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Family function and health self-management ability among older adults from mountainous areas in China: moderated mediation model in a cross-sectional study

Jian-Hua Chen¹, Mei-Fen Chen², Norhasmah Mohd Zain³, Chee-Yeong Yap⁴, Azlina Yusuf³ and Bi-He Ying^{1*}

Abstract

Background Improving the health self-management ability (HSMA) of older adults is a feasible strategy for addressing population ageing and the high incidence of non-communicable diseases. Identifying psychosocial factors that facilitate better self-management of health is key to developing effective interventions. This study explored whether self-efficacy mediates the relationship between family function and HSMA and whether this mediation is moderated by personal income.

Methods A multicentre cross-sectional survey was conducted with 596 participants (response rate of 97.2%) in the mountainous Lishui region of China by using a multi-stage, stratified, cluster-sampling procedure. The survey included questions on sociodemographic characteristics, the Adult Health Self-Management Skills (Ability) Rating scale, family APGAR scale and General Self-Efficacy (GSE) scale. Data were analysed using descriptive statistics, Spearman's correlation, and multiple regression analysis with mediation and moderated mediation models.

Results The average score for HSMA, family function, and GSE were 149.6 ± 18.1 (out of 190), 8.2 ± 2.2 (out of 10), and 24.0 ± 6.0 (out of 40), respectively, which indicate moderate HSMA and family function levels and low GSE among older adults in Lishui. Significant correlations were observed between family function and GSE ($r_s = 0.150$, $P < 0.001$), GSE and HSMA ($r_s = 0.336$, $P < 0.001$), and family function and HSMA ($r_s = 0.297$, $P < 0.001$). The mediation model explained 21.5% of the variance in HSMA, with significant total (c : $B = 0.343$, $P < 0.001$) and indirect effects (ab : $B = 0.0505$, 95% CI = [0.0227, 0.0830]). The indirect effects (family function \rightarrow GSE \rightarrow HSMA) decreased with decreasing income (high income, $B = 0.0497$; middle income, $B = 0.0353$; low income, $B = 0.0233$), while the direct effect (family function \rightarrow HSMA) increased with decreasing income (high income, $B = 0.189$; middle income, $B = 0.270$; low income, $B = 0.350$).

Conclusion HSMA, APGAR score and GSE score were positively related among older adults in the Lishui region, highlighting potential areas for improvement. The results clarify the mediating effect of GSE on the relationship between family function and HSMA along with the moderating role of personal income. Strengthening family function may enhance HSMA, especially in low income older adults, while boosting GSE may benefit those with higher incomes. Future longitudinal studies should confirm these relationships and their causal direction.

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Keywords Community, Family function, Financial situation, General self-efficacy, Health self-management ability, Mountainous areas, The elderly

Introduction

The rate of population aging has intensified, particularly in developing nations. By 2050, approximately 80% of older people are projected to be living in low- and middle-income countries [1]. As an upper-middle-income country, China is witnessing one of the most rapid rates of population aging worldwide due to increased life expectancy, declining fertility rates, and effective control of infectious diseases [2]. The health conditions of older adults have become a global concern due to the rapidly aging population. According to the World Health Organization (WHO), approximately 75% of older adults suffer from noncommunicable diseases (NCDs), even with equal access to healthcare across all geographical areas in China [2]. However, hypertension is more common in rural regions of China than in urban areas [3]. Hypertension is an independent risk factor for cardiovascular diseases and the leading cause of disease burden [4]. Furthermore, inequality remains; disparities in the allocation of medical and health resources and health services between urban and mountainous regions have increased in China since 2007 [5, 6]. Such inequity is mainly caused by the area, policies and characteristics of regional populations [7], leading to stark disparities between older adults living in urban and mountainous regions. Enhancing the health self-management ability (HSMA) of older adults is a formidable task that is critical for coping with NCDs and improving quality of life (QoL). Health self-management behaviors (HSMBs) have been reported to be predictive of QoL [8, 9] and are the main components of HSMA [10]. However, few studies have focused on increasing HSMA among older adults in mountainous regions.

Older adults must take responsibility for managing their own health as their family structures become smaller. This matter is particularly critical for older adults living in mountainous regions, which suffer from inequity in health service resource allocation and have higher percentages of residents with low educational attainment and income [5–7], leading to the underutilisation of health care and poor health conditions. Additionally, factors such as general self-efficacy (GSE) [11, 12], living environment (e.g. family function, community-based health services, and social support), and individual economic factors (e.g. personal income and pension type) can influence health conditions in a region [13]. Good family function has been shown to benefit self-efficacy among older adults [14, 15], and improving GSE can

improve their HSMBs and health conditions [16, 17]. Most existing studies have examined various variables independently; as a result, the relationship between family function and HSMA is controversial [18]. The connections between family function, GSE and HSMA remain under-researched, with present research focusing primarily on the direct effects of family function and indirect effects of family function through GSE on HSMBs or consciousness in specific populations with NCDs. However, the mechanisms underlying the differences in HSMA among community-dwelling older adults with different family functions are incompletely understood, and whether similar effects exist in community-dwelling older adults from mountainous areas remains unclear. Additionally, most related studies focused on HSMA among older adults from urban municipalities [9, 12, 19, 20]; few studies focused on rural areas [21, 22], and evidence from mountainous regions is particularly limited.

Personal income, which is a significant indicator of socioeconomic status that is related to GSE [11] and family function [23], has been recognised as an independent factor that influences HSMA [24]. Personal income can also moderate subjective well-being among older adults [25]. Furthermore, unlike other socioeconomic (e.g. past occupation or education) and demographic (e.g. age or gender) characteristics, personal income can be adjusted among older adults through support from family members or government assistance. A moderated mediation mechanism may exist, in which the indirect effects of family function on HSMA through GSE vary according to the level of personal income. However, few studies have examined the moderating effects of personal income on the direct and indirect influence of family function on HSMA via GSE. In this study, we focused on older adults living in community dwellings in Lishui, a mountainous region in China. The aims of this study were to 1) investigate the level of family function, GSE and HSMA among these individuals; 2) determine the relationships between family function, GSE and HSMA; and 3) examine the direct and indirect effects of family function on HSMA via GSE, and whether personal income moderates these effects.

Health self-management ability, family function and general self-efficacy

HSMA refers to an individual's ability to maintain their health and contribute to society [10, 26]. It comprises

three components: health self-management environment (HSME), HSMB, and health self-management cognition (HSMC) [10]. The Adult Health Self-Management Skills (ability) Rating Scale (AHSMSRS) is a validated tool for assessing HSMA among urban-dwelling older adults in China [10]. Reported HSMA scores range from (153.60 ± 20.21) to (161.65 ± 23.16) in urban areas [12, 19] but are lower in rural populations, particularly among those with chronic diseases (131.25 ± 24.18) [21, 27]. However, little research has examined HSMA in older adults from mountainous regions.

Family function refers to the physical, emotional, and psychological interactions within a household that influence well-being [28]. Especially for older adults, family function is critical during the aging process and profoundly affects the life and health of older adults. For instance, it affects lifestyle behaviours such as nut intake [29], mental health [30], cognitive health [31], self-perception of aging [32], and QoL [33–35]. Strong family function enhances spiritual health [36], while dysfunction contributes to adverse outcomes [37]. Changes in family structure due to economic and societal shifts have increased dysfunction, affecting individuals and their families [38]. To meet the needs of development and public health services, nursing care has expanded to include both patients and families, with family function being increasingly emphasised [39]. The family APGAR scale, which is widely used to assess family function [40], has reported scores ranging from (6.11 ± 2.45) to (8.35 ± 0.14) among community-dwelling older adults [29, 31]. However, little research focuses on older adults in mountainous areas.

GSE, which is a key concept in social cognitive theory, reflects confidence in managing life challenges [41]. It influences coping strategies, health behaviors and functional outcomes [42]. Among community-dwelling older adults, GSE scores range from (21.55 ± 7.47) to (34.17 ± 7.5) [43]. Low GSE is associated with poorer health behaviors and higher healthcare utilisation [43]. Although studies have examined the link between GSE and family function in caregivers [44], early adolescents [45] and university students [46], research on older adults in mountainous areas remains scarce, despite GSE's recognized role in predicting health outcomes over time [47]. Therefore, GSE was considered a variable in this study.

GSE as a mediator

Individual and family self-management theory (IFSMT) [23] and GSE theory [41] provide a framework for understanding the relationships among family function, GSE and HSMA. IFSMT integrates individual and family factors, self-efficacy and social facilitation to explain health

behaviours and outcomes [23]. GSE, as part of IFSMT, plays a crucial role in self-management and health promotion [41]. Studies suggest that strong family function enhances self-efficacy [14, 15] and that higher GSE is associated with better self-management behaviors in older adults [16, 20]. However, causal links between GSE and HSMA remain underexplored, and inconsistencies exist with regard to the impact of family function on HSMA due to variations in participants' health conditions [18]. Some research suggests poor family function hinders self-care [48]. Given the complexity of HSMA, which involves cognition, behaviors, and the environment, its relationships with family function is particularly unclear among older adults in mountainous areas. While GSE has been proposed as a mediator between family function and HSMA [16]. Empirical evidence remains limited.

The moderating role of personal income

Personal income may moderate the relationship between family function, GSE and HSMA, aligning with IFSMT's context dimension [23] and GSE theory [41]. A study conducted in China revealed that income moderated the association between grandparenting and subjective well-being [25]. As an indicator of socioeconomic status, personal income influences family function [49], health outcomes [50] and self-efficacy in managing chronic conditions [51]. It may also buffer the impact of family function on HSMA, suggesting a moderated mediation model in which the indirect effects of family function on HSMA through GSE vary with income levels.

Given the statement above, the following hypotheses were proposed for this study (Fig. 1):

Hypothesis 1: Significant positive correlations exist between family function, GSE, and HSMA.

Hypothesis 2: GSE mediates the relationships between family function and HSMA.

Hypothesis 3: Personal income, as a moderator, strengthens the indirect relationship between family function and HSMA when GSE acts as a mediator.

Hypotheses 4: Personal income, as a moderator, decreases the direct relationship between family function and HSMA when GSE acts as a mediator.

Methods

Study design and participants

A cross-sectional study was conducted among community-dwelling older adults from Lishui, a mountainous region in China. Lishui, a prefecture-level city in the southwest region of Zhejiang Province (latitude: 28°N), is renowned as a 'health-preserving land and hometown of longevity'. The ageing population in Lishui is largely due

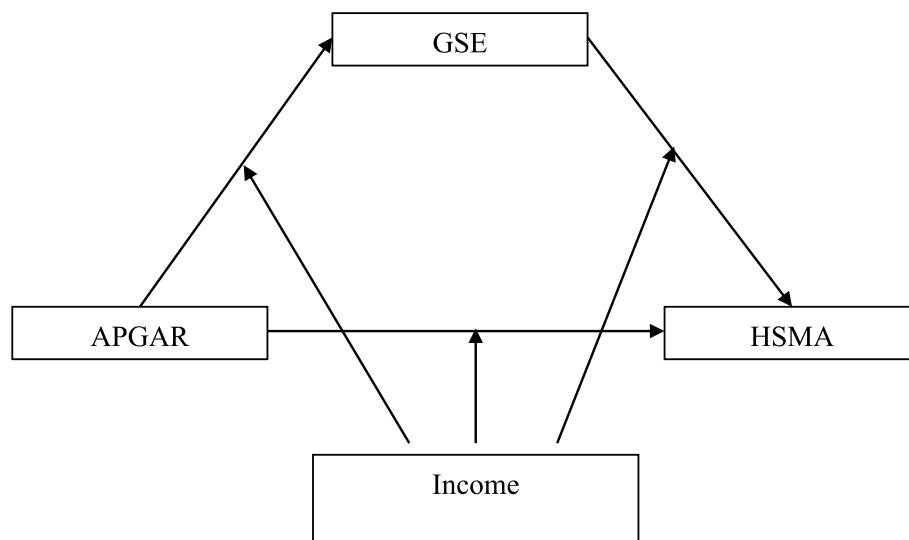


Fig. 1 Hypothesis: A Moderated mediation model between APGAR and HSMA mediated by GSE, and all associations were moderated by income. APGAR = Family function; GSE = General self-efficacy; HSMA = Health self-management ability

to the extended life expectancy in this region. Additionally, the proportion of the ageing population is higher in rural than in urban areas. The proportion of the ageing population in Zhejiang Province was 18.7%, which was much lower compared with 21.24% of adults aged 60 years old and above living in the mountainous areas of Lishui within the same province [52, 53].

However, despite being located in Zhejiang, which is a developed and prosperous province in China relative to other areas, Lishui has a low level of economic development, leading to relatively low personal income for residents. Socioeconomic vulnerability is pronounced in Lishui; the China Health and Retirement Longitudinal Study revealed that the vast majority (93.32%) of rural older adults lack upper secondary education [54]. Thus, as depicted in Fig. 2, the research area of this study is confined to Lishui to better reflect the characteristics of community-dwelling older adults in the mountainous region.

A multicentre, multi-stage, stratified, cluster sampling procedure was employed to account for the geography of the area. Liandu District is the administrative, political, economic and cultural centre of Lishui and is considered a city; one county-level city (Long Quan City) and seven other counties are considered counties (or non-urban). A total of nine counties and cities were selected as the research settings by using a non-random process. Communities were then randomly selected in each of the nine cities/counties. Finally, older adults living in community dwellings were selected through random cluster sampling. In this study, ‘community-dwelling’ refers to individuals who live independently

in a residential community setting (e.g. their own home or family homes) and participate in local activities without requiring institutionalized care (e.g. nursing homes, hospitals, departments or long-term care facilities). This term distinguishes populations on the basis of their living arrangements and care needs, which is similar to a previous study [55, 56].

The sample size was calculated using the following formula: $n = \frac{Z_{1-\alpha/2}^2 SD^2}{d^2}$ [57] based on a previous study [58], where n is the sample size; $Z_{1-\alpha/2}$ is the standard normal variance (at 5% type 1 error, $P < 0.05$), which was 1.96 in this study; and SD is the standard deviation, which was 20.2% [58]; d is the absolute error for a precision of 5% and a type 1 error of 5%. Hence, the sample size n was determined as 63. Considering a non-investigation rate of approximately 5%, a total of 66 participants was needed. The research setting covered the entirety of Lishui, which contains nine counties and cities (Fig. 2). Thus, a total of $66 \times 9 = 594$ participants were needed to ensure the representativeness of participants and avoid bias. A total of 613 older adults were enrolled, and 17 were excluded (three did not meet the inclusion criteria; four were excluded on the basis of the exclusion criterion; and 10 had incomplete data). A total of 596 participants responded to and completed all items in the survey, corresponding to a response rate of 97.2%.

The inclusion criteria were as follows: (1) aged 60 years and above and retired at home; (2) resided in the local community for at least 1 year; (3) not diagnosed with a severe disability or severe dementia; (4) has the ability to express and comprehend simple Chinese characters; (5) has the ability to understand and respond to the

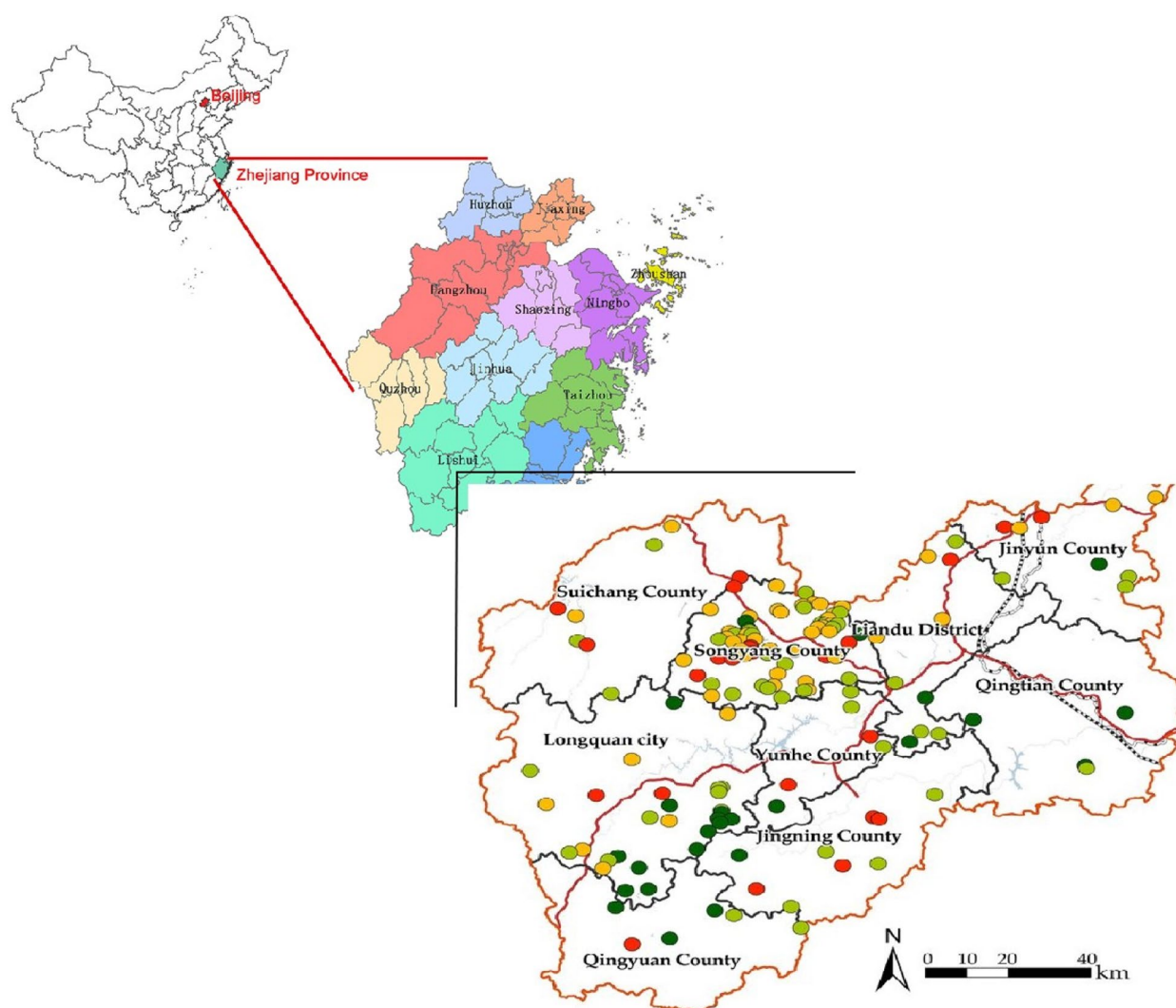


Fig. 2 A map of Lishui contains Liandu District, one county-level city and seven counties

questions on the survey and willing to participate in the study; and (6) signed informed consent documents. The exclusion criteria were (1) a medical history of chronic alcoholism or brain trauma; (2) hearing impairment; (3) speech impairment; (4) cognitive impairment and inability to understand or respond to the questions; (5) severe mental illness; (6) severe or terminal illness; and (7) housed in nursing homes or unwilling to participate in the study.

Measurements

The Adult Health Self-Management Skills (ability) Rating Scale (AHSMSRS-38) was used to assess HSMA. This scale, which was developed by Zhao and Huang at the Harbin Medical University School of Nursing in China [10], employs a five-point Likert scale for 38 items across the following three dimensions: HSMB, HSME,

and HSMC. The score ranges from 38–190, with higher scores indicating better HSMA [10]. The total AHMSRS-38 scores were classified into three levels: low (38–76 points), medium (77–152 points), and high (153–190 points) [59]. This scale demonstrated a Cronbach's alpha of 0.93 and content validity of 0.90 [10]. The AHMSRS-38 is reliable for use among older Chinese community-dwelling adults in urban and rural areas [10, 26].

Family function was evaluated using the family APGAR instrument [40], which consists of five items: adaptation (A), partnership (P), growth (G), affection (A), and resolve (R). Each item has three possible responses from 0 to 2 scores (0=hardly ever, 1=sometimes, and 2=almost always). The total scores range from 0 to 10 and indicate the level of satisfaction with family function, with a higher score reflecting a greater level of satisfaction. Total scores of 0–3, 4–7 and 8–10 indicate severe, moderate,

and positive family functions, respectively [33]. The Chinese version of the scale demonstrated Cronbach's alpha values ranging from 0.55–0.91 for individual items and 0.73 overall [60]. The family APGAR scale has been validated as a reliable tool for using among older individuals, particularly those residing in rural areas [61].

General self-efficacy (GSE) was measured using the 10-item single-dimension scale [42]. The alternatives use a four-point response scale (1 = not at all, 2 = hardly true, 3 = moderately true, and 4 = exactly true). A higher score indicates greater self-efficacy. The Chinese version of the scale has demonstrated good construct validity in community-dwelling Chinese soon-to-be-aged adults, with a reported Cronbach's alpha of 0.89 [62].

Other variables

Additional variables considered in this study included sociodemographic characteristics such as age, gender, education, past occupation, marital status, personal income, living arrangement, and history of chronic illnesses. By responding to 'yes/no' questions, participants indicated whether they had chronic diseases during the research period, with the option to specify hypertension or other diseases. The self-reported chronic diseases were cross-verified with registered medical practitioners from class II grade A or above hospitals.

Data collection

Data collection was conducted from July to September 2019 by a survey team comprising one principal investigator (PI) and eight research assistants. To ensure interrater reliability, the PI provided training to the survey team on the questionnaire content and survey techniques. Prior to the data collection, the PI contacted leaders of the selected communities in Lishui to obtain permission to conduct the study. Additionally, all older adults in these areas were informed one day in advance about the research team's visit. The survey team then visited the selected communities to identify potential participants. Individuals were screened for their eligibility before being briefed on the study's purpose and procedures. All participants were informed that participation was voluntary and anonymous, and they were assured that confidentiality would be maintained. After their written consent was obtained, the participants completed a self-administered questionnaire. Research assistants assisted the participants with low literacy levels or poor vision by reading the questions aloud and recording the participants' responses. The completed questionnaires were subsequently reviewed and collected by the surveyors.

Data analysis

Descriptive statistics were used to summarise the sociodemographic characteristics of the participants. The

normality of the distribution of data was checked using the Shapiro–Wilk test; the assumption of normality was met for HSMA but not for family function or GSE, necessitating the use of multiple methods. Reliability estimates were calculated using Cronbach's alpha. T-tests and Mann–Whitney U tests were performed to explore urban and county differences in HSMA, family functions, and GSE. Spearman's correlation analyses were also conducted to determine the correlations between variables. The significance level was set at $P=0.05$ for all analyses. Finally, multiple regression analyses were conducted [63] to test the mediating effect of GSE on the relationship between family function and HSMA. As recommended by Hayes [63], independent mediation analyses were performed when conducting mediation analyses with multiple variables. Family function was introduced as the independent variable (X), while GSE was the mediating variable (M), and HSMA was the dependent variable (Y). The analysis tested the associations between family function and GSE (path a), between GSE and HSMA (path b), and between family function and HSMA (path c , also called 'total effects') after controlling for covariation. The direct effects of family function on HSMA were computed after controlling for GSE and other covariates (c' path). The indirect effects were tested with bias-corrected bootstrapping ($n=5000$) for a 95% confidence interval (CI). The effect size of the mediated relationship was estimated as the completely standardized direct and indirect effects (Ccs) [63]. In moderated mediation analyses, the previous covariables remained in the model, and personal income was introduced as the moderator (W). All analyses were performed using IBM SPSS software 26.0. The mediation model (Model 4) and the moderated mediation model (Model 59) were tested using PROCESS macro v.4.2 [64].

Results

Demographic characteristics

A total of 596 participants from nine cities/counties completed all items of the questionnaire. The participants ranged in age from 60 to 99 years, with an average of 71.63 years ($SD=7.15$), and 328 (55%) participants were female. Educational attainment was primary school or below for 68.1% ($n=406$) of the participants, while 31.9% ($n=190$) completed junior high school or above. About 54.0% ($n=322$) of the participants were primarily employed as farmers, 72% ($n=433$) were married and 23.9% ($n=143$) were widowed. With regard to income, 37.4% ($n=223$) reported an average personal monthly income of less than 500 RMB, 18.5% ($n=109$) reported 1001–2000 RMB, and 14.4% ($n=86$) reported more than 4001 RMB. The primary sources of income for older adults were retirement pensions (33.2%), old-age

pensions (32.2%), and offspring (11.7%). Most participants (68.8%, $n=410$) were empty-nesters (those who lived alone or only with their spouse). The majority of the participants resided in county areas (84.4%; $n=503$), and 15.6% ($n=93$) resided in the city (Liandu District). The demographic characteristics are summarised in Table 1. Significant differences were observed in the total scores of HSMA among community-dwelling older adults

Table 1 Socio-demographic characteristics of the participants ($n=596$)

| Variables | | n (%) / Mean \pm SD |
|-------------------------|----------------------------------|-----------------------|
| Age | | 71.63 \pm 7.15 |
| Gender | Male | 268 (45.0) |
| | Female | 328 (55.0) |
| Education | Illiterate | 177 (29.7) |
| | Primary school | 229 (38.4) |
| | Junior high school | 109 (18.3) |
| | Senior high school | 65 (10.9) |
| | College and above | 16 (2.7) |
| Past Occupation | Farmer | 322 (54.0) |
| | Worker | 112 (18.8) |
| | Government-sponsored institution | 60 (10.1) |
| | Individual freelancer | 34 (5.7) |
| | Soldier | 9 (1.5) |
| | Others | 59 (9.9) |
| Marital status | Married | 433 (72.7) |
| | Unmarried | 10 (1.7) |
| | Divorce | 10 (1.7) |
| | Widowed | 143 (23.9) |
| Personal income/monthly | 500 RMB or less | 223 (37.4) |
| | 501 ~ 1000 RMB | 29 (4.9) |
| | 1001 ~ 2000 RMB | 109 (18.3) |
| | 2001 ~ 3000 RMB | 80 (13.4) |
| | 3001 ~ 4000 RMB | 69 (11.6) |
| | 4001 or more RMB | 86 (14.4) |
| Major source of income | Retirement pension | 198 (33.2) |
| | Old-age pension | 191 (32.2) |
| | Offspring | 70 (11.7) |
| | Lowest living security | 12 (2.0) |
| | Others | 52 (8.7) |
| | No source | 73 (12.2) |
| living arrangement | Living alone | 79 (13.3) |
| | With spouse | 331 (55.5) |
| | With children | 177 (29.7) |
| | Others | 9 (1.5) |
| Disease condition | No disease | 243 (40.8) |
| | Hypertension | 239 (40.1) |
| | Other diseases | 114 (19.1) |
| Place of residence | City areas | 93 (15.6) |
| | County areas | 503 (84.4) |

from county (151.23 ± 17.69) and city (Liandu District [140.78 ± 18.03]) areas in Lishui ($P < 0.05$). No significant differences were observed in the total scores of family function, GSE, age group and medical insurance between participants from the county and city areas in Lishui ($P > 0.05$).

HSMA, family function, and GSE scores

The HSMA, family function, and GSE scores are summarised in Table 2. The HSMA score among older adults in this study was 149.6 (SD=18.1), ranging from 93–190. Among the participants, 45.3% ($n=270$) showed high HSMA, while 54.7% ($n=326$) had medium HSMA. No participants had low HSMA scores. The total family function score (Md=9, Q1=7, Q3=10) was slightly higher than the average of the possible range for this scale (7–10). Approximately 69.5% ($n=414$) of the participants had positive family function on the basis of the family APGAR score, while moderate and severe family dysfunction was respectively indicated in 26.8% ($n=160$) and 3.7% ($n=22$) of the population. The GSE score (Md=24, Q1=20, Q3=28, M=24.0, SD=6.0) was close to the average of the possible range for this score (10–40). Only 2 participants (0.3%) achieved the highest possible total score of 40, and 3 participants (0.5%) received the lowest possible total score of 10.

Correlation analysis

As shown in Table 2, significant positive correlations were observed between the family function and GSE scores ($r_s=0.150$, $P < 0.001$), GSE and HSMA scores ($r_s=0.336$, $P < 0.001$), and family function and HSMA scores ($r_s=0.297$, $P < 0.001$) of older adults in this study. Significant positive correlations were also found between personal income and GSE ($r_s=0.249$, $P < 0.001$) and between personal income and HSMA ($r_s=0.304$, $P < 0.001$). A small but significant positive correlation was found between personal income and family APGAR scores ($r_s=0.130$, $P < 0.01$).

Mediating effect of GSE

Figure 3 presents the mediation analysis results for Hypothesis 2, which postulates that the relationship between the family function (APGAR score) and HSMA is mediated by GSE. According to the model constructed on the basis of Hypothesis 2, the total effect of APGAR score on HSMA was statistically significant (path c : $B=0.343$, $p < 0.001$), and 21.5% of HSMA could be explained by this model (Table 3). The indirect effect of APGAR score on HSMA through GSE was also statistically significant (path ab : $B=0.0505$, 95% CI = [0.0227, 0.0830]). These results support Hypothesis

Table 2 Correlation coefficients (Spearman's rho) between family function (APGAR), GSE, HSMA total scores (TS) and factors, and personal income monthly and age, both M(SD) and Md (Q1; Q3) of the variables

| Variables | APGAR | GSE | HSMA-TS | Income | Age | M (SD) | Md (Q1; Q3) |
|-----------|----------|----------|-----------|--------|-----|--------------|-----------------|
| - APGAR | 0.820 | | | | | 8.2 (2.2) | 9 (7;10) |
| - GSE | 0.15*** | 0.907 | | | | 24.0 (5.9) | 24 (20;28) |
| HSMA-TS | 0.297*** | 0.336*** | 0.905 | | | 149.6 (18.1) | 151 (137;161.8) |
| Income | 0.130** | 0.249*** | 0.304*** | - | | 3.0 (1.9) | 3 (1;5) |
| Age | 0.049 | -0.120** | -0.151*** | -0.054 | - | 71.6 (7.2) | 71 (66;76) |

Cronbach's alpha values are shown in the diagonal, *APGAR* Family function, *GSE* General self-efficacy, *HSMA-TS* Health self-management ability total score, income: 1 = less than 500RMB, 2 = 501-1000RMB, 3 = 1001-2000 RMB, 4 = 2001-3000 RMB, 5 = 3001-4000RMB, 6 = 4001 and more RMB

Abbreviations: *M* Mean, *SD* Standard deviations, *Md* Median, *Q* quartile

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

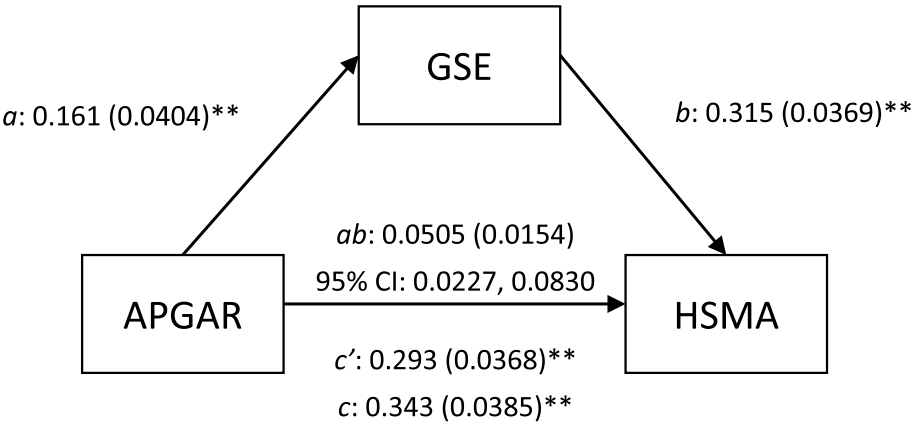


Fig. 3 Mediation effects of GSE on the relationship between APGAR and HSMA; results were presented in the form of B (SE); ** $p < 0.001$. CI: confidence interval. APGAR = Family function; GSE = General self-efficacy; HSMA = Health self-management ability

Table 3 Mediating effect of GSE on the relationship between APGAR and HSMA score

| | | | | | |
|-----------------------------------|--------|--------|--------------|--------------|---|
| GSE | | | | | |
| | B | SE | <i>t</i> | <i>p</i> | <i>R</i> ² / <i>F</i> / <i>p</i> |
| APGAR (<i>a</i>) | 0.161 | 0.0404 | 3.972 | < 0.001 | 0.0259/15.776/ < 0.001 |
| constant | 0.001 | 0.0404 | 0.0204 | 0.984 | |
| HSMA | | | | | |
| | B | SE | <i>t</i> | <i>p</i> | <i>R</i> ² / <i>F</i> / <i>p</i> |
| APGAR (direct effect, <i>c'</i>) | 0.293 | 0.0368 | 7.95 | < 0.001 | 0.215/81.065/ < 0.001 |
| GSE (<i>b</i>) | 0.315 | 0.0369 | 8.538 | < 0.001 | |
| Indirect effect (<i>ab</i>) | 0.0505 | 0.0154 | LLCI: 0.0227 | ULCI: 0.0830 | |
| Total effect (<i>c</i>) | 0.343 | 0.0385 | 8.922 | < 0.001 | |
| constant | 0.001 | 0.0364 | 0.0151 | 0.988 | |

Analysis conducted in PROCESS model 4, *N* = 596

APGAR Family function, GSE General self-efficacy, HSMA Health self-management ability

2 by demonstrating that GSE mediated the relationship between APGAR score and HSMA. Statistically significant associations were also found between APGAR score and GSE (path *a*: $B = 0.161$, $P < 0.001$) and between GSE and HSMA (path *b*: $B = 0.315$, $P < 0.001$). The positive associations among APGAR, GSE, and HSMA imply that higher APGAR scores are associated with higher GSE and, consequently, greater HSMA.

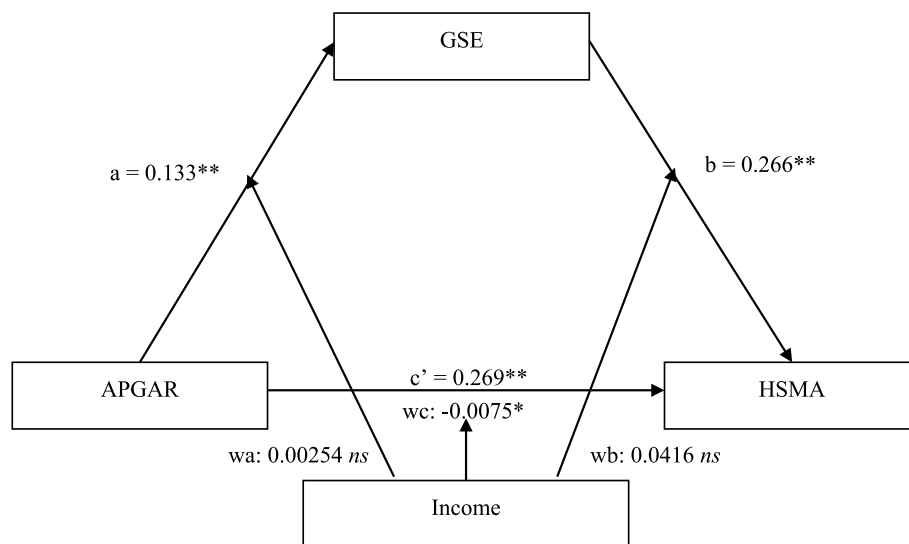


Fig. 4 Moderated mediation model between APGAR and HSMA mediated by GSE, and all associations were moderated by income; * $p < 0.05$; ** $p < 0.001$; *ns* = not significant. APGAR = Family function; GSE = General self-efficacy; HSMA = Health self-management ability

Table 4 Mediating effect of GSE on the relationship between APGAR and HSMA moderated by income

| GSE | | | | | |
|---------------------|----------|--------|---------|---------|------------------------|
| | B | SE | t | p | R ² /F/p |
| APGAR (a) | 0.133 | 0.0397 | 3.356 | < 0.001 | 0.0859/18.555/ < 0.001 |
| Income | 0.245 | 0.0396 | 6.199 | < 0.001 | |
| APGAR x Income (wa) | 0.0254 | 0.0391 | 0.648 | 0.517 | |
| constant | -0.00230 | 0.0395 | -0.0582 | 0.954 | |
| HSMA | | | | | |
| | B | SE | t | p | R ² /F/p |
| APGAR (c') | 0.269 | 0.0361 | 7.447 | < 0.001 | 0.259/41.272/ < 0.001 |
| GSE (b) | 0.266 | 0.0371 | 7.170 | < 0.001 | |
| Income | 0.200 | 0.0370 | 5.399 | < 0.001 | |
| APGAR x Income (wc) | -0.0750 | 0.0360 | -2.085 | 0.0375 | |
| GSE x Income (wb) | 0.0416 | 0.0369 | 1.127 | 0.260 | |
| constant | -0.00120 | 0.0367 | -0.0338 | 0.973 | |

Analysis conducted in PROCESS model 59, N = 596

APGAR Family function, GSE General self-efficacy, HSMA Health self-management ability

Moderating effect of personal income

Figure 4 and Table 4 illustrate the results of the moderated mediation analysis between family function (APGAR score) and HSMA, as mediated by GSE and moderated by personal income. In this model, the moderating effect of income (*wc*) on the direct path (*c'*) between APGAR score and HSMA ($B = -0.0075$, $P = 0.0375$) was statistically significant. However, the moderating effects of income on the paths between APGAR score and GSE (*wa*) and between GSE and HSMA (*wb*) were not statistically significant ($B = 0.00254$, $P = 0.517$ and $B = 0.0416$, $P = 0.260$,

respectively), suggesting that income does not meaningfully moderate these relationships.

Table 5 provides further details on the conditional direct and indirect effects of APGAR on HSMA, as moderated by income. The conditional indirect effects through GSE were statistically significant in the middle- and high-income groups and increased in magnitude as the income level increased. Specifically, for middle-income participants, the conditional indirect effect was $B = 0.0353$, with a 95% confidence interval of [0.0124, 0.0622]; for high-income participants, the indirect effect increased to $B = 0.0497$ with a 95% CI of [0.0108, 0.0990].

Table 5 Conditional direct and indirect effects of APGAR on HSMA through GSE

| Effects | Moderator | B | SE | 95% CI | |
|--------------------------|---------------|--------|--------|---------|--------|
| | | | | Lower | Upper |
| Direct effects: | | | | | |
| APGAR → HSMA | Low-income | 0.350 | 0.0505 | 0.251 | 0.449 |
| | Middle-income | 0.270 | 0.0361 | 0.199 | 0.340 |
| | High-income | 0.189 | 0.0551 | 0.0807 | 0.297 |
| Indirect effects: | | | | | |
| APGAR → GSE → HSMA | Low-income | 0.0233 | 0.0142 | -0.0014 | 0.0541 |
| | Middle-income | 0.0353 | 0.0127 | 0.0124 | 0.0622 |
| | High-income | 0.0497 | 0.0221 | 0.0108 | 0.0990 |

The values of the moderator are the 16th, 50th, and 84th percentiles

APGAR Family function, GSE General self-efficacy, HSMA Health self-management ability

In contrast, the indirect effect for low-income participants was not statistically significant ($B=0.0233$, 95% CI $[-0.0014, 0.0541]$), as indicated by the inclusion of zero in the confidence interval. These results indicate that the mediating role of GSE strengthens with increasing income. However, the lack of statistical significance for low-income participants reflects variability in the relationship at this level.

The conditional direct effects, as moderated by income, follow a different pattern. These effects became weaker as income increased. The direct effect was strongest for low-income participants ($B=0.350$, 95% CI $[0.251, 0.449]$) and weakest for high-income participants ($B=0.189$, 95% CI $[0.0807, 0.297]$), with a moderately strong direct effect observed for middle-income participants ($B=0.270$, 95% CI $[0.199, 0.340]$). Although this trend is consistent with the hypothesis, an important detail to note is that the confidence intervals for these conditional direct effects overlap substantially across income levels, suggesting that the differences in these effects between income groups may not be statistically significant. This overlap highlights the need for caution when interpreting these findings as evidence of clear differences across income levels.

Overall, the results partially support Hypothesis 3 by showing that the indirect effect of APGAR score on HSMA through GSE strengthens as income increases. However, this support is incomplete because the indirect effect was not statistically significant for the low-income group, and the moderating effects on paths a and b (wa and wb) were non-significant. In contrast, Hypothesis 4 is supported by the statistically significant moderating effect (wc) on the direct path, that is, the direct effect of APGAR score on HSMA became weaker with increasing income. These findings suggest a shifting dynamic in the relationships: As income level increases, the predictive direct effect of APGAR score on HSMA weakens,

while the mediating role of GSE strengthens. However, the overlapping confidence intervals across income levels underscore the need for careful interpretation and caution with regard to any significant differences in these effects.

Discussion

HSMA, family function, and GSE

To the best of our knowledge, this work is the first multicentre cross-sectional study that covers both the cities and counties of Lishui to investigate HSMA, family function, and GSE among community-dwelling older adults in the mountainous regions of China. The results indicate moderate HSMA and family function levels along with low GSE in this region. These HSMA levels align with a previous study [58] but are inferior to those of community-dwelling older adults in Hangzhou, the capital city of Zhejiang Province, China [19]. These differences might be attributed to the characteristics of the study participants. Compared with the participants from Hangzhou [19], the participants in this study had lower educational levels (Lishui vs. Hangzhou: primary school or below, 68.1% vs. 49.5%; junior high school and above, 31.9% vs. 50.5%), lower incomes (personal monthly income ≤ 2000 RMB, 60.1% vs. 16.6%), and a greater proportion of low-skill past occupation (e.g., farmer, 54.0% vs. 17.0%). The low educational attainment and low-skill past occupations of Lishui residents may hinder their ability to access health-related information and understanding ability and limit their health self-management attitudes, cognition and interpersonal interaction skills, leading to their poor HSMA. Meanwhile, poor economic conditions could hinder access to health services and lead to poor HSMA [24]. All these factors likely contribute to poor HSMA in the later stages of life.

The family function levels in this study were moderate, with the average family APGAR score surpassing that reported for older adults with coronary heart disease in Lanzhou City, the capital city of Gansu Province in China [33]. The APGAR scores in this study also align with reports from Mexico [35] and urban China [32]. In this study, 69.5% of participants reported positive family function, which was higher than the 47.8%–53.1% range reported for nonagenarians and centenarians [21] or residents with coronary heart disease [33] in other Chinese cities. However, it is lower than the percentages reported in India (76.1%) [30], Brazil ($> 80.0\%$) [31], and Chengdu and Handan in China (90.8%–92.6%) [32, 29]. In our study, 3.7% of individuals exhibited severe family dysfunction, which falls within the range of 0.7%–18.8% reported in China [21, 29, 33]. These findings indicate that the family functions of community-dwelling

older adults have been modified by the rapid migration of labour from rural to urban areas combined with the shrinking family structure in China, including the mountainous regions.

The GSE scores in this study were remarkably low, falling short of the scores reported for community-dwelling older adults from various locations, including China [43], Norway [11], and Hebei and Shandong Provinces in China [65, 66]. Notably, only 0.3% of participants in this study received the highest possible total GSE score of 40, which is less than the percentage reported in a related study (2.8%) [11]. The low GSE level may be attributed to the participants' age; our findings showed that GSE scores decreased with increasing age, which is consistent with previous studies conducted in Norway [11] and Shanghai, China [67]. The low GSE scores may also be related to the low education level in the study region. All participants resided in a mountainous rural region, with primary school being the highest educational level attained by 68.0% of participants, which likely contributed to the low GSE levels. Similarly, other studies found that higher GSE is associated with higher education and urban residency [68]. Given the importance of GSE in QoL [68], the findings indicate that more attention should be given to the GSE of older adults residing in mountainous regions at different stages of life.

Positive relationships between family function, GSE, and HSMA and the influence of personal income

Positive relationships were found between the three variables (family function, GSE, and HSMA) and personal income in this study, consistent with self-efficacy theory [41], thereby supporting the IFSMT [23] and the multiple sclerosis self-management model [69]. These models address the effect of personal and situation (specific) on the individual's confidence, ability and the relationships between the individual and their situations. These findings indicate that family function, GSE, personal income, and HSMA have a positive interaction. In older adults, high personal income levels are beneficial for family function and positively influence GSE and HSMA, consistent with previous studies [70, 49] that found that income conditions 1) considerably influence the lives of individual family members, ensuring access to a variety of food and enabling them to positively change old habits to access health services; 2) help predict personal characteristics and health conditions; 3) can enhance individuals' motivation and confidence; 4) influence personal self-management ability and health conditions; and 5) are associated with better family function, which reflects better adaptation and partnership; promotes growth, affection and resolve; and helps enhance their satisfaction and happiness.

Additionally, positive relationships exist between personal income and family function, which aligns with a related study [49]. This condition might be explained by the high percentage of participants with low personal income and moderate family function in this study, in addition to societal changes such as population ageing, urbanisation and shifting birth rates along with shrinking family structures. The discrepancy between ideals and lived experiences, particularly in the postmodern context, exacerbates family system dysfunction [38]. Older adults, particularly those who live in mountainous areas, have low-income levels and live with chronic diseases, may struggle to cope with societal changes. More family support is needed in daily living activities, especially for older adults with disabilities [71]. However, in this study, all participants who resided in communities did not have disabilities, which may have contributed to the relatively weak association between personal income and family function.

In this study, the GSA score, HSMA score, and personal income decreased with increasing participant age; the same trend was not observed for family function, consistent with previous studies [11, 24, 72, 73]. These findings demonstrate that confidence and ability (e.g. HSMA) decrease among older adults as they age. Support from the external environment (e.g. family function) might help mitigate these decreases. Theories such as self-efficacy theory [41] and situation-specific theory [23] could be improved by incorporating an understanding of how age affects self-efficacy, HSMA, family function and personal income. Consequently, an urgent task is to identify additional external support (e.g. family, community, and social assistance) to mitigate the negative effects of increasing age among older adults, especially those with low income and low self-efficacy, weak family function and/or poor HSMA.

Mediating effect of GSE

The findings of this study confirm the critical mediating mechanism of GSE, which might explain why community-dwelling older adults with good family function display enhanced HSMA. These results were supported by situation-specific theory [23] and self-efficacy theory [41] and aligned with previous studies on the mediating role of GSE [15, 16] among community-dwelling older adults with chronic diseases. This study further highlights the vital role of GSE in promoting HSMA and emphasizes the need for interventions aimed at improving family function to enhance HSMA. Such interventions must also account for the GSE level among community-dwelling older adults, in line with previous reports [14, 70]. Improved GSE can benefit HSMA among older adults, consistent with related studies [16, 17]. GSE reflects an

individual's confidence in their capabilities and personality traits [46], including self-competence. Thus, GSE is pivotal for successful aging and fosters HSM behaviors among older adults. GSE incorporates four key sources of information: prior experiences in health self-management; vicarious experience or observation of others in the HSME; verbal persuasion; and physiological information from HSMC and HSMB. HSMA, in turn, represents the ability of an individual to promote their psychological health and foster harmonious development within living contexts and society [58]. This multidimensional, complex phenomenon affects both individuals and their living environment (family, community, and others) across all developmental stages [23]. Family function, which is a crucial individual and social environmental factor, influences HSMA along with its components (HSMC, HSMB and HSME), especially in mountainous regions of China, in alignment with previous studies [74]. Consequently, intervention strategies that incorporate GSE may be suitable for multidimensionally improving HSMA among older adults.

Moderating effects of personal income

In this study, personal income moderated the indirect effect of family function on HSMA through GSE; however, the effect was significant for middle and high income levels only, in alignment with related studies [49–51]. These findings suggest that interventions to improve HSMA by targeting GSE may be less effective among older adults with low personal income; in contrast, alternative intervention strategies such as health promotion and disease management programs could help foster GSE among those with higher income levels. Health care professionals should develop effective strategies to enhance HSMA among older adults in consideration of their circumstances, particularly for those with low-income levels.

This study demonstrated that personal income moderates the direct effects of family function on HSMA, consistent with related studies [70, 49, 75]. Personal income, as a socioeconomic indicator, plays a complex role in family function. A strong family function can mitigate the effects of low-income levels on HSMA. In contrast, the effect of family function is diminished for individuals with middle and high income levels. This observation aligns with a previous study conducted in rural western China, which found that older adults with disabilities that affected their daily activities often received economic support from their families [76]. Higher income was shown to improve health outcomes in this population by increasing access to medical appointments. This trend was observed in both developing and developed countries [75, 76]. Conversely, lower-income individuals make

greater use of family support [18, 51], suggesting that family function might be a main factor that influences HSMA by moderating and mitigating the negative effects of low income. Given these findings, promoting GSE and focusing on family function and support, especially for older adults with low income levels in mountainous areas, might be an effective strategy for enhancing HSMA among older adults.

Strengths and Limitations

This study examines both mediating and moderating effects within a single model, revealing the intricate mechanisms through which family function, GSE and personal income collectively affect HSMA among community-dwelling older adults in a mountainous region. The hypotheses tested in this study are grounded in well-established theories, leading to clear justification for the associations being investigated. Moreover, we applied advanced statistical methods instead of traditional mediation analysis to investigate whether the direct and indirect effects were moderated. The participants for this multicentre cross-sectional study were randomly selected from nine cities and counties in the mountainous region of Lishui. Approximately 68.1% of the participants were older adults with a primary school education or lower, and the mean age was 72 years. These demographic characteristics reflect the key characteristics of older adults in mountainous regions. The findings of this study enhance our understanding of how family function affects HSMA with GSE as a mediating factor and personal income as a moderating factor. The findings also clarify the circumstances in which these associations are the strongest, thereby highlighting potential strategies for targeted interventions.

Several limitations of this study must be considered. Firstly, its cross-sectional design meant that we had to rely solely on self-reported measures and could not elucidate the temporal sequence of the independent variables, mediators and dependent variables. This approach could not establish causal links and may have introduced biases based on, for example, social desirability. Future longitudinal and experimental studies are needed to better comprehend the causal relationships between family function, GSE, personal income and HSMA among community-dwelling older adults in mountainous regions. For the moderated mediation analysis, several limitations should be acknowledged. Firstly, the non-significant moderation effects on certain paths (e.g. APGAR to GSE) suggest that income may not fully capture the contextual factors that influence these relationships; other potentially important moderators such as education and cultural context were not considered. Secondly, the overlap of confidence intervals across income levels indicates

a lack of clear distinctions between groups, resulting in weak conclusions about the moderating role of income. This situation highlights the need for greater statistical power or refined group definitions in future research. Furthermore, the results may not be generalizable to a clinical population of older adults because of the non-clinical sample. Finally, although we accounted for several significant covariates, other confounding factors, such as context-cultural ones, that were not considered in this study may exist.

Conclusion

This study confirmed the positive relationships between family function, GSE, HSMA and personal income among older adults. Family function was positively correlated with HSMA, and this association was significantly mediated by GSE and moderated by personal income. As personal income increased, the predictive effect of family function on HSMA became weaker, while the mediating effect of GSE on the relationship between family function and HSMA became stronger. The results underscore the potential moderating effects of personal income on the associations among family function, GSE and HSMA. The findings suggest that interventions aimed at improving HSMA could target family function among older adults with low personal income and GSE among those with moderate or high personal income. In addition, these paths and relationships should be verified before interventions are designed to investigate them in further studies.

Abbreviations

| | |
|---------|--|
| HSMA-TS | Health self-management ability total score |
| HSM-C | Health self-management cognition |
| HSM-E | Health self-management environment |
| HSM-B | Health self-management behaviours |
| GSE | General self-efficacy |
| APGAR | Family function |

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Author's contributions

JHC, MFC, Mohd Zain N, CYY, Yusuf A and BHY*. JHC, MFC and BHY contributed to designing the project and data collection. JHC, CYY, Mohd Zain N and BHY performed the statistical analyses. JHC, MFC, BHY CYY and Mohd Zain N and Yusuf A drafted the manuscript, and all participated in the interpretation of results. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Review Committee of Lishui University (No. 2023YD001). All methods were carried out under relevant guidelines and conducted in accordance with the Declaration of Helsinki. All participants took part in this study voluntarily, covered by informed consent, and gave their written consent.

Consent for publication

No application.

Competing interests

The authors declare no competing interests.

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