHD from the Cardiology Department of a tertiary hospital in Wuxi between September 2023 and June 2024. The research included 20 variables, as per observational research sample calculation guidelines. All potential participants were approached during their hospital stay and those who agreed to participate were interviewed face-to-face by trained researchers using a standardized questionnaire. Clinical data were also extracted from hospital records to ensure data accuracy. Prior to enrolment, written informed consent was obtained from each participant. According to the regression analysis, the sample size should be 5–10 times the number of independent variables plus an extra 10% to account for attrition. Aiming for a sample size of 112–223 people with 20 independent variables, of the 274 patients approached, 254 agreed to participate, a response rate of approximately 92.7% (Ping et al., 2010). The study ultimately included 254 cases. In order to enhance the robustness of the findings and to represent the population more fully. Participants were eligible if they: (1) had a confirmed clinical diagnosis of coronary heart disease: angiographically confirmed stenosis of $\geq 50\%$ in ≥ 1 major coronary heart or previous revascularisation (according to ESC guidelines) (Byrne et al., 2023); (2) were 60 years or older; and (3) voluntarily agreed to participate,

signed an informed consent form, and could communicate effectively. Exclusion criteria encompassed: (1) individuals with tuberculosis, advanced malignant tumors, HIV, severe chronic gastrointestinal diseases, or psychiatric disorders such as schizophrenia and depression; (2) those who had participated in a clinical drug trial within the past 3 months; and (3) patients classified as NYHA Cardiac Function Class IV. The Ethics Committee of the Affiliated Hospital of Jiangnan University approved this study (approval number LS2023085).

2.2 General information questionnaire

Following the researcher's methodology, various patient data were extracted from medical records. These included demographic information such as age, gender, body mass index (BMI), and educational background. Additionally, lifestyle factors like living arrangements, treatment modalities, tobacco use, alcohol consumption, sleep patterns, and exercise habits were documented. The study also considered clinical aspects, including CHD classification, cardiac function status, presence of multiple chronic conditions (defined as two or more), and medication history.

2.3 The tilburg frailty indicator (TFI)

Gobbens et al. (2015) created the TFI in 2010 to evaluate multidimensional frailty in patients. The instrument consists of 15 items covering three domains: physical, psychological, and social frailty. Each item is scored as either '0' or '1,' with a maximum total score of 15 points. The physical frailty domain ranges from 0 to 8 points, psychological frailty from 0 to 4 points, and social frailty from 0 to 3 points. Multidimensional frailty is indicated by a score ≥ 5 , while domain-specific frailty is indicated by scores ≥ 3 for physical frailty and ≥ 2 for both psychological and social domains. Higher scores indicate greater frailty severity (Gobbens et al., 2021). Xing et al. (2013) translated the scale into Chinese and validated it in older patients with chronic diseases. The Chinese version showed good reliability with a Cronbach's α coefficient of 0.686 (Xing et al., 2013), making it a valid tool for assessing multidimensional frailty in older patients with chronic conditions in China.

2.4 The Q12-item short-form health survey (SF-12)

Ware et al. (1996) developed a simplified version called SF-12. This assessment consists of 12 items covering eight health dimensions: general health, physical functioning, physical role, emotional role, bodily pain, vitality, mental health, and social functioning. These dimensions are categorized into Physical Health (PCS) and Mental Health (MCS) components. The SF-12 requires data reassignment and standardized transformation of raw scores, utilizing specific assignment and transformation methods (Hongyu, 2016). Scores range from 0 to 100, with higher scores indicating better quality of life. The SF-12 has been extensively validated in a population of community-dwelling older adults in China, showing high internal consistency reliability (a Cronbach's α coefficient of 0.910) (Shou et al., 2016) and good construct validity (the two-factor model explained

60.7% of the total variance) (Shou et al., 2016). It also showed strong convergent and discriminant validity, and correlated well with the SF-36 total score, making the scale suitable for Chinese older adults.

2.5 Survey and quality control methods

The study's data was gathered through paper surveys administered within 48 h of hospital admission. The department's head nurse received training content provided by the researcher and conducted the survey. The training covered the background, objectives and methods of the study, followed by several practical simulations. Nurses' competence was assessed through pre-test assessments and ongoing performance monitoring during the pilot phase. Only after passing the competency assessment were they assigned to conduct the survey. In this study, only one investigator was employed to ensure consistency and quality of data. The researcher, who was also the survey administrator, provided participants with a comprehensive explanation of the study's objectives and importance. Participants then gave their consent by signing an informed consent document before the survey began. Questionnaires were immediately collected upon completion. The retrieved forms were examined for completeness, with any incomplete surveys being discarded. The remaining questionnaires underwent a double-check process before the data was entered into the system.

A number of measures were taken to minimize the potential for bias. To address the issue of observer bias, all investigators were trained to collect data with a uniform terminology and to standardize data collection protocols. This included the use of standardized questionnaires and measurement tools, as well as blind testing of investigator-participant exposure where possible. This approach helped to reduce inter-observer variability and ensure consistency and objectivity in the assessment of results.

2.6 Statistical methods

Statistical analysis was conducted using SPSS27.0. For normally distributed quantitative data, results were presented as mean \pm standard deviation ($\bar{X} \pm S$) while skewed data were expressed as M (Q1, Q3). Qualitative data were reported as frequencies and percentages. One-way analyses employed t-tests and H-tests. The relationship between multidimensional frailty and quality of life was examined using Spearman correlation analysis. Stratified regression analyses were performed with quality of life scores as the outcome variable; and statistically significant factors from univariate analyses and multidimensional frailty as predictors. Model 1 incorporated general data as independent variables, while Model 2 added multidimensional frailty. Statistical significance was set at $p < 0.05$.

3 Results

3.1 Evaluating the quality of life metrics for older adults with CHD across various demographic and clinical factors

The study involved 254 older adults with CHD. Their average physical health score was 39.55 ± 7.39 points, with significant

variations observed among groups based on age, exercise habits, sleep issues, cardiac function classification, and presence of multimorbidity groups ($p < 0.05$). The mean mental health score was 44.80 ± 4.98 points, showing significant differences between various sleep groups ($p < 0.05$). Further details are provided in [Table 1](#).

3.2 Comparison of quality of life scores in different frailty groups

In this study involving 254 participants, the multidimensional frailty prevalence was 53.15% based on the TFI scoring criteria.

TABLE 1 Assessment of life quality scores for older adults with CHD, categorized by various characteristics ($n = 254$).

| Characteristic | Number | PCS | Statistic | p -value | MCS | Statistic | p -value |
|--|-------------|-------------------|-------------|------------|----------------------|-------------|------------|
| Age (years, $\bar{X} \pm S$) | | | $t = 3.86$ | <0.001 | | $t = 0.19$ | 0.846 |
| 60–74 | 180 (70.87) | 40.67 ± 7.13 | | | 44.84 ± 5.06 | | |
| ≥ 75 | 74 (29.13) | 36.83 ± 7.35 | | | 44.71 ± 4.82 | | |
| Sex | | | $t = 1.71$ | 0.088 | | $t = 1.71$ | 0.088 |
| Male | 175 (68.90) | 40.08 ± 7.39 | | | 44.65 ± 4.83 | | |
| Female | 79 (31.10) | 38.37 ± 7.28 | | | 45.13 ± 5.31 | | |
| BMI [(kg/m ²), $\bar{X} \pm S$] | | | $F = 2.27$ | 0.106 | | $F = 0.85$ | 0.427 |
| <18.5 | 6 (2.36) | 44.99 ± 9.23 | | | 43.97 ± 4.38 | | |
| 18.5–23.9 | 102 (40.16) | 38.80 ± 7.53 | | | 45.29 ± 5.30 | | |
| >23.9 | 146 (57.48) | 39.85 ± 7.15 | | | 44.49 ± 4.77 | | |
| Education [$\bar{X} \pm S/M$ (Q1, Q3)] | | | $F = 2.32$ | 0.076 | | $H = 4.51$ | 0.211 |
| Uneducated | 16 (6.30) | 38.34 ± 7.11 | | | 42.81 (40.85, 44.86) | | |
| Primary | 56 (22.05) | 38.29 ± 7.70 | | | 45.40 (41.02, 48.34) | | |
| Middle | 119 (46.85) | 40.84 ± 6.96 | | | 44.51 (41.47, 48.43) | | |
| High school and above | 63 (24.80) | 38.55 ± 7.72 | | | 45.41 (42.61, 47.50) | | |
| Marital status ($\bar{X} \pm S$) | | | $F = 2.45$ | 0.089 | | $F = 0.55$ | 0.580 |
| Unmarried | 2 (0.79) | 46.51 ± 5.87 | | | 42.69 ± 8.35 | | |
| Married | 215 (84.65) | 39.83 ± 7.23 | | | 44.71 ± 4.82 | | |
| Divorced or widowed | 37 (14.57) | 37.54 ± 8.01 | | | 45.47 ± 5.76 | | |
| Live alone ($\bar{X} \pm S$) | | | $t = -1.01$ | 0.314 | | $t = -0.01$ | 0.995 |
| Yes | 22 (8.66) | 41.07 ± 7.25 | | | 44.80 ± 4.87 | | |
| NO | 232 (91.34) | 39.41 ± 7.40 | | | 44.81 ± 6.19 | | |
| Medical insurance ($\bar{X} \pm S$) | | | $F = 0.55$ | 0.651 | | $F = 1.71$ | 0.165 |
| Countryside | 21 (8.27) | 37.93 ± 6.81 | | | 42.88 ± 4.57 | | |
| Urban residents | 225 (88.58) | 39.63 ± 7.49 | | | 45.02 ± 4.98 | | |
| Employee | 6 (2.36) | 41.24 ± 4.22 | | | 42.56 ± 5.60 | | |
| Other | 2 (0.79) | 42.41 ± 11.68 | | | 46.67 ± 2.72 | | |
| Types of CHD ($\bar{X} \pm S$) | | | $t = 0.78$ | 0.439 | | $t = -0.56$ | 0.576 |
| Acute type | 142 (55.91) | 39.87 ± 7.13 | | | 44.65 ± 4.99 | | |
| Stabilized | 112 (44.09) | 39.14 ± 7.71 | | | 45.00 ± 4.99 | | |
| Smoking ($\bar{X} \pm S$) | | | $F = 2.36$ | 0.096 | | $F = 0.43$ | 0.649 |
| Never | 110 (43.31) | 38.51 ± 7.76 | | | 44.91 ± 5.27 | | |
| Smoking | 91 (35.83) | 39.92 ± 6.95 | | | 44.44 ± 4.93 | | |
| Quit smoking | 53 (20.87) | 41.08 ± 7.10 | | | 45.19 ± 4.46 | | |

(Continued)

TABLE 1 (Continued)

| Characteristic | Number | PCS | Statistic | <i>p</i> -value | MCS | Statistic | <i>p</i> -value |
|---|-------------|------------------|-------------|-----------------|------------------|-------------|-----------------|
| Drinking alcohol ($\bar{X} \pm S$) | | | $F = 1.36$ | 0.258 | | $F = 0.17$ | 0.847 |
| Never | 129 (50.79) | 38.85 \pm 7.32 | | | 44.95 \pm 5.15 | | |
| Drinking | 58 (22.83) | 40.69 \pm 7.05 | | | 44.49 \pm 4.55 | | |
| Quit drinking | 67 (26.38) | 39.91 \pm 7.75 | | | 44.79 \pm 5.06 | | |
| Exercise ($\bar{X} \pm S$) | | | $F = 5.57$ | 0.004 | | $F = 1.97$ | 0.142 |
| Never | 49 (19.29) | 38.87 \pm 8.00 | | | 43.82 \pm 6.17 | | |
| Occasionally | 106 (41.73) | 38.12 \pm 7.22 | | | 44.61 \pm 4.74 | | |
| Often | 99 (38.98) | 41.42 \pm 6.90 | | | 45.49 \pm 4.51 | | |
| Insomnia ($\bar{X} \pm S$) | | | $t = -2.29$ | 0.023 | | $t = -2.56$ | 0.011 |
| Yes | 91 (35.83) | 38.14 \pm 8.07 | | | 43.74 \pm 5.47 | | |
| No | 163 (64.17) | 40.34 \pm 6.87 | | | 45.39 \pm 4.60 | | |
| Pain ($\bar{X} \pm S$) | | | $t = -0.75$ | 0.452 | | $t = -0.41$ | 0.681 |
| No | 193 (75.98) | 39.35 \pm 7.78 | | | 44.73 \pm 4.84 | | |
| Yes | 61 (24.02) | 40.17 \pm 6.00 | | | 45.03 \pm 5.45 | | |
| Cardiac function classification ($\bar{X} \pm S$) | | | $F = 11.97$ | <0.001 | | $F = 2.23$ | 0.109 |
| I class | 129 (50.79) | 41.27 \pm 6.94 | | | 45.11 \pm 5.15 | | |
| II class | 102 (40.16) | 38.64 \pm 7.14 | | | 44.87 \pm 4.98 | | |
| III class | 23 (9.06) | 33.90 \pm 7.62 | | | 42.75 \pm 3.45 | | |
| PCIs ($\bar{X} \pm S$) | | | $F = 0.66$ | 0.575 | | $F = 0.88$ | 0.453 |
| 0 | 180 (70.87) | 39.51 \pm 7.63 | | | 44.79 \pm 5.09 | | |
| 1 | 54 (21.26) | 39.09 \pm 6.99 | | | 44.27 \pm 4.67 | | |
| 2 | 14 (5.51) | 40.13 \pm 6.28 | | | 46.51 \pm 4.47 | | |
| 3 | 6 (2.36) | 43.48 \pm 5.67 | | | 46.03 \pm 5.44 | | |
| Number of medications ($\bar{X} \pm S$) | | | $F = 0.38$ | 0.687 | | $F = 1.10$ | 0.333 |
| 0 | 1 (0.39) | 45.93 | | | 37.52 | | |
| 1–4 | 75 (29.53) | 39.58 \pm 7.78 | | | 44.95 \pm 4.72 | | |
| ≥ 5 | 178 (70.08) | 39.50 \pm 7.24 | | | 44.78 \pm 5.08 | | |
| Multimorbidity ($\bar{X} \pm S$) | | | $t = 2.04$ | 0.043 | | $t = 0.47$ | 0.638 |
| 0–1 | 203 (79.92) | 40.04 \pm 6.67 | | | 44.88 \pm 5.00 | | |
| ≥ 2 | 51 (20.08) | 37.59 \pm 9.56 | | | 44.51 \pm 4.95 | | |
| Falling ($\bar{X} \pm S$) | | | $t = -0.19$ | 0.851 | | $t = 0.47$ | 0.640 |
| No | 223 (87.80) | 39.52 \pm 7.57 | | | 44.86 \pm 5.05 | | |
| Yes | 31 (12.20) | 39.78 \pm 6.00 | | | 44.41 \pm 4.47 | | |

Continuous variables are expressed as mean \pm SD ($\bar{X} \pm S$) and analyzed by t test or F test; Continuous variables are expressed as the median (interquartile spacing) and analyzed by H test.

Frail older patients with coronary artery disease scored lower in physical health (36.62 \pm 6.51) compared to their non-frail counterparts (42.88 \pm 6.91). Statistically significant differences in physical health were observed between groups with multidimensional frailty, physical frailty, and psychological frailty ($p < 0.05$). Similarly, frailty older patients with CHD scored lower in mental health (43.10 \pm 4.75) than non-frailty patients (46.73 \pm 4.53). The difference in mental health scores among multidimensional frailty, physical frailty, and psychological frailty groups was also statistically significant ($p < 0.05$). Further details are provided in [Table 2](#).

3.3 Examining the relationship between multidimensional frailty and quality of life among older adults with CHD

An examination of the relationship between multidimensional frailty and quality of life in older adults with CHD using Spearman correlation analysis; revealed that multidimensional frailty had a stronger correlation with physical health compared to mental health ($r = -0.513$, $p < 0.01$). Regarding the three components of multidimensional frailty, the PCS showed a moderate negative correlation with physical frailty ($r = -0.454$, $p < 0.01$), while psychological frailty ($r = -0.360$, $p < 0.01$)

TABLE 2 Comparison of quality of life scores in different frailty groups ($n = 254$).

| Characteristic | Number | PCS | t | p -value | MCS | t | p -value |
|--|-------------|------------------|-------|------------|------------------|------|------------|
| Multidimensional frailty ($\bar{X} \pm S$) | | | 7.43 | <0.001 | | 6.21 | <0.001 |
| No | 119 (46.85) | 42.88 \pm 6.91 | | | 46.73 \pm 4.53 | | |
| Yes | 135 (53.15) | 36.62 \pm 6.51 | | | 43.10 \pm 4.75 | | |
| Physical frailty ($\bar{X} \pm S$) | | | 6.04 | <0.001 | | 3.16 | <0.001 |
| No | 101 (39.76) | 42.78 \pm 7.12 | | | 46.00 \pm 5.15 | | |
| Yes | 153 (60.24) | 37.42 \pm 6.78 | | | 44.01 \pm 4.71 | | |
| Psychological frailty ($\bar{X} \pm S$) | | | 4.17 | <0.001 | | 4.97 | <0.001 |
| No | 84 (33.07) | 42.21 \pm 6.76 | | | 46.91 \pm 4.55 | | |
| Yes | 170 (66.93) | 38.23 \pm 7.34 | | | 43.76 \pm 4.86 | | |
| Social frailty ($\bar{X} \pm S$) | | | -0.77 | 0.440 | | 0.06 | 0.873 |
| No | 233 (91.73) | 39.44 \pm 7.39 | | | 44.82 \pm 4.85 | | |
| Yes | 21 (8.27) | 40.74 \pm 7.40 | | | 44.59 \pm 6.34 | | |

PCS, Physical Component Summary; MCS, Mental Component Summary. Continuous variables are expressed as mean \pm SD ($\bar{X} \pm S$) and analyzed by t test.

and social frailty ($r = -0.228$, $p < 0.01$) exhibited weak negative correlations with PCS. The MCS demonstrated moderate negative correlations with physical frailty, psychological frailty, and social frailty ($r = -0.269$, -0.392 , -0.265 , $p < 0.01$), which were weakly negatively correlated with PCS. Further details can be found in [Table 3](#).

3.4 Layered regression evaluation of elements influencing the quality of life among older adults with CHD

The stratified regression analysis incorporated variables that demonstrated statistically significant differences in quality of life among older adults with CHD, as identified through univariate analysis. [Table 4](#) presents the results of this analysis. In PCS model 1, age, cardiac function grading, and exercise habits emerged as the primary predictors of PCS in older adults with CHD ($R^2 = 0.177$, $F = 10.669$, $p < 0.001$). PCS model 2, which included multidimensional frailty, revealed that age, cardiac function classification, exercise habits, and multidimensional frailty were the main predictors of quality of life in stroke patients ($R^2 = 0.268$, $F = 15.036$, $\Delta R^2 = 0.091$, $p < 0.001$). This indicates that multidimensional frailty independently accounts for 9.1% of PCS variance, suggesting a significant negative impact on PCS. For MCS, model 1 identified sleep disturbance as the primary predictor in older adults with CHD ($R^2 = 0.025$, $F = 6.554$, $p = 0.011$). The addition of multidimensional frailty in MCS model 2 showed that it was the main predictor of MCS ($R^2 = 0.138$, $F = 20.102$, $\Delta R^2 = 0.113$, $p < 0.001$), independently explaining 11.3% of MCS variance and implying a significant adverse effect on MCS.

4 Discussion

A cross-sectional investigation was conducted to explore the relationship between multifaceted frailty and life quality among older adults with CHD. The study evaluated multidimensional frailty and quality of life in 254 older adults with coronary artery disease. Results

TABLE 3 Examining the relationship between multidimensional frailty and quality of life among older adults with CHD ($n = 254$).

| Characteristic | PCS | MCS |
|--------------------------|----------|----------|
| Multidimensional frailty | -0.513** | -0.428** |
| Physical frailty | -0.454** | -0.269** |
| Psychological frailty | -0.360** | -0.392** |
| Social frailty | -0.228** | -0.265** |

* p -value < 0.05, ** p -value < 0.01. PCS, Physical Component Summary; MCS, Mental Component Summary.

indicated that 53.15% of these older adults exhibited multidimensional frailty, with frail individuals scoring lower on the quality of life measures compared to their non-frail counterparts. The research revealed a significant negative correlation between quality of life and multidimensional frailty across physical, psychological, and social domains. Furthermore, stratified linear regression analysis identified multidimensional debility as a key predictor of life quality in this older population.

Contrary to earlier findings, this investigation revealed a substantially higher prevalence of multidimensional frailty in older adults with CHD admitted (53.15% compared to 30.9%) ([Liu et al., 2024](#)). The observed difference in frailty prevalence may stem from the study's use of an integrated frailty model. Unlike traditional frailty assessments, which predominantly focus on physical aspects such as muscle weakness and fatigue, the integrated model expands its scope to incorporate psychological and social frailty. This comprehensive approach likely captures a broader spectrum of frailty-related factors, which may account for the higher prevalence observed in this study. Additionally, variations in measurement tools and criteria across studies can lead to discrepancies in findings. For instance, different frailty indices or scales employed in various studies may influence how frailty is identified and classified, further contributing to the observed differences. The pathogenesis of CHD may also contribute to this difference, as chronic inflammation and immune activation, along with elevated inflammatory markers,

TABLE 4 Stratified regression analysis examining factors associated with quality of life among older adults with CHD (n = 254).

| Model | Independent variables | β | SE | β' | t | p-value |
|---------|-------------------------------|---------|-------|----------|--------|---------|
| PCS | | | | | | |
| Model 1 | Age | −3.199 | 0.957 | −0.197 | −3.578 | 0.001 |
| | Heart Function Classification | −2.603 | 0.671 | −0.230 | −3.881 | <0.001 |
| | Exercise | 1.696 | 0.477 | 0.207 | 3.553 | <0.001 |
| | Insomnia | 1.102 | 0.903 | 0.072 | 1.221 | 0.072 |
| | Multimorbidity | −1.426 | 0.867 | −0.096 | −1.644 | 0.102 |
| Model 2 | Age | −2.161 | 0.924 | −0.133 | −2.337 | 0.020 |
| | Heart Function Classification | −2.081 | 0.641 | −0.184 | −3.247 | 0.001 |
| | Exercise | 1.262 | 0.458 | 0.154 | 2.755 | 0.006 |
| | Insomnia | 0.158 | 0.871 | 0.010 | 0.181 | 0.857 |
| | Multimorbidity | −1.473 | 0.820 | −0.100 | −1.797 | 0.074 |
| | Multidimensional frailty | −4.792 | 0.874 | −0.324 | −5.481 | <0.001 |
| MCS | | | | | | |
| Model 1 | Insomnia | 1.650 | 0.645 | 0.159 | 2.560 | 0.011 |
| Model 2 | Insomnia | 0.787 | 0.626 | 0.076 | 1.257 | 0.210 |
| | Multidimensional frailty | −3.445 | 0.601 | −0.346 | −5.729 | <0.001 |

PCS, Physical Component Summary; MCS, Mental Component Summary. Model 1 in PCS: $R^2 = 0.177$, adjusted $R^2 = 0.160$, $F = 10.669$, $p < 0.001$; Model 2: $R^2 = 0.268$, adjusted $R^2 = 0.250$, $F = 15.036$, $\Delta R^2 = 0.091$, $p < 0.001$; Model 1 in MCS: $R^2 = 0.025$, adjusted: $R^2 = 0.021$, $F = 6.554$, $p = 0.011$; Model 2: $R^2 = 0.138$, adjusted $R^2 = 0.131$, $F = 20.102$, $\Delta R^2 = 0.113$, $p < 0.001$.

contribute to physical debilitation. Additionally, cellular changes, including mitochondrial dysfunction, and metabolic imbalances such as low testosterone and vitamin D deficiency, play a role in somatic deterioration (Veronese et al., 2021). Regarding disease characteristics, older CHD patients typically present with multi-branch lesions and atypical clinical symptoms. These may manifest as asymptomatic myocardial ischemia, ischemic heart failure, or sudden cardiac death (Huayong, 2014). The disease has a prolonged onset and duration, with a 70.3% incidence rate in autumn and winter (Ping and Caihua, 2008) and a recurrence rate of 40–50% (Galimzhanov et al., 2023). From a psychological perspective, these patients experience increased distress due to recurring episodes and financial burdens, leading to higher rates of anxiety and depression. This stress activates the hypothalamic–pituitary–adrenal (HPA) axis, leading to elevated levels of cortisol and adrenaline (James et al., 2023). Chronically elevated hormones can impair cognitive function and increase the incidence of depression (Dziurkowska and Wesolowski, 2021). Research confirms that chronic stress and associated hormonal changes are linked to neurodegenerative diseases and mental health disorders (Knezevic et al., 2023). In addition, lack of social support can cause emotional agitation, accompanied by increased fatigue, headaches, and lethargy (Wang, 2022; Ling et al., 2021), exacerbating the risk of multidimensional frailty. The integrated frailty model suggests that frailty can be reversed or delayed. And multidimensional frailty is prevalent in older patients with CHD, therefore, it is clinically necessary to assess and monitor changes in the condition of older adults with CHD, as well as evaluate and manage frailty holistically and promptly.

This research classified multidimensional frailty into physical, psychological, and social components, revealing that these aspects are linked to the quality of life in older CHD patients during hospitalization. Research has shown that quality of life scores for

older CHD patients with comorbid frailty are lower than those without frailty. This aligns with previous studies indicating that frailty worsens the health of these patients, resulting in a diminished quality of life (Veronese et al., 2022; Nguyen and Arnold, 2023). A negative relationship was observed between physical frailty and quality of life ($r = -0.454$, $p < 0.01$); increased physical frailty corresponded with decreased quality of life in older CHD patients. Physical frailty encompasses physiological, endurance, balance, and mobility aspects (Gobbens et al., 2021), and prior research has shown that older CHD patients experience reduced exercise capacity and insufficient physical activity as they age, resulting in diminished quality of life (Katsi et al., 2021; Wardoku et al., 2019). Psychological frailty was negatively associated with quality of life ($r = -0.454$, $p < 0.01$), Nonka et al. (2021) demonstrated that elevated levels of depression and anxiety, coupled with poor social functioning, lead to reduced quality of life and survival rates in CHD patients. Frailty and depression significantly overlap, representing two prevalent conditions in the older cardiovascular population, with pathogenesis linked to inflammation, metabolic dysregulation, and cerebral white matter lesion sites (Aihti et al., 2023). Depression and anxiety are also elements of psychological vulnerability. Similarly, social frailty negatively correlates with quality of life ($r = -0.454$, $p < 0.01$). A longitudinal study emphasized the importance of assessing loneliness, confirming that it predicts quality of life in coronary artery disease patients after 9 months (Fan et al., 2023). This is associated with the repetitive stress of life events and social isolation triggers dysregulation of the sympathetic nerves. The hypothalamic–pituitary–adrenal (HPA) axis may increase inflammation, endothelial dysfunction, atherosclerosis, and a heightened risk of CHD (Gronewold et al., 2021). Recent studies continue to emphasize the complex relationship between social frailty and CHD. One prospective cohort study found that patients with high social isolation had a 15% higher risk of developing CHD compared to

those with low social isolation (HR = 1.15, 95% CI: 1.05–1.26; $p = 0.0017$) (Sharif-Nia et al., 2025). Likewise, loneliness was linked to a 15% increased risk of coronary heart disease (HR = 1.15, 95% CI: 1.10–1.20; $p < 0.001$) (Yang et al., 2025). Notably, the correlation coefficient between multidimensional frailty and quality of life surpassed the coefficients for individual physical, mental, and social frailty ($r = -0.454$, $p < 0.01$). This suggests that healthcare professionals should focus on the role of multidimensional frailty in the quality of life of older CHD patients and conduct comprehensive frailty assessments.

Although current research has focussed on physical frailty in older persons with CHD, the present study highlights the importance of incorporating multidimensional physical frailty as a key factor affecting quality of life. This study is unique in that it emphasizes the multidimensional nature of frailty (including physical, psychological and social), which is a departure from previous studies that have focused primarily on physical aspects. This research approach provides a more comprehensive understanding of frailty and its impact on quality of life in older patients with CHD. In addition to this, this study advocates a comprehensive assessment of frailty and personalized interventions based on individual frailty in order to improve the quality of life of older persons with CHD.

Based on the results of this study, we encourage healthcare professionals to conduct regular multidimensional frailty assessments in older patients with coronary artery disease. Such assessments should include physical, psychological, and social aspects to provide a comprehensive assessment of frailty. In addition, comprehensive programmes addressing these dimensions should be designed and implemented to improve the patient's health. These programmes may include physical interventions: Exercise rehabilitation programmes tailored to the individual's frailty condition, focusing on improving strength, endurance and mobility. Psychological support: Counseling and mental health interventions to address anxiety, depression and emotional distress. Social support: Community-based programmes and social engagement activities to reduce isolation and improve overall quality of life.

This research has several constraints. First, its cross-sectional nature prevents the establishment of a causal link between multidimensional frailty and quality of life among older individuals with CHD. Second, the study's limited scope, focusing only on Wuxi, may compromise its accuracy and fail to represent a wider population. To address these limitations, future research should aim to increase the sample size and conduct studies across various locations, thereby enhancing generalizability. Additionally, longitudinal studies are necessary to gain deeper insights into how multidimensional frailty affects the quality of life and prognosis of older patients with CHD following their discharge from the hospital.

5 Conclusion

Older adults with CHD frequently experience multidimensional frailty, which is strongly linked to their quality of life. As a key factor influencing life quality, multidimensional frailty should be identified early through screening and assessment by healthcare professionals. To enhance patients' quality of life and potentially prevent or slow the development of multidimensional frailty, medical staff should implement individualized care strategies.

Data availability statement

The datasets presented in this article are not readily available because of the privacy of the participants. Requests to access the datasets should be directed to yanxiao1109@163.com.

Ethics statement

The studies involving humans were approved by the Affiliated Hospital of Jiangnan University, Wuxi (LS2023085). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

DoM: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft. YY: Writing – review & editing. DeM: Conceptualization, Data curation, Methodology, Writing – original draft. YH: Formal analysis, Methodology, Project administration, Validation, Writing – review & editing. XW: Funding acquisition, Resources, Supervision, Visualization, Writing – review & editing.

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Conflict of interest

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

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Perceived health, quality of life and happiness among older professional artisans in a UNESCO Creative City of crafts and folk art

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Globally, it is a priority to understand how to improve health, quality of life, and happiness in a long-lived and rapidly aging population. Evidence on the health outcomes of working in later life is mixed, with some studies suggesting it benefits mental health by preserving identity, status, social participation, and a sense of purpose, while others highlight potential adverse effects. Research on aging at work has seldom focused on older adults professionally engaged in artistic activities, particularly across different craft sectors, in contrast to the extensive research on art-based interventions aimed at promoting well-being among older individuals. This study aims to describe the perceptions of health, quality of life, and happiness among older professional artisans from a UNESCO Creative City of Crafts and Folk Art in Portugal, and examine the associations with sociodemographic and professional variables. A cross-sectional study was conducted, involving primary data collection through a survey administered in the participants' ($N = 55$) work environments. Eligible participants were individuals aged 55 or older, living in the community, and working in various craft sectors. The artisans completed the WHOQOL-BREF scale, were assessed for depressive symptoms with the PHQ-8 scale, and were inquired on happiness with life using an item from the European Survey on Aging Protocol (ESAP). Most artisans perceived their overall quality of life as 'good', with the psychological domain receiving the highest score ($M = 84.92$; $SD = 10.98$). Most artisans (56.4%) also reported feeling 'very happy' and being satisfied or very satisfied with their health (60%). Age was positively correlated with happiness ($p = 0.020$). A significant difference was observed in the WHOQOL-BREF environment domain between craft sectors ($p = 0.023$). An association was observed between different craft sectors and their perceived benefits, particularly regarding health, quality of life, and well-being. This study contributes to aging research by focusing on professional activity in the craft and folk art sector, highlighting the intersection of aging, work, and artistic engagement, and offering insights for policy development to support aging craftspeople and promote traditional crafts.

KEYWORDS

older adults, crafts, health, quality of life, happiness, active ageing

1 Introduction

Mental health in older adults can be improved through the promotion of active and healthy aging ([World Health Organization, 2023](#)). The WHO defines mental health as a state of well-being in which an individual is aware of their abilities, can manage the normal stresses of daily life, work productively and fruitfully, and is able to contribute to their community.

Emotional well-being and mental health are as important in old age as at any other stage of the life cycle (Santos, 2020). The primary aim of active and healthy aging is well-being, a holistic concept that encompasses all the elements and components of life valued by the individual (Benavente, 2020).

Intergovernmental organizations, such as the United Nations, have encouraged countries to use well-being indicators in making important policy decisions, in addition to traditional economic indicators, recognizing the limitations of this approach (Kim et al., 2021; United Nations, 2023). The literature supports the planning of healthy policies that consider the perspectives of older adults, providing resources and activities related to health, participation, and safety, thereby contributing to a better quality of life (Wongsala et al., 2021).

In this sense, quality of life is characterized by its multidimensionality (Diener and Suh, 1997; Fernández-Ballesteros, 1998; Canavarró, 2010) and highlight the need to consider aspects valued by older adults for overall well-being, such as health, life satisfaction, and psychological well-being, as well as satisfaction with the social and physical environment in which they are situated (Paúl, 2017). The quality of life of older adults depends on the context or circumstances in which they live. The ingredients of quality of life are dependent on lifestyle (Fernández-Ballesteros, 1998).

Individual well-being has emerged as a new political ambition for old age, and the ability to remain active is a condition for that well-being (Baeriswyl and Oris, 2021). Happiness and well-being have been associated with favorable profiles of health-related biomarkers and go beyond reduced health issues and mortality; they are linked to a higher quality of life (Ryff, 1989; Ryff, 1995; Diener et al., 1998; Diener, 2000; Novo, 2000; Steptoe, 2019; Becker and Trautmann, 2022; Kokubun et al., 2022).

Furthermore, aging requires that the role of older adults extend beyond just physical and occupational activities to include, among other aspects, participation in social, economic, and cultural processes. Productive activities are those that hold significant meaning for the individual and create social value, whether they are compensated or not (Vega-Tinoco et al., 2022). Professional activity assumes special importance. Work is not only associated with income; it should also be seen as a source of personal achievement, contributing to the maintenance of one's status and identity outside the family context (Quartilho, 2010). From these conclusions arises the proposal to provide the older population with opportunities for aging through broader professional participation (Park and Lee, 2022). Education and employment consistently appear as primary determinants of health and economic outcomes across all stages of life, including in old age (United Nations, 2023).

Research on active aging has expanded over the past few decades. However, the body of studies on activities related to crafts performed by older adults, in natural contexts, and not resulting from therapeutic interventions, is limited and rarely focuses on crafts and folk art, involving both male and female artisans (Tzanidaki and Reynolds, 2011; Liddle et al., 2013; Noice et al., 2014; Pöllänen and Weissmann-Hanski, 2020; Chacur et al., 2022). This article explores the perception of health, quality of life, and happiness in a sample of older professional artisans from Barcelos, a UNESCO Creative City of Crafts and Folk Art in Portugal. The study provides a unique analysis of this context, involving both men and women, as well as artisans from various craft sectors within the region. It also examines the association between

sociodemographic characteristics, professional sector variables, and health, quality of life, and happiness.

In the early 1990s, the concept of active aging began to develop, offering a policy framework that emphasizes the connection between activity, health, independence, and aging well (Paúl and Lopes, 2016). At the beginning of the 21st century, the world summit on population endorsed active aging—"the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" as the primary objective of social and health policies for older adults (World Health Organization, 2002, p. 12). Active aging remains a complex construct, and studies have shown that, globally, subjective and objective health and functionality are its main components. By staying active, older adults seem to overcome difficulties and remain highly motivated to participate in the social world and engage in healthy behaviors that enhance quality of life throughout the aging process (Paúl et al., 2012).

The central rhetoric of active aging emphasizes the autonomy and capacity of older adults to engage in meaningful social actions, contrasting with disengagement and opposing the culture of early retirement. It advocates for the removal of age-related barriers to labor market participation and the extension of active careers to delay or prevent reductions in social and institutional engagement. This approach promotes healthy lifestyles and overall quality of life, positioning continuous participation in society as a key component of successful aging (Cabral et al., 2013; Paúl and Lopes, 2016).

Active aging is a powerful discourse because it aligns more closely with the actual capabilities of older adults. It is important to recognize that there are multiple pathways for older individuals to age actively. Active aging policies should focus on overall life participation, rather than limiting the concept to economic activity or highly physical activities (Boudiny, 2013). Over the decades, a substantial amount of research has accumulated on individual, work-related, team, organizational, non-work, and social factors that contribute to active aging in the workplace. Evidence-based implications for organizations can be derived from this research (Zacher et al., 2018).

The concept of active aging was originally based on three pillars: participation, health, and security. In 2015, this approach was reviewed and expanded to include lifelong learning, which strengthens the original pillars and recognizes information as an essential element for active aging (Bárrios, 2015; Paúl and Lopes, 2016). The WHO model of active aging was revised to emphasize the optimization of four key pillars, providing older individuals with a policy framework to maximize their well-being potential, which, in turn, may contribute to greater longevity (Hijas-Gómez et al., 2020). On the other hand, healthy aging, as defined by the WHO, is "the process of developing and maintaining functional ability that enables well-being in older age," and it replaced the emphasis previously placed on active aging, a policy framework developed in 2002 (World Health Organization, 2020; United Nations, 2023). Healthy aging emphasizes the importance of developing and maintaining functional abilities, recognizing that these depend on each individual's intrinsic capacity, the surrounding environment, and the interactions between both (United Nations, 2023).

Healthy aging has become the focus of the World Health Organization, as reflected in the designation of the Decade of Healthy Aging (2021–2030). However, an emphasis on the need for action across multiple sectors endures, to ensure that older adults continue to be a resource for their families, communities, and economies

(United Nations, 2020, 2023). Governments should remove barriers to older adults' participation in the workforce while supporting their learning and skills development throughout their lifetime (United Nations, 2023).

In this regard, paying closer attention to the potential of older adults and their contributions to society involves shifting away from the dominant view of them as mere beneficiaries of innovation to a perspective that recognizes innovation created by older adults. This includes adopting a more positive mindset towards aging, where the voices of older individuals are heard (Noack and Federwisch, 2020).

There is a growing interest in understanding and exploring how the arts contribute to health and quality of life in older adults. There is a need to consider contributions for improving life, as well as the quality and best practices of various art-based modalities, in order to understand the impact of the arts on older individuals (Fraser et al., 2015; Archibald and Kitson, 2020). The therapeutic use of the arts has been documented since antiquity. For centuries, artists, philosophers, doctors, and other professionals have highlighted the specific benefits of the arts for health and well-being. Interest in using the arts to influence health grew substantially in the 20th century (Chapline and Johnson, 2016). In this context, the literature has identified improvements in health, well-being and quality of life in older adults through active participation and engagement in the arts and arts-based programs (Gale et al., 2012; Noice et al., 2014; Curtis et al., 2018; Ho et al., 2019; Lewis et al., 2021; Pesata et al., 2022). Artistic activities, by combining cognitive flexibility, creativity, interpersonal behaviors, generosity, and cooperation, can be particularly effective in reducing symptoms in those with depression (Dunphy et al., 2019; Fancourt and Ali, 2019). Numerous benefits have been described in the literature regarding the impact of engaging in the arts on mental health (Van Lith et al., 2013; Williams et al., 2019; Burns and Van Der Meer, 2021; Nan et al., 2021; Jenabi et al., 2022; Keisari et al., 2022). The body of research on activities related to arts by older adults has rarely focused on crafts and folk arts (Fraser et al., 2015; Chacur et al., 2022), not only as an hobby but also as an economic activity.

This study focuses on older professional artisans working in crafts and folk art across various sectors of a UNESCO Creative City (Município de Barcelos, 2023; UNESCO, 2024). There is a growing concern about the role of employment in the subjective well-being of older populations (Chang and Yen, 2011). Craft has been classified as one of the art forms in research on arts and health (Davies et al., 2012). Improving and maintaining the well-being of older individuals while reducing healthcare costs are compelling goals for promoting successful aging worldwide. A sense of meaning may be a promising target for promoting successful aging among older adults (Zhang et al., 2018).

A considerable body of research demonstrates that the self is a valuable source of meaning in work (Rosso et al., 2010). Individuals craft the meaning of their work by reorganizing tasks, redefining relationships, and reframing perceptions to assign meaning, purpose, and identity to their professional activity (Wrzesniewski and Dutton, 2001). Moreover, they are active agents who seek to realize their potential and develop harmonious passions associated with their activities (Vallerand, 2012). Recent studies on the purpose of life indicate that more resilient individuals tend to have a clear sense of purpose, which is associated with higher levels of psychological well-being and happiness (Tavoosi et al., 2024). Positive associations have been found between subjective happiness and generativity (Shahen

et al., 2019), and happiness was significantly predicted by engagement in the creating arts and crafting (Keyes et al., 2024). Previous studies in other activity contexts have shown that work is an important factor for quality of life, highlighting the need for further research to clarify the relationship between occupation and health-related factors, such as depression (Min and Cho, 2018).

It is important to investigate health, quality of life, and happiness in older adults, especially in light of psychological development stages. Erikson's Theory of Psychosocial Development (1950) expands the understanding of human development across the lifespan, recognizing that psychological growth does not cease in adulthood but continues throughout life. Erikson identifies that in old age, the central conflict is between integrity and despair, where individuals must reflect on their lives and attain a sense of fulfillment and acceptance. For older adults, what matters most is their vital engagement—with people, activities, materials, ideas, and institutions—which significantly contributes to psychological well-being (Kivnick and Wells, 2014; Bugajska, 2017).

This study draws on this theory to describe a sample of older professional artisans, exploring their sociodemographic and professional profiles, as well as their perceived health, quality of life, and happiness. Furthermore, it examines the association between sociodemographic characteristics and professional sector variables with health, quality of life, and happiness.

The study investigates variables related to health status, quality of life, and happiness among older professional artisans. The literature suggests that work and continued engagement in occupational activities can enhance health and quality of life while also helping to mitigate age-related discrimination. The WHO highlights the urgent need to implement effective anti-ageism strategies to combat age-related prejudice (World Health Organization, 2021). Previous studies conducted in various occupational contexts that assessed quality of life among older adults who are employed and those who are not indicate that maintaining an occupation is a crucial factor for preserving physical and mental health in older individuals. Additionally, it contributes to autonomy, as well as cognitive and sensory abilities, with working older adults showing higher average scores across most domains, particularly in the psychological domain (Costa et al., 2018). Furthermore, the literature suggests that factors such as gender, educational level, and living arrangements influence engagement in physical activities. The environment and social interactions of older adults are critical in understanding how their contextual surroundings impact a healthy lifestyle (Parra-Rizo et al., 2022). There is also a lack of evidence regarding the quality of life of older workers and a scarcity of interventions aimed at enabling them to extend their healthy professional lives (Baxter et al., 2021).

In the context of older professional artisans, the activity provided by working in crafts and folk art may have an impact on their perceived health, quality of life, and happiness. In this context, it is important to investigate this perception among artisans, as well as the relationship between sociodemographic characteristics, professional sector variables with health, quality of life, and happiness. It is important to note that, in addition to being a less explored area in the literature, it involves a sample of professional artisans from different sectors of crafts and folk art, and includes both male and female artisans (Noice et al., 2014; Fraser et al., 2015; Chacur et al., 2022). This may provide important insights into the understanding of this group of older adults and the benefits of active

aging. The results could offer valuable information for the field of aging science, as well as allow for comparisons with international research.

The domain of crafting has always been challenging to define conceptually. The production of objects and artifacts appears to follow two main directions: on one hand, the increasing production of practical tools; on the other, the development of activities with objectives that gain symbolic, ritualistic, and magical dimensions, demonstrating significant autonomy (Pereira, 2024).

Craft or artisanal products are defined by UNESCO as “Products that are produced by artisans, either completely by hand or with the help of hand-tools or even mechanical means, as long as the direct manual contribution of the artisan remains the most substantial component of the finished product... The special nature of artisanal products derives from their distinctive features, which can be utilitarian, aesthetic, artistic, creative, culturally attached, decorative, functional, traditional, religiously and socially symbolic and significant” (UNESCO Institute for Statistics, 1997).

Consequently, craft activities, besides being a mean of subsistence, can support psychological well-being and contribute to a fulfilling life in the long term, serving as a meaningful occupation for those with an interest in this area (Pöllänen and Weissmann-Hanski, 2020). People who engage in crafting often invest emotionally in these activities, and many continue to do so throughout all stages of life (Kenning, 2015).

In Barcelos (Portugal), the commitment to crafts is both evident and fascinating. The crafts are sold and appeal to the market, and there is an ongoing production where thematic and formal models are repeated and recreated by personal interpretation. The total identification with a culture inherited through tradition, the preservation of its myths, and even the repetition of its products did not hinder more original artistic creation in Barcelos (Costa, 1991, 2024).

Barcelos is a region distinguished by its extensive artisanal activities across various craft sectors, with a natural predominance in pottery and clay figurines. This region has been designated by UNESCO as a Creative City of Crafts and Folk Art. The ateliers in the area encompass not only ceramics-related arts but also other sectors of traditional crafts and folk art, including Imagery, Pottery, Embroidery and Weaving, Iron and Derivatives, Wood, Basketry and Wicker, and Contemporary Crafts. The Pottery of Barcelos (Olaria de Barcelos), the Imagery of Barcelos (Figurado de Barcelos), and the Crivo Embroidery of São Miguel da Carreira (Bordado de Crivo de São Miguel da Carreira) are certified artisanal products (Comissão Nacional da UNESCO, 2023; Município de Barcelos, 2023; UNESCO, 2024).

In addition to the fact that research on artistic activities rarely focuses on crafts and folk art, no studies have been identified that examine the perception of health status and quality of life among older professional artisans across different sectors of crafts. In light of this, the article aims to describe a sample of older professional artisans from a UNESCO Creative City of Crafts and Folk Art in Portugal (Barcelos), considering their sociodemographic and professional characteristics, their perception of health, quality of life, and happiness; and to examine the association between sociodemographic characteristics, professional sector variables with health, quality of life, and happiness.

2 Materials and methods

2.1 Study design

An observational, cross-sectional study was conducted, involving in-person primary data collection through a survey that was hetero-administered in the participants' working environments. This approach is appropriate for this study as it allows for the description of artisans' characteristics and their perceptions of health, quality of life, and happiness, as well as the analysis of associations between these variables.

2.2 Participants and recruitment

Primary data were collected from a non-probabilistic sample of older professional artisans working in Barcelos, a UNESCO Creative City of Crafts and Folk Art. Eligible participants were individuals aged 55 or older, living in the community (not in institutional care), and working in the craft sector in ateliers located in Barcelos, Portugal. If meeting the eligibility criteria, artisans from any of the following craft sectors could participate: Imagery, Pottery, Embroidery and Weaving, Iron and Derivatives, Wood, Basketry and Wicker, and Contemporary Crafts. Potential participants were identified through public platforms, including the websites of artisans with online presences and the official website of the Municipality of Barcelos, which maps the craft routes (a list of artisans, including those without an online presence, with their atelier addresses and contact details) by craft sector. A convenience sample was used, aiming to include participants who represented the various sectors of crafts in the region. Artisans were contacted, fully informed about the study, and invited to participate. Those agreeing to participate were assessed for eligibility, and subsequent data collection stages were scheduled with those who met the criteria. All participants signed consent forms to participate in the research.

Data collection was conducted in-person in the first quarter of 2024, at the participants' ateliers and according to a previously agreed-upon schedule.

This study received a favourable opinion by the Ethics Committee of the Centro Hospitalar Universitário de Santo António, E.P.E. (CHUdSA) and the School of Medicine and Biomedical Sciences, University of Porto (ICBAS-UP) [CHUdSA/ICBAS Ethics Committee] [reference 2024/CE/P02 (P418/2023/CETI)]. The study was conducted in accordance with local legislation and institutional requirements. All participants were provided with information about the project and signed the informed consent form, which was free and fully explained, for participation in the research study.

2.3 Instruments

A purposefully designed questionnaire was administered to study participants to collect sociodemographic, professional, and health-related information.

Information was collected on the sociodemographic characteristics of older professional artisans, such as age, gender, marital status, variables related to education and professional training, housing arrangements, and economic situation.

Health-related information included the type of health subsystem, use of health services in the last year frequency of appointments to the health centre and diagnosed diseases.

Information collected on the professional craft activity included the craft sector, starting age, weekly hours dedicated to the activity, and whether the atelier is in the place of residence. The perceived benefits of their artistic activity were also assessed and questions to explore activities undertaken in addition to professional work, as well as the time dedicated to them.

For a comprehensive assessment of the variables under analysis, validated and widely used instruments were employed to measure the perception of quality of life (World Health Organization, 1996; Canavarro et al., 2010), assess the presence of depressive symptoms (Spitzer et al., 2006; Kroenke et al., 2009; Kroenke et al., 2010) and evaluate the perception of happiness (Fernández-Ballesteros et al., 2004), complementing the information collected through a detailed questionnaire specifically developed for this study.

To explore perceptions of quality of life and health status, the World Health Organisation Quality of Life scale WHOQOL-BREF (World Health Organization, 1996; Canavarro et al., 2010) was used. The WHOQOL-BREF consists of 26 questions, with two questions addressing the overall perception of quality of life and health, and the remaining 24 questions distributed across the four domains: physical, psychological, social relationships, and environment. Examples of representative items for each domain include: for the physical domain, “How satisfied are you with your ability to perform your daily living activities?”; for the psychological domain, “How satisfied are you with yourself?”; for the social relationships domain, “How satisfied are you with your personal relationships?”; and for the environment domain, “How satisfied are you with your access to health services?” Responses are based on a Likert scale, with scores ranging from one to five. Higher scores for each domain indicate a better quality of life. The European Portuguese version of the WHOQOL-BREF has demonstrated strong psychometric properties, indicating the instrument’s quality for assessing quality of life in Portugal. The instrument has good internal consistency indices when considering all 26 questions that constitute the instrument ($\alpha = 0.92$). When analyzed individually, the domains also present very acceptable Cronbach’s alphas: Social Relationships ($\alpha = 0.64$), Environment ($\alpha = 0.78$), Psychological ($\alpha = 0.84$), and Physical ($\alpha = 0.87$) (Canavarro et al., 2010).

The Patient Health Questionnaire PHQ-8 scale (Kroenke et al., 2009) was added to assess the presence of depressive symptoms. It consists of eight items, with answers summed to produce a severity score ranging from zero to twenty-four. Representative examples of items from this scale include: “Little interest or pleasure in doing things”; “Feeling down, depressed, or hopeless”; “Feeling tired or having little energy.” Scores are calculated by assigning zero to three points to statements based on frequency, ranging from “never” to “almost every day.” Scores of five, ten, fifteen, and twenty represent cut-off points for mild, moderate, moderately severe, and severe depression, respectively (Spitzer et al., 2006).

The PHQ-8 demonstrates good sensitivity and specificity for detecting depressive disorders (Kroenke et al., 2010). The diagnostic algorithm or a cutoff score of ≥ 10 can be used to define current depression (Kroenke et al., 2009). Studies that have evaluated the PHQ-8, in Portugal and internationally, indicated that the PHQ-8 has a unidimensional structure with evidence of good validity and reliability (Monteiro et al., 2019; Vasconcelos-Raposo et al., 2022). The validation of the PHQ-8 in Portugal showed a good internal

consistency of the instrument ($\alpha = 0.89$) (Vasconcelos-Raposo et al., 2022).

Finally, a question of happiness from The European Survey on Aging Protocol (ESAP) (Fernández-Ballesteros et al., 2004) was used to assess the degree of happiness participants feel about their current life. The question, “Compared to other people and considering the balance between the good and bad events in your life, to what extent do you feel well and happy at this moment?” is answered on a scale from one to four, with one corresponding to an extremely low level of satisfaction and four to an extremely high level of satisfaction. Based on the responses, participants were classified into four categories of happiness: very happy, happy, somewhat unhappy, and very unhappy.

2.4 Data analysis

Descriptive statistics were calculated to characterize participants in terms of sociodemographic, professional, health-related, quality of life, and happiness appraisal variables (Tables 1–3).

For the WHOQOL-BREF scale, the original scores for each domain were transformed to a scale of 0 to 100 for interpretability purposes, following scoring guidelines (World Health Organization, 1996; Canavarro et al., 2010).

Absolute and relative frequencies were used to describe the distribution of the data. Measures of central tendency (e.g., mean and median) and dispersion (e.g., standard deviation and variance) were applied to summarise and analyse the location and variability of the data.

To examine the associations between sociodemographic characteristics and professional sector variables with health, quality of life, and happiness parametric and non-parametric tests were chosen as appropriate, based on data distribution. Means and data distributions were compared using the t-test for parametric continuous variables, and the Mann–Whitney U test for non-parametric continuous or ordinal variables. Associations between categorical variables were analysed using the chi-squared test and Fisher’s exact test, as appropriate. Correlations were examined using Pearson’s correlation coefficient and Spearman’s rank correlation coefficient, depending on the nature of the data. The F-statistic was used in ANOVA to compare means across multiple groups. Statistical tests were two-tailed, and the significance level was set at 0.05 (Table 4). Data analysis was performed using SPSS version 29. The present study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement, which provides guidelines for reporting observational studies (von Elm et al., 2007). The STROBE checklist is included in Supplementary material 1.

3 Results

3.1 Sociodemographic, health condition, and professional characteristics

Table 1 describes the study variables related to participants’ sociodemographic characteristics and health condition. The sample consisted of 55 individuals, representing 27.36% of the artisans in the territory. Participants had a mean age of 67.49 years (SD 8.02), ranging from 55 to 88 years. More than half were men (60%, $n = 33$).

TABLE 1 Describes the study variables related to participants' sociodemographic characteristics and health conditions.

| Variables | N | Descriptive statistics |
|--|----|------------------------|
| Sociodemographic characteristics | | |
| Age (years), M (SD) | 55 | 67.49 (8.02) |
| Gender, <i>n</i> (%) | 55 | |
| Male | | 33 (60) |
| Marital status, <i>n</i> (%) | 55 | |
| Married | | 47 (85.5) |
| Widow(er) | | 5 (9.1) |
| Divorced | | 2 (3.6) |
| Single | | 1 (1.8) |
| Years education, M (SD) | 55 | 6.42 (3.32) |
| Professional training, <i>n</i> (%) | 55 | |
| Yes | | 13 (23.6) |
| Retired, <i>n</i> (%) | 55 | |
| Yes | | 33 (60) |
| Main professional activity, crafts, <i>n</i> (%) | 55 | |
| Yes | | 49 (89.1) |
| Main source of income, <i>n</i> (%) | 55 | |
| Crafts | | 54 (98.2) |
| Pension/Retirement | | 32 (58.2) |
| Other income | | 6 (10.9) |
| Monthly income, based on the National Minimum Wage (NMW), <i>n</i> (%) | 55 | |
| Monthly income ≤ NMW | | 35 (63.6) |
| Monthly income > NMW | | 20 (36.4) |
| Health condition | | |
| Frequency of visits to the Health Center, <i>n</i> (%) | 55 | |
| Every 1 to 3 months | | 11 (20) |
| Every 6 months | | 29 (52.7) |
| Once a year | | 13 (23.6) |
| Less than once a year | | 2 (3.6) |
| Healthcare utilization in the past year | | |
| Primary Care Center, <i>n</i> (%) | 55 | |
| Yes | | 52 (94.5) |
| Specialty consultations, <i>n</i> (%) | 55 | |
| Yes | | 34 (61.8) |
| Emergency services, <i>n</i> (%) | 55 | |
| Yes | | 9 (16.4) |
| Hospitalization, <i>n</i> (%) | 55 | |
| Yes | | 4 (7.3) |

TABLE 2 Describes the study variables related to participants' professional and artistic sector.

| Variables | N | Descriptive statistics |
|--|----|------------------------|
| Craft sector, <i>n</i> (%) | 55 | |
| Imagery | | 29 (52.7) |
| Pottery | | 7 (12.7) |
| Wood | | 5 (9.1) |
| Iron and derivatives | | 4 (7.3) |
| Embroidery | | 3 (5.5) |
| Contemporary crafts | | 3 (5.5) |
| Weaving | | 2 (3.6) |
| Basketry and wicker | | 2 (3.6) |
| Age of entry into the craft sector, M (SD) | 55 | 18.65 (16.10) |
| Atelier location at the residence, <i>n</i> (%) | 55 | |
| Yes | | 48 (87.3) |
| Hours per week of craft activity, M (SD) | 55 | 51.24 (17.05) |
| Weekly hours dedicated to non-professional activities, M (SD) | 55 | 10.05 (9.33) |
| Most frequently reported non-professional activities, <i>n</i> (%) | 55 | |
| Household activities and subsistence farming | | 25 (45.5) |
| Physical activity | | 20 (36.4) |
| Sociocultural activities | | 16 (29.1) |
| Perceived main benefits of involvement in the craft sector, <i>n</i> (%) | 55 | |
| Well-being | | 41 (74.5) |
| Economic | | 18 (32.7) |
| Health | | 13 (23.6) |
| Quality of life | | 12 (21.8) |
| Social status | | 7 (12.7) |

Most participants were married (85.5%; $n = 47$). The average number of years of education was 6.42 years (SD 3.32). The range of education was from 0 to 19 years, with 43.6% ($n = 24$) of the participants having completed up to 4 years of education and 25.5% ($n = 14$) having completed between 7 and 9 years. Overall, 23.6% ($n = 13$) of the sample had professional training, with 11 different areas reported ($n = 11$). Most participants (60%, $n = 33$) were retired and nearly all (96.4%, $n = 53$) lived in their own house. The mean years of residence in the parish was 56.00 (SD = 19.50, range 3–84 years).

Overall, 89.1% ($n = 49$) of the participants considered their craft activity to be their main occupation. Almost all artisans,

TABLE 3 Describes objective health indicators and outcomes related to health, quality of life, and happiness.

| Variables | N | Descriptive statistics |
|---|----|------------------------|
| Diagnosed diseases, <i>n</i> (%) | 55 | |
| Yes | | 45 (81.8) |
| Most commonly reported diseases, <i>n</i> (%) | | |
| Osteoarthritis | | 10 (18.2) |
| Spinal disorders | | 9 (16.4) |
| Hip diseases, knee diseases | | 7 (12.7) |
| PHQ-8 Patient Health Questionnaire, <i>n</i> (%) | 55 | |
| Without depression (< 10) | | 54 (98.1) |
| With depression (≥ 10) | | 1 (1.8) |
| WHOQOL-BREF | | |
| Question 2: How satisfied are you with your health? <i>n</i> (%) | 55 | |
| Dissatisfied | | 3 (5.5) |
| Neither satisfied nor dissatisfied | | 19 (34.5) |
| Satisfied and very satisfied | | 33 (60) |
| Question 1: How would you rate your quality of life? <i>n</i> (%) | 55 | |
| Poor | | 1 (1.8) |
| Neither good nor poor | | 13 (23.6) |
| Good | | 34 (61.8) |
| Very good | | 7 (12.7) |
| WHOQOL-BREF, M (SD) | 55 | |
| WHOQOL-BREF, Overall Quality of Life (questions 1 and 2) | | 68.64 (13.58) |
| WHOQOL-BREF, Psychological Domain | | 84.92 (10.98) |
| WHOQOL-BREF, Social Relationships Domain | | 80.76 (12.61) |
| WHOQOL-BREF, Environment Domain | | 78.81 (9.48) |
| WHOQOL-BREF, Physical Domain | | 78.64 (11.91) |
| Question of happiness | | |
| Level of happiness, <i>n</i> (%) | 55 | |
| Very happy | | 31 (56.4) |
| Happy | | 23 (41.8) |
| Somewhat unhappy | | 1 (1.8) |

98.2% (*n* = 54) considered that their main source of income was from work in crafts, with 58.2% (*n* = 32) also citing retirement, and only a minority (10.9%, *n* = 6) mentioning other sources of income. Most artisans (63.6%, *n* = 35) reported that their monthly income was equal to or less than the national minimum wage.

TABLE 4 Significant associations between sociodemographic and professional variables, objective health indicators, and outcomes of health, quality of life, and happiness.

| Sociodemographic and professional variables, objective health indicators vs. health, quality of life, and happiness outcomes | <i>p</i> -value* |
|--|---|
| Age vs. Happiness | 0.020 ¹ |
| Gender: Female vs. Most commonly reported diseases: Osteoarthritis | < 0.001 ² ; < 0.001 ³ |
| Gender: Female vs. Perceived main benefits of involvement in the craft sector: Quality of life | 0.033 ² ; 0.047 ³ |
| Gender: Male vs. Main benefit of involvement in the craft sector: Well-being | 0.032 ² |
| Monthly income, based on the National Minimum Wage vs. WHOQOL-BREF, overall quality of life and health (questions 1 and 2) | 0.018 ⁴ |
| Monthly income, based on the National Minimum Wage vs. WHOQOL-BREF, Environment Domain | 0.027 ⁵ ; < 0.001 ⁶ |
| Reported Illnesses / No Reported Illnesses vs. Main benefit of involvement in the craft sector: Health | 0.030 ² ; 0.045 ³ |
| Reported Illnesses / No Reported Illnesses vs. WHOQOL-BREF, overall quality of life and health (questions 1 and 2) | 0.017 ⁴ |
| Imagery craft sector vs. Main benefit of involvement in the craft sector: Health | 0.008 ² ; 0.011 ³ |
| Imagery craft sector vs. Main benefit of involvement in the craft sector: Quality of life | 0.016 ² ; 0.022 ³ |
| Imagery craft sector/Other craft sectors vs. WHOQOL-BREF, Environment Domain | 0.023 ⁶ |
| Other craft sectors vs. Main benefit of involvement in the craft sector: Well-being | < 0.001 ² ; < 0.001 ³ |

**p* < 0.05. Statistical analysis methods used:

¹Spearman's Rank Correlation Coefficient: *r*_s

²Chi-square Test: χ^2 .

³Fisher's Exact Test: FET.

⁴Mann–Whitney U Statistic: U.

⁵F-statistic (used in ANOVA): *F*.

⁶*t*-test Statistic: *t*.

All participants had the National Health Service as their health subsystem, and the majority (52.7%, *n* = 29) reported visiting the Health Center every 6 months.

In the past year, nearly all participants (94.5%, *n* = 52) utilized the Health Center, and the majority (61.8%, *n* = 34) also attended specialty consultations. Emergency services were used by 16.4% (*n* = 9) of participants. A minority (7.3%, *n* = 4) reported having been hospitalized, with durations ranging from 1 to 12 days.

Most participants (52.7%, *n* = 29) work in the Imagery sector, followed by 12.7% (*n* = 7) in the Pottery sector, and 9.1% (*n* = 5) in the Wood sector.

The age at which participants started their craft activity ranges from 4 to 63 years, with a median of 12 years. A large proportion

(43.6%, $n = 24$) began in childhood (by the age of 10), while only one participant (1.8%) started after the age of 60. Most artisans (87.3%, $n = 48$) have their artistic atelier located at their residence.

On average, artisans dedicate 51.24 h (SD 17.05, range 18–96) per week to their craft activity. The majority of participants (69.1%, $n = 38$) engage in craft activity for more than 40 h per week.

In addition to their activity on weekdays, artisans also engage in their craft on Saturdays (65.5%, $n = 36$), and 30.9% ($n = 17$) reported doing so occasionally on Sundays.

With respect to activities regularly pursued outside their craft work, artisans allocate an average of 10.05 h per week (SD 9.33). The most mentioned were household activities and subsistence farming (45.5%, $n = 25$), physical activity (36.4%, $n = 20$) and sociocultural activities (29.1%, $n = 16$). A total of 16.4% ($n = 9$) of the participants reported not engaging in any regular non-professional activities. Table 2 describes the study variables related to the participants' professional and artistic sector.

3.1.1 Associations between sociodemographic and professional characteristics

Age positively correlated with the number of years of residence in the parish ($p < 0.001$) and negatively correlated with years of education ($p < 0.001$), the number of weekly hours dedicated to non-professional activities ($p < 0.001$), as well as with the age at which individuals began their activity in the craft sector ($p < 0.032$).

A positive correlation was observed between years of education and the age at which individuals began working in the craft sector ($p = 0.012$) and with the number of weekly hours dedicated to regularly performed non-professional activities ($p < 0.006$).

Women engaged significantly more in household activities during their non-professional time ($p < 0.001$), while they were less likely than men to report involvement in cultural activities ($p = 0.034$). A small difference was observed in the comparison of mean of hours dedicated to craft activities between retirees and non-retirees ($M = 50.70$, $SD = 16.17$; $M = 52.05$, $SD = 18.65$) which was not statistically significant.

A significant association was also found between non-professional activities and caregiving ($p = 0.011$), indicating that non-retirees are more likely to engage in caregiving activities.

A statistically significant difference was observed in the number of years of residence in the parish between individuals who reported a monthly income equal to or less than the national minimum wage and those with a higher monthly income ($p = 0.032$). Individuals with a lower income have resided in the parish for a longer period (Mean Rank = 31.50) compared to those with a higher income (Mean Rank = 21.88). Although the results indicate that the average age is slightly higher in the lower-income group ($M = 68.23$, $SD = 7.535$) compared to the higher-income group ($M = 66.20$, $SD = 8.877$), the tests performed did not show a significant difference in variances between the groups.

No statistically significant difference was found in the variable of the number of hours dedicated each week to craft activity between the income groups.

Regarding activities performed outside of craft work, caregiving ($p = 0.049$) and participation in household activities ($p = 0.025$) were more frequently reported by the Imagery sector.

3.2 Variables related to health, quality of life, and happiness

Regarding disease status, 81.8% ($n = 45$) of individuals reported having been diagnosed with at least one disease throughout their lifetime. In the frequency analysis, the most commonly reported were one disease ($n = 22$, 40%), two diseases ($n = 17$, 30.9%), and no disease ($n = 10$, 18.2%).

Various diseases were reported ($n = 23$), with osteoarthritis being the most mentioned (18%, $n = 10$), followed by spinal disorders (16.4%, $n = 9$), and bone diseases such as those affecting the hip and knees (12.7%, $n = 7$).

According to the cutoff points of the Patient Health Questionnaire (PHQ-8), 41.8% ($n = 23$) of participants scored the minimum of zero, and the remaining scores were below the cutoff for mild depression, indicating no depression, except for one participant who scored 13, suggesting moderate depression.

The observation of responses on the WHOQOL-BREF quality of life scale showed that, regarding general health perception (Question 2: How satisfied are you with your health?), the majority of artisans (60%, $n = 33$) considered themselves satisfied or very satisfied with their health, 34.5% ($n = 19$) reported feeling neither satisfied nor dissatisfied, and a minority (5.5%, $n = 3$) reported being dissatisfied.

The general perception of the majority of artisans (61.8%, $n = 34$) regarding their quality of life was 'good' (Question 1: How would you rate your quality of life?). The transformed scores from the WHOQOL-BREF quality of life assessment instrument showed that the mean score for overall quality of life perception (questions 1 and 2) was 68.64 (SD = 13.58). The psychological domain had the highest average score ($M = 84.92$, $SD = 10.98$), followed by the social relationships domain ($M = 80.76$, $SD = 12.61$), the environment domain ($M = 78.81$, $SD = 9.48$), and the physical domain ($M = 78.64$, $SD = 11.91$).

Most artisans (56.4%, $n = 31$) reported feeling "very happy" about their current life (Table 3 describes the objective health indicators and outcomes related to health, quality of life, and happiness).

Regarding the perceived main benefits from craft work (well-being, economic, health, quality of life, social status), well-being was by far the most frequently reported by artisans (74.5%, $n = 41$), followed by economic (32.7%, $n = 18$), health (23.6%, $n = 13$), quality of life (21.8%, $n = 12$), and social status (12.7%, $n = 7$). The analysis of these benefits by craft sector, Imagery versus Pottery, Basketry and Wicker, Iron and Derivatives, Wood, Embroidery, Weaving, and Contemporary Crafts, confirmed that well-being remained the most frequently cited benefit regardless of the sector.

3.3 Associations between sociodemographic and professional variables, objective health indicators, and outcomes related to health, quality of life, and happiness

A significant positive correlation was observed between age and the degree of happiness ($n = 55$, $r_s = 0.312$, $p = 0.020$).

The happiness questionnaire revealed that most women (63.6%, $n = 14$) rated themselves as very happy, while 36.4% ($n = 8$) felt good and happy. Among men, 51.5% ($n = 17$) felt very happy, and 45.5% ($n = 15$) felt good and happy.

There was a significant association between gender and the presence of osteoarthritis in the hands and/or fingers [$\chi^2(1) = 12.731$, $p < 0.001$], also verified by Fisher's exact test ($p < 0.001$), indicating that this condition is more prevalent among women.

Significant differences were observed between genders in two of the main benefits of involvement in the craft sector (well-being, economic, health, quality of life, social status). Women were more likely to perceive the benefit related to quality of life [$\chi^2 = 4.548$; $df = 1$; $p = 0.033$; Fisher's Exact Test: $p = 0.047$ (2-sided)], while men were more likely to identify well-being as the primary benefit ($\chi^2 = 4.615$; $df = 1$; $p = 0.032$).

The overall perception of quality of life and health as measured by the WHOQOL-BREF showed a significant difference based on income ($U = 223.500$, $Z = -2.366$, $p = 0.018$). The mean score was higher in the group reporting a higher income (Mean Rank = 34.33) compared to individuals reporting a lower income (Mean Rank = 24.39). A statistically significant difference was also observed in the environmental domain of quality of life between income groups ($F = 5.157$, $p = 0.027$; $t = -3.884$, $p < 0.001$). The Cohen's d value is -0.987 (95% CI: -1.563 to -0.402), indicating a large effect, with a higher mean score in the higher-income group ($M = 34.95$, $SD = 2.114$) compared to the lower-income group ($M = 32.23$, $SD = 3.059$).

The PHQ-8 results indicated that nearly all participants (98.1%) scored between zero and below the minimum cutoff point for depressive symptoms. A significant negative correlation was found between the Environment domain of the WHOQOL-BREF and the PHQ-8 scores ($n = 55$, $r_s = -0.294$, $p = 0.029$), indicating that better conditions in this domain are strongly associated with lower levels of depressive symptoms.

Among the examined variables of the main benefits of craft activities, the Chi-square test revealed a significant difference in the health-related benefit between the groups with and without diseases [$\chi^2(1) = 4.706$, $p = 0.030$].

Significant differences were examined in quality of life and health status variables between participants who reported one or more illnesses ($n = 45$) and those who did not report any illnesses ($n = 10$). The results indicate that the WHOQOL-BREF General Quality of Life variable showed a statistically significant negative difference ($U = 123.000$, $Z = -2.380$, $p = 0.017$) between the groups. The general perception of quality of life and health status was higher in the group that did not report any illnesses (Mean Rank: 38.20) compared to the group that reported illnesses (Mean Rank: 25.73).

Regarding the average hours spent weekly on craft activities between the group that reported one or more diseases and the group without reported diseases, the average did not differ significantly ($p > 0.05$).

Additionally, non-professional activities are not strongly associated with the presence or absence of diseases.

Associations and statistically significant differences were investigated between the Imagery sector ($n = 29$) and other craft sectors, including Pottery, Basketry and Wicker, Iron and Derivatives, Wood, Embroidery, Weaving, and Contemporary Crafts ($n = 26$).

Significant differences were observed in the variable concerning the main benefits of craft work (well-being, economic, health, quality of life, social status). Chi-square and Fisher's Exact Test results revealed that participants in the Imagery sector reported health benefits more frequently [$\chi^2 = 6.945$; $df = 1$; $p = 0.008$; Fisher's Exact

Test: $p = 0.011$ (2-sided)], and quality of life benefits [$\chi^2 = 5.768$; $df = 1$; $p = 0.016$; Fisher's Exact Test: $p = 0.022$ (2-sided)]. Conversely, well-being was reported more frequently by participants from other sectors [$\chi^2 = 12.134$; $df = 1$; $p < 0.001$; Fisher's Exact Test: $p < 0.001$ (2-sided)].

There is a statistically significant difference [$t(53) = -2.346$, $p = 0.023$] in the environment domain of quality of life between the Imagery sector and the other sectors (Pottery, Embroidery, Weaving, Iron and Derivatives, Wood, Basketry and Wicker, Contemporary Crafts). The second group reported a higher average score ($M = 34.19$, $SD = 2.367$) compared to the Imagery sector ($M = 32.34$, $SD = 3.330$), with a mean difference of -1.847 , 95% CI $[-3.427, -0.268]$. The Cohen's d value of -0.634 indicates a medium effect size (Table 4 summarizes the significant associations between sociodemographic and professional variables, objective health indicators, and outcomes related to health, quality of life, and happiness).

In the descriptive analysis, the psychological domain of quality of life remained the highest rated among both the Imagery sector ($M = 83.48$, $SD = 11.54$) and the other craft sectors ($M = 86.54$, $SD = 10.29$). For the other domains, the second highest rating in the Imagery sector was the social relationships domain ($M = 80.46$, $SD = 12.25$), whereas in the other sectors it was the environment domain ($M = 81.85$, $SD = 7.39$), followed by social relationships ($M = 81.09$, $SD = 13.24$). The least rated domain in the other sectors was the physical domain ($M = 78.57$, $SD = 10.49$), while in the Imagery sector, the least rated domain was the environment domain ($M = 76.08$, $SD = 10.40$).

4 Discussion

This study differs from previous research in several important ways and provides relevant scientific evidence on the perception of health status, quality of life, and happiness among older individuals engaged in crafting, based on a sample of professional artisans from a UNESCO Creative City of Crafts and Folk Art.

All study variables were tested to examine significant associations between sociodemographic characteristics, professional activity-related variables, and measures of health, quality of life, and happiness.

Several significant correlations and differences were observed between the sociodemographic and psychosocial variables of the participating artisans, reflecting the association of factors such as age, education, and professional craft activity with different aspects of the participants' health status, quality of life and happiness. The results showed a trend in which older artisans reported greater happiness, had fewer years of formal education on average, spent fewer weekly hours on non-craft activities, and began their craft work at a younger age, reflecting generational differences in work trends. Like in other professions, people in the past generally started their craft activity earlier than they do today. It was found that individuals with more years of education started their craft activity later, which suggests an association with the evolution of mandatory education over time. Furthermore, these younger individuals also tend to dedicate more weekly hours to other activities during their non-professional time.

The results also showed that older artisans remained in the same locality as they aged, which may indicate residential stability, a connection to the place, family, and local community, and a stronger bond with the sociocultural territory.

On the other hand, the significant positive correlation found between age and the level of happiness suggests that older participants experience higher levels of happiness. This finding appears to be aligned with previous research indicating that happiness tends to increase after the age of 50 (Becker and Trautmann, 2022). However, the U-shaped pattern of happiness over the lifespan remains a controversial finding in the literature. While some studies support this trend, others suggest that happiness can be shaped through practice (Esch, 2022) or that happiness is malleable and can be enhanced (Steptoe, 2019).

Among the benefits of engaging in crafting, it was observed that gender may influence the perception of certain benefits. Women placed a higher value on quality of life, while men valued well-being more. For activities regularly performed during leisure time, women showed a significantly greater tendency to engage in domestic activities and less in cultural activities compared to men. In light of this result, a significant trend or difference in the time dedicated to crafting between men and women was anticipated, but this was not observed. This may indicate that a lack of leisure time beyond professional activities might limit women's participation in activities other than domestic chores. This finding is consistent with previous studies (Cruz, 2004; Fernandes, 2024) examining gender issues in this field, which note that while both women and men worked with clay, there was a division of labor, with women alternating between figurine crafting and domestic responsibilities, including child care. These results suggest that this dynamic may still be present.

The data shows that most individuals, both female and male, reported feeling very happy. Previous studies have provided relevant insights into the individual and social importance of everyday creativity related to craft-based activities for promoting well-being and overall health (e.g., Tzanidaki and Reynolds, 2011; Kenning, 2015; Pöllänen and Weissmann-Hanski, 2020). The results of this study expand the scope of diversity in the analysis by including additional sectors related to craft.

When comparing retirees and non-retirees, a difference in the number of hours dedicated to craft activity was anticipated; however, the results showed no statistically significant differences in the weekly hours spent on the activity. While age is a characteristic that clearly differentiates the two groups, both retirees and non-retirees are intensively engaged in the activity.

Furthermore, the similar amount of time dedicated to craft activities, regardless of income, appears to reflect intrinsic motivations, such as a passion for their art and personal satisfaction. Previous studies have highlighted that various factors contribute to the meaning of work (Rosso et al., 2010). Harmonious passion has a positive effect on psychological well-being, physical health, positive relationships, and high-level performance. Therefore, having a harmonious passion for an activity can greatly contribute to living a meaningful life (Vallerand, 2012). Although the situation regarding income has not revealed a difference in the number of hours dedicated to craft activity, as both groups, those with a monthly income equal to or below the national minimum wage and those with an income above it, showed similar levels of dedication to the activity, income appears to significantly influence the perception of quality of life and health, as well as the environment domain. Indeed, the higher-income group perceives their quality of life more positively compared to the lower-income group. This suggests that, for these artisans, while income does not appear to affect their dedication to craft activity, it does influence

other factors related to their overall perception of quality of life and health. Specifically, aspects of the WHOQOL-BREF environment domain (such as opportunities for acquiring new information and skills, participation and/or opportunities for recreation and leisure, physical environment, transportation), are perceived differently by those with lower income.

Previous studies assessing quality of life among older adults who work and those who do not have demonstrated that staying in work, in addition to providing health benefits, contributes to autonomy and improves quality of life. It was observed that older adults who do not work show lower averages in the environment domain, which are associated with quality of life impairments due to factors such as income (Costa et al., 2018). These findings emphasize the relevance of income as an influential factor on quality of life among older populations, as demonstrated by the results of the present study, conducted with a population professionally dedicated to craftsmanship.

These results highlight the importance of public policies that promote income improvement as a strategy to enhance quality of life for all artisans. The environment or social context are among the factors that influence the meaning attributed to work (Rosso et al., 2010). In this study, it is particularly important to highlight the favorable context for the valuation of craftsmanship in the analyzed territory. This is a region with a long tradition of craftsmanship and folk art. In this territory, the municipality has been implementing public policies and initiatives that value craftsmanship, such as certified craft productions, and it is recognized by UNESCO as a Creative City of Crafts and Folk Art (Município de Barcelos, 2023; UNESCO, 2024).

This set of factors appears to play a significant role in creating a context conducive to the development of craftsmanship, functioning as a socially and culturally protective environment for this population dedicated to craftsmanship. This environment also seems to help explain some of the positive results observed, such as the perception of happiness associated with aging, as indicated by the positive correlation between age and happiness, although further studies should be conducted.

These results align with studies that, when analyzing how older adults experience and describe the fundamental pillars of active aging suggested by the WHO, describe health as the absence of barriers to daily living, security as manageable living conditions, participation as meaningful activities, highlighted perspectives related to daily life experiences and local culture, add motivations for engagement linked to local traditions, and clarify that appropriate participation creates a sense of belonging in society (Wongsala et al., 2021).

Our results showed an almost complete absence of depressive symptoms, which is a positive indicator of the mental health status of these older professional artisans, considering the findings from the latest National Health Survey data conducted in Portugal using the PHQ-8 methodology. This national survey concluded that approximately 60% of individuals showed mild symptoms, and 40.2% exhibited severe depressive symptoms. The study also found that the prevalence was more pronounced among the older population (Instituto Nacional de Estatística, 2020). This stresses further the good condition of our population, comprising individuals aged 55 and older, of whom 41.8% had a score of zero, and the remaining being below the cut-off score for depression with the exception of one participant.

The significant negative correlation identified between the environment domain of the WHOQOL-BREF and the PHQ-8 shows that better conditions in the environment domain are associated with lower levels of depressive symptoms. This indicates that positive environmental conditions may have a significant impact on individuals' mental and emotional health, and that good mental health may also influence a better perception of environmental conditions.

The findings support larger-scale studies conducted in Portugal that analyzed active aging in later life and identified the relevance of psychological aspects in active aging, such as the absence of psychological distress, the presence of happiness and optimism, and quality of life, to enable active engagement with life despite common health issues in advanced age (Paúl et al., 2017).

The most reported illnesses in this study align with findings from other studies conducted in Portugal. The conclusions described in the most recent National Health Survey regarding chronic conditions self-reported by the Portuguese population include osteoarthritis, lower back pain or other chronic back problems, and cervical pain. That study concluded that these conditions affect women more than men (Instituto Nacional de Estatística, 2020). Consistent with these findings, our study shows more women reporting the most common diseases among participants (e.g., osteoarthritis).

It was anticipated that there would be an association between the group with reported diseases and a lower number of hours dedicated to craft activities. Although this group shows a lower perception of overall quality of life and the physical domain, the results regarding the number of hours dedicated reveal that the dedication to craft activities remains strong. These data suggest that the reported diseases do not have a significant impact on the amount of time participants devote to their craft activities. This behavior may reflect an effort and adaptation to maintain involvement in the craft, even in the face of some physical difficulty or limitation.

The study also revealed a significant difference between the group with reported illnesses and the group without reported illnesses regarding the perceived main benefits of craft activities, particularly in relation to the health benefit. The fact that the group without reported illnesses valued good health as a benefit of these activities suggests that, for these individuals, participation in craft activities may play an important role in the perception of health improvement or maintenance. Furthermore, it was also in the group without reported illnesses that a better overall perception of quality of life and health status was observed on the WHOQOL-BREF scale compared to the group that reported illnesses. The involvement of older individuals in these activities may be associated with a positive impact on health, aligned with results from previous studies (Kenning, 2015; Pöllänen and Weissmann-Hanski, 2020).

Most comparisons between participants from the Imagery sector and those from other sectors did not indicate statistically significant differences, suggesting similarities between the participants in the groups in characteristics such as age, education level, age at the start of their craft career, average number of hours per week dedicated to craft activity, length of residence in the parish, as well as in the Patient Health Questionnaire (PHQ-8) and WHOQOL-BREF scales, particularly in the physical, psychological, social relationships domains, and in the measures of overall quality of life and general health perception. The degree of happiness of artisans when considering their current life also indicates similarity between both groups. Only one statistically significant difference was identified

between the sectors in the environment domain of the WHOQOL-BREF quality of life scale. The group from the Pottery, Embroidery, Weaving, Iron and Derivatives, Wood, Basketry and Wicker, and Contemporary Crafts sectors showed a higher average, suggesting that these participants have a more positive perception of the facets included in the environment domain compared to the Imagery sector group. In the quality of life scale, the environment domain includes facets such as: physical safety; home environment; economic resources; health and social care (availability and quality); opportunities to acquire new information and skills; participation in and/or opportunities for recreation and leisure; physical environment (pollution/noise/traffic/climate); and transportation. The observed difference may suggest that the Imagery sector might involve specific characteristics or challenges that affect participants' perceptions of their environment, such as opportunities for acquiring new information and skills.

Additionally, significant differences were observed in the perceived benefits of craft activity (well-being, economic benefits, health, quality of life, social status) among the craft sectors, particularly in health, quality of life, and well-being. Participants from the Imagery sector highlighted more benefits related to health and quality of life, while well-being was more frequently reported by participants from other sectors. These findings align with studies that concluded that active engagement in participatory arts enhances quality of life, self-assessed health, and life meaning (Ho et al., 2019).

Additionally, the results are consistent with studies that used the WHOQOL-BREF scale to assess quality of life, which included older adults who remain active in the workforce. Previous studies identified higher mean scores in most of the scale domains, particularly in the psychological domain ($M = 70.0$; $SD = 11.8$), suggesting that work is an important factor for quality of life among older adults (Costa et al., 2018). In the present study, conducted with older professional artisans, a similar pattern was observed, with an even more pronounced focus on the psychological domain ($M = 84.92$; $SD = 10.98$). Moreover, the results were higher across all domains of the scale. High scores were also observed in the assessment of happiness, as well as results indicating the near absence of depressive symptoms, as reported by the participants in the depression symptomatology assessment. These findings are particularly relevant when compared to other studies conducted in the same country using the same scale (Instituto Nacional de Estatística, 2020).

The results observed in this sample of individuals whose daily lives are primarily filled with craft-related activities suggest consistency with findings from various international studies (Zhang et al., 2018; Pöllänen and Weissmann-Hanski, 2020; Keyes et al., 2024). Studies involving artisans up to the age of 88 have shown that crafting improves participants' psychological well-being in various ways and can lead to a richer, more purposeful life through self-fulfillment, excellence in craftsmanship, and a sense of belonging (e.g., Pöllänen and Weissmann-Hanski, 2020). Furthermore, other research has verified that a sense of meaning in life is associated with happiness and can contribute to health and utilization of health services among older adults (e.g., Zhang et al., 2018). Additionally, studies have demonstrated that engaging in creating arts and crafting significantly predicts increased life satisfaction, a sense that life is worthwhile and happiness (e.g., Keyes et al., 2024).

Unlike most studies, this one focuses on activities within the craft and folk art sector, conducted in the context of spontaneous

professional engagement by older adults (e.g., [Chacur et al., 2022](#)). It contributes to the recognition of these individuals by highlighting their creativity and their role as an asset in the economic and sociocultural dynamics of their families and communities.

These results may be related to the type of activity performed by the professional artisans and the meanings attributed to these activities ([Wrzesniewski and Dutton, 2001](#); [Rosso et al., 2010](#); [Vallerand, 2012](#)), which can have positive implications for quality of life and psychological health in older adults. Participation in creative and culturally meaningful activities, such as crafts and folk art, can be seen as an expression of generativity, a central concept in [Erikson's \(1950\)](#) theory. It argues that the continuity of psychological development throughout life is essential, and the stage of old age is characterized by the search for integrity rather than despair. Work and activities that promote active engagement, such as crafts, allow older individuals to experience a dynamic balance of opposites, a fundamental principle for well-being and psychological health in old age ([McAdams and de St Aubin, 1992](#); [McAdams et al., 1993](#); [Kivnick and Wells, 2014](#)). These findings suggest that older professional artisans may be achieving integrity, a state of acceptance and satisfaction with their lived life, which is crucial for their psychological health. However, additional studies are needed to confirm these findings and further explore these relationships.

4.1 Study contributions and future research

No previous studies have identified the contribution of craft and folk art to the health, quality of life and happiness among older professional artisans. To the best of our knowledge, this study represents an original and significant contribution to the field of aging research. It addresses gaps that have been identified in the literature by expanding the scope of artistic activities considered, such as arts and crafts ([Fraser et al., 2015](#); [Chacur et al., 2022](#)). It provides innovative information by presenting data that explores various craft sectors and diverse variables related to the health status, quality of life and happiness of older professional artisans, such as gender, retirement status, income, time devoted to craft activities, extra-professional activities, and health-related factors. The diversity of this study is a significant strength, both in terms of representing various activities and in including both men and women, which also broadens the scope of previous studies (e.g., [Tzanidaki and Reynolds, 2011](#); [Kenning, 2015](#); [Pöllänen and Weissmann-Hanski, 2020](#)).

While there is a wealth of research on older adults' participation in artistic activities, other activities, such as arts and crafts, are underrepresented ([Chacur et al., 2022](#)). Although intervention studies analyzing artistic activities are common, research on spontaneous artistic activities that occur in natural contexts (i.e., not resulting from interventions) remains sparse ([Tzanidaki and Reynolds, 2011](#); [Chacur et al., 2022](#)). The study contributes to this knowledge and stands out for the variety of variables collected to characterize the perceptions of older professional artisans. It includes a broad set of contextual and psychosocial data, both modifiable and non-modifiable (sociodemographic variables, variables related to artistic activity and health, multidimensional

quality of life assessment, depression symptomatology evaluation, and happiness assessment) to provide a detailed and comprehensive analysis of the sociodemographic profiles and the role of crafting in the perceptions of health status, quality of life, and happiness among older professional artisans.

This study adds to previous research highlighting the need for investigation into the role of active aging in quality of life and health ([Hijas-Gómez et al., 2020](#)), by demonstrating the benefits of remaining active in old age.

However, there are some study limitations, namely the inexistence of a control group of old people in the same city that have other occupations (e.g., agriculture), and the study of a convenience sample, which may affect the generalizability of the findings. Nevertheless, it must be noted that the sample represents almost 30% of the artisans in the territory, providing a useful insight into this population. To explore in depth the perceptions of artisans related to health and quality of life, as well as associations between craft sectors, it would also be useful to understand contextual factors influencing perceptions of health status, quality of life, and happiness. Other factors as personal motivation, family cohesion, and the legacy of craftsmanship, which may be related to commitment to artistic activity would be relevant to the comprehension of the role of crafts in the selected outcomes.

Future research would benefit from a larger sample and longitudinal studies, both quantitative and qualitative, also involving younger professional artisans from different sectors. Increasing the sample size would allow for comparative analyses between groups of different ages, enabling the exploration of associations that could expand the understanding of the relationships between sociodemographic characteristics, professional sector variables, and perceptions of health, quality of life, and happiness. In future studies, it is recommended to incorporate a multidimensional happiness assessment tool, which would allow for a more comprehensive analysis of different domains of subjective well-being. Such studies, could provide relevant scientific insights and help create more targeted programs that address specific needs, allowing for the exploration of observed associations and providing more robust data.

Investigating how working conditions can be adjusted to better accommodate the needs of older individuals with physical conditions and health issues common in advanced ages could provide valuable insights to science. Studies that delve into associations between craft sectors and examine the implications of health conditions on productivity and well-being, and that explore how health-related situations affect the subjective experience of working in craft activities, could contribute additional information.

Despite its limitations, the findings from this study serve as important starting points for future empirical research, enabling a critical understanding of the relationship between professional craft and folk art activities among older artisans and their perception of health status, quality of life, and happiness, as well as for comparative studies between different UNESCO creative territories.

Recent studies on active aging ([Shahla et al., 2023](#)) conclude that researchers, when designing active aging programs, should pay special attention to factors such as gender and cultural background of older adults, as these are significant considerations in program design. Our study adds valuable information to active

aging programs by considering these and other factors, based on activities related to the sociocultural identity of the participants (UNESCO, 2024).

The information emerging from this study can be valuable in guiding the development of targeted programs aimed at enhancing the health and quality of life of professional artisans. Initiatives focusing on occupational health promotion, along with educational actions on safe work practices, can benefit artisans by reducing the incidence of work-related illnesses. These measures can improve quality of life while fostering a safe and healthy work environment.

The development of health and wellness programs could be considered. Actions focusing on correct posture techniques, proper tool usage, and practices that minimize physical stress can help reduce the prevalence of occupational diseases. Incorporating breaks and appropriate physical exercises can aid in injury prevention, thereby mitigating the impact of these conditions on health. Activities focused on creating appealing opportunities for older adults, which encourage participation in physical, educational, and sociocultural activities tailored to their needs and health conditions, can support the balance between professional and personal life and contribute to improving the health and quality of life for artisans. Additionally, these results highlight positive concepts associated with aging. They align with the current global agenda for promoting a more equitable, inclusive, and sustainable society, and contribute valuable information to the fight against ageism (Nações Unidas, 2018; World Health Organization, 2020, 2021).

Finally, at a time when countries are increasingly seeking innovative and cost-effective methods to improve the health and well-being trajectories of rapidly aging populations, and where there is a growing emphasis on measures of quality of life, well-being, and happiness as decision-making metrics for guiding public policies (Helliwell et al., 2023; United Nations, 2023), this study, by expanding the professional involvement of older adults and the artistic activities within the craft and folk art sector, provides new insights and avenues for research in the scientific community.

4.2 Conclusion

The study aligns with national and international strategies for active and healthy aging (United Nations, 2020; World Health Organization, 2020, 2021; United Nations, 2023; Presidência do Conselho de Ministros, 2024).

A strong dedication to craft activities among older individuals was observed in this study. The findings highlight significant participation of older adults in these crafts, indicating that their involvement has continued over time, as supported by the literature on certain crafts in this region. For example, in activities related to clay figures: “it is the older adults who are the creators of this realism, and they are the only ones who make everything” (Costa, 1991, n.p.; Costa, 2024, p. 145).

The results show a trend where older artisans reported higher levels of happiness. This finding aligns with previous studies that indicate an increase in happiness after the age of 50

(Becker and Trautmann, 2022). However, this finding should be interpreted with caution, considering the ongoing debate in the literature regarding the life-course pattern of happiness (Steptoe, 2019; Becker and Trautmann, 2022; Esch, 2022). Further research is needed on this topic, employing multidimensional instruments for the assessment of happiness. This study suggests an almost complete absence of depressive symptoms, which is a positive indicator of the health status of these older professional artisans, especially when considering the high prevalence of depression in old people reported in the most recent National Health Survey conducted in Portugal (Instituto Nacional de Estatística, 2020).

In this study, the WHOQOL-BREF quality of life instrument showed a significant association between the environment domain and different craft activity sectors between the Imagery sector and the sectors of Pottery, Embroidery, Weaving, Iron and Derivatives, Wood, Basketry and Wicker, and Contemporary Crafts, with the latter group reporting a higher average score.

The associations observed in the environment domain of the quality of life scale may indicate a favorable context for older adults (World Health Organization, 2007).

An association was found between the different craft sectors and the perceived benefits of the activity, specifically in terms of health, quality of life, and well-being. Although these benefits were perceived differently across sectors, a larger number of participants from the Imagery sector considered health and quality of life as the primary benefits of their activity, whereas artisans from other sectors emphasized well-being. The artisans' perceptions regarding economic benefits and social status appeared to be quite homogeneous across the craft sectors. In the analysis of health-related variables, it was observed that the health benefit was more highly valued, which may suggest that craft-related activities play a therapeutic or supportive role. On the other hand, economic benefits and social status did not show the same relevance for these artisans.

Considering the high regard for the work of artisans in this region, both nationally and internationally (e.g., Fernandes, 2005; Costa et al., 2024; UNESCO, 2024) a significant association between craft sectors and the perception of social status as a benefit was anticipated. Curiously, this association was not observed. Instead, well-being, health, and quality of life emerged as the more prominent perceived benefits, as confirmed by the results, an interesting conclusion from our study.

This highlights the importance of the active aging and development strategies to help people remain engaged with life (Paül et al., 2017).

The results of this study can contribute to informed decision-making regarding active and healthy aging, promoting the health, quality of life, and happiness of older adults. This is relevant for both healthcare professionals and policymakers involved in developing public policies focused on the craft and folk art sector.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Ethics Committee of the Centro Hospitalar Universitário de Santo António, E.P.E. (CHUdSA) and the School of Medicine and Biomedical Sciences, University of Porto (ICBAS-UP) [CHUdSA/ICBAS Ethics Committee] [reference 2024/CE/P02(P418/2023/CETI)]. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SI: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. ST: Conceptualization, Methodology, Supervision, Writing – review & editing. CP: Conceptualization, Methodology, Resources, Supervision, Writing – review & editing.

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Conflict of interest

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

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2025.1536447/full#supplementary-material>

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Relationship between burnout syndrome and age among employees of the Mexican manufacturing industry

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Introduction: Nowadays, burnout syndrome (BS) has been widely studied due to the increasing and high work demands to which workers are exposed. To date, there is a lack of studies that analyze the relationship between age and its impact on employees in the Mexican manufacturing industry.

Objective: This research aims to determine the relationship between BS, its dimensions, and age among operative employees, senior, and middle managers in this industry.

Methods: The 16-item Maslach Burnout Inventory-General Survey (MBI-GS) was used to gather data and measure BS by grade and level. Nine hundred thirty-three employees voluntarily answered the instrument. First, the instrument was validated through psychometric tests to ensure reliability. Kaiser-Meyer-Olkin (KMO) and sphericity tests confirm the feasibility of the factorial analysis. The model's fit adjustment was tested using structural equation modeling with AMOS. Then, the BS was obtained by grades and levels. Subsequently, the Spearman Rho correlation analysis was carried out between the BS grades by dimension (Emotional exhaustion, Cynicism, and Lack of Professional Efficiency) and age group (up to 40 years and over 40 years). Finally, a hypothesis test for differences between means was conducted to determine whether there were significant differences by BS dimension's grade regarding age.

Results: The instrument's reliability is good, with Cronbach's alpha value greater than 0.8 for each dimension. The instrument's structure was confirmed through exploratory factor analysis (EFA). However, the structural equation models do not meet the goodness-of-fit criteria when the sample is divided into two age groups. Furthermore, the entire sample obtained medium grades for each dimension and a medium level of BS. Significant but weak correlations were obtained between age, cynicism, and professional efficiency. The mean test shows significant differences in the dimensions of cynicism (P – value 0.004) and professional efficiency (P – value 0.003). Likewise, the Tukey test with $\alpha = 0.05$ revealed significant differences in these dimensions between the 51 and 60 age group and the 21-30 and 31-40 age groups.

Conclusion: The sample studied has a medium BS level. Accordingly, age exhibits negative and positive correlations with cynicism and professional efficiency, respectively, even when they are weak. Psychometric tests corroborate the instrument's reliability, not its validity.

KEYWORDS

burnout syndrome, age, manufacturing industry, validation, relationship

1 Introduction

Burnout syndrome (BS) or occupational exhaustion BS is considered a neuropsychological disorder resulting from chronic stress at work (Arji et al., 2023). It is a widespread, multifactorial, and psychological phenomenon (Listopad et al., 2021). Additionally, according to the World Health Organization, BS is considered an occupational phenomenon, not a medical condition (World Health Organization, n.d.).

BS is a phenomenon with significant consequences at both personal and professional levels. Several studies have explored its effects in different contexts, highlighting its impact on mental health, academic performance, and job stability. Other studies in the academic context found that BS affects medical students, leading to feelings of cynicism and inadequacy. Collaboration and peer learning can help mitigate these effects, but BS remains a significant problem affecting students' performance and mental health (Gómez et al., 2024).

In the workplace, BS can increase employee turnover intentions. However, contextual factors often mediate the mechanisms linking burnout to these outcomes. A study conducted at the Portuguese Tax and Customs Authority found that occupational stress and BS are significantly associated with intentions to leave (Freitas et al., 2023). However, this relationship may be weaker in organizations with robust support systems, suggesting that structural interventions could mitigate turnover. Employees who experience high stress levels and BS tend to look for other jobs due to a lack of motivation and emotional exhaustion. Additionally, studies among healthcare professionals have shown that BS has even more serious consequences since a study in Portugal revealed that BS is related to an increase in suicidal behaviors (de Jesus et al., 2023). These authors informed that self-esteem could moderate these effects, but the risk of suicidal behaviors remains high when BS is severe. In addition, toxic leadership can exacerbate BS, increasing employee turnover intentions. Emotional intelligence can moderate this relationship, helping employees better manage the stress and negative emotions associated with BS (Lopes et al., 2025).

Consequently, recent studies have found that BS can affect students, employees of various professions, and job positions of various ages at multiple levels or grades.

Conventionally, BS is measured by emotional exhaustion, depersonalization or cynicism, and reduced professional efficacy. The first dimension can manifest as feelings of being overextended. Depersonalization/cynicism refers to cynical and negative attitudes toward work and the people with whom one interacts (e.g., patients and coworkers), and reduced professional efficacy is associated with poor work performance (Maslach et al., 2001). However, new evidence has emerged suggesting that this phenomenon may be

more extensive, and therefore, the three dimensions may not fully capture its complex and multifaceted nature (Listopad et al., 2021). In addition, several sociodemographic variables such as gender (Marchand et al., 2018), marital status (Armenta et al., 2021), schooling (Norlund et al., 2010), daily working hours (Macias-Velasquez et al., 2020), seniority (Korman et al., 2022), among others, have been related to the presence of BS in employees of a wide variety of professions.

Still, the relationship between age and BS has been uncertain in industrial employees, mainly middle and senior managers; while some authors affirm that BS rates increase with age (Marchand et al., 2018; Arji et al., 2023), other authors affirm that this relationship can be both (Rožman et al., 2017, 2018, 2019a), and other authors reveal a moderating effect (van der Westhuizen et al., 2015). Employees in these job positions are critical for the accomplishment of the companies' objectives, supporting drastic changes for improvement by facilitating communication and information among other managers or subordinates (Abdullah and Sofyan, 2022), but they are also more vulnerable to BS effects (Ahola et al., 2010; Rožman et al., 2019b). Furthermore, several factors, including age, work involvement, and coworker cohesion, have been linked to BS dimensions among industrial workers. Specifically, work pressure is linked to emotional exhaustion and depersonalization, while professional accomplishment is related to job satisfaction (Lam et al., 2022).

As established previously, part of the problem is that the relationship between age and BS remains undefined in the literature. In addition, several studies in the Mexican manufacturing industry context have determined the prevalence of this syndrome among their employees (Maldonado-Macías et al., 2015; Macias-Velasquez et al., 2020; Armenta-Hernández et al., 2021). These authors address these gaps by focusing on Mexican industrial managers, a population underrepresented in the literature, while controlling for moderators like work hours and marital status. However, the relationship between age and burnout remains unclear. This research aims to determine the relationship, dimensions, and age among frontline employees and senior and middle managers in the industry.

2 Literature review

2.1 Maslach burnout inventory-GS grades and levels

As verified in the literature, BS can be measured along three dimensions. Additionally, five levels of BS derived from

combinations of these three dimensions (Emotional Exhaustion, Cynicism, and lack of Professional Efficacy) can provide a framework to identify the intensity of BS and guide interventions. These levels can be interpreted based on established norms and cut-offs and are usually labeled as follows (Bakker et al., 2002; Schaufeli et al., 2010; Wang et al., 2024):

1. *No BS*: This level indicates that the individual is functioning well with no signs of BS, including low exhaustion, low cynicism, and high professional efficacy.
2. *Mild BS*: Moderate exhaustion and/or cynicism accompanied by sustained professional efficacy. This is a warning stage at which some symptoms of BS may begin to appear.
3. *Moderate BS*: This involves increased exhaustion and cynicism, accompanied by potential declines in professional effectiveness. Individuals may feel detached and experience increasing stress.
4. *Severe BS*: Characterized by high exhaustion, cynicism, and significant reductions in professional efficacy. Individuals at this level are at a critical juncture where their work performance and personal well-being are severely impacted.
5. *Critical BS*: Extreme exhaustion, cynicism, and low professional efficacy. As BS is deeply entrenched at this stage, individuals may require urgent interventions.

2.2 Relationship between age and Maslach burnout

A search of three databases (IEEE, ScienceDirect, ACM) by keyword found that few studies present evidence of a relationship between age and BS among industry workers.

Among these works analyzed two groups of workers in Saudi Arabia: one under 40 and the other 41 and older. His study found no significant differences between the two groups regarding stress, BS, or age. BS is more significant among civilian government workers in China's Shandong province who are under 36 years old. These results align with those reported analyzed a sample of 444 workers in a service area in Germany. Their findings suggest that age indirectly predicts less BS and greater commitment through emotional regulation strategies, superficial performance, and anticipatory deep performance. In the case of the work presented by Hatch et al. (2018), a sample of 400 nursing workers in a health system in the southeastern United States found that older workers may be better able to take advantage of cognitive, psychological, and work strengths that improve with age.

Additionally, in a study carried out with 9,922 people, of whom 7,765 were of working age, BS does not increase or decrease constantly concerning age but probably decreases and increases with age, taking as a differentiator the various phases of the work career and family life since today, employees do not remain in the same situation throughout their working careers. Although some positions may be more likely for BS during specific years, such as becoming a parent during the first few years of work or a manager during later years,

transitions can affect the accumulation of the total burden in each age group (Ahola et al., 2008). Additionally, Rožman reports diverse results from three studies conducted on various samples of workers in Slovakia. In two studies, BS is found to have a negative relationship with age (Rožman et al., 2017, 2019a), whereas in another study, it is positive (Rožman et al., 2017).

In the industrial and service sectors, the relationship between BS and age remains poorly understood (Marchand et al., 2018). For example, in the results mentioned that female workers under 25 exhibit higher rates of BS compared to other age ranges, as observed in a study conducted among 1,081 female workers in Guangdong, China. In contrast, Marchand et al. (2018), found that BS presents a positive relationship concerning age in an age group of workers under 30; subsequently, the relationship becomes negative until 55, and at the end, it becomes positive again, this in a sample of 2,073 workers in the manufacturing and service industry in the province of Quebec, Canada.

In contrast, the work published by van der Westhuizen et al. (2015), which used a sample of 246 workers from an international integrated energy and chemicals company in South Africa, found no statistically significant evidence to support differences between age categories. However, they found they could be used as predictors in some dimensions. According to other studies, older workers exhibit better mental stability due to their experience, unlike younger workers, who often experience higher levels of stress and family conflicts. Younger workers may still need to learn to adapt to the work environment, while older workers may be more resilient in adjusting to a changing environment (Hsu, 2019; Jurek, 2024).

Therefore, some other authors have found that these variations may stem from:

1. *Cultural differences*: For instance, younger workers in collectivist cultures (e.g., China) may experience higher burnout due to familial pressures absent in individualist contexts.
2. *Career stages*: Transitions (e.g., parenthood, promotions) may temporarily spike burnout, confounding age effects (Ahola et al., 2008).
3. *Methodological limitations*: Cross-sectional designs (Macias-Velasquez et al., 2020) cannot disentangle age from cohort effects.

3 Materials and methods

3.1 Study design

This research employs a quantitative approach, featuring a cross-sectional design and correlational scope (Hernández et al., 2014). It aims to investigate how age affects BS among Ciudad Juárez manufacturing industry workers. The Institutional Committee of Ethics and Bioethics of the Autonomous University of Ciudad Juárez endorsed this research on October 22, 2019 (Folio: CIEB-2019-1-098).

3.2 Participants

The sample comprises 933 participants who voluntarily completed the instrument after signing the informed consent: 92 managers, 236 supervisors, 242 technicians, 105 group leaders, and 258 frontline employees. The exhibition features various industries, including medical products, automotive, electronics, and miscellaneous sectors, located in Ciudad Juárez, Chihuahua, Mexico. The study was conducted from November 2019 to November 2021.

3.3 Instrument

The Spanish version of the Maslach Burnout Inventory-General (MBI-GS) was used for data collection, having been translated and adapted by [Moreno-Jimenez et al. \(2001\)](#). This instrument contemplates three dimensions. The first dimension is emotional exhaustion, which involves feelings of exhaustion resulting from the high physical and mental demands of work. It is indeed considered an obvious manifestation of the syndrome. On the other hand, the dimension of cynicism identifies when the person tries to distance himself from the service recipient. It is presented as a negative response to various aspects of work, where the worker only wants to do their job without being involved in additional activities. Finally, the dimension of reduced professional efficiency is considered a self-evaluation. Address feelings of incompetence and lack of work productivity ([Maslach et al., 2001](#)).

The instrument consists of 16 items grouped into three dimensions: emotional exhaustion, professional efficacy, and cynicism. They are seven-point Likert scales where 0 = never, 1 = rare throughout the year, 2 = sometimes throughout the year, 3 = on many occasions throughout the year, 4 = frequently throughout the year, 5 = almost every day, and 6 = every day. Of the 16 items, 10 have a negative meaning, and only six are positive (see [Table 1](#)).

3.4 Methods

The study was developed through four stages (see [Figure 1](#)). The objective was to determine the degrees and levels of BS among workers in the manufacturing industry. Subsequently, the type of relationship between age and the presence of the syndrome was determined. Additionally, the reliability and validity of the instrument used were confirmed. In this context, studies such as those by [Macias-Velasquez et al. \(2019\)](#) and [Armenta-Hernández et al. \(2021\)](#) served as a reference for the analysis and interpretation of the results obtained from the instrument. Refer to Hair et al.'s multivariate data analysis book for the psychometric tests.

3.4.1 Stage 1. Reliability and validity of the instrument in the sample

In research, it is essential to corroborate the reliability and validity of the instrument. On the other hand, reliability corresponds to the precision with which the variable studied is measured. Among the most used indicators to measure it is Cronbach's alpha, obtained through the correlations between the

TABLE 1 Dimensions of the Maslach BS inventory-general survey instrument.

| Dimension | Item code | Feeling that represents |
|-------------------------|----------------------|---------------------------------|
| Emotional exhaustion | 1. Totally exhausted | Exhausted emotionally |
| | 2. Exhausted | Finishing at the end of the day |
| | 3. Fatigued | Fatigued at dawn |
| | 4. Stressed | Work is stressful |
| | 6. Exhausted | Exhausted by my work |
| Professional efficiency | 5. Resolve | Able to solve problems |
| | 7. Contribution | Contribution to the work |
| | 10. Good | I am good at doing my job. |
| | 11. Carried out | I feel fulfilled |
| | 12. Value | Realized worthwhile things |
| | 16. Efficacy | Effective in doing my job |
| Cynicism | 8. Interest | Loss of interest |
| | 9. Enthusiasm | Loss of enthusiasm |
| | 13. Bothered | Do not bother me |
| | 14. Indifferent | I have become indifferent. |
| | 15. Doubt | I doubt the value of my work |

Adapted from [Moreno-Jimenez et al. \(2001\)](#).

items that comprise the instrument. Values greater than 0.70 correspond to an acceptable level of reliability ([Bland and Altman, 1997](#); [Tavakol and Dennick, 2011](#); [Rodríguez-Rodríguez and Reguant-Álvarez, 2020](#)). In addition to evaluating the instrument's reliability with the complete sample, the instrument was divided into two groups, using the age of 40 years as a reference. The first group is up to 40, while the second group includes workers over 40.

Once the instrument's reliability is confirmed, it is necessary to perform the construct validation to ensure that it measures what it intends to measure. Factor analysis is recognized as the ideal technique to guarantee the viability of the sample and the validation of the construct ([Pérez-Gil et al., 2000](#)). However, the relevance of the factor analysis must be verified first. For this purpose, the indicators used were the determinant of the correlation matrix, the Bartlett's sphericity test, and the Kaiser-Meyer-Olkin index (KMO).

Subsequently, it is recommended to start with exploratory factor analysis (EFA) to confirm that the items were grouped into the correct dimensions according to the structure proposed by [Moreno-Jimenez et al. \(2001\)](#). Factorial extraction was performed using the principal component method. Factors with a self-value greater than one were excluded. The initial matrix was rotated using the Varimax orthogonal method, which provides the most obvious factorial separation ([Hair et al., 2013](#)) and shows little likelihood of producing inadequate solutions ([Fabrigar et al., 1999](#); [Stevens, 2012](#)).

The construct validation was performed through confirmatory factor analysis when these procedures were conducted. This analysis was performed using structural equation modeling in the statistical software AMOS® version 22. This analysis aimed to confirm that the instrument's dimensions comply with the statistical parameters ([Byrne, 2016](#)). The maximum likelihood

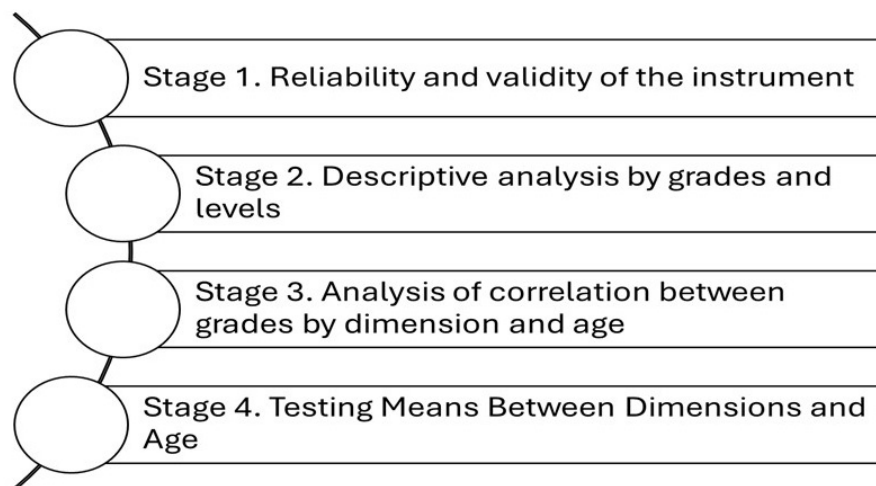


FIGURE 1
Stages of the methodology. Source: The authors.

TABLE 2 Sample description.

| Age | | Job position | |
|----------------------|-----|--------------------|-----|
| Under 21 (years old) | 11 | Manager | 92 |
| 21-30 | 291 | Supervisor | 236 |
| 31-40 | 323 | Technical | 242 |
| 41-50 | 234 | Group leader | 105 |
| 51-60 | 69 | Frontline employee | 258 |
| More than 60 | 5 | | |
| Company sector | | | |
| Electronics | 67 | Automotive | 318 |
| Medical products | 397 | Miscellaneous | 151 |

Source, the authors.

TABLE 3 Relevant indicators for the EFA.

| Indicator | Value | Reference |
|----------------------------|------------------------------------|---------------------|
| Determinant | 0.00001061 | Value \neq 0 |
| Bartlett's sphericity test | 10603.866 120 DF $p = 0.000$ | p -value < 0.05 |
| Kaiser-Meyer-Olkin (KMO) | 0.897 | Value > 0.7 |

Source: The authors.

method was used to calculate the factor loads. The parameters used to evaluate the absolute fit of the model were the chi-square statistic (χ^2), the chi-square ratio concerning the degrees of freedom (χ^2/df), the root-mean-square error of approximation (RMSEA), the goodness-of-fit (GFI), and the adjusted goodness-of-fit statistic (AGFI). On the other hand, the Normed fit index (NFI), the Comparative fit index (CFI), and the Tucker-Lewis index (TLI) were used to evaluate incremental fit. The AFC was performed on the entire sample (933 participants) and age-related groups. The

first sample corresponds to participants up to 40 years old, and the second corresponds to participants over 40 (308 participants).

3.4.2 Stage 2. Descriptive analysis by grades and levels

The database was created, cleaned, and registered on June 29, 2022, and its registration number is 03-2022-062712044100-01 according to the National Institute of Authorship Rights in Mexico (INDAUTOR). The first step was to divide the sums of each dimension's responses and use the 33.3 and 66.6th percentiles as cut-off points to determine the degree of BS (low, medium, high). Subsequently, the mean scores by dimension were calculated and used to determine the grade for each dimension according to the values presented in Table 1. Finally, the level of BS is a categorical variable of five categories (none, low, moderate, high, and extremely high). These levels are obtained from the 27 possible combinations derived from the three degrees of BS. The statistical analysis was performed using SPSS version 24 software.

3.4.3 Stage 3. Analysis of the correlation between grades by dimension and age

Because the data are ordinal and we wanted to know the relationship between the dimensions of BS (emotional exhaustion, cynicism, and reduced professional efficiency) and age (taking 40 years as a reference), Spearman's Rho was used as a correlation index. This is a non-parametric measure of correlation, through which the relationship between two variables is described.

3.4.4 Stage 4. Testing means between dimensions and age

The Tukey test is used to identify precisely where the means (compared to each other) are different from the rest (Benites, 2022). This test was performed at this stage to identify the differences between the BS's grades according to six age range groups (under 21, 21-30, 31-40, 41-50, 51-60, and over 60).

TABLE 4 Rotated matrix of components and communalities.

| # | Item description | Factor | | | Communalities |
|---|--|--------|-------|-------|---------------|
| | | 1 | 2 | 3 | |
| 1 | I feel emotionally drained by my work. | | 0.794 | | 0.730 |
| 2 | I feel finished at the end of the workday. | | 0.895 | | 0.826 |
| 3 | I feel fatigued when I wake up in the morning and must start another day of work | | 0.867 | | 0.743 |
| 4 | Working all day is stressful for me. | | 0.825 | | 0.700 |
| 6 | I feel finished with my work | | 0.651 | | 0.596 |
| 5 | I can effectively solve problems that arise in my work | 0.785 | | | 0.691 |
| 7 | I feel that I am making an effective contribution to the activity of my organization | 0.830 | | | 0.702 |
| 10 | In my opinion, I am very good at doing my job | 0.924 | | | 0.823 |
| 11 | I feel fulfilled when I accomplish something in my work | 0.906 | | | 0.850 |
| 12 | I have done a lot of worthwhile things in my work | 0.914 | | | 0.823 |
| 16 | In my work, I am sure that I am effective at doing things | 0.905 | | | 0.744 |
| 8 | Since I started the job, I have been losing interest in my work | | | 0.788 | 0.669 |
| 9 | I have been losing enthusiasm for my work | | | 0.802 | 0.676 |
| 13 | I want to do my job and not be bothered | | | 0.522 | 0.363 |
| 14 | I have become more indifferent about whether my work is worth anything | | | 0.834 | 0.363 |
| 15 | I doubt the value of my work | | | 0.866 | 0.706 |
| Extraction method: principal component analysis. Rotation method: Promax with Kaiser normalization. | | | | | |
| To. The rotation has converged in 5 iterations. | | | | | |

Source: The authors.

4 Results

4.1 Sample characteristics

The sample comprises 626 men and 307 women working in manufacturing companies. The most frequent age range was 31–40. In addition, various positions and company sectors were considered, with the medical products sector obtaining the highest number of responses (see Table 2).

4.1.1 Stage 1 Results. Reliability and validity of the instrument in the sample

4.1.1.1 Reliability

Cronbach's alpha corroborated the instrument's reliability. Overall reliability was 0.856, while by dimension, it was emotional exhaustion (0.878), cynicism (0.811), and professional efficiency (0.941). Likewise, when analyzing the reliability of the groups, values higher than 0.80 were obtained in both groups. The first group was 0.868, and the second was 0.831. Values greater than 0.8 refer to good reliability (Bland and Altman, 1997; Rodríguez-Rodríguez and Reguant-Álvarez, 2020).

4.1.1.2 Construct validity

Subsequently, the feasibility of factor analysis was verified through the three minimum indicators: the determinant, Kaiser-Meyer-Olkin (KMO), and Bartlett's sphericity test. Statistical

analysis was performed using SPSS version 26 software. Table 3 shows the results that corroborate the feasibility of factor analysis (Kaiser and Rice, 1974; García-Castellanos et al., 2020).

On the other hand, in the exploratory factor analysis, three factors were extracted, which represent 70.723% of the total variance explained. The distribution of the items in these factors confirms the structure proposed by Moreno-Jimenez et al. (2001).

Only items with a value equal to or greater than 0.4 were considered to determine their influence on the factor. Table 4 shows the arrangement of the items and the resulting loads of each item. Likewise, communalities allow us to know how each item correlates with others. This represents the amount of deviation explained in terms of each item, and values higher than 0.1 are recommended (Barrera Ortiz et al., 2015).

Once the instrument's structure has been verified through the EFA, the construct validity was evaluated by modeling structural equations. AMOS version 22 software was used (Byrne, 2016). Table 5 shows the results obtained. For the model that includes the entire sample ($n = 933$), it is observed that it complies with two of the absolute adjustment parameters, the Root Mean Square Error Approximation (RMSEA) and the Goodness-of-fit Index (GFI). The (RMSEA) represents the anticipated adjustment with the population's value and not only the sample. The GFI determines how much of the variance and covariance of the sample is explained by the model.

On the other hand, when separating the sample into two groups, up to and over 40 years of age, a considerable change in

TABLE 5 Structural confirmatory model.

| Index | Sample values | | | Recommended |
|---|---|---|---|-------------------|
| | Complete | Up to 40 years old | Over 40 years old | |
| Model fit | | | | |
| Chi-square of the estimated model X^2 | 499.766 DF = 95 Value p = 0.000 | 687.955 df = 94 Value p = 0.000 | 400.89 Shadow Fiend = 100 Value p = 0.000 | $p > 0.05$ |
| χ^2 /DF | 5.261 | 7.319 | 4.009 | <5 |
| Absolute fit measures | | | | |
| RMSEA | 0.068 | 0.101 | 0.099 | \leq value 0.08 |
| 90% RMSEA CI | (0.062; 0.074) | (0.094; 0.108) | (0.089; 0.109) | |
| GFI | 0.908 | — | 0.836 | > 0.90 |
| AGFI | 0.868 | — | 0.777 | > 0.90 |
| Incremental fit measures | | | | |
| TLI | 0.788 | 0.899 | 0.712 | > 0.90 |
| NFI | 0.803 | 0.910 | 0.708 | > 0.90 |
| CFI | 0.832 | 0.921 | 0.760 | > 0.95 |

The numbers in bold refer to those values that comply with the reference values.

the parameters is observed. Referring to the model, those up to 40 years old do not comply with any absolute adjustment parameters. However, it complies with incremental fit parameters, which measure the degree to which the model's fit is improved compared to the hypothetical model. These parameters are regularly used to explain the models better since absolute indicators such as the chi-square are highly dependent on the sample size (Schmukle and Hardt, 2005) and are challenging to comply with. Furthermore, the incremental parameters, such as Tucker–Lewis's (TLI) and the non-normed fit index (NNFI), compare the model studied against the hypothetical model. Commonly, this indicator performs best in small samples (Byrne, 2016) and is usually compared against 0.9 to indicate an acceptable fit (McDonald and Ho, 2002). In this study, a marginal value of 0.899 is nearly acceptable. Likewise, the model achieved the Normed fit index (NFI). The first analyzes the improvement of the fit by comparing the studied model against the hypothetical model (Hooper et al., 2008); the second compares the chi-square of the model studied against the hypothetical one. For both parameters, a value greater than 0.9 is considered acceptable (Gefen et al., 2011). Finally, the model with participants over 40 years of age only complies with one absolute fit parameter: the chi-square ratio for degrees of freedom, with a value less than 5.

4.1.2 Stage 2. Descriptive analysis by grades and levels

When analyzing the qualities of the Emotional Exhaustion (EE) dimension, it shows us a score with ranges from 0 to 30 points, with an arithmetic mean of 7.8574 and a standard deviation of 5.95801. The trend on the cynicism (CC) dimension takes us to a range of 0–28 points, with an arithmetic mean of 7.0214 and a standard deviation of 5.57158. While in the professional efficiency (PE) dimension, a minimum range of 1 to 36 points is observed, with an arithmetic mean of 23.0043 and a standard deviation of 9.38358. Likewise, Table 6 shows that the analyzed sample reports a medium degree for the three dimensions.

TABLE 6 Distribution of scores by dimension.

| Dimension | Emotional exhaustion EE | Cynicism CC | Professional efficiency PE |
|-----------|-------------------------------|-------------------------------|----------------------------------|
| Low | 5 points | 4 points | 18 points |
| Medium | 6–9 points (7.86) | 5–9 points (7.02) | 19–29 points (23.00) |
| High | 10 points | 10 points | 30 points |

The values in bold correspond to the average scores per dimension.

On the other hand, when analyzing the levels of BS, the sample is similarly, distributed in the five levels (see Figure 2). However, 56 % of the sample presents levels of the syndrome ranging from moderate to critical. Employees experiencing these levels of BS may present adverse symptoms such as being detached and continuously more stressed, reducing performance at work, affecting personal wellbeing, and requiring urgent interventions (Maslach and Jackson, 1986; Bakker et al., 2002).

4.1.3 Stage 3. Analysis of the correlation between grades by dimension and age

Once the degrees and levels of BS in the sample were analyzed, the relationship between the degree values reported in each dimension and the age of participants was determined by the index Spearman's Rho. In this case, six age groups and ranges were studied: under 21 years old, 21–30, 31–40, 41–50, 51–60, and over 60 years. As a result, although the dimensions are highly correlated with each other, age was only significantly related to the dimension of cynicism (CC) (−0.084) and professional efficiency (PE) (0.069) with a significance level of 0.05. Accordingly, age exhibits negative and positive correlations with cynicism and professional efficiency, respectively, even when they are weak (see Table 7).

In addition, the index Spearman's Rho was recalculated to determine the correlation analysis between the BS degree value for

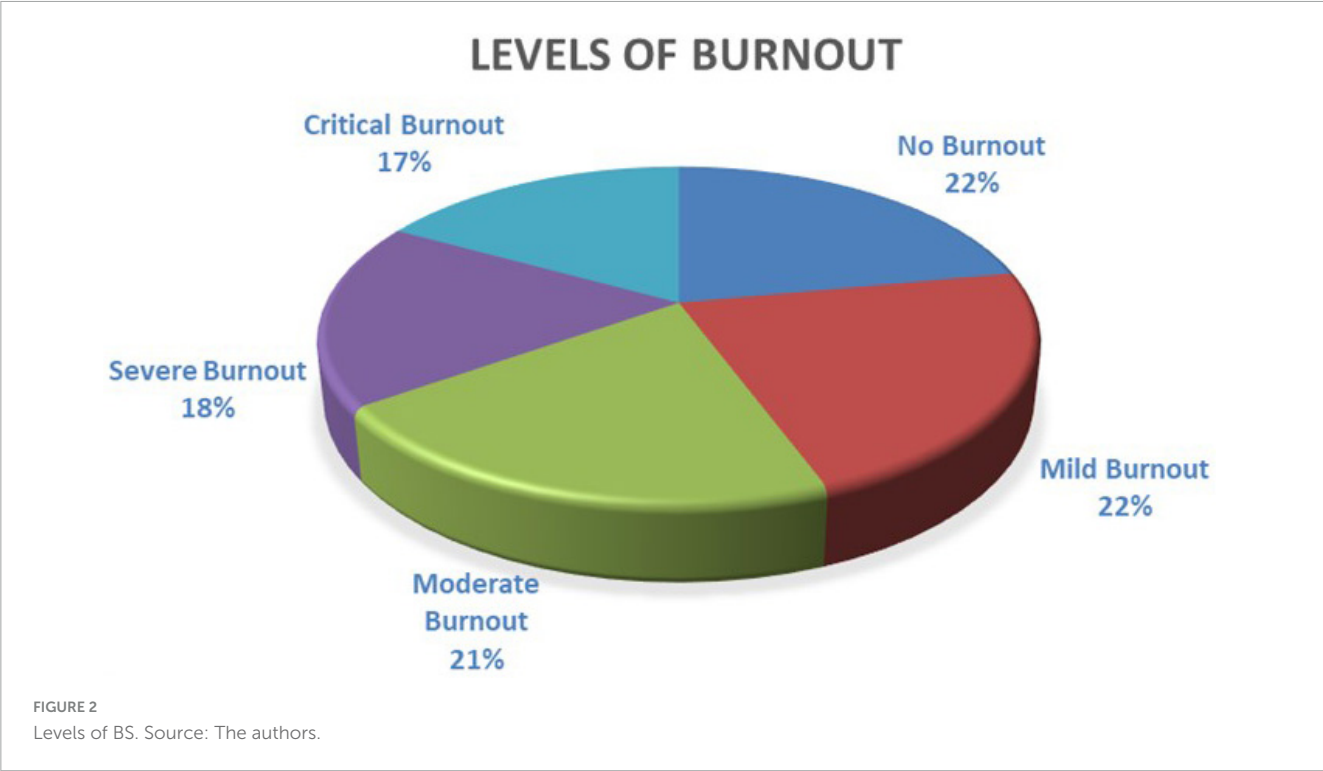


TABLE 7 Correlation between age and grades by dimension.

| Dimension | | Age | EE | CC |
|------------------------------|-------------------------|---------|---------|----------|
| Cynicism (CC) | Correlation Coefficient | −0.084* | 0.272** | 1 |
| | Sig. (bilateral) | 0.01 | 0.001 | |
| Professional efficiency (PE) | Correlation coefficient | 0.069* | 0.217** | −0.288** |
| | Sig. (bilateral) | 0.036 | 0.001 | 0.001 |

*The correlation is significant at the 0.05 level (bilateral). **The correlation is significant at the 0.01 level (bilateral).

each dimension and age. Unlike the first correlation analysis, the sample was divided into two groups: less than or equal to 40 and over 40 years (see Table 8). The results confirm the presence of a significant correlation between age among the three dimensions of BS, and age is significantly correlated with cynicism and the professional efficiency dimension, with a significance level of 0.01. Accordingly, age exhibits negative and positive correlations with cynicism and professional efficiency, respectively, even when they are weak.

4.1.4 Stage 4. Testing means between BS dimensions and age

So far, correlation analyses have shown significant relationships between cynicism grades and the dimensions of professional efficiency and age.

In addition, the Tukey test was performed to compare the means and identify the age groups with a significant difference. The BS level and the degrees of the three dimensions concerning the age range were analyzed. When analyzing the levels of BS, there were no significant differences between the ages studied. While

TABLE 8 Correlation between age and BS grades by dimension.

| Dimension | | Age (40 years old) | EE | CC |
|------------------------------|-------------------------|--------------------|---------|----------|
| Cynicism (CC) | Correlation coefficient | −0.094** | 0.272** | 1 |
| | Sig. (bilateral) | 0.004 | 0.001 | |
| Professional efficiency (PE) | Correlation coefficient | 0.098** | 0.217** | −0.288** |
| | Sig. (bilateral) | 0.003 | 0.001 | 0.001 |

**The correlation is significant at the 0.01 level (bilateral).

analyzing by dimension, it was found that in emotional exhaustion, there were two significant differences between the means of the age groups: under 21 and from 31 to 40 years old; 21-30 and 31-40 years old. In both the cynicism and professional efficiency dimensions, significant mean differences were shown between the 21-30 and 31-40 age groups and those aged 51-60, finally, in the Professional Efficiency dimension (Table 9).

5 Discussion

The results of our study expand the evidence regarding the necessity and importance of addressing BS as a multifactorial issue affecting employees across diverse professions and organizational levels (Lindblom et al., 2006; Armenta-Hernández et al., 2021; Singh et al., 2024). Likewise, it is observed that the correlation values in the few studies found in the literature between age and BS dimensions have also been weak, even with other study variables

TABLE 9 Tukey test with α 0.05.

| Dependent variable | (I) What is your age | (J) What is your age | Mean difference (I-J) | Desv. Error | Sig. | 95% confidence interval | |
|-------------------------|----------------------|----------------------|-----------------------|-------------|-------|-------------------------|-------------|
| | | | | | | Lower limit | Upper limit |
| Emotional exhaustion | 31-40 | Under 21 | −0.771* | 0.260 | 0.036 | −1.51 | −0.03 |
| | | 21-30 | −0.216* | 0.068 | 0.021 | −0.41 | −0.02 |
| Cynicism | 51-60 | 21-30 | −0.313* | 0.109 | 0.046 | −0.62 | 0.00 |
| | | 31-40 | −0.339* | 0.108 | 0.021 | −0.65 | −0.03 |
| Professional efficiency | 51-60 | 21-30 | 0.339* | 0.108 | 0.021 | 0.03 | 0.65 |
| | | 31-40 | 0.440* | 0.107 | 0.001 | 0.13 | 0.74 |

*The difference in means is significant at the 0.05 level.

such as suicidal behaviors, turnover, and motivation, learning, among others (Lindblom et al., 2006; Ahola et al., 2008; de Jesus et al., 2023; Gómez et al., 2024; Singh et al., 2024; Lopes et al., 2025). Hence, these findings may make it challenging to design proper and effective interventions to diminish BS symptoms according to age.

Additionally, BS's effects on industrial employees vary and can be severe depending on contextual, workplace, organizational, and individual factors. Among these, age is a critical variable that must be considered when studying and understanding the effects of BS and determining appropriate interventions and further research. The relationship between age and the dimensions of BS—emotional exhaustion, cynicism, and professional efficacy—has garnered significant attention in occupational health research, particularly in industrial settings. Recent studies have highlighted how age influences these dimensions, often interacting with other variables such as gender and workplace stressors. Furthermore, several of these studies, including ours, have contributed to confirming the validity of the 16-item Maslach BS Inventory (MBI-GS) across a wide range of samples, professions, and contexts.

Our findings provide a basis for comparison with relevant studies and contribute to a deeper understanding of the relationship between age and the dimensions of BS.

5.1 Age and emotional exhaustion

While the correlation analysis did not show significant correlations between emotional exhaustion and age, our findings align with previous studies, such as research conducted in a Moroccan private company, which demonstrated that younger workers (<35 years) exhibit higher levels of emotional exhaustion than their older counterparts. Specifically, our study revealed significant differences in emotional exhaustion between participants aged 3140 years and those under 21 years ($p = 0.036$), and the group aged 2130 years ($p = 0.021$). These results differ from the negative correlation between age and emotional exhaustion reported by other researchers (Macias-Velasquez et al., 2019), suggesting that older workers may develop more effective coping strategies or exhibit greater emotional resilience in response to occupational demands.

5.2 Age and cynicism

Significant correlations were obtained between age and cynicism ($r = -0.084$; $p = 0.01$) with a significance level of 0.05. However, although significant, the index is weak. This coincides with studies such as Flores Ortiz et al., 2016 and Posso-Yépez et al., 2025. Likewise, when the correlation analysis was performed with the sample divided into two age groups (less than or equal to 40 years and over 40 years), the significant correlation ($r = -0.094$; $p = 0.004$) was slightly increased with a significance level of 0.01.

Also, our findings are consistent with prior research indicating that cynicism tends to be more pronounced among younger workers, particularly those transitioning into industrial roles. We observed significant differences in cynicism between the 51-60 age group and the younger cohorts aged 21-30 years ($p = 0.046$) and 31-40 years ($p = 0.021$). These results align with the adaptive perspective highlighted in studies of middle managers in the maquiladora industry, where younger employees exhibited higher levels of cynicism as a response to workplace stressors and limited emotional resilience (Armenta-Hernández et al., 2021). Furthermore, our results support the negative correlation between age and cynicism (Armenta-Hernández et al., 2021; Arji et al., 2023), with younger workers often displaying higher levels of CC, reflected in correlation values ranging from -0.2 to -0.4 . These findings underscore the importance of considering age-specific interventions to address cynicism and its underlying causes among younger industrial employees.

5.3 Age and professional efficacy

Significant correlations were obtained between age and professional efficiency ($r = 0.069$; $p = 0.036$) with a significant level of 0.05. However, although significant, the index is weak. This indicates that age is not a variable that determines the degree of the professional efficiency dimension. Similarly, when the correlation analysis was performed with the sample divided into two age groups (less than or equal to 40 years and over 40 years), the significant correlation ($r = 0.098$; $p = 0.003$) was slightly increased with a significance level of 0.01.

In addition, our results reveal significant differences in professional efficacy between the 51-60 age group and the younger cohorts aged 21-30 ($p = 0.021$) and 31-40 ($p = 0.001$), suggesting that professional efficacy varies substantially across age groups. Although older workers tend to report lower professional effectiveness, especially in sectors where technological change is occurring more rapidly, this decrease in reported effectiveness could be attributed to difficulties adapting to new technologies and changes in the demands to carry out the activities assigned to their jobs. This decrease in reported effectiveness could be attributed to difficulties adapting to new technologies and changes in demand levels to carry out the activities assigned to their job. In contrast, despite experiencing higher levels of BS, younger employees demonstrate greater professional effectiveness, probably due to being more familiar with new technologies and ways of integrating with modern workflows. These findings emphasize the need for targeted training programs for older employees to bridge technological skill gaps and sustain their professional efficacy in dynamic industrial environments.

5.4 The Maslach BS Inventory General Survey

The results regarding the 16-item Maslach BS Inventory General Survey (MBI-GS) provide strong support for its three-dimensional representation of BS and demonstrate good internal consistency, consistent with findings from prior studies (Adanaqué-Bravo et al., 2023; De Beer et al., 2024; Wang et al., 2024). The structure of the MBI-GS was validated using exploratory factor analysis (EFA), which showed good fit indices for the complete sample. However, when the sample was divided into age groups, the model's fit indices did not meet the same standards, suggesting that these indicators are sensitive to sample size and that this sensitivity impacts the model's performance across different age groups. Similar findings regarding cross-cultural occupational validity have been reported in other studies (Bakker and de Vries, 2021; Adanaqué-Bravo et al., 2023). Furthermore, our results align with those of Wang et al. (2024), which confirmed the overall reliability of the instrument and observed good fit indices both dimensionally and across age groups. However, further research is needed to use the MBI-GS across a broader range of professions to assess the consistency of its psychometric properties within the Mexican population. Future research may address these challenges to improve the applicability and accuracy of the instrument in diverse populations and age groups.

5.5 Future directions

Our research focused on analyzing how age interacts with the dimensions of BS in industrial settings. In line with this purpose, age can be an important moderating variable when making practical interventions tailored to a specific context. According to our results, younger workers could benefit from stress management programs and mentoring.

In comparison, older workers should focus on continuous professional development to achieve and maintain suitability in technologically changing environments.

Future studies, building upon our research, should focus on:

1. Exploring longitudinal trends in the relationship between age and BS.
2. Validating BS measurement tools within more detailed demographic categories.
3. Investigating the moderating effects of other factors, such as gender, job role, and organizational culture, on age-BS dynamics.

6 Conclusion

The sample studied presents an average level of BS. When analyzing the BS levels, the sample distribution is similar in the five levels considered. The results reveal that, although the dimensions of BS are highly correlated, age only shows a significant relationship with the dimensions of cynicism and professional efficiency. In addition, the correlation analysis between the degree of BS of each dimension and age, categorized in two ranges: less than or equal to 40 years and greater than 40 years, confirms the existence of a significant correlation between age and the three dimensions of BS. In this analysis, age presents a significant correlation with the dimensions of cynicism and professional efficiency, with a significance level of 0.01, even when weak.

When examining the levels of BS, no significant differences were found between the ages studied. However, when analyzing each dimension separately, significant differences were found in emotional exhaustion between the age groups under 21 years and 31-40 years, and between the groups 21-30 and 31-40 years. In both the cynicism and professional efficacy dimensions, significant mean differences were observed between the 21-30 and 31-40 age groups and the 51-60 age groups. Accordingly, age exhibits negative and positive correlations with cynicism and professional efficiency, respectively, even when weak. Therefore, these findings may challenge the design of proper age-based interventions to diminish BS in the Mexican manufacturing industry employees and diminish its adverse effects.

6.1 Limitations of the study

As a limitation of the study, it is necessary to note that although significant effects were found between the correlations of the variables in this study, they are noticeably weak. This implies debate with other authors who found higher relationships between the study variables, but these are still weak relationships.

In addition, a considerable change in the parameters was observed since the sample was separated into two groups, up to and over 40 years of age. Referring to the model, those up to 40 years old do not comply with any absolute adjustment parameters. However, it complies with incremental fit parameters, which measure the degree to which the model's fit is improved compared to the hypothetical model. This fact was considered enough statistical

proof to compare age cohorts. Finally, the model with participants over 40 years of age only complies with one absolute fit parameter: the chi-square ratio for degrees of freedom, with a value less than 5.

Accordingly, few studies have yielded conclusive results on the relationship between BS dimensions and age. Similarly, studies that relate the dimensions of BS to other variables, such as suicidal tendencies, turnover, motivation, and learning, have also found weak correlations and moderating effects.

Additionally, this study acknowledges a limitation in the absence of control variables, such as gender, seniority in employment, sector, or educational level, within the sample. The interpretation of the age-BS relationship may be incomplete without these crucial variables. Their inclusion is necessary for a comprehensive understanding of the effect of age on the manifestation of BS in employees of the Mexican manufacturing industry. This limitation highlights the need for further research in this area.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Comité Institucional de Ética y Bioética de la Universidad Autónoma de Ciudad Juárez-CIB-2019-1-098. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

AAM-M: Conceptualization, Resources, Writing – review and editing, Writing – original draft, Data curation, Validation, Visualization. MGG-H: Conceptualization, Writing – original draft, Methodology, Software, Validation, Writing – review and

editing. MAB-B: Investigation, Writing – original draft, Validation, Visualization. YR: Visualization, Writing – review and editing. AR-V: Writing – review and editing.

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Conflict of interest

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

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Examining factors influencing the adoption of smart integrated devices by the elderly in the digital era: insights from behavioral design theory

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Introduction: Digitalization and aging are two defining characteristics of contemporary social transformation. As smart integrated devices become increasingly embedded in everyday life, understanding how elderly individuals interact with these technologies is essential for promoting digital inclusion and social integration. Although previous research has examined digital engagement among older adults, the specific behavioral and contextual factors that shape their usage of smart devices in a digital society remain underexplored. This study seeks to clarify how these factors operate and how they may be leveraged to support the well-being of the aging population.

Methods: This study utilized data from the 2020 China Longitudinal Aging Social Survey (CLASS), focusing on elderly individuals living in urban areas. A combination of logistic regression analysis, Lasso regression, and robustness tests was employed to identify the key predictors of smart integrated device usage. The analysis examined a range of variables including demographic characteristics, health status, education, income, internet usage experience, and family structure. Comparisons were made across groups to assess how these factors influence usage behavior, and Lasso regression was used to identify the most robust predictors.

Results: The analysis revealed that elderly individuals are more likely to use smart devices if they are male, older, married, in poorer health, more highly educated, have lower income, have fewer children, and have previous experience using the internet. Among these, internet usage experience emerged as the most significant and consistent predictor across all models, as identified by the Lasso regression. Furthermore, the purposes for which the elderly use the internet, such as communication, information, or entertainment. These patterns were found to be stable even after controlling for potential confounding variables.

Discussion: The findings challenge traditional assumptions about fixed sensory or cognitive hierarchies in aging populations and instead suggest that smart device usage among the elderly is shaped by a dynamic interplay of motivational, ability-based, and environmental factors. Drawing on Behavioral Design Theory, the study interprets these patterns through three lenses: motivation (e.g., health monitoring and social interaction), ability (e.g., physical and cognitive usability of devices), and triggers (e.g., technical and emotional support from family members). Under this framework, digital engagement appears to be highly context-dependent, with adaptive resource allocation and social support playing a crucial role in determining whether and how elderly individuals use smart technologies. The results emphasize the importance of designing inclusive digital environments and policies that respond to the nuanced needs and experiences of the aging population.

KEYWORDS

smart integrated devices, elderly usage behavior, behavioral design theory, digital inclusion, internet usage experience

1 Introduction

With the rapid development of information technology and the acceleration of global aging, digitalization and aging have become defining features of contemporary social transformation (Francis et al., 2019). Digital technologies have profoundly reshaped lifestyles, work practices, and social interactions, influencing nearly every aspect of daily life. At the same time, the growing elderly population has raised significant concerns about their well-being, social integration, and quality of life (Repetti and Fellay-Favre, 2024; Wang et al., 2024). Understanding how digital technology can support older adults is essential for promoting their integration into modern society.

Despite the numerous benefits brought by digitalization, older adults still face various challenges when using smart integrated devices such as smartphones, tablets, and smart home systems. Physiological factors (including declining vision and motor skills), psychological barriers (such as technophobia), and social obstacles (such as limited digital literacy) create difficulties in adopting these technologies (Backåberg et al., 2025). These barriers highlight the necessity of studying the determinants of smart device adoption among older adults and developing user-friendly solutions to bridge the digital divide (Choudrie et al., 2022).

The primary objective of this study is to examine how socioeconomic, psychological, and physiological factors influence the adoption and use of smart devices among the elderly. While existing research has primarily focused on aging-related aspects such as health, economic status, and social support, limited attention has been paid to digital behavior among older adults. For instance, a study on predictors of physical activity levels among older adults found that gender, education level, recreational activities, and health status are key factors influencing physical activity. Engaging in leisure activities such as games and visiting friends indirectly contributes to increased physical activity (Parra-Rizo et al., 2022). Understanding the environmental characteristics that enhance physical activity among older adults is crucial for promoting active and healthy aging. However, limited scholarly attention has been given to the digital behavior of older adults. This study aims to fill this gap by analyzing the mechanisms influencing digital participation, thereby expanding research in gerontology, sociology, and digital inclusion.

This study draws on multiple theoretical frameworks to analyze the adoption of smart devices among older adults. The Technology Acceptance Model (TAM) emphasizes that perceived ease of use and perceived usefulness are critical factors influencing technology adoption. However, cognitive decline and limited social support may weaken these perceptions among older adults, thereby affecting their likelihood of adopting smart devices (Guner and Acarturk, 2020). Additionally, Social Network Theory posits that social support networks play a vital role in technology adoption. Older adults often rely on children, relatives, and community members for assistance, and this social support can enhance their interest and confidence in using smart devices (Zhang et al., 2021).

The core theoretical framework of this study is Behavioral Design Theory, which suggests that technology adoption is influenced by motivation, ability, and triggers (Abdukadirov, 2016; Tusyadiah, 2017; Zacher and Froidevaux, 2021). For older adults, motivation primarily stems from health management and social connection. Smart devices offering health monitoring functions and social interaction tools can increase their willingness to adopt these technologies. Regarding ability, the design of smart devices should accommodate the physiological and cognitive characteristics of older adults, such as simplified interfaces, larger fonts, and voice control functions. Triggers refer to external factors that encourage the continued use of smart devices, such as health monitoring reminders, encouragement from family members, and digital skills training provided by governments and communities. These external supports help boost confidence in technology use and facilitate long-term adoption.

This study focuses on the urban elderly population in China, utilizing a nationally representative dataset and advanced analytical methods to investigate the factors influencing smart device adoption. Data from the 2020 China Longitudinal Aging Social Survey (CLASS) is used, employing logistic regression analysis, Lasso analysis, and robustness tests to conduct a comprehensive empirical examination of the determinants of smart device usage among older adults. The findings provide valuable insights for public policy design and the development of accessible technologies, facilitating the digital inclusion of the elderly in modern society.

2 Literature review and theoretical hypotheses

The Technology Acceptance Model (TAM) has been widely used to explain the adoption of new technologies. It posits that perceived ease of use and perceived usefulness are the primary determinants of an individual's willingness to embrace technology (Davis, 1989; Guner and Acarturk, 2020). For older adults, however, cognitive decline and physical limitations can significantly hinder their perceived ease of use, making it difficult for them to navigate digital interfaces (Brydie, 2009; Charness and Boot, 2016). Additionally, social and economic factors influence their perceived usefulness, as individuals with greater financial security and digital literacy are more likely to see smart devices as beneficial (Venkatesh et al., 2012). Research suggests that interventions such as digital skills training and the implementation of user-friendly designs can mitigate these challenges, making technology more accessible for the elderly (Chen and Chan, 2014).

While TAM provides an essential framework for understanding individual decision-making in technology adoption, it does not fully account for the impact of social structures. Social Network Theory offers a complementary perspective, emphasizing the role of interpersonal relationships in shaping technology use (Marin and Wellman, 2011; Zhang et al., 2021). Many elderly individuals have limited social circles and rely on their children, extended family, and

community members for technological assistance (Charness and Boot, 2016). Luo (2023) highlights the significance of intergenerational digital support, showing that younger relatives play a crucial role in helping older adults learn and use digital devices. Additionally, strong social connections can increase motivation to adopt smart technology, particularly when it facilitates meaningful interactions and access to relevant content. Studies indicate that older adults who are more socially connected are also more likely to engage with digital tools (Goddard, 2025; Tsai, 2012), suggesting that digital inclusion initiatives should focus not only on individual ability but also on strengthening social networks.

Beyond individual cognition and social influence, the design and usability of technology play a fundamental role in adoption among older adults. Behavioral Design Theory underscores the importance of motivation, ability, and triggers in driving behavioral change (Fogg and Echnner, 2019).

First, motivation is a crucial factor influencing technology adoption among older adults. Many elderly users are driven by intrinsic and extrinsic motivations (Ademi et al., 2019). Intrinsically, they seek to maintain independence, improve their quality of life, and stay cognitively engaged. Extrinsically, concerns about health management, social inclusion, and pressure from family members can encourage them to adopt digital tools (Ma et al., 2023). Studies have shown that older adults who perceive clear personal benefits—such as the ability to monitor their health through wearable devices (Liang et al., 2022) or communicate with distant family members—are more likely to embrace technology (Bisset and Lockton, 2010; Blohm and Leimeister, 2013).

Second, ability refers to an individual's capacity to successfully use a technology, which can be influenced by physical, cognitive, and technological barriers (Nielsen et al., 2021). Physically, reduced vision, hearing, and dexterity make standard interfaces difficult to navigate. Cognitively, memory decline and unfamiliarity with digital interfaces can create additional hurdles. Technologically, older adults often struggle with complex user interfaces, frequent system updates, and a lack of prior digital experience. To enhance usability, design interventions such as simplified navigation (Heree et al., 2022), larger fonts, high-contrast visuals, haptic feedback, and voice-controlled features can significantly reduce these barriers and improve accessibility (Rachmad, 2022; Sespiani and Ernungtyas, 2022; Yekinni and Ogbuanya, 2025).

Finally, triggers serve as external stimuli that prompt older adults to engage with technology. These can be reminders, social encouragement, or necessity-driven interventions. For instance, health-related notifications—such as medication reminders or fall detection alerts—provide direct benefits that encourage sustained use. Social triggers, such as family members introducing and guiding older adults through digital platforms, also play a critical role. Matsumura et al. (2015) found that seniors who receive consistent external encouragement, whether from caregivers, peers, or healthcare professionals, are more likely to integrate digital devices into their daily routines. Additionally, external supports like structured training programs and user-friendly onboarding experiences can reinforce long-term engagement (Ge et al., 2021).

By addressing these three components—enhancing motivation through personal relevance, improving ability via inclusive design, and reinforcing usage with effective triggers—technology can be made

more accessible and appealing to older adults, ultimately fostering greater adoption (Schroeder et al., 2023) and integration into their daily lives.

Demographic and socioeconomic factors further influence the adoption of smart devices among older adults. Gender differences are evident, with men demonstrating greater confidence and interest in digital activities compared to women (Venkatesh et al., 2012; Heart and Kalderon, 2013; Pelau et al., 2021). While it is commonly assumed that younger elderly individuals are more likely to adopt technology, some studies suggest that older segments of the elderly population show higher adoption rates due to the necessity of staying connected and accessing essential services (Peek et al., 2014; Gell et al., 2015; Choudrie et al., 2018). Marital status also plays a role, as married elderly individuals are more likely to use smart devices due to spousal support and shared interests (Mitzner et al., 2010; Thielke et al., 2012). Additionally, while poor health can deter technology use, it can also serve as a driver for those seeking digital health management solutions (Mitzner et al., 2010; Heart and Kalderon, 2013). Education and income levels have been found to correlate with technology adoption, with higher educational attainment linked to greater digital engagement (Friemel, 2016) and lower income levels acting as a potential barrier (Choi and DiNitto, 2013; Helsper and Reisdorf, 2017). Prior experience with the internet enhances digital confidence, reducing anxiety and improving technology use (Van Deursen and Van Dijk, 2011; Quan-Haase et al., 2018). Furthermore, the number of children influences reliance on smart devices for social interaction, as elderly individuals with fewer children often use digital tools to compensate for reduced face-to-face interaction (Cotten et al., 2013; Tsai et al., 2017; Nimrod, 2017).

Based on these insights, the study proposes the following hypotheses:

- H1:* Male elderly individuals are more likely to use smart integrated devices compared to female elderly individuals.
- H2:* Older elderly individuals are more likely to use smart integrated devices compared to younger elderly individuals.
- H3:* Married elderly individuals are more likely to use smart integrated devices compared to unmarried, widowed, or divorced elderly individuals.
- H4:* Elderly individuals with lower health status are more likely to use smart integrated devices for health monitoring.
- H5:* Elderly individuals with higher educational attainment are more likely to use smart integrated devices.
- H6:* Elderly individuals with lower income levels are more likely to use smart integrated devices.
- H7:* Elderly individuals with prior internet usage experience are more likely to use smart integrated devices.
- H8:* Elderly individuals with fewer children are more likely to use smart integrated devices for social interaction and support.

These hypotheses provide a structured approach to understanding the diverse factors influencing smart device adoption among the urban elderly population in digital era.

3 Data and methodology

3.1 Data source

This study utilizes data from the 2020 China Longitudinal Aging Social Survey (CLASS), a nationally representative dataset conducted by Renmin University of China in collaboration with various research institutions and government agencies. CLASS aims to provide high-quality, policy-relevant data on China's aging population to inform academic research and policy development in elderly care and social welfare.

CLASS employs a multi-stage stratified probability sampling method to ensure national representation, covering a wide range of provinces and balancing urban and rural populations. The survey spans across Eastern, Central, and Western China, including key provinces such as Beijing, Shanghai, Jiangsu, Zhejiang, Guangdong (Eastern); Henan, Hubei, Hunan, Anhui (Central); and Sichuan, Chongqing, Shaanxi, Gansu (Western). This broad geographical coverage ensures that the dataset accurately reflects regional differences in aging trends, socio-economic conditions, and healthcare accessibility.

The sampling process consists of four stages:

- ① Province-Level Selection: Ensuring nationwide representation by covering a mix of developed and developing regions.
- ② City, County, and District-Level Selection: Including urban centers, mid-sized cities, and rural areas to capture diversity.
- ③ Community-Level Selection: Targeting residential committees and village units within selected urban and rural areas.
- ④ Household Selection: Randomly selecting one elderly individual (aged 60 and above) per household for detailed interviews.

Data collection was conducted primarily through face-to-face structured interviews, where trained surveyors collected information on a wide range of topics, including demographic characteristics, socio-economic conditions, health status, and social participation. Additionally, community-level data were gathered to assess environmental factors such as eldercare services, medical facilities, and social infrastructure. To ensure the accuracy and reliability of the dataset, CLASS employs rigorous data quality control measures, including standardized interviewer training, validation checks, and logical consistency tests. This extensive data collection process allows CLASS to serve as a gold-standard dataset for studying aging in China, widely used in both academic research and policy analysis. The longitudinal nature of the survey enables tracking of aging trends over time, making it an invaluable resource for understanding the evolving needs of elderly populations in China.

By utilizing this extensive dataset, this study aims to provide detailed, evidence-based conclusions to inform policy development and interventions that enhance digital inclusion and quality of life among China's elderly population. Based on the World Health Organization (WHO) definition of the elderly and considering that 60 years old is commonly regarded as the

retirement threshold in China, this stage marks significant changes in individuals' social roles, lifestyles, and technology usage needs, while also posing new challenges in adapting to digital technologies. Therefore, this study selects data from individuals aged 60 and above as the research sample, allowing for a more precise analysis of the behavioral characteristics and influencing factors of elderly individuals in smart device usage, ultimately providing more targeted empirical support for improving their digital inclusion.

3.2 Variables

3.2.1 Dependent variable

The dependent variable in this study is the use of smart integrated devices. This is measured using the CLASS 2020 survey question:

"Do you use any of the following smart devices—smart integrated devices (e.g., Baidu Xiaodu, Xiaomi Xiaoi)?"

Responses are coded as 1 = Yes and 0 = No, making this a binary outcome variable.

3.2.2 Independent variables

We consider multiple individual- and household-level variables:

① Individual-Level Variables:

Education Level: Measured on a 7-point scale (1 = No formal education, 7 = Bachelor's degree and above). Higher values indicate higher education levels.

Internet Usage Experience: Binary variable (1 = Yes, 0 = No), based on the question: "Do you use the internet (including mobile phones or other electronic devices)?"

Self-rated Health: Measured using the question: "How would you rate your current health status?" with five response options:

"Very unhealthy," "Relatively unhealthy," "Average," "Relatively healthy," and "Very healthy."

Due to the binary nature of the dependent variable and for ease of interpretation, responses are categorized as:

1 = Healthy (combining "Relatively healthy," "Average," and "Very healthy").

0 = Unhealthy (combining "Very unhealthy" and "Relatively unhealthy").

This consolidation simplifies analysis while preserving meaningful distinctions in health status.

Personal Income: Measured as total annual income in the past 12 months, log-transformed for analysis to mitigate skewness.

TABLE 1 Summary statistics.

| Variables | (1) | (2) | (3) | (4) | (5) |
|---------------|-------|--------|--------|-----|---------|
| | N | Mean | sd | min | max |
| Gender | 2,330 | 0.479 | 0.500 | 0 | 1 |
| Education | 2,330 | 3.989 | 1.087 | 1 | 7 |
| Income | 2,330 | 13,819 | 13,913 | 450 | 240,000 |
| Smart_device | 2,330 | 0.171 | 0.376 | 0 | 1 |
| Age | 2,330 | 70.84 | 6.763 | 60 | 97 |
| Living_status | 2,330 | 0.805 | 0.397 | 0 | 1 |
| Health | 2,330 | 0.522 | 0.500 | 0 | 1 |
| Internet | 2,330 | 0.549 | 0.498 | 0 | 1 |
| Child | 2,330 | 1.775 | 1.025 | 0 | 8 |
| Province | 2,330 | 10.384 | 8.233 | 1 | 26 |

② Household-Level Variables:

regression coefficients to zero, thereby performing automatic variable selection. The objective function of Lasso is:

Number of Children: Total number of biological and adopted children, reflecting family support availability.

Marital Status: 1 = Married with spouse, 0 = Widowed, divorced, or never married, reflecting the impact of spousal support on technology adoption.

Descriptive statistics of the main variables are shown in Table 1.

3.3 Methodology

Due to the binary nature of the dependent variable (use or non-use of smart devices), this study employs logistic regression analysis, a widely used statistical method for examining the factors influencing binary outcomes. The independent variables include gender, age, living status, health status, education level, income level, internet usage experience, and the number of children. Logistic regression is used to quantify the impact of each factor on the likelihood of smart device adoption among the elderly:

$$\begin{aligned} &\text{logit}\big(P\big(\textit{Using Smart Integrated Devices}=1\big)\big) \\ &= \beta_0 + \beta_1\textit{gender} + \beta_2\textit{age} + \beta_3\textit{living_status} + \beta_4\textit{health} \\ &\quad + \beta_5\textit{education} + \beta_6\textit{income} + \beta_7\textit{child} + \beta_8\textit{internet} \end{aligned}$$

Among them, $\beta_1 - \beta_8$ are the regression coefficients of their respective variables. By calculating odds ratios $e^{\beta_1 - \beta_8}$, we obtain the impact of each independent variable on the use of smart integrated devices by the elderly.

To address potential multicollinearity issues and improve variable selection, Lasso (Least Absolute Shrinkage and Selection Operator) regression was employed. Lasso is a statistical method for regression analysis and feature selection, introduced by Tibshirani, 1996. By incorporating an L1 regularization term into the regression model, Lasso not only ensures better model fitting but also shrinks some

$$\min \sum_{i=1}^n \left(y_i - \beta_0 - \sum_{j=1}^p \beta_j x_{ij} \right)^2 + \lambda \sum_{j=1}^p |\beta_j|$$

where λ is a tuning parameter that controls the degree of shrinkage. This method is particularly useful for identifying the most relevant factors influencing the use of smart integrated devices while preventing overfitting. By integrating logistic regression and Lasso analysis, this study ensures a robust and reliable examination of the determinants of digital adoption among older adults, providing a strong empirical basis for policy recommendations.

4 Results

Based on the results of the multilevel logistic regression model reported in Table 2, we can derive research conclusions regarding the factors influencing smart device use among the elderly.

Firstly, gender shows a significant positive correlation with the use of smart devices among the elderly (odds ratio= $e^{0.213}$). Elderly males are more likely to seek the use of smart devices, which may be attributed to their higher enthusiasm for adopting and using technology. Age is also significantly positively correlated with the use of smart devices. As the age of elderly individuals increases, the probability of using smart devices also significantly increases (odds ratio= $e^{0.0272}$). Living status is another factor that significantly influences the use of smart devices (odds ratio= $e^{0.347}$). Married elderly individuals are more likely to use smart devices, which could be due to the support and encouragement from their spouses. Education level has a very significant impact on the use of smart devices (odds ratio= $e^{0.194}$). The higher the educational attainment, the more likely the elderly are to use smart devices. This indicates that individuals with higher education levels are more exposed to and accepting of new technologies, using them widely in their daily lives. Health status is significantly negatively correlated with the use of smart devices among the elderly (odds ratio= $e^{-0.239}$). This suggests that elderly individuals with poorer health are more likely to

TABLE 2 Multilevel logistic regression modeling of factors influencing smart device use among Chinese older adults.

| Variables | (1) | (2) | (3) | (4) |
|----------------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------|
| | m1 | m2 | m3 | m4 |
| | smart_device | smart_device | smart_device | smart_device |
| Gender | 0.244** | 0.215* | 0.200 | 0.213* |
| | (0.123) | (0.125) | (0.125) | (0.128) |
| Age | −0.0442*** | −0.0316*** | −0.0203* | 0.0272** |
| | (0.0109) | (0.0111) | (0.0122) | (0.0136) |
| Living_status | 0.478*** | 0.437** | 0.434** | 0.347* |
| | (0.178) | (0.180) | (0.179) | (0.185) |
| Health | −0.0953 | −0.182 | −0.187 | −0.239* |
| | (0.127) | (0.130) | (0.130) | (0.134) |
| Education | | 0.300*** | 0.277*** | 0.194*** |
| | | (0.0668) | (0.0678) | (0.0697) |
| Income | | −1.64e-05*** | −1.60e-05*** | −1.37e-05** |
| | | (5.86e-06) | (5.85e-06) | (5.80e-06) |
| Child | | | −0.188** | −0.179** |
| | | | (0.0843) | (0.0852) |
| Internet | | | | 1.475*** |
| | | | | (0.168) |
| Constant | 0.844 | −1.081 | −1.447 | −5.412*** |
| | (0.822) | (0.942) | (0.955) | (1.082) |
| Hosmer-Lemeshow χ^2 | 12.34 (<i>p</i> = 0.14) | 10.76 (<i>p</i> = 0.21) | 10.49 (<i>p</i> = 0.23) | 8.69 (<i>p</i> = 0.37) |
| Cox-Snell <i>R</i> ² | 0.123 | 0.145 | 0.158 | 0.197 |
| Nagelkerke <i>R</i> ² | 0.165 | 0.194 | 0.213 | 0.267 |
| Model χ^2 | 45.67*** | 56.39*** | 64.58*** | 78.92*** |
| Observations | 2,330 | 2,330 | 2,330 | 2,330 |

Standard errors in parentheses. ****p* < 0.01, ***p* < 0.05, **p* < 0.1.

seek the use of smart integrated devices, possibly due to their need for health monitoring and assistance.

Income is also negatively correlated with the use of smart devices. This implies that elderly individuals with better economic status are less dependent on smart integrated devices, possibly because they have access to alternative resources or services. The number of children an elderly person has is negatively related to the use of smart integrated devices. The more children the elderly have, the lower the probability of using smart integrated devices. This might be because they receive more direct assistance from their children. Finally, internet usage experience positively affects the use of smart integrated devices among the elderly. Elderly individuals with prior internet usage experience are more likely to use smart integrated devices, as they are more familiar with digital technology and its benefits.

The results of the multilevel logistic regression analysis demonstrate that the models provide a good fit and explain a meaningful portion of the variance in smart device use among Chinese older adults. The Hosmer-Lemeshow test shows that the models fit the data well, with *p*-values ranging from 0.14 to 0.37, indicating no significant misfit. The Cox-Snell and Nagelkerke *R*² values increase progressively across models, with Nagelkerke *R*² reaching 0.267 in the final model, suggesting

that the models explain a moderate proportion of the variance in smart device use. Additionally, the Model Chi-Square statistics are highly significant (*p* < 0.001) for all models, confirming that the predictors collectively contribute to the explanation of smart device use. These results support the robustness of the findings and the validity of the models in explaining the factors influencing smart device use among older adults.

Furthermore, to delve deeper into the relative importance of various factors influencing the use of smart integrated devices by the elderly, we employed the Lasso estimation method. Lasso estimation not only handles high-dimensional data but also effectively performs variable selection and regularization, thus avoiding multicollinearity issues. Our analysis revealed that the internet usage experience of the elderly is the most significant and enduring factor affecting their use of smart integrated devices. This factor demonstrated a substantial impact within our model, as shown in Figure 1. The findings indicate that elderly individuals with prior internet usage experience are more likely to adapt to and use smart integrated devices, providing a crucial basis for formulating policies to promote the digital inclusion of the elderly.

In the preceding sections, we identified internet usage experience as the most significant factor influencing the use of smart integrated

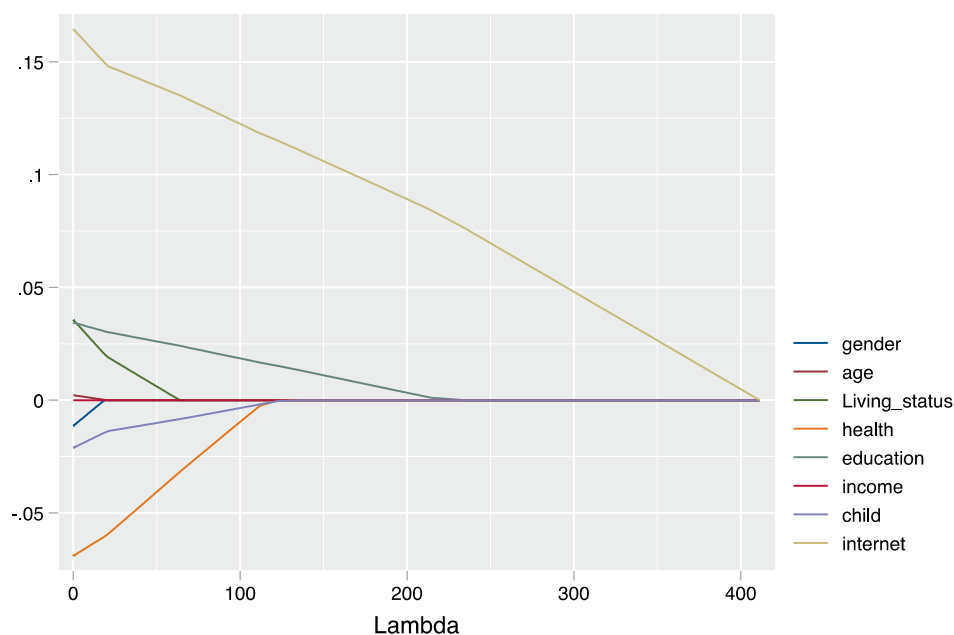


FIGURE 1
Factors most influencing the use of smart all-in-one devices by older adults in China (lasso model estimates).

devices among the elderly. Building on this finding, we further explored the impact of different internet usage purposes on the use of smart integrated devices by the elderly. To this end, we constructed interaction terms between internet usage and various activities, such as voice and video chatting, shopping, reading news, obtaining information, transportation, and financial investments (e.g., stock trading, buying funds). The results of our study are presented in Table 3.

The study revealed that elderly individuals who rely more on the internet for voice and video chatting with family and friends tend to use smart integrated devices less frequently. This might be because their social needs are already being met through other means, reducing their dependence on smart integrated devices. Conversely, elderly individuals who primarily use the internet to obtain information may have poorer health and therefore rely more on smart integrated devices for accessing medical and health-related information and services.

Furthermore, the study showed that elderly individuals who use the internet mainly for transportation arrangements, indicating more outdoor activities, tend to be less dependent on smart integrated devices. In contrast, those who use the internet predominantly for financial investments focus more on the financial markets and thus have less need for the companionship provided by smart integrated devices.

The results suggest that the models fit the data well, as indicated by the Hosmer-Lemeshow test ($p > 0.05$ for both models). The explanatory power of the models is moderate, with the Nagelkerke R^2 increasing from 0.169 in model m1 to 0.202 in model m2, reflecting a better explanation of the variance in smart device use when control variables are included. Both models are statistically significant, with model Chi-Square values of 48.75 for m1 and 57.34 for m2 ($p < 0.001$).

In summary, our research highlights the role of smart integrated devices in providing companionship to the elderly and underscores the varying impacts of different internet usage purposes on this companionship role. These findings offer valuable insights for further enhancing the user experience of smart devices among the elderly.

5 Discussion

This study provides a comprehensive analysis of the factors influencing the adoption of smart integrated devices among the elderly. The findings highlight key demographic, social, and technological determinants, emphasizing the role of prior internet usage experience, which emerged as the most significant predictor. The use of Lasso regression allowed for the systematic identification of the most relevant factors without overfitting the model, demonstrating a methodological advancement over previous studies.

The results indicate that gender plays a significant role in the adoption of smart devices among the elderly, with males showing a higher likelihood of using these devices. This can be attributed to several factors, including a generally higher enthusiasm for technology among older males. Men might also be more inclined to explore and utilize new technologies due to their historical and cultural exposure to technological advancements. Age is a positively correlated factor, meaning that as individuals grow older, their likelihood of using smart devices increases. This finding is particularly interesting as it contrasts with the common perception that younger elderly individuals might be more technologically adept. One explanation is that smart integrated devices, particularly voice assistants and health monitoring systems, serve as assistive tools for daily life rather than mere entertainment gadgets. Younger elderly individuals may not yet require these functionalities, whereas older seniors, who experience greater health challenges and mobility restrictions, are more likely to rely on such technologies for assistance and safety. This finding aligns with the notion that smart devices play a crucial role in supporting independent living among older adults, providing functionalities that compensate for declining physical and cognitive abilities.

Furthermore, the results indicate that internet usage experience is the most significant and enduring factor influencing smart device adoption among the elderly. Elderly individuals with prior exposure to the internet are more likely to embrace smart devices, as they are

TABLE 3 The impact of different internet usage uses on the use of smart all-in-one devices for the elderly in China.

| Variables | (1) | (2) |
|--------------------------------|---------------------|---------------------|
| | m1 | m2 |
| | smart_device | smart_device |
| Internet × chat | −1.211** | −1.143** |
| | (0.476) | (0.485) |
| Internet × shopping | −0.00668 | −0.0118 |
| | (0.213) | (0.217) |
| Internet × watching | −0.132 | −0.0682 |
| | (0.178) | (0.184) |
| Internet × getting information | 0.768*** | 0.860*** |
| | (0.185) | (0.191) |
| Internet × transport | −0.801*** | −0.760*** |
| | (0.214) | (0.217) |
| Internet × invest | −0.729** | −0.721** |
| | (0.292) | (0.301) |
| Control variables | No | Yes |
| Hosmer-Lemeshow χ^2 | 8.45 ($p = 0.39$) | 7.92 ($p = 0.44$) |
| Cox-Snell R^2 | 0.127 | 0.151 |
| Nagelkerke R^2 | 0.169 | 0.202 |
| Model χ^2 | 48.75*** | 57.34*** |
| Observations | 1,251 | 1,251 |

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

already accustomed to digital interactions and understand the benefits of these technologies. This underscores the importance of digital literacy programs, which can bridge the gap for those with limited prior exposure and facilitate broader technology adoption among aging populations.

Income level exhibited a somewhat unexpected trend, revealing that lower-income elderly individuals are more likely to use smart devices. This result challenges the assumption that smart technologies are primarily accessible to wealthier individuals. In China, the affordability of smart home products and digital devices makes them widely accessible, even to lower-income groups. Compared to other countries where such devices may be considered luxury items, the relatively low cost of consumer electronics in China promotes widespread adoption across different economic demographics. This highlights the inclusivity of digital solutions and their potential to support elderly individuals across various socioeconomic backgrounds. Another possible explanation is that low-income elderly individuals may rely more on smart devices for social support and daily life assistance compared to higher-income groups. Due to limited financial resources, they may not have access to expensive caregiving services or offline social interactions, making them more inclined to use smart devices for information access, social engagement, health management, and government benefits. For example, smart voice assistants, online medical consultations, and digital services provided by the government can compensate for the lack of real-life resources, enabling them to better adapt to modern society. Additionally, smart devices offer cost-effective entertainment and communication options, helping to reduce social isolation, which could be another reason why low-income groups depend more on these technologies.

Another key finding relates to marital status and family structure. Married elderly individuals are more likely to use smart devices, likely due to encouragement and support from their spouses. In contrast, elderly individuals with more children tend to rely less on digital technology, as they receive in-person care and support from family members. This suggests that family networks play a dual role: they can either facilitate or substitute the need for technology-based assistance. Policymakers should consider these nuances when designing interventions to promote digital inclusion among older populations.

6 Conclusion and policy implications

In This study stands out by focusing on the urban elderly population in China and employing a nationally representative dataset combined with advanced analytical methods. By incorporating Lasso regression, this study identifies the most critical determinants influencing smart device adoption among elderly individuals, providing a methodological advantage over previous research. The use of Lasso allows for precise variable selection and minimizes multicollinearity issues, enhancing the robustness of the findings. These methodological innovations, along with the study's focus on a specific population, contribute to a more comprehensive understanding of digital inclusion among the elderly.

In summary, this research highlights the multifaceted role of smart integrated devices in the lives of elderly individuals. Different factors, including gender, age, marital status, education level, health status, income, number of children, and internet usage experience, influence the adoption and use of these technologies. Additionally, the specific purposes of internet usage play a crucial role in determining the extent

of reliance on smart devices. These findings offer valuable insights for policymakers and practitioners aiming to enhance digital inclusion and improve the user experience of smart devices among the elderly. By addressing the identified factors and tailoring interventions to the specific needs and contexts of seniors, broader and more effective adoption of smart technologies can be promoted in this demographic.

To better assist the elderly in sharing the benefits of the digital age and achieving the goal of positively addressing population aging, a concerted effort from families, society, and the government is required. Governments and communities should organize digital skills training targeted at the elderly, enhancing their acceptance and usage capabilities of smart devices. For elderly individuals with limited economic means, government subsidies and preferential policies can lower the barriers to using smart devices. Manufacturers of smart devices should focus on the needs of elderly users, designing devices that are simple to operate and practical in function. Family members and community workers should actively assist and support the elderly in using smart devices, offering necessary technical and psychological support. Through media publicity and policy promotion, increasing the elderly's awareness and acceptance of smart devices can create a favorable social atmosphere.

By making concerted efforts across multiple domains, we can jointly create an elderly-friendly digital device environment. This can effectively promote the elderly's adaptation to and integration into the digital society, enhancing their quality of life and well-being, and advancing sustainable societal development.

7 Limitations and future research

While this study provides meaningful insights, certain limitations must be acknowledged. First, the analysis is based on national survey data, which, while comprehensive, does not capture the qualitative dimensions of technology adoption among the elderly. Future research should incorporate qualitative methods, such as focus groups and in-depth interviews, to gain richer insights into elderly users' experiences, challenges, and motivations.

Second, the findings are based on cross-sectional data, which limits the ability to infer causal relationships. A longitudinal study would help track changes in smart device adoption patterns over time, providing stronger evidence of causality between influencing factors and adoption behaviors.

Third, cultural and social factors, such as familial caregiving expectations and social stigmas surrounding technology use in older age, were not explicitly analyzed. Future research should explore how cultural dynamics influence digital inclusion among the elderly, particularly in different geographic and economic contexts.

By addressing these limitations in future studies, researchers can further refine the understanding of digital adoption among the elderly and contribute to the development of more effective interventions that promote digital inclusion in aging societies.

Data availability statement

This study is based on the publicly available dataset from the 2020 China Longitudinal Aging Social Survey (CLASS). Researchers interested in accessing the data may obtain it through public search or by contacting the corresponding author.

Ethics statement

The studies involving humans were approved by Research Ethics Committee (CERec) of the Autonomous University of Barcelona (CER/IT/0001-01-EN). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft. NQ: Methodology, Writing – review & editing. HL: Conceptualization, Writing – review & editing, Data curation, Formal analysis, Methodology. LX: Conceptualization, Writing – review & editing.

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Conflict of interest

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

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Association between subjective well-being trajectories and anxiety/depression: findings from a nationally representative cohort study

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Background: Subjective well-being (SWB) in older adults is a key indicator of psychological health and quality of life. However, research on trajectories of SWB is quite limited, and little is known about the relationship between anxiety/depression and trajectories of SWB in older adults. This study aimed to identify the trajectories of SWB in older adults and examine the association between anxiety/depression and trajectories of SWB.

Methods: A population-based cohort study, the National Health and Aging Trends Study in the United States from 2015 to 2022. SWB was assessed through 11 items, including positive/negative emotions (4 items), self-realization (4 items), self-efficacy, and resilience (3 items). Anxiety/depression symptoms were assessed by the Patient Health Questionnaire-4 (PHQ-4). The group-based trajectory modeling identified trajectories. The design-based weighted multinomial logistic regression was used to examine the association between anxiety/depression and SWB trajectories.

Results: Of 5,057 included older adults, 59.22% were aged between 60 and 74 years old, 55.5% were female, and 82.23% were non-Hispanic White. Four trajectories of SWB were identified: Group 1 (*low, slightly-declining SWB*, 8.7%), Group 2 (*moderate, declining SWB*, 25.4%), Group 3 (*moderate, slightly-declining SWB*, 42.2%), and Group 4 (*high, slightly-declining SWB*, 23.7%). Higher anxiety/depression scores were associated with low or moderate SWB trajectories: Group 1 (odds ratio, OR: 3.35, 95% confidence interval, CI: 2.73, 4.00), Group 2 (OR: 2.59, 95% CI: 2.20, 3.00), and Group 3 (OR: 1.80, 95% CI: 1.49, 2.18).

Conclusion: The trajectories of SWB varied among older adults. Anxiety/depression was significantly associated with SWB trajectories. Evidence-based effective strategies for the management of anxiety/depression are needed to maintain SWB at a high level in older adults.

What does this paper contribute to the broader global clinical community?

- This study identifies four distinct trajectories of subjective well-being in older adults.
- Anxiety/depression is significantly associated with subjective well-being trajectories.

- Our study highlights the importance of screening and longitudinally tracking SWB in older adults.
- Effective prevention and intervention of anxiety/depression is a high priority to maintain or improve SWB in older adults.

KEYWORDS

subjective well-being, cohort study, trajectories, anxiety, depression

Introduction

As fertility rates continued to decline and life expectancy increased, global population aging became a pressing public health issue (Kanasi et al., 2016). Epidemiological studies indicated that 11% of the global population was over 60 years old, and this proportion was projected to reach 22% by 2050 (Newgard and Sharpless, 2013). In response to this trend, the World Health Organization (WHO) introduced the concept of “healthy ageing” in 1990, and in its 2015 *Global Report on Ageing and Health*, defined it as “the process of developing and maintaining the functional capabilities that enable older people to live well” (Beard et al., 2016, p. 29). Within this framework, maintaining physical and mental well-being was essential to improving quality of life and promoting active, inclusive aging.

Subjective well-being (SWB), as a key psychological indicator of life quality, has received increasing attention in aging research. SWB encompasses both cognitive evaluations (e.g., life satisfaction) and emotional experiences (e.g., positive and negative affect) (Diener et al., 1999), and was widely considered a core marker of psychological health and adaptive functioning in older adults (Jopp et al., 2015; Toh et al., 2020). Cross-sectional studies showed that SWB was associated with a range of sociodemographic and health-related factors, including gender, age, marital status, physical health, education, and economic status (Lee, 2022; Martín-Maria et al., 2023; Upenieks and Liu, 2022). Notably, these studies consistently identified a negative correlation between SWB and anxiety (Ventura-León et al., 2022), with anxiety being associated with lower life satisfaction and heightened negative emotions (Malone and Wachholtz, 2018).

However, because SWB was inherently dynamic—shaped by life events, health fluctuations, and social changes over time (Luhmann, 2017; Steinmayr et al., 2019)—cross-sectional studies, which captured only a snapshot at a single time point, were insufficient to uncover its developmental patterns. They failed to reveal intra-individual changes and the evolving nature of SWB in later life. To overcome these limitations, a longitudinal approach was warranted to systematically investigate how SWB changed over time and how it might have been influenced by psychological factors such as anxiety/depression.

Group-based trajectory modeling (GBTM), a statistical method based on finite mixture modeling, offered a robust analytical framework for uncovering distinct developmental trajectories within a heterogeneous population (Choi et al., 2012). Developed by Nagin and colleagues, GBTM allowed for the identification

of subgroups of individuals who followed similar temporal patterns, thereby providing a nuanced understanding of how psychological constructs evolved with age (Nagin and Odgers, 2010). Unlike traditional longitudinal analyses, which relied heavily on predefined group classifications, GBTM empirically derived trajectory groups directly from the data, enhancing its capacity to detect naturally occurring patterns and test hypothesized pathways (Nagin and Odgers, 2010, p. 2).

Given these advantages, GBTM was particularly suited to examining the temporal dynamics of SWB in older adults. It revealed how individuals differed in their longitudinal experiences of well-being, and whether psychological risk factors such as anxiety/depression contributed to these divergent patterns.

Therefore, drawing on nationally representative longitudinal data, this study aimed to (1) identify distinct trajectories of SWB in older adults using GBTM and (2) examine how anxiety/depression levels were associated with these developmental trajectories.

Materials and methods

Data source and study population

The data used in this study were derived from the National Health and Aging Trends Study (NHATS), a nationally representative longitudinal study designed to provide an in-depth understanding of the health, functional status, disability, and long-term care needs of older adults in the United States. NHATS was launched in 2011 (Round 1), enrolling approximately 8,245 individuals aged 65 and older, who have since been followed annually. In 2015 (Round 5), a supplemental sample was added to maintain national representativeness.

To obtain a nationally representative sample of older adults, NHATS employed a multi-stage stratified sampling method. In the first stage, counties (or county equivalents) were used as the sampling units, from which Primary Sampling Units (PSUs) were selected nationwide. In the second stage, address-based sampling was conducted within these PSUs to ensure coverage across various racial/ethnic groups and geographic regions. In the third stage, eligible older adults were identified from the sampled addresses and selected for individual interviews.

Data were collected annually through face-to-face interviews, with response rates ranging from 71.6 to 96% (Liu et al., 2024). The data for each year were weighted to ensure national representativeness. NHATS provided weight variables for each

survey round, including cross-sectional and longitudinal weights. These weights were adjusted to account for differences in sampling probabilities (e.g., oversampling of the oldest-old), non-response bias, and alignment with census data. These methodological adjustments ensure that the survey results statistically represent the characteristics of the U.S. population aged 65 and over.

This current study used data from Round 5 (2015) to Round 12 (2022) for analysis. The inclusion criteria were that SWB scores were without missing values in Round 5, Round 6, and Round 7. Finally, a total of 5,057 older adults were included in our study.

Subjective well-being assessment

In this study, we assessed SWB through three domains, including positive/negative emotion (four items), self-realization (four items), and self-efficacy and resilience (three items). The total scores for SWB range from 11 to 41 points, with higher scores reflecting a higher level of SWB (Shown in [Supplementary Table S1](#)).

Anxiety/depression

The Patient Health Questionnaire-4 (PHQ-4), with a Cronbach's alpha coefficient of 0.82 ([Meidl et al., 2024](#)), was used to assess anxiety/depression in older adults ([Freedman et al., 2022](#)). The total scores range from 0 to 12, with higher scores reflecting a more severe level of anxiety/depression.

Covariates

Covariates in this study include sociodemographic factors (e.g., age, gender, race, marital status, health status, education level, and annual income); lifestyle factors (e.g., body mass index (BMI) and smoking status); and clinical symptoms (e.g., hearing impairment, pain, speech problems, visual problems, swallowing problems, and breathing problems).

Statistical analysis

We used Stata 17.0 (Stata Corp.) for the whole analysis. First, we used GBTM, developed by [Nagin \(2005\)](#), to identify the potential developmental trajectories of SWB among older adults. Considering model parsimony and clinical interpretability, the model shapes were fitted from two trajectory groups to five trajectory groups, with the polynomial function of time defined from cubic, square, to linear. After the modeling, model fit and classification accuracy were the core criteria for selecting the final model. We chose the Bayesian Information Criterion (BIC) as the preferred standard for evaluating group-based trajectory models because it balances model fit with complexity control, is applicable across various sample settings, and provides objective statistical support when constructing model structures based on theoretical considerations. Additionally, we used the Average Posterior Probability (AvePP) as an

important basis for assessing the appropriateness of the trajectory model, as it allows for an objective evaluation of classification reliability and discriminative power in the absence of known true group membership. Furthermore, AvePP offers a clear empirical benchmark (e.g., ≥ 0.7), which effectively aids in both model selection and validation. The advantage of OCC (Odds of Correct Classification) lies in its ability to reflect not only classification accuracy but also the degree of improvement relative to random assignment, thereby offering stronger discriminative validity. When $OCC \geq 5.0$, it indicates that the model has a high level of classification reliability; a value close to one suggests that the classification performance is nearly random and lacks practical utility. Therefore, using OCC as a diagnostic statistic for model selection helps assess the stability and reliability of the classification structure, aiding in the determination of the optimal number of trajectory groups and model scheme ([Nagin, 2005](#)). Based on Nagin's suggestions, the following criteria were used to determine the final trajectory shapes: (1) BIC approaching 0; (2) AvePP ≥ 0.7 ; and (3) OCC > 5 . After the SWB trajectories were identified, they were named according to their shapes and identified using a database statistical technique.

We accounted for the complex sampling designs during the analysis, including stratified sampling, primary sampling units, and weights. Weighted proportions described the distribution of categorical variables, and the distribution of continuous variables was presented by weighted medians (with standard errors, SE). Multinomial logistic regression was employed to analyze the association between anxiety/depression and SWB trajectories. The statistical significance was set at $P < 0.05$.

Results

Characteristics of the participants

This study included 5,057 participants in total (shown in [Supplementary Figure S1](#)). Among the participants, 59.22% were aged 60–74 years, 55.5% were female, and 82.23% were non-Hispanic White. SWB scores ranged from 35 (0.052) in 2015 to 35 (0.083) in 2022 (Shown in [Supplementary Table S2](#)). More details are displayed in [Table 1](#).

SWB trajectories

Using the statistics from the GBTM, we identified four trajectories of SWB, namely, Group 1 (*low, slightly-declining SWB*), Group 2 (*moderate, declining SWB*), Group 3 (*moderate, slightly-declining SWB*), and Group 4 (*high, slightly-declining SWB*), accounting for 8.7, 25.4, 42.2, and 23.7% of the included participants, respectively. Each of the four trajectory groups reflects the pattern of SWB scores over time as determined by the model. In Group 1, older adults had low SWB scores at baseline but slightly declined over time. In Group 2, older adults had moderate SWB scores at baseline, but decreased over time; In Group 3, older adults had moderate SWB scores at baseline, with a slight decline over time; and in Group 4, participants got high SWB scores at baseline,

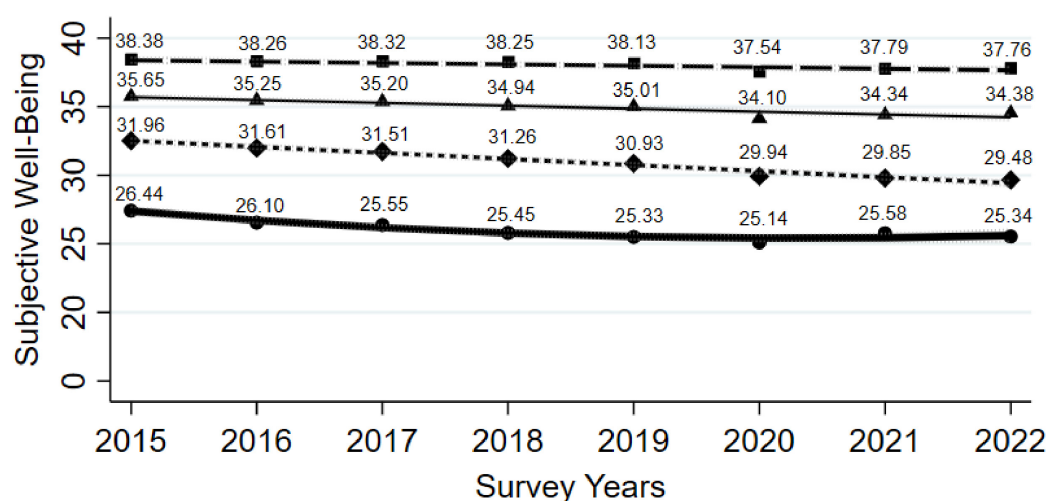
TABLE 1 Characteristics and distribution differences across subgroups.

| Characteristics | Total 5,057 | Group 1 (8.7) | Group 2 (25.4) | Group 3 (42.2) | Group 4 (23.7) | P |
|----------------------------------|----------------|------------------|-------------------|-------------------|-------------------|--------|
| Anxiety/depression, median, (SE) | 1(0.041) | 4(0.286) | 3(0.120) | 1(0.060) | 0(0.039) | <0.001 |
| Age, (%) | | | | | | |
| 60–74 years | 59.22 | 4.11 | 11.58 | 26.88 | 16.64 | <0.001 |
| 75–84 years | 31.51 | 2.78 | 8.15 | 13.86 | 6.72 | |
| 85 + years | 9.28 | 1.29 | 3.07 | 3.49 | 1.43 | |
| Gender, (%) | | | | | | |
| Male | 44.50 | 37.52 | 41.61 | 44.9 | 48.76 | 0.007 |
| Female | 55.50 | 62.48 | 58.39 | 55.1 | 51.24 | |
| Race, (%) | | | | | | |
| Non-Hispanic white | 82.23 | 80.91 | 80.89 | 83.14 | 82.23 | 0.622 |
| Non-Hispanic black | 8.12 | 7.32 | 8.55 | 8.01 | 8.19 | |
| Other | 3.08 | 2.37 | 3.59 | 3.11 | 2.8 | |
| Hispanic | 6.57 | 9.4 | 6.97 | 6.24 | 5.87 | |
| Marital status, (%) | | | | | | |
| Partnered | 58.27 | 44.63 | 50.35 | 61.29 | 64.66 | <0.001 |
| Not partnered | 41.73 | 55.37 | 49.65 | 38.71 | 35.34 | |
| Level of education, (%) | | | | | | |
| College degree | 31.24 | 18.91 | 21.74 | 41.34 | 31.24 | <0.001 |
| level | 29.30 | 20.72 | 29.21 | 30.04 | 30.89 | |
| High school | 24.68 | 30.83 | 30.00 | 24.41 | 18.26 | |
| Less than high school | 14.78 | 29.53 | 19.05 | 12.81 | 9.50 | |
| Annual total income, (%) | | | | | | |
| > \$60,000 | 37.00 | 18.43 | 24.22 | 39.93 | 49.67 | <0.001 |
| \$45,000–60,000 | 12.43 | 9.38 | 11.94 | 12.6 | 13.56 | |
| \$30,000–49,999 | 15.87 | 13.96 | 17.29 | 16.05 | 14.88 | |
| \$15,000–29,999 | 20.84 | 29.21 | 27.45 | 19.44 | 14.51 | |
| < \$15,000 | 13.86 | 29.03 | 19.11 | 11.98 | 7.37 | |
| BMI, % | | | | | | |
| Normal/non-obesity (<30) | 67.37 | 61.96 | 63.24 | 68.69 | 70.51 | 0.008 |
| Obesity (≥30) | 32.63 | 38.04 | 36.76 | 31.31 | 29.49 | |
| Self-rated health, (%) | | | | | | |
| Good | 81.52 | 46.40 | 68.33 | 87.87 | 93.90 | <0.001 |
| Fair | 15.15 | 35.85 | 26.33 | 10.86 | 5.69 | |
| Poor | 3.33 | 17.75 | 5.34 | 1.27 | 0.41 | |
| Smoke, (%) | | | | | | |
| Yes | 14.86 | 19.63 | 18.69 | 13.13 | 11.95 | 0.006 |
| No | 85.14 | 80.37 | 81.31 | 86.87 | 88.05 | |
| Hearing impairment, (%) | | | | | | |
| Yes | 13.29 | 11.77 | 14.51 | 12.7 | 13.74 | 0.472 |
| No | 86.71 | 88.23 | 85.49 | 87.3 | 86.26 | |
| Visual impairment, (%) | | | | | | |
| Yes | 62.83 | 67.13 | 60.95 | 63.31 | 62.27 | 0.259 |
| No | 37.17 | 32.87 | 39.05 | 36.69 | 37.73 | |

(Continued)

TABLE 1 (Continued)

| Characteristics | Total 5,057 | Group 1 (8.7) | Group 2 (25.4) | Group 3 (42.2) | Group 4 (23.7) | <i>P</i> |
|----------------------------|----------------|------------------|-------------------|-------------------|-------------------|----------|
| Swallowing impairment, (%) | | | | | | |
| Yes | 7.98 | 10.25 | 6.69 | 2.38 | 1.60 | <0.001 |
| No | 92.02 | 89.75 | 93.31 | 97.62 | 98.40 | |
| Speech impairment, (%) | | | | | | |
| Yes | 3.81 | 10.23 | 6.69 | 1.85 | 1.65 | <0.001 |
| No | 96.19 | 89.77 | 93.71 | 98.15 | 98.35 | |
| Pain, (%) | | | | | | |
| Yes | 53.33 | 76.82 | 64.51 | 52.32 | 37.12 | <0.001 |
| No | 46.67 | 23.18 | 35.49 | 47.68 | 62.88 | |
| Breathing problems, (%) | | | | | | |
| Yes | 18.24 | 40.67 | 26.66 | 14.35 | 10.06 | <0.001 |
| No | 81.76 | 59.33 | 73.34 | 85.65 | 89.94 | |



Trajectory Groups of Subjective Well-Being in Older Adults

- Group 1 (low, slightly-declining SWB) 8.7%
- Group 2 (moderate, declining SWB) 25.4%
- Group 3 (moderate, slightly-declining SWB) 42.2%
- Group 4 (high, slightly-declining SWB) 23.7%

FIGURE 1

Trajectory groups of subjective well-being in older adults.

but slightly declined over time (shown in Figure 1). The fitting parameters in Supplementary Table S3 indicate a good model fit.

Association between anxiety/depression and SWB trajectories

Compared to those in Group 4, participants in Group 1, Group 2, and Group 3 were more likely to have higher anxiety/depression scores ($P < 0.01$). When analyzing the

association between anxiety/depression and the trajectory groups, we used a weighted multinomial logistic regression model. We found that anxiety/depression was strongly associated with SWB trajectories. In specific, when using participants in Group 4 as a reference, participants with higher anxiety/depression scores were more likely to be categorized into Group 1 (odds ratio, OR:3.35, 95% confidence interval (CI):2.73, 4.09), Group 2 (OR:2.59, 95% CI:2.20, 3.06), and Group 3 (OR:1.80, 95% CI:1.49, 2.18) after adjustment for all covariates (shown in Table 2).

TABLE 2 Weighted estimates of adjusted or in logistic regression of factors associated with subjective well-being in trajectory group membership (ref. group 4).

| Subgroups | Group1 | | | Group2 | | | Group3 | | |
|---|--------|--------------|---------|--------|--------------|---------|--------|--------------|---------|
| | RRR | (95% CI) | P-value | RRR | (95% CI) | P-value | RRR | (95% CI) | P-value |
| Anxiety/depression | 3.35 | (2.73–4.09) | < 0.001 | 2.59 | (2.20–3.06) | < 0.001 | 1.80 | (1.49–2.18) | < 0.001 |
| Age, years (reference: 60–74) | | | | | | | | | |
| 75–84 | 1.63 | (0.81–3.25) | 0.166 | 1.49 | (1.03–2.15) | 0.034 | 1.12 | (0.82–1.53) | 0.479 |
| 85 + | 1.09 | (0.26–4.57) | 0.908 | 1.90 | (0.86–4.17) | 0.109 | 1.02 | (0.61–1.69) | 0.951 |
| Sex (reference: male) | | | | | | | | | |
| Female | 0.40 | (0.17–0.98) | 0.044 | 0.52 | (0.35–0.78) | 0.002 | 0.70 | (0.50–0.98) | 0.037 |
| Race and ethnicity (reference: non-Hispanic white) | | | | | | | | | |
| Non-Hispanic black | 0.23 | (0.09–0.60) | 0.003 | 0.51 | (0.33–0.81) | 0.005 | 0.81 | (0.52–1.27) | 0.346 |
| Other | 0.00 | (0.00–0.00) | < 0.001 | 3.58 | (0.83–15.40) | 0.086 | 2.92 | (0.54–15.85) | 0.209 |
| Hispanic | 0.78 | (0.24–2.54) | 0.681 | 0.37 | (0.16–0.89) | 0.027 | 0.60 | (0.25–1.47) | 0.258 |
| Marital status (reference: partnered) | | | | | | | | | |
| Not partnered | 2.07 | (0.87–4.93) | 0.099 | 0.96 | (0.58–1.60) | 0.874 | 1.12 | (0.76–1.63) | 0.565 |
| Education status (reference: less than a college degree) | | | | | | | | | |
| Diploma level | 0.36 | (0.14–0.90) | 0.030 | 0.90 | (0.54–1.49) | 0.673 | 1.09 | (0.72–1.65) | 0.682 |
| High school | 1.02 | (0.38–2.73) | 0.972 | 1.99 | (1.18–3.36) | 0.011 | 1.34 | (0.83–2.15) | 0.222 |
| Less than high school | 1.65 | (0.47–5.77) | 0.427 | 1.39 | (0.70–2.77) | 0.344 | 1.01 | (0.54–1.87) | 0.986 |
| Annual income, \$ (reference: > 60,000) | | | | | | | | | |
| 45,000–60,000 | 0.51 | (0.11–2.49) | 0.401 | 1.39 | (0.68–2.83) | 0.362 | 0.77 | (0.50–1.21) | 0.254 |
| 30,000–44,999 | 1.79 | (0.65–4.92) | 0.252 | 1.68 | (0.86–3.29) | 0.126 | 0.98 | (0.54–1.78) | 0.945 |
| 15,000–29,999 | 1.81 | (0.55–6.00) | 0.323 | 1.67 | (0.83–3.38) | 0.148 | 1.29 | (0.71–2.35) | 0.398 |
| <15,000 | 2.57 | (0.67–9.91) | 0.166 | 1.89 | (0.72–4.92) | 0.190 | 1.78 | (0.87–3.63) | 0.114 |
| BMI (reference: normal/non-obesity) | | | | | | | | | |
| Obesity | 0.87 | (0.39–1.94) | 0.731 | 1.21 | (0.75–1.94) | 0.425 | 0.90 | (0.60–1.36) | 0.620 |
| Self-rated health (reference: good) | | | | | | | | | |
| Fair | 5.31 | (1.97–14.32) | 0.001 | 4.13 | (2.18–7.81) | < 0.001 | 1.53 | (0.86–2.73) | 0.240 |
| Poor | 7.77 | (0.66–91.81) | 0.102 | 5.99 | (0.82–43.57) | 0.076 | 2.19 | (0.31–15.68) | 0.340 |
| Smoke (reference: yes) | | | | | | | | | |
| No | 0.42 | (0.15–1.13) | 0.083 | 0.68 | (0.39–1.17) | 0.159 | 1.00 | (0.59–1.69) | 0.991 |
| Hearing impairment (reference: no) | | | | | | | | | |
| Yes | 1.08 | (0.29–4.06) | 0.903 | 1.08 | (0.61–1.91) | 0.792 | 0.97 | (0.64–1.49) | 0.898 |
| Visual impairment (reference: no) | | | | | | | | | |
| Yes | 1.98 | (0.75–5.25) | 0.166 | 0.99 | (0.63–1.54) | 0.962 | 1.13 | (0.79–1.60) | 0.505 |
| Swallowing impairment (reference: no) | | | | | | | | | |
| Yes | 2.09 | (0.57–7.63) | 0.260 | 1.66 | (0.61–4.55) | 0.319 | 1.84 | (0.68–5.00) | 0.228 |
| Speech impairment (reference: no) | | | | | | | | | |
| Yes | 1.71 | (0.50–5.79) | 0.384 | 1.08 | (0.38–3.11) | 0.884 | 0.79 | (0.28–2.19) | 0.640 |
| Pain (reference: no) | | | | | | | | | |
| Yes | 6.78 | (2.96–15.55) | < 0.001 | 2.59 | (1.79–3.73) | < 0.001 | 1.81 | (1.37–2.40) | < 0.001 |
| Breathing problems (reference: no) | | | | | | | | | |
| Yes | 1.47 | (0.72–3.00) | 0.285 | 1.26 | (0.79–1.99) | 0.320 | 0.94 | (0.55–1.61) | 0.819 |

Discussion

Understanding the relationship between SWB and anxiety/depression among older adults was not straightforward, likely due to multiple complex factors. First, as individuals aged, they experienced various physical, psychological, and social changes that affected different individuals differently, resulting in significant heterogeneity in well-being trajectories. Although anxiety/depression was considered a common mental health issue among older adults, its dynamic interaction with SWB over time had not been sufficiently explored. Many existing studies relied on cross-sectional data, which limited the understanding of causal relationships and long-term change patterns. Additionally, cultural, social, and individual differences further complicated this relationship, as the experience of anxiety/depression and well-being varied across different populations and environments. Therefore, studying how anxiety influences the developmental trajectories of SWB in older adults was of great importance for identifying vulnerable groups, understanding underlying mechanisms, and developing targeted interventions to promote successful aging.

Empirical findings: heterogeneous SWB trajectories

However, most previous studies of SWB in older adults have focused on cross-sectional designs, and the results generally showed that the overall SWB of older adults was not optimistic (Lee, 2021; Qin et al., 2024). However, cross-sectional studies have limitations and cannot track long-term changes in the SWB of older adults. Different from those cross-sectional studies, through a 7-year longitudinal cohort study utilizing the GBTM, our study identified four distinct patterns of SWB trajectories: group 1 (*low, slightly-declining SWB*), group 2 (*moderate, declining SWB*), group 3 (*moderate, slightly-declining SWB*), and group 4 (*high, slightly-declining SWB*). The dynamic characteristics of SWB in the elderly have been confirmed, and individual differences have been emphasized. Therefore, healthcare professionals should focus more on the long-term changes in elderly SWB, rather than just the health status at a single time. As a result, there is an urgent need for early screening, regular monitoring, and longitudinal tracking of SWB.

Methodological considerations: use of GBTM

In terms of methodological choice, our study selected GBTM as the core analytical strategy, primarily due to its strong compatibility with our dataset's characteristics and the study's objectives. Unlike traditional growth curve modeling or repeated measures ANOVA, which typically assume that the overall sample follows a single average trajectory with individual deviations around it, GBTM is a data-driven, person-centered approach that identifies substantively distinct latent subgroups and characterizes their developmental trajectories over time. This method was particularly well-suited to the NHATS dataset, a large-scale, multi-wave, nationally representative longitudinal panel. Among

older adults, the trajectories of SWB often exhibit substantial heterogeneity. By applying GBTM, we were able to effectively capture such variations, thereby overcoming the limitations of conventional methods. During the model selection process, we conducted a comprehensive theoretical and methodological assessment of GBTM's appropriateness. We found that it not only provided a statistically valid modeling framework but also significantly enhanced the interpretability and practical value of our findings. This facilitated the precise identification of psychologically vulnerable subpopulations and provided a robust empirical basis for developing targeted interventions and policies aimed at promoting SWB among older adults. Thus, the application of GBTM in this study was methodologically justified and offered a novel perspective for understanding the diverse developmental trajectories of mental health in later life.

Mechanisms linking anxiety/depression and SWB

Importantly, the study results indicate a significant negative correlation between anxiety/depression and the trajectory of SWB. Older adults with higher anxiety/depression scores are more likely to be classified into poorer trajectory groups. This finding could be explained through multiple interconnected physiological, psychological, and behavioral mechanisms. Firstly, anxiety/depression significantly impact the normal functioning of the hypothalamic-pituitary-adrenal (HPA) axis, leading to disruptions in cortisol secretion rhythms. This dysregulation of the neuroendocrine system triggers a range of typical physiological symptoms, including sleep disturbances, changes in appetite, and persistent fatigue (Kinlein et al., 2022). Notably, these physiological disruptions not only directly impair individuals' daily functioning but also further diminish quality of life by depleting physical and mental reserves, ultimately leading to a sustained decline or severe fluctuations in SWB (Lenneis et al., 2024).

Secondly, anxiety/depression can significantly impair emotional regulation abilities, making them more vulnerable when facing daily stressors and challenges. This depletion of psychological resources leads to a reduction in positive life experiences and a continuous decline in SWB. This phenomenon is particularly pronounced among the elderly. Existing evidence suggests that anxiety/depression levels in older adults are significantly negatively correlated with self-efficacy (Luszczynska et al., 2005), which is an important psychological resource for SWB. Specifically, the higher the levels of anxiety/depression, the weaker the elderly's confidence in perceiving and coping with challenging situations (Mateusz Cybulski et al., 2017). Current research provides a reasonable explanation for this phenomenon: anxiety/depression amplify individuals' subjective perception of stress while simultaneously depleting their coping resources (Omran and Mcmillan, 2018). Moreover, as these psychological states persist, individuals may develop feelings of loneliness and helplessness, which further weaken self-efficacy, making them more prone to interpret life events negatively and to evaluate their quality of life poorly (Lee et al., 2023). A previous study also reported a significant inverse relationship between anxiety/depression

and resilience. One study found that resilience was negatively correlated with depression ($r = -0.39$, $p = 0.002$) and anxiety ($r = -0.27$, $p = 0.04$) (Kutcher et al., 2023). In other words, the lower the resilience level, the harder it is for older adults to recover from life adversities, making them more likely to fall into a vicious cycle of negative emotions (Cybulski et al., 2017; Górska et al., 2022). The lack of resilience and self-efficacy, as psychological protective factors, contributes to an adverse development in the trajectory of SWB.

Finally, anxiety/depression not only affect older adults' daily functioning, social participation, and overall quality of life (Han et al., 2020; Liu et al., 2023) but might also further influence their social functioning through behavioral pathways. These emotional states were often closely associated with social withdrawal, loss of interest, and reduced activity, weakening the protective function of the social support system among older adults, resulting in a vicious cycle of "emotional distress–social isolation," ultimately exerting a profound negative impact on their SWB (Liao et al., 2022).

Cultural considerations and social context

Our study speculated that this process might be more pronounced within specific cultural contexts. In the United States, the sociocultural environment strongly emphasizes individualism, independence, and the pursuit of self-worth (Markus and Kitayama, 2014). Many older adults tend to maintain an independent living style, which can enhance their sense of autonomy and control over life, aligning with the concept of "successful aging." However, given the condition of declining health, the loss of a spouse, or physical limitations, living alone, older adults might be lacking in emotional support and experience increased feelings of loneliness. Compared to those living with others, older adults living independently are more susceptible to social isolation and psychological distress, thereby experiencing more pronounced negative effects of anxiety/depression on mental health (Cacioppo and Cacioppo, 2014). This structural vulnerability embedded within the cultural context may further exacerbate the decline in SWB and affect its long-term developmental trajectory in later life.

Protective factors and stable high SWB trajectories

In contrast, older adults with lower anxiety/depression scores were more likely to maintain higher or more stable levels of SWB. Previous studies showed that life attitude, chronic disease management abilities, and the quality of social networks were significantly associated with higher level of well-being in older adults (Stephens et al., 2015). Older adults in the "high but slightly declining well-being" trajectory exhibited more positive characteristics in terms of self-efficacy, social participation, and family support. They might possess a higher sense of self-efficacy, actively engage in regular physical exercise and various social activities, and maintain stable and close interpersonal relationships

and social networks, thereby effectively mitigating the negative impacts of aging (Liu et al., 2016).

Implications

The longitudinal assessment of SWB in older adults provides valuable insights with significant clinical and policy implications for promoting mental health and enhancing functional independence in later life. By identifying individuals in the "low decline" and "moderate decline" trajectories at an early stage, healthcare providers could implement timely and targeted interventions to mitigate the risk of further deterioration in SWB. Notably, this study highlights the significant impact of anxiety/depression symptoms on the trajectories of SWB, underscoring the necessity of incorporating mental health screening and management into routine geriatric care. Based on our findings, we suggest that community healthcare services implement regular psychological screening programs to detect anxiety/depression in older adults. Psychosocial interventions such as emotional regulation workshops, peer-support groups, and exercise-based therapies should be actively promoted to address emotional distress and maintain a high level of SWB over time in older adults. From a policy standpoint, strengthening the structure and accessibility of social support networks is equally essential, as these resources play a critical role in helping older adults cope with psychological stressors. Developing integrated, community- and home-based mental health service models can contribute to sustaining higher levels of SWB and enhancing the overall quality of life in the aging population.

Limitations

This study had several limitations. First, it failed to collect key time-sensitive information, such as sudden changes in health status or major life events, which could have significantly impacted the trajectories of SWB. Second, although the study employed GBTM to identify four distinct SWB trajectories, GBTM, as a finite mixture model, assumed that each individual belonged exclusively to a specific trajectory group. This "hard classification" approach might have overlooked the potential fluidity of individuals across different trajectories. Furthermore, the model-fitting results largely depended on the researchers' subjective decisions regarding the shape of the trajectories and the number of groups, which could have led to variations in the identified trajectories and affected the stability and generalizability of the conclusions. Future studies should enhance the dynamic monitoring and collection of time-sensitive events to better capture the key factors influencing changes in SWB. In addition, it is recommended that the findings be replicated in larger samples or across different cultural contexts to improve their external validity and practical applicability.

Conclusion

In conclusion, this study is the first to identify the trajectories of SWB in older adults, and we found a significant association between anxiety/depression and the trajectories of SWB in older adults.

This finding provides a theoretical basis for future mental health interventions. Particularly, our study highlights the importance of screening and longitudinally tracking SWB in older adults, as well as effective evidence-based strategies for the prevention of anxiety/depression to maintain or improve in older adults.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Johns Hopkins University Bloomberg School of Public Health. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

XW: Data curation, Methodology, Writing – original draft. QK: Writing – review & editing. PL: Writing – original draft. DL: Supervision, Writing – review & editing. WZ: Data curation, Supervision, Writing – review & editing.

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Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2025.1573260/full#supplementary-material>

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How age-inclusive human resource practices relate to career sustainability: the role of work-family enrichment and protean career orientation

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Drawing on conservation of resource theory and work-home resources model, this study explores how age-inclusive human resource (HR) practices related to employees' career sustainability through their work-family enrichment. In line with work-home resource model, we introduce a boundary condition, protean career orientation, to explain when our proposed association may unfold. We collected data in three waves from 244 employees to test our hypotheses. Results show that age-inclusive HR practices promote employees' career sustainability through the mediating effect of work-family enrichment. Our findings also emphasize that protean career orientation strengthens the relationship between age-inclusive HR practices and work-family enrichment. Age-inclusive HR practices were more positively linked to career sustainability via work-family enrichment when employees had a high (versus low) protean career orientation. Our research provides a better understanding of how and when age-inclusive HR practices lead to sustainable career.

KEYWORDS

age-inclusive HR practices, career sustainability, work-family enrichment, protean career orientation, work-home resource model

Introduction

With the global trend of workforce aging, the proportion of older employees in the labor force continues to increase (Oliveira, 2021; Kooij et al., 2020). Such as, relevant data show that by 2030, nearly half of China's working-age population will be those over 45 years old (Peng et al., 2022). This demographic change has sparked several career-related challenges. For instance, age-related discrimination may prevent employees from staying engaged and productive (Oliveira and Cabral Cardoso, 2018; Ng and Feldman, 2012), thereby undermining their sustainable employability (Akkermans and Kubasch, 2017). From this, designing an age-inclusive work environment that fosters employees' career sustainability, that is, a continuous sequence of career experiences over time crossing several social spaces including indicators related to well-being (e.g., health and happiness) and productivity (e.g., performance) (De Vos et al., 2020; Tordera et al., 2020), is more critical than ever.

One promising approach may be the use of age-inclusive HR practices, which emphasize having equal opportunities for employees of all age groups with regard to recruiting, training and development, promotion, and managerial support (Boehm et al., 2021). In this way, organizations can provide all employees with different resources to develop their knowledge, skills, and abilities, ultimately performing their jobs successfully and contributing to organizational goals (Kunze et al., 2015). Employees usually want to use the resources provided

by the organization to improve both their work performance and non-work lives. However, most studies of age-inclusive HR practices have primarily focused on their effects on work-related outcomes (Boehm et al., 2014; Burmeister et al., 2018; Fan et al., 2023), overlooking its broader implications for career-related outcomes. Hence, it remains unknown whether age-inclusive HR practices can promote employees' performance and personal well-being as reflecting indicators of career sustainability. These outcomes encompass both work domains (e.g., performance) and non-work domains (e.g., well-being). Furthermore, it is unclear which mechanisms underpin these relationships and produce salient effects on non-work and work domains. The current study aims to address this gap by examining the underlying processes and boundary conditions that enable age-inclusive HR practices to enhance employees' career sustainability.

To examine *how* and *when* age-inclusive HR practices promote career sustainability, we draw on the work-home resources (WH-R) model (Ten Brummelhuis and Bakker, 2012) and conservation of resources (COR) theory (Hobfoll, 1989). According to WH-R model, contextual resources from work domains can enhance personal resources through the process of work-family enrichment, which are subsequently leveraged to improve home and work outcomes (Ten Brummelhuis and Bakker, 2012). Specifically, we propose that age-inclusive HR practices promote work-family enrichment by providing valuable resources to employees. In turn, enhanced work-family enrichment is expected to improve employees' career sustainability, as reflected in work productivity and psychological well-being. Using a resource perspective, this study explores how age-inclusive HR practices contribute to career sustainability through the mediating effect of work-family enrichment.

Furthermore, this study investigates the boundary conditions that explain how age-inclusive HR practices and employees' work and non-work outcomes may vary. Drawing on WH-R model, a specific type of resource—protean career orientation, which is defined as a preference for employees to self-manage their careers (Briscoe and Hall, 2006)—is considered a salient boundary condition. Most conceptions of protean career orientation implicit the whole life perspective, such as pursuing a balanced work life (Hall and Richter, 1990; Drenzo et al., 2015) and serving the whole person, family, and life purpose (Hall, 2004). Thus, we argue that protean career orientation is a meaningful key resource that may amplify the effect of age-inclusive HR practices on work-family enrichment, fostering the transfer of resources from the work domain to employees' personal lives.

This study contributes to extant literature in several ways. First, we contribute to age-inclusive HR practices literature by extending its outcomes. Prior research has mainly focused on the impact of age-inclusive HR practices on work-related outcomes (e.g., Boehm et al., 2014; Fan et al., 2023), overlooking the role played in enabling career outcomes. By emphasizing the value and usefulness of all age groups, age-inclusive HR practices can shape employees' perceptions of their future occupational opportunities (Oliveira, 2021). In this regard, age-inclusive HR practices may be privileged levers available to organizations that can promote sustainable careers. Our study also answers the call for attention to the role of HR practices (specifically, age-inclusive HR practices) in the development of sustainable careers (Inkson et al., 2012). Second, this study introduces a resource perspective into the age-inclusive HR practices literature. Previous studies primarily used social exchange theory (e.g., Ali and French,

2019; Sousa et al., 2019; Bieling et al., 2015; Boehm et al., 2014; Rudolph and Zacher, 2021) and socio-emotional selectivity theory (Oliveira, 2021) to explain how age-inclusive HR practices promote employees' work-related outcomes by building a reciprocal relationship between organizations and employees. Recent studies also consider other explanation mechanisms, such as social learning theory (e.g., Fasbender and Gerpott, 2022), to explain older employees' knowledge seeking from younger colleagues. Drawing on WH-R model and COR theory, this study investigates the impact of age-inclusive HR practices on non-work outcomes, such as work-family enrichment and career sustainability, from the perspective of resource spillover effects. Third, by identifying protean career orientation as a boundary condition that helps maximize the potential effect of age-inclusive HR practices on work-family enrichment and career sustainability, this research addresses recent calls to understand the role of individual differences in the effectiveness of age-inclusive HR practices. Although a few studies have examined the boundary conditions under which age-inclusive HR practices affect employee work outcomes (e.g., Sousa et al., 2019; Fan et al., 2023), little is known about when age-inclusive HR practices enhance or weaken employee non-work outcomes. By integrating contextual resources and key personal resources, we define protean career orientation as a boundary condition that determines the efficacy of age-inclusive HR practices in promoting work-family enrichment and sustaining employees' careers.

Theory and hypotheses development

COR theory and WH-R model

The core tenet of COR theory is that people are motivated to protect their current resources and acquire new resources (Hobfoll, 1989). Resources are loosely defined as objects, personal attributes, conditions, energies, and other things that people value. The COR theory is built on two basic assumptions (Hobfoll, 1989, 2002). The first is the *gain spiral* of resources, which posits that individuals with more resources are in a better position to invest resources and acquire more resources. The second is the *loss spiral* of resources, wherein individuals with fewer resources are more likely to experience resource losses.

The WH-R model integrates the basic assumptions of COR theory into the work-home interface (Ten Brummelhuis and Bakker, 2012). Given the important role of resources in COR theory, Ten Brummelhuis and Bakker (2012) also distinguished different types of resources in more detail. Contextual resources (e.g., age-inclusive HR practices) are external to the self and can be found in the social contexts of the individual, while personal resources (e.g., time, energies, knowledge, and skills) are proximate to the self and usually found within the individual. These distinctions assist in understanding how employees gain and utilize resources in their work environments to achieve their desired outcomes, such as career sustainability. Work-family enrichment is depicted as the process whereby contextual resources lead to the development of personal resources. To clarify the conditions that are most likely to achieve work-home enrichment, the WH-R model proposes key resources and macro resources. The former refers to stable personal characters that facilitate the selection, alteration, and implementation of other resources (e.g., conscientiousness; Halbesleben et al., 2009; Penney et al., 2011). The latter refers to characteristics of

the larger economic, social, and cultural system in which a person is embedded (Halbesleben et al., 2014). Contextual resources do not affect all individuals equally, and people with key resources are more likely to effectively leverage their contextual resources to gain personal resources (Ten Brummelhuis and Bakker, 2012).

Drawing on the WH-R model, this study explores how age-inclusive HR practices, as a type of contextual resource in the workplace, can enhance employees' career sustainability through the process of work-home enrichment. Furthermore, this study examines whether protean career orientation, conceptualized as a key resource, serves as a boundary condition that influences this relationship, thereby testing the applicability of the WH-R model.

Age-inclusive HR practices and work-family enrichment

Work-family enrichment is defined as the degree to which role experiences and resources from the work domain enhance the quality of life in the family domain (Greenhaus and Powell, 2006). From the perspective of the WH-R model, work-family enrichment can be understood as a process in which contextual resources from the work domain are translated into personal resources (Ten Brummelhuis and Bakker, 2012). Specifically, work-family enrichment occurs through two pathways: the instrumental path and the affective path (Greenhaus and Powell, 2006). The instrumental path involves the acquisition of direct resources at work, such as skills, experiences, and social capital, which directly enhance family role performance. The affective path, on the other hand, refers to resources obtained at work that foster one's positive emotions, which in turn improve outcomes in the family domain (Lapierre et al., 2018).

Age-inclusive HR practices refer to effective management practices designed to accommodate the growing workforce aging (Boehm et al., 2014). In line with the WH-R model, these practices are posited to influence employees' work-family enrichment through two pathways. First, through the instrumental pathway, age-inclusive HR practices provide employees with equitable access to training, promotion, and career development opportunities regardless of their age (Hennekam and Herrbach, 2015; Boehm et al., 2021). Resources acquired through these practices, such as enhanced skills or increased compensation, can directly improve employees' functioning in family role. For instance, skills developed through training may help resolve both work-related challenges and similar family issues (Greenhaus and Powell, 2006), while higher compensation can better support household expenses, thereby improving the quality of life at home (Heinrich, 2014). Second, through affective pathway, age-inclusive HR practices address age discrimination issues by ensuring fair treatment for employees of all ages (Fan et al., 2023; Li et al., 2021; Boehm et al., 2014). This fosters feelings of being valued and supported, thereby enhancing employees' affective commitment to their organization (Fan et al., 2023; Sousa et al., 2021). These positive emotions can spill over into family domain, improving family-related outcomes (Chan et al., 2022). Supporting these arguments, previous studies have demonstrated that contextual resources from the work domain can enhance work-family enrichment through both instrumental and affective pathways (e.g., Hammond et al., 2015; Liu et al., 2024). Thus, we propose the following hypothesis:

Hypothesis 1: Age-inclusive HR practices are positively related to work-family enrichment.

Work-family enrichment and career sustainability

Career sustainability is defined as "sequences of career experiences reflected through a variety of patterns of continuity over time, thereby crossing several social spaces, characterized by individual agency, herewith providing meaning to the individual" (Van der Heijden and De Vos, 2015). Health, happiness, and productivity are the three elements that constitute sustainable careers (De Vos et al., 2020). Building on this framework, Tordera et al. (2020) refined two dimensions — *well-being* (health and happiness) and *productivity* (performance)—to be the reliable indicators for career sustainability. Well-being and work performance have also been regarded as important non-work and work outcomes for employees (Warr and Nielsen, 2018; Kong et al., 2023).

A sustainable career across the lifespan requires individuals to invest personal resources and balance interests across multiple social domains, such as work and family (De Vos et al., 2020). According to COR theory and WH-R model, the value of resources is that it helps one achieve his or her goals, thereby enhancing one's well-being and performance (Wright and Hobfoll, 2004; Panaccio and Vandenberghe, 2009). In terms of well-being, work-family enrichment facilitates the transfer of resources and skills between work and family domains, extending the positive experience at work to the family and life domains (Liu et al., 2018; Hunter et al., 2010; Jing et al., 2021). These aspects will enhance life satisfaction and well-being (Henry and Desmette, 2018). Moreover, work-family enrichment can increase one's positive mood in the form of enthusiasm and energy, enabling the individual a sense of self-fulfillment (Carlson et al., 2011). Overall, work-family enrichment meets employees' psychological needs, thereby improving their satisfaction and well-being (Chan et al., 2020; Baumann and Wilson, 2024).

In terms of productivity, work-family enrichment can place employees in a resource-abundant state, which enhances their capability and willingness to engage in productive work behaviors. When employees accumulate resources in the family role due to work-family enrichment, they are more likely to generate a sense of reciprocity toward the organization and commit to reinvesting resources into the work role, resulting in improved productivity (Ten Brummelhuis and Bakker, 2012). Second, skills, knowledge, behaviors, and perspective obtained from one's experiences at work and family life are resources that generates benefits across life domains (Carlson et al., 2006). For instance, a sense of focus or necessity to sustain work in order to support a family can also be described as a resource that enables employees to be better workers. Therefore, in line with WH-R model, we predict that these resources will demonstrate gains in the form of work engagement and work performance (Timms et al., 2015; Carlson et al., 2011). Overall, work-family enrichment enhances individuals' competencies and motivational resources for work, promoting sustainable careers. Taken together, we propose the following hypothesis:

Hypothesis 2: Work-family enrichment is positively related to employees' career sustainability (well-being and productivity).

In summary, we argue that age-inclusive HR practices positively related to career sustainability through the mediating effect of work-family enrichment. Based on COR theory and the WH-R model, gaining contextual resources lead to the accumulation of personal resources (i.e., work-family enrichment), which in turn re-invest their

resources and efforts in the work and life domains. The argument is further supported by prior studies, which indicate that work-family enrichment is associated with increased well-being and productivity (McNall et al., 2010; Odle-Dusseau et al., 2012). We thus hypothesize an indirect effect of age-inclusive HR practices on career sustainability through work-family enrichment.

Hypothesis 3: Work-family enrichment mediates the relationship between age-inclusive HR practices and employees' career sustainability (well-being and productivity).

The moderating role of protean career orientation

Protean career orientation (PCO) refers to an individual's tendency to achieve subjective success through proactive career management, including two dimensions: self-direction and value-driven orientation (Hall et al., 2018). Self-direction is manifested in individuals' continuous learning and strengthening of their capabilities to achieve their career goals (Cortellazzo et al., 2020), accompanied by a strong desire for autonomy and self-actualization (Li et al., 2019). Value-driven orientation refers to the pursuit of career goals that align with one's intrinsic values (Li et al., 2019). Clear values guide individuals to manage their careers with a more holistic and long-term perspective (Briscoe and Hall, 2006; Cortellazzo et al., 2020).

The self-directed and value-driven orientation inherent in PCO equips individuals with stronger capability and motivation to control and select resources, making it a key resource (Direnzo et al., 2015). Based on the WH-R model, we propose that PCO, as a key resource, enables individuals to better utilize contextual resources in the work domain (i.e., age-inclusive HR practices) to achieve work-family enrichment. On one hand, PCO are self-directed and can proactively scan and reshape external environment around them to seek resources that meet its expectations (Hall et al., 2018; Cortellazzo et al., 2020). Therefore, individuals with high PCO are better at identifying and leveraging both the instrumental and emotional resources that age-inclusive HR practices provide, thereby enhancing work-family enrichment. On the other hand, individuals with high PCO adopt a holistic perspective on career development (Direnzo et al., 2015; Direnzo and Greenhaus, 2011). They view career development not as a process limited to self-development within the work domain, but as a comprehensive form of self-development that spans all life domains (Direnzo et al., 2015; Hall and Chandler, 2005). Thus, individuals with high levels of PCO are more motivated to transfer the resources identified in the work domain to the life domain, thereby promoting enrichment across both work and family domains.

However, individuals with low levels of PCO may lack the proactivity and awareness to pursue opportunities, making it difficult for them to effectively utilize potential resources in the organizational environment. Additionally, individuals with low PCO may lack value-driven guidance, making it challenging for them to recognize the importance and prioritize matters related to career development. As a result, they may become dependent on and controlled by the external environment, without a sufficient perspective to guide their own career development, thereby hindering their ability to achieve work-family enrichment (Briscoe and Hall, 2006). Based on this, we propose the following hypothesis:

Hypothesis 4: Protean career orientation moderates the positive relationship between age-inclusive HR practices and work-family enrichment, such that this relationship is stronger when protean career orientation is higher (versus lower).

Based on the COR theory and the WH-R model, we further propose that PCO moderates the indirect effect of work-family enrichment between age-inclusive HR practices and career sustainability. Individuals with high level of PCO are guided to proactively identify resources and support provided by age-inclusive HR practices and to invest these resources across work and family domains with a long-term perspective, thereby achieving comprehensive enrichment and maintaining career sustainability. Conversely, individuals with low level of PCO often lack proactivity and may struggle to uncover potential applicable resources within organizational support. Due to a lack of a holistic and long-term developmental perspective, they find it challenging to convert available resources into enrichment across multiple domains such as work and family, which hampers their ability to plan and manage their careers systematically (Briscoe and Hall, 2006). Based on the above arguments, we offer the following model (see Figure 1).

Hypothesis 5: The indirect effect of work-family enrichment between age-inclusive HR practices and career sustainability is stronger when protean career orientation is higher (versus lower).

Methods

Sample and procedures

We collected our data from knowledge employees working at various organizations in China. One of the main reasons is that the core competitiveness of knowledge workers depends on continuous knowledge updating and experience accumulation. Compared with manual laborers, their career life cycle is longer, and they face a more significant risk of knowledge aging. Thus, this study mainly uses a sample of knowledge workers to test the relationship between age-inclusive HR practices and career sustainability. We recruited participants in the Credamo platform¹, which has been commonly used in organizational studies (e.g., Cheng et al., 2024; Huang et al., 2023). During the data collection process, we informed all participants that this survey would be used for research purposes only and that their responses would be kept strictly confidential. In order to increase the response rate, we paid each participant the bottom-line compensation set by the platform.

In order to better identify the causal relationships among variables and avoid the effects of common method biases, we conducted a three-wave data collection process, with a two-week interval. At the first time point (Time1), participants were asked to fill out a relatively comprehensive questionnaire measuring variables including demographic variables (i.e., gender, age, education, and tenure), age-inclusive HR practices, protean career orientation, and initial level of career sustainability (well-being and productivity). Initially, we distributed a total of 400 questionnaires. We used a screening

¹ <https://www.credamo.com/>

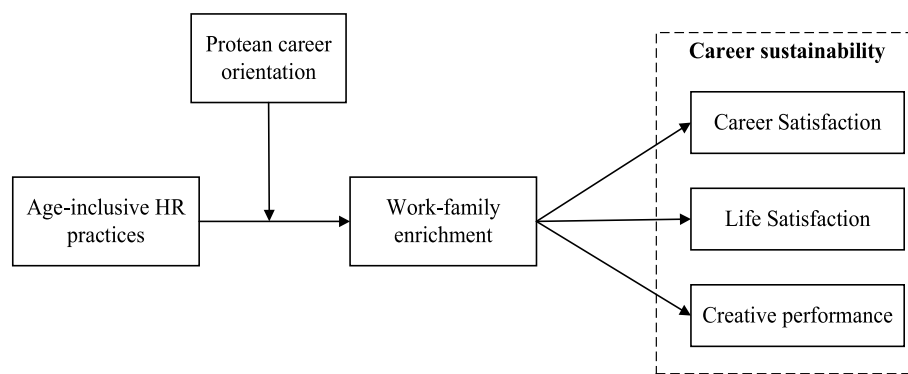


FIGURE 1
Hypothesized research model.

question to excluding those who did not answer truthfully, finally receiving 339 valid employee questionnaires, a response rate of 84.8%. Two weeks later, at Time 2, we asked these 339 employees to rate their work-family enrichment. A total of 296 employees completed their questionnaires, generating a response rate of 87.3%. At Time 3, we invited 296 employees to report the level of career sustainability (well-being and productivity) and obtained 244 responses, generating a response rate of 82.4%. Finally, we matched 244 responses with the three-wave data using the platform's user IDs.

Among these employees, 31.1% were male and 68.9% were female; the average age of participants was 33.69 years ($SD = 7.22$, with a missing value); the average organizational tenure was 6.21 years ($SD = 4.72$). In terms of education, most had undergraduate degrees (59%), while 23.1% had postgraduate degrees and above, 15.6% had college degrees, and 4.1% had high school qualifications.

Measures

In our study, we measured all variables using well-established scales that were originally developed in English. We translated these scales into Chinese using the back-translation procedure (Brislin, 1970). Unless otherwise stated, all items were measured by a 5-point Likert scale (from 1 = *strongly disagree* to 5 = *strongly agree*).

Age-inclusive HR practices

We measured age-inclusive HR practices using a five-item scale developed by Boehm et al. (2014). The five items of this scale measured the degree to which employees perceived age-inclusive HR practices in their organization. An example item was “our company offers equal access to training and further education for all age groups.” The Cronbach's alpha in this study was 0.87.

Protean career orientation

A seven-item scale developed by Baruch (2014) was used to assess employees' protean career orientation. One example item was “For me, career success is how I am doing against my goals and values.” The Cronbach's alpha for this scale was 0.84.

Work-family enrichment

Employees rated their work-family enrichment at Time 2 using a four-item scale established by Wayne et al. (2004). One example was “The things you do at work help you deal with personal and practical issues at home.” The Cronbach's alpha was 0.90.

Career sustainability

According to De Vos et al.'s (2020) conceptual model, we used life satisfaction, career satisfaction, and creative performance as key indicators of career sustainability. Well-being is typically measured by individuals' perceptions of life satisfaction and career satisfaction (e.g., Kong et al., 2023; Tordera et al., 2020). Specifically, we measured career satisfaction with a five-item scale developed by Greenhaus et al. (1990). One of example items was “I am satisfied with the success I have achieved in my career” ($\alpha = 0.92$). We used a five-item scale developed by Diener et al. (1985) to measure life satisfaction. Participants were asked to indicate how satisfied they were with their lives. Typical an item was “In most ways, my life is close to my ideal” ($\alpha = 0.93$). In terms of productivity, Baer and Oldham's (2006) 4-item scale were used to measure employee creative performance. An example item was “I often come up with creative solutions to problems at work” ($\alpha = 0.88$).

Control variables

We controlled for gender, age, education and organizational tenure owing to their established relationships with career satisfaction, life satisfaction and creative performance (e.g., Ng and Feldman, 2013; Jiang and Hu, 2016; Kong et al., 2022; Solomon et al., 2022). Furthermore, in line with previous research (e.g., Ren et al., 2024), to verify that age-inclusive HR practices have incremental effects on career sustainability above prior levels, we also controlled for the level of career sustainability at Time 1. We assessed career satisfaction ($\alpha = 0.92$), life satisfaction ($\alpha = 0.90$), and creative performance ($\alpha = 0.88$) using the same scales as Time 3. We note that removing these controls does not affect the statistical significance of our findings. In order to rigorously test the hypothesis, we report the results of including these control variables.

Analytical strategy

To test our hypotheses, we conducted path analysis using Mplus 8.3 (Muthén and Muthén, 2019). To examine the mediating effects and moderated mediation effects, we used the Monte Carlo simulations with 20,000 replications to calculate the 95% confidence intervals (Selig and Preacher, 2008). When confidence intervals do not contain zero, the indirect association was significant. To examine the moderating effects, we grand-mean centered all independent variables (Cohen et al., 2003). Then, we plotted simple slopes at one standard deviation below and above the mean of the moderator to interpret our results (Aiken and West, 1991).

Results

Table 1 presents the results of descriptive statistics and correlations. As shown, A high level of education made it easier for employees to have career satisfaction ($r = 0.19, p < 0.01$), life satisfaction ($r = 0.21, p < 0.01$) and creative performance ($r = 0.30, p < 0.001$). Organizational tenure was positively related to work-family enrichment ($r = 0.13, p < 0.05$). Age-inclusive HR practices had a positive and significant relationship with work-family enrichment ($r = 0.29, p < 0.001$). Similarly, work-family enrichment was positively related to employees' career satisfaction ($r = 0.36, p < 0.001$), life satisfaction ($r = 0.36, p < 0.001$), and creative performance ($r = 0.26, p < 0.001$). These results provided preliminary support for hypothesis testing.

Test of measurement model

To test discriminant validity, we conducted a confirmatory factor analysis (CFA) on six focal variables (i.e., age-inclusive HR practices, protean career orientation, work-family enrichment, career satisfaction, life satisfaction, and creative performance). As shown in the Table 2, results suggested that the hypothesized six-factor model fits the data well ($\chi^2 = 829.01, df = 390, CFI = 0.92, TLI = 0.91, RMSEA = 0.07, SRMR = 0.06$) and better than any of the five-factor models.

Testing the hypotheses

We performed path analysis to test our hypotheses using Mplus 8.3 software and the results were summarized as Table 3. Age-inclusive HR practices was positively associated with work-family enrichment ($B = 0.45, SE = 0.10, p < 0.001$). Thus, Hypothesis 1 was supported. In addition, work-family enrichment had a significantly positive effect on employees' career satisfaction ($B = 0.21, SE = 0.05, p < 0.001$), life satisfaction ($B = 0.18, SE = 0.06, p < 0.01$) and creative performance ($B = 0.11, SE = 0.05, p < 0.05$). These results supported hypotheses 2 that work-family enrichment had positive relationships with employee career sustainability.

In support of Hypothesis 3, we used the Monte Carlo simulations with 20,000 replications to calculate the 95% confidence intervals. Results showed that the indirect effect of age-inclusive HR practices on employee career satisfaction (indirect effect = 0.09, $SE = 0.03$, 95% CI = [0.04, 0.17]), life satisfaction (indirect effect = 0.08, $SE = 0.03$,

95% CI = [0.03, 0.15]), and creative performance (indirect effect = 0.05, $SE = 0.02$, 95% CI = [0.01, 0.11]) through work-family enrichment were positive and significant. The result suggested that work-family enrichment mediated the relationship between Age-inclusive HR practices and career sustainability, supporting hypothesis 3.

Hypothesis 4 proposes that protean career orientation moderates the relationship between age-inclusive HR practices and work-family enrichment. Results showed that the interaction term between age-inclusive HR practices and protean career orientation had a significant effect on work-family enrichment ($B = 0.19, SE = 0.07, p < 0.01$), providing initial support for the moderating of protean career orientation. We further plotted the interaction at conditional values of protean career orientation (Figure 2). For the relationship between age-inclusive HR practices and work-family enrichment, the slope was stronger when employees' protean career orientation was higher (simple slope = 0.57, $p < 0.001$) rather than lower (simple slope = 0.34, $p < 0.01$). The difference in simple slope between the two conditions was significant ($p < 0.01$). Therefore, Hypothesis 4 was supported.

We also examined the conditional indirect effects of age-inclusive HR practices on career sustainability through work-family enrichment at varying levels of protean career orientation (one SD above the mean and one SD below the mean). As shown in Table 4, the results indicated that the conditional indirect effects of age-inclusive HR practices via work-family enrichment on employees' career satisfaction were significant at both high (indirect effect = 0.12, $SE = 0.04$, 95% CI = [0.06, 0.21]) and low (indirect effect = 0.07, $SE = 0.03$, 95% CI = [0.03, 0.14]) levels of protean career orientation. The conditional indirect effect of age-inclusive HR practices via work-family enrichment on employees' life satisfaction was significantly positive at both high (indirect effect = 0.10, $SE = 0.04$, 95% CI = [0.04, 0.19]) and low (indirect effect = 0.06, $SE = 0.03$, 95% CI = [0.02, 0.12]) levels of protean career orientation. The conditional indirect effect of age-inclusive HR practices via work-family enrichment on employees' creative performance was significantly positive at both high (indirect effect = 0.06, $SE = 0.03$, 95% CI = [0.004, 0.14]) and low (indirect effect = 0.04, $SE = 0.02$, 95% CI = [0.003, 0.10]) levels of protean career orientation. The differences in the indirect effects between the two conditions were 0.05 (career satisfaction), 0.04 (life satisfaction), 0.03 (creative performance) with a 95% bias-corrected CI of (0.01, 0.10), (0.01, 0.09), and (0.004, 0.07), respectively. Thus, Hypothesis 5 was supported.

Figure 3 summarizes the results of hypotheses paths, including direct and indirect effects.

Discussion

This study provides empirical evidence concerning the mechanism through which age-inclusive HR practices relate to employees' career sustainability. Our results show that age-inclusive HR practices are not only directly associated with career sustainability, but also relate to career sustainability via work-family enrichment. This finding extends an assumption of social exchange theory, which suggest that age-inclusive HR practices make employees feel support from organizations, and in exchange, employees of all ages will tend to reciprocate the organizational support through beneficial work attitudes and behaviors (Ali and French, 2019; Sousa et al., 2019; Bieling et al., 2015; Rudolph and Zacher, 2021).

TABLE 1 Mean, standard deviations, and zero-order correlations.

| Variables | <i>M</i> | <i>SD</i> | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|-----------------------------------|----------|-----------|--------|----------|---------|-------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 1 Gender | 0.69 | 0.46 | | | | | | | | | | | | | |
| 2 Age | 33.69 | 7.22 | −0.03 | | | | | | | | | | | | |
| 3 Education | 2.98 | 0.73 | 0.07 | −0.26*** | | | | | | | | | | | |
| 4 Organizational tenure | 6.21 | 4.72 | −0.15* | 0.50*** | −0.14* | | | | | | | | | | |
| 5 Career satisfaction (T1) | 3.88 | 0.91 | 0.01 | 0.12 | 0.15* | 0.12 | (0.92) | | | | | | | | |
| 6 Life satisfaction (T1) | 3.67 | 0.93 | 0.07 | 0.13* | 0.11 | 0.12 | 0.78*** | (0.90) | | | | | | | |
| 7 Creative performance (T1) | 3.93 | 0.78 | −0.02 | 0.14* | 0.14* | 0.07 | 0.70*** | 0.57*** | (0.88) | | | | | | |
| 8 Protean career orientation (T1) | 4.11 | 0.61 | 0.001 | −0.02 | 0.20** | −0.02 | 0.59*** | 0.52*** | 0.67*** | (0.84) | | | | | |
| 9 Age-inclusive HRM (T1) | 3.94 | 0.84 | 0.01 | −0.06 | 0.20** | −0.01 | 0.69*** | 0.61*** | 0.63*** | 0.71*** | (0.87) | | | | |
| 10 Work-family enrichment (T2) | 3.77 | 0.92 | −0.02 | 0.02 | −0.02 | 0.13* | 0.35*** | 0.41*** | 0.30*** | 0.15* | 0.29*** | (0.90) | | | |
| 11 Career satisfaction (T3) | 3.92 | 0.86 | −0.03 | 0.05 | 0.19** | 0.09 | 0.55*** | 0.53*** | 0.41*** | 0.30*** | 0.40*** | 0.36*** | (0.92) | | |
| 12 Life satisfaction (T3) | 3.59 | 0.97 | 0.08 | 0.08 | 0.21** | 0.11 | 0.50*** | 0.62*** | 0.33*** | 0.23*** | 0.36*** | 0.36*** | 0.77*** | (0.93) | |
| 13 Creative performance (T3) | 3.99 | 0.79 | −0.002 | 0.09 | 0.30*** | 0.12 | 0.46*** | 0.40*** | 0.47*** | 0.28*** | 0.39*** | 0.26*** | 0.74*** | 0.73*** | (0.88) |

N = 244; Alpha reliabilities appear in the parentheses along diagonal. *SD* = standard deviation; Gender is code as “0 = man, 1 = woman”; Education is code as “1 = high school and below, 2 = junior college diploma, 3 = bachelor, 4 = master and above.”

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

Alpha reliabilities appear in parentheses along the diagonal and are in bold.

TABLE 2 Model fit results for confirmatory factor analyses.

| Models | $\chi^2(df)$ | (df) | χ^2/df | CFI | TLI | RMSEA | SRMR |
|---|--------------|------|-------------|------|------|-------|------|
| Hypothesized six-factor model | 829.01 | 390 | | 0.92 | 0.91 | 0.07 | 0.06 |
| Five-factor model (combing AHRP and protean career orientation) | 917.12 | 395 | 88.11/5*** | 0.90 | 0.89 | 0.07 | 0.07 |
| Five-factor model (combing AHRP and work-family enrichment) | 1440.25 | 395 | 611.24/5*** | 0.80 | 0.78 | 0.10 | 0.10 |
| Five-factor model (combing protean career orientation and work-family enrichment) | 1486.69 | 395 | 657.68/5*** | 0.79 | 0.77 | 0.11 | 0.11 |
| Five-factor model (combing career satisfaction and life satisfaction) | 1002.50 | 395 | 173.49/5*** | 0.88 | 0.87 | 0.08 | 0.07 |
| Five-factor model (combing work-family enrichment and creative performance) | 1534.61 | 395 | 705.60/5*** | 0.78 | 0.76 | 0.11 | 0.16 |

△ = change relative to the measurement model; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; SRMR = standardized root mean-square residual. ****p* < 0.001.

TABLE 3 Unstandardized coefficients of path model.

| Variables | Work-family enrichment | | Career satisfaction | | Life satisfaction | | Creative performance | |
|-----------------------------|------------------------|------|---------------------|------|-------------------|------|----------------------|------|
| | Estimate | SE | Estimate | SE | Estimate | SE | Estimate | SE |
| Gender | 0.01 | 0.12 | −0.08 | 0.10 | 0.10 | 0.11 | 0.01 | 0.09 |
| Age | −0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.004 | 0.01 |
| Education | −0.06 | 0.08 | 0.17** | 0.07 | 0.24*** | 0.07 | 0.28*** | 0.06 |
| Organizational tenure | 0.03 | 0.01 | 0.002 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 |
| Career satisfaction (T1) | | | 0.34*** | 0.05 | | | | |
| Life satisfaction (T1) | | | | | 0.46*** | 0.05 | | |
| Creative performance (T1) | | | | | | | 0.30*** | 0.05 |
| AHRP (T1) | 0.45*** | 0.10 | 0.06 | 0.07 | 0.02 | 0.07 | 0.11 | 0.06 |
| PCO (T1) | −0.05 | 0.14 | | | | | | |
| AHRM*PCO | 0.19** | 0.07 | | | | | | |
| Work-family enrichment (T2) | | | 0.21*** | 0.05 | 0.18** | 0.06 | 0.11* | 0.05 |
| R ² | 0.14** | 0.04 | 0.31*** | 0.05 | 0.36*** | 0.05 | 0.30*** | 0.05 |

N = 244; AHRP = Age-inclusive human resource practices; PCO = protean career orientation. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

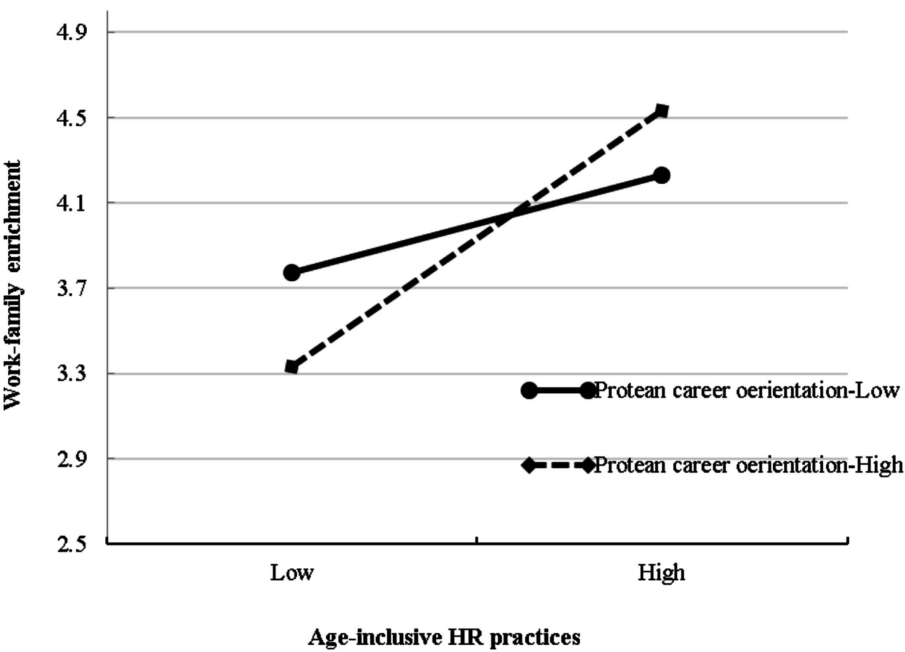


FIGURE 2
Interaction between age-inclusive HR practices and protean career orientation on work-family enrichment.

TABLE 4 Moderated mediation results.

| Outcomes variables | Levels of protean career orientation | Indirect effect | SE | 95% bias-corrected CI | Difference of effects and 95% bias-corrected CI |
|----------------------|--------------------------------------|-----------------|------|-----------------------|---|
| Career satisfaction | Low (-1SD) | 0.07 | 0.03 | [0.03, 0.14] | 0.05 [0.01, 0.10] |
| | High (+1SD) | 0.12 | 0.04 | [0.06, 0.21] | |
| Life satisfaction | Low (-1SD) | 0.06 | 0.03 | [0.02, 0.12] | 0.04 [0.01, 0.09] |
| | High (+1SD) | 0.10 | 0.04 | [0.04, 0.19] | |
| Creative performance | Low (-1SD) | 0.04 | 0.02 | [0.003, 0.10] | 0.03 [0.004, 0.07] |
| | High (+1SD) | 0.06 | 0.03 | [0.004, 0.14] | |

N = 244; SE = standard error; CI = confidence intervals. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

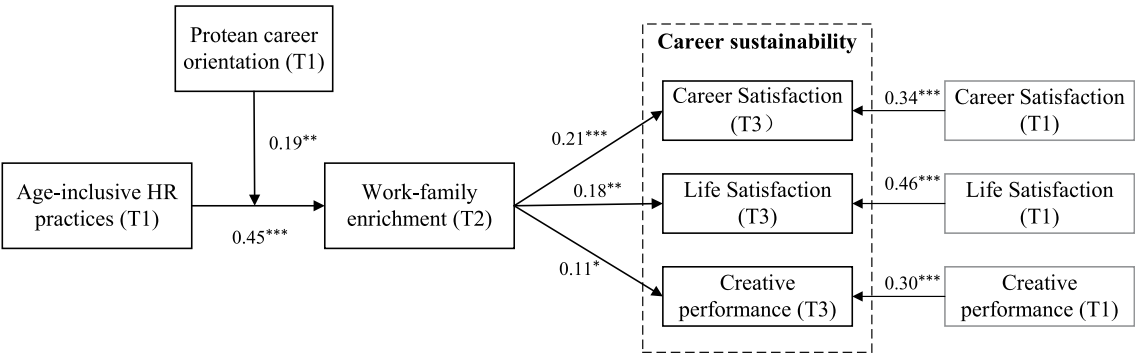


FIGURE 3
Unstandardized estimates of path coefficients. Effects of the control variables and direct effects between age-inclusive HR practices and career sustainability are not included for the purpose of clarity. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

However, recent studies have suggested that reciprocity is not the only mechanism through which to understand the effects of age-inclusive HR practices on employees' outcomes (e.g., Sousa et al., 2019; Oliveira, 2021; Fasbender and Gerpott, 2022). The current study introduces a resource perspective into age-inclusive HR practices literature, which reveals the mechanism of age-inclusive HR practices on career sustainability (well-being and productivity). Results show that work-family enrichment plays an important role in linking age-inclusive HR practices to better career satisfaction, life satisfaction, and creative performance.

Moreover, our study shows that protean career orientation moderates the indirect effect of work-family enrichment between age-inclusive HR practices and career sustainability. The results indicate that for employees with a high level of protean career orientation, age-inclusive HR practices are more positively related to career sustainability via work-family enrichment. Prior research has emphasized that protean career orientation can directly link to a wide range of employees' career outcomes (e.g., Baruch et al., 2020; Cortellazzo et al., 2020; Herrmann et al., 2015) and work-life balance (e.g., Drenzo et al., 2015). Considering with the contextual resources and personal key resources interaction perspective, we identified protean career orientation as a moderator that strengthens the positive effects of age-inclusive HR practices on work-family enrichment and career sustainability, which enriches the boundary condition of personal attributes in WH-R model.

Theoretical implications

This study has several theoretical contributions to literature about age-related HR practices and sustainable career. First, our study extends the age-related HRM literature by demonstrating a positive association between age-inclusive HR practices and career sustainability. Although scholars have showed the significant role played by age-inclusive HR practices in predicting organizational and individual outcomes (Boehm et al., 2014; Fan et al., 2023), the relationship between age-inclusive HR practices and career outcomes remains unclear. By identifying career sustainability as a critical outcome of age-inclusive HR practices, this study responds to the call to focus on the role of HR practices (specifically, age-inclusive HR practices) in the development of sustainable careers (Inkson et al., 2012).

Second, we extend previous research to understand the impact mechanism of age-inclusive HR practices on desirable outcomes by introducing a resource perspective. Previous studies have mainly used social exchange theory to explain the impact of age-inclusive HR practices (Ali and French, 2019). Nevertheless, social exchange relationships usually explain the reciprocity between employees and organization, and it remains unknown how age-inclusive HR practices benefit employees outside the organization. Combining the WH-R model and COR theory, contextual resources from the work domain (i.e., age-inclusive HR practices) are effective in enabling individuals to achieve home-related and career-related goals (Halbesleben, 2006). In line with this stream of research, we found that work-family enrichment helps employees to gain personal resources, thus benefiting their well-being and productivity. Therefore, beyond the understanding of the relationship between age-inclusive HR practices and work outcomes, it is also important to consider the spillover effects of resources, which explain how work-family enrichment associated with age-inclusive HR practices affects career sustainability.

Third, this study contributes to the HRM literature by showing how age-inclusive HR practices interacts with employees' protean career orientation to influence work-family enrichment. Although prior studies demonstrated that protean career orientation directly links to work-life balance (e.g., Drenzo et al., 2015), its boundary role in the relationship between HR practices and their work-family outcomes is unexplored. From a whole life perspective, protean career orientation emphasizes more than an orientation toward work but rather extends to other domain in an individual's life, such as family domain (Drenzo et al., 2015). Therefore, it is pivotal to consider career orientation when exploring the effects of age-inclusive HR practices on work-family enrichment. Based on WH-R model, resources are essential to effective functioning in different life domains (Ten Brummelhuis and Bakker, 2012). Employees with high protean career orientation can facilitate one's ability to transfer resources across different life spaces. Considering the interaction perspective of contextual resources and key resources, we identified protean career orientation as a moderator that strengthens the positive effect of age-inclusive HR practices on work-family enrichment, which enriches the boundary condition of personal attributes in WH-R model.

Practical implications

Our findings have some practical implications. We found that age-inclusive HR practices are significantly related to work-family enrichment and, subsequently, to sustainable careers. Hence, the value of age-inclusive HR practices should be recognized by organizations and managers. Organizations, particularly those with diverse age groups, could provide equal opportunities in recruitment, promotion, and career development for all employees, regardless of their age. These practices are beneficial to the development of both employees and their organizations.

Second, our findings support that work-family enrichment plays a gain process in personal resources. For organizations, recognizing that employees are individuals with multiple identities may be more beneficial in achieving both individual and organizational long-term goals. Specifically, work-family enrichment, as a prime example of positive interaction between work and family life, holds significant value and deserves attention. Moreover, organizations and managers should also implement timely interventions to manage the process of realizing work-family enrichment, such as providing resources related to family support. Notably, research indicates that training supervisors to be more supportive of employees' nonwork life is an effective approach for improving employee work, family, and health outcomes (Russo et al., 2018; Crain and Stevens, 2018).

Third, the relationship between age-inclusive HR practices and work-family enrichment was stronger for employees with high protean career orientation. This suggests that managers should be concerned about their subordinates' career orientation when conducting age-inclusive HR practices. Supervisors should notice the value of protean career orientation in such an age-diverse work environment and support employees to self-manage their careers. Leaders also need to pay attention to those employees who have been embedded in high protean career orientation, which helps them to select adaptable employees as role models and effective assets within companies. These employees may play positive roles in promoting work-family enrichment and maintaining career sustainability in the age diverse organizational context.

Limitations and future directions

Despite its strengths, this study has several limitations. First, although the multi-wave design of this study can reduce common method bias, it cannot make accurate causal inferences. That is, more caution is needed in interpreting the relationship between age-inclusive HR practices and career sustainability. We encourage future research to adopt experimental designs or longitudinal studies to address this limitation. In addition, future research can also use longitudinal research designs to examine the impact of career sustainability on employees' subsequent work outcomes (such as psychological contract, work engagement, and organizational belonging). Given the reciprocal nature of resources in the work and family domains as described by the WH-R model, future studies could simultaneously examine how contextual resources in the work domain affect career sustainability and, conversely, how career sustainability impacts work-domain outcomes. This approach would provide a more comprehensive understanding of the interplay between these factors. Second, this study focuses on the role played by protean career orientation in the relationship between age-inclusive HR practices and work-family enrichment. There might be other potential contextual factors, for example, inclusive leadership (Carmeli et al., 2010; Javed et al., 2019) and macro culture, that will also moderate the effects of age-inclusive HR practices on employees' reactions. Third, the survey sample of this study is mainly for knowledge workers, and manual workers are not considered. There may be significant differences in career development and future expectations between knowledge workers and manual workers. Future research can further expand and test the conclusions of this study in a larger sample.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Beijing Institute of Petrochemical Technology. The studies were conducted in accordance with the local legislation and institutional requirements.

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Author contributions

LH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. RS: Formal analysis, Methodology, Validation, Writing – original draft. ZW: Writing – review & editing, Data curation, Investigation. JZ: Project administration, Supervision, Writing – review & editing.

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Conflict of interest

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

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