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Examining the impact of Co-residence with a daughter-in-law on older adult health in China: Evidence from a frailty index-based study

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ABSTRACT

Background: The increasing geriatric population and variation in the disease spectrum among older adults in China contribute to a growing demand for more aged adult care in Chinese society. Relevant studies have shown that living arrangements with various family members have variable impacts on the older adult's health. This study employs the Frailty Index as a unified measurement standard to assess the overall health levels, integrating the specific "in-law relationships" into the research on living arrangements and the health of older adults.

Methods: This study used data from the China Longitudinal Aging Social Survey 2016–2018. OLS and Quantile Regression were used to investigate the in-law relationship on older adult health and whether this impact is homogeneous across older individuals with varying infirmity levels. The study used a lag model and propensity score matching to compensate for potential endogeneity concerns.

Results: The study found that residing with a daughter-in-law (20.22%) had a significant positive correlation with the frailty index (β=0.0088, $P < 0.001$), indicating that the relationship between parents-in-law and daughters-in-law can influence the health of the older adult. This impact is nonlinear and non-homogeneous for older adult people with various levels of frailty, exhibiting an approximately decreasing and then increasing U-shaped distribution, which denotes that older adult people with different health conditions have distinct demands for intergenerational care. In addition, this impact varies among older adult groups of disparate genders, urban and rural areas, and age groups.

Conclusion: This study investigates the impact of "in-law relationships" within living arrangements on the health of older adults. It shows that co-residing with a daughter-in-law has adverse effects on the health of older adults. Therefore, the study suggests that when the health and economic conditions of the elderly permit, a "live-near-but-not-with" living arrangement with their children can be considered.

1. Introduction

1.1. Background

The World Health Organization's China Country Assessment Report on Aging and Health (World Health Organization, 2015a) and World Report on Aging and Health (World Health Organization, 2015b) emphasize the accelerated aging of China's population, its enormous scope, and an expanding transition towards an elderly demographic. This presents two primary challenges. Firstly, the aging process in China is accelerating. The China Statistical Yearbook reveals that China's geriatric population (65 years and over) reached 209.78 million (14.9%) at the end of 2022 (National Bureau of Statistics of China, 2023), respectively, making it the nation with the largest elderly population globally. Based on the United Nations' assumptions of medium fertility and mortality rates, it is projected that by 2050, China's population over 65 will reach 329 million, nearly a third of the total population, indicating an impending profound aging phase (Chen & Sun, 2020). Secondly, accelerated aging has led to a transition in the health status and disease patterns of China's older adults. The disease burden has transitioned from infectious to chronic non-communicable diseases like heart disease, arthritis, and dementia. This demographic transition and altered disease spectrum substantially heighten older adults' need for care. From 2010 to 2050, China's total population dependency ratio will rise from 5.6% to 6% (Harwood et al., 2004). Although the increase seems minor, it translates to a significant increase in scope. Of the 76.2 million people requiring daily care in 2010, 33.2% (25.3 million) were aged 60 and above. This proportion will reach approximately 59.7% (66

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million) out of 110.5 million dependents by 2050. Addressing the care requirements of such a large, vulnerable geriatric population is a pressing issue.

The elder care paradigm in China is predominantly delineated by the "9073" ratio, indicating that 90% of the old adults are looked after by family members, 7% rely on community care services, and 3% are accommodated in nursing homes. This trend is rooted in traditional Chinese values, wherein nursing homes are typically regarded as a secondary option. Additionally, the present availability of public nursing homes needs to cater to the varied care requirements of old adults. Private nursing homes, although providing superior services, are frequently beyond financial reach and scarce in quantity. From 2015 to 2020, the Chinese government allocated 5 billion yuan (equivalent to approximately 743 million US dollars), incentivizing 203 cities to initiate new pilot projects for home-based elder care services (Krings et al., 2022). Over the past decade, home-based elder care has emerged as a focal point in aging policy. Traditional home-based elder care predominantly hinges on the direct caregiving provided by family members, particularly children and spouses. This approach underscores the significance of familial emotional support and intergenerational engagement, covering aspects such as assistance with daily living tasks, health surveillance, and emotional companionship. Nevertheless, in technological progress and social evolution, contemporary home-based elder care amalgamates professional services and technological aids, including health management provided by professional caregivers, domestic services, remote medical consultations, and health monitoring devices (Hu et al., 2020). In summary, home-based elder care aims to ensure the overall well-being of old adults through comprehensive services, enabling them to enjoy a high-quality life in the comfort and familiarity of their home environment.

1.2. Literature review

Global research has explored the influence of living arrangements on multiple dimensions of individual health, encompassing mortality risk (Sandoval & Alvear Portaccio, 2022), subjective well-being (Hwang & Sim, 2021), dementia (Cantu et al., 2022; Roystonn et al., 2020), feelings of loneliness (Wei et al., 2022), mental health (Hamid et al., 2021), and daily living self-sufficiency (Melchiorre et al., 2021). As an example, research conducted in South Korea has substantiated that independent of physical frailty conditions, solitary eating, and living constitute significant risk factors for the emergence of depressive symptoms among older adults residing in communities (Moon et al., 2022). Furthermore, older adults who face economic challenges and live alone have a higher risk of suicide (Ju et al., 2016). Flawinne et al. (2023) uncovered evidence of excess mortality in nursing homes across several European countries, predating the COVID-19 pandemic. Moreover, various scholars from China have posited that alterations in living arrangements could influence mortality rates among old adults. They found no significant impact on mortality rates when transitioning between living alone and co-residing with family. However, a marked increase in mortality rates was observed among those consistently residing in nursing homes or transitioning from other living arrangements to nursing homes (Fong & Feng, 2018). A survey of 1600 individuals in Guangzhou, China, found that those choosing community home care exhibited improved health-related quality of life (HRQOL) than their counterparts in institutional care (Su & Wang, 2019). In contrast to residing with family members, Fujian Hakka older adults living independently exhibited a higher propensity for health risk behaviors, including drinking, smoking and physical inactivity (Liu et al., 2023).

Further, global studies underscore the vital role of family, notably intergenerational relationships and marital, in shaping living arrangements. Xu (2018) spotlighted children's gender when investigating living arrangements' impact on geriatric mental health, finding that living with daughters was most advantageous. Imamura et al. (2020), using survey data from individuals aged 65+ in Kurihara, Japan, confirmed that co-residence with children decreased functional capacity in older women. Dunifon et al. (2020) reported that seniors living with descendants felt happier during joint activities, yet grandparents-only households reported lower contentment than three-generation homes. Quashie et al. (2022) found that co-residing male seniors were less likely to receive health support from offspring during illness than their female counterparts. Sun and Zimmer (2022) and Kandapan et al. (2023) both established that residing with children enhanced life contentment in older adults. In addition to research related to blood relatives such as children and grandchildren, Researchers from both India and Pakistan have observed that widowed and solitary elderly individuals face a more than 50% increased likelihood of depression compared to their married and cohabiting counterparts (Bhamani et al., 2013; Srivastava et al., 2021). Considering the limited research on in-law dynamics, this investigation thoroughly examines the impact of cohabitation with daughters-in-law, as non-blood kin, on the physical and psychological well-being of the elderly population in China.

To recapitulate, the current corpus of global research provides rich insights and lays a solid foundation for future studies, yet opportunities for further exploration still exist. Firstly, while the connection between living arrangements and the health of older persons is established, there needs to be agreement on the extent, direction, or mechanism through which various living arrangements impact geriatric health. Secondly, the current research perspective and methods mainly concentrate on examining a subsystem of the health system. Although this approach can detail the health status of the elderly, there is still no scientific and unified standard for measuring their health levels. Additionally, most existing empirical studies focus on spouses and (grand)children while neglecting the impact of non-blood relatives such as sons-in-law and daughters-in-law on older adult health. Therefore, this study incorporates the increasingly focused in-law relationship into research on elderly living arrangements (Deng et al., 2022; Lee et al., 2020; Peng et al., 2021). We introduce the frailty index, a comprehensive measure of older adult health status, thus providing a more holistic assessment of physical and mental health and offering a solid basis for factor analysis.

1.3. Purposes and hypothesis

We propose the following hypotheses.

Hypothesis 1. (H1): The relationship between parents-in-law and daughters-in-law affects the health of older adults.

Hypothesis 1a (H1a): Co-residence with a daughter-in-law will have a negative impact on the health of old adults. Furthermore, considering existing research indicating that changes in living arrangements affect elderly health (Evandrou et al., 2021), we aim to explore whether changes in the living relationship between parents-in-law and daughters-in-law will influence the health of old adults. Therefore, we propose **Hypothesis 1b (H1b)**: Older adults transitioning from not residing with a daughter-in-law to a cohabitation arrangement will experience negative health impacts. Conversely, shifting from living with a daughter-in-law to separate living conditions will benefit health.

Hypothesis 2. (H2): The health effects of the relationship between parents-in-law and daughters-in-law demonstrate nonlinear and heterogeneous disparities among senior individuals with varying frailty degrees.

Hypothesis 3. (H3): The impact of the relationship between parents-in-law and daughters-in-law on elderly health varies according to the gender, place of residence, and age of older adult individuals.

2. Methods

2.1. Design

We employ the following research design: We assume that the health

status of older adults in 2018 is a function of their living arrangements in 2016 and other relevant factors. This approach can reduce endogeneity issues arising from omitted variables and the chronological order. Utilizing the OLS regression, we analyze the impact of living with a daughter-in-law on the frailty index of older adults and corroborate the robustness of the conclusions above from the perspective of how changes in living arrangements influence the frailty index. Refer to Equations (1) and (2) for the regression formulas:

$$FI_{2018} = \alpha_1 + \alpha_2 living_{2016} + \alpha_3 X_{2016} + \varepsilon_{2016} \quad (1)$$

$$FI_{2018} = \beta_1 + \beta_2 change_{1618} + \beta_3 X_{2016} + \varepsilon_{2016} \quad (2)$$

In this research, FI_{2018} signifies the frailty index for the geriatric population in 2018, while $living_{2016}$ functions as the primary explanatory variable. The variable $change_{1618}$ represents the transition in residential circumstances between 2016 and 2018. X_{2016} comprises control variables such as fundamental demographic characteristics, socioeconomic factors, familial attributes, and the health status of older adults. Constants α_1 and β_1, along with the random error term ε_{2016}, are incorporated into the model, with the remaining variables as estimable parameters.

Concurrently, we execute heterogeneity analyses on subgroups of the geriatric population based on gender, urban and rural distinctions, and age brackets. Equation (3) presents the quantile regression model.

$$Q_{i\theta}(Y_i|X_i) = X_i\beta_{i\theta} + \mu_{i\theta} \quad (3)$$

In our study, $Q_{i\theta}(Y_i|X_i)$ signifies the conditional quantile of the frailty index Y_i, given X_i. We have selected quantiles at the 10%, 25%, 50%, 75%, and 90% levels, and the corresponding coefficient estimates are determined through equation (4).

$$min\left\{\sum_{i:Y_i \geq X_i\beta(\theta)} \theta|Y_i - X_i\beta(\theta)| + \sum_{i:Y<X_i\beta(\theta)} (1-\theta)|Y_i - X_i\beta(\theta)|\right\} \quad (4)$$

Our analysis employs both OLS and quantile regression models. Although the lag model design controls for endogeneity issues to some extent, it fails to address the potential self-selection bias that may affect the results. To combat this, we use the Propensity Score Matching method, grounded in the counterfactual framework, to mitigate self-selection bias effectively. The PSM method entails calculating propensity scores and matching samples from two groups: those living with a daughter-in-law (the intervention group) and those not living with a daughter-in-law (the control group). This procedure guarantees the absence of systematic differences in covariates between the two groups, approximating a randomized trial effect. A vital aspect of PSM is measuring the average treatment effect on the treated (ATT). This value represents the net effect of residing with a daughter-in-law on the frailty index of older adults, emphasizing the difference between this observed impact and its counterfactual (Rosenbaum & Rubin, 1983; Yun et al., 2022). This calculation is detailed in equation (5). However, the counterfactual state in equation (5) is unobservable. Consequently, we rely on the observed outcomes of older adults in non-intervention status as a substitute. Therefore, the ATT value can be further represented as per equation (6):

$$ATT = E(Y_{1i}|I_i = 1) - E(Y_{0i}|I_i = 1) \quad (5)$$

$$ATT = E(Y_{1i}|I_i = 1) - E(Y_{0i}|I_i = 0) = ATT + Selection\ Bias \quad (6)$$

2.2. Data

Our study utilizes data from the 2016 and 2018 China Longitudinal Aging Social Survey (CLASS) furnished by the National Survey Research Center at Renmin University of China (NSRC). All procedures performed in the study involving human participants followed the institutional and national research committee's ethical standards and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The survey was also conducted within articles 38, 39, and 40 of the Constitution of the People's Republic of China and the legal framework governed by Chapter I, Article 9 from the statistics law of the People's Republic of China. The survey was reviewed and approved by the Renmin University of China Academic Ethics Committee. Verbal informed consent was obtained from all individual participants included in the survey. The design of this survey was within articles 38, 39, and 40 of the Constitution of the People's Republic of China and the legal framework governed by Chapter I, Article 9 from the statistics law of the People's Republic of China. Moreover, the interviewer also documented more detailed information on obtaining informed consent, which included whether to agree to attend this study, the time of agreeing to attend this study, and the reasons for disagreeing to attend this study. Details of informed consent was stored by the Institute of Gerontology and National Survey Research Center at Renmin University of China.

The CLASS targets Chinese citizens aged 60 and above. The survey scope covers 30 provinces across China, encompassing 476 villages or neighborhood committees. The recruitment flow chart of the current study is indicated in Fig. 1.

2.3. Variables and measures

2.3.1. Dependent variable

In our investigation, the health status of the geriatric population functions as the dependent variable. Drawing from prior research, we utilize the Frailty Index (F.I.) to evaluate their health. Conceived by Rockwood and associates, the F.I. is an evaluative instrument grounded in the "cumulative health deficit" paradigm. Rather than concentrating on individual health deficits, the F.I. provides a comprehensive portrayal of overall frailty, understanding that an increase in cumulative health deficits correlates to heightened frailty. The index can be programmatically tailored to specific requirements, typically encompassing 30 to 92 items, but must constitute at least 30 indicators (Kojima et al., 2018; Rockwood & Mitnitski, 2007). Our research covers five dimensions: (1) Self-rated health; (2) Disability, as indicated by BADL and IADL measures; (3) Chronic diseases; (4) Cognitive ability, gauged through the Mini-Mental State Examination (MMSE); and (5) Depression, assessed via the Center for Epidemiological Studies Depression Scale (CES-D). Depending on their classifications, health variables in each dimension are designated appropriate values: binary variables receive a 0 or 1; ternary variables receive a 0, 0.5 or 1; quinary variables receive a 0, 0.2, 0.4, 0.6, 0.8 or 1. The frailty index is computed by dividing the number of health deficits by the total number of items included. For the objective of this analysis, we included 61 indicators. The F.I. scale ranges from 0 to 1, with higher values denoting increased infirmity in older adults. A supplementary table shows this more detail (see Supplementary Table S1).

2.3.2. Independent variable

The core independent variable in this study concerns the existence of a "parent-in-law and daughter-in-law" relationship within the household, specifically co-residence and shared meals. This unique familial bond arises between a woman and her husband's parents through marriage. It differs from the intimate conjugal bond between spouses and the more stable hereditary ties between parents and offspring. This parent-in-law and daughter-in-law relationship is a compassionate and vulnerable aspect of family relations, often functioning as a significant source of family instability due to the concentrated tensions inherent in familial interactions. In East Asian countries such as China, Japan, and South Korea, daughters-in-law are crucial in providing informal care for older adults (Do et al., 2015; Du, 2022; Nishi et al., 2010). In this investigation, we categorize living with a daughter-in-law as one and not living with a daughter-in-law as 0.

2.3.3. Control variables

In this analysis, we organize control variables into four

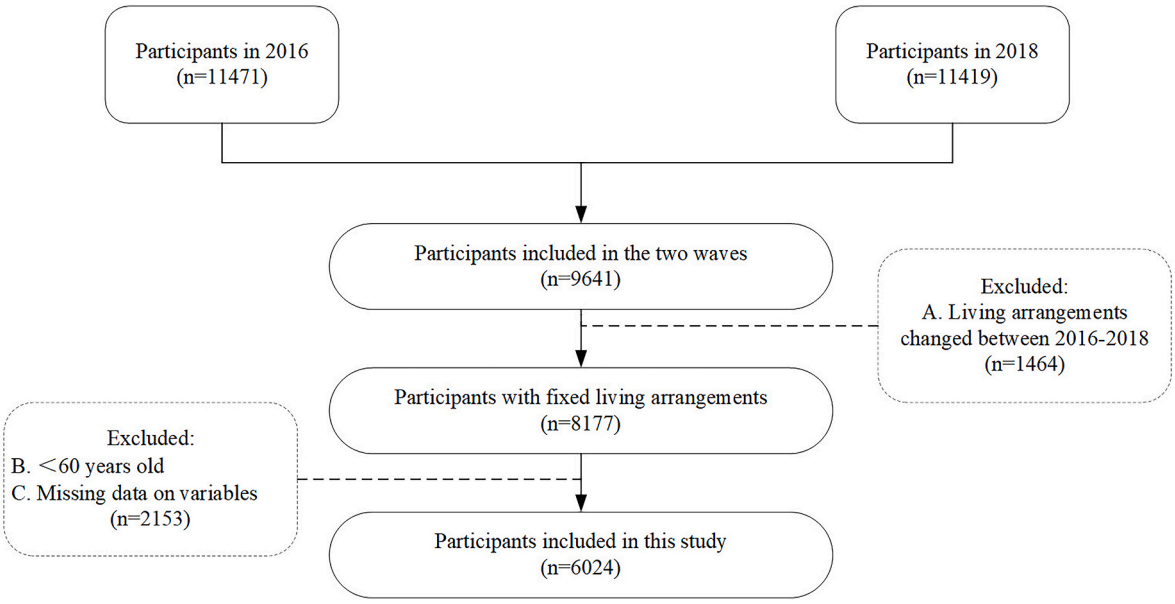

Fig. 1. Recruitment flow chart.

classifications: (1) Demographic attributes comprising gender, age, place of residence, and marital status; (2) Socioeconomic indicators, which include education level, work status, pension insurance enrollment, and the number of owned properties (spouse included); (3) Family dynamics: this encapsulates the number of surviving children, the frequency of interactions with children, the receipt and provision of financial support to or from children; (4) Health and lifestyle habits: sleep quality, smoking history, and the status of social networks (measured by the abbreviated Lubben Social Network Scale, see Supplementary S2 Table) This partitioning of control variables provides an exhaustive comprehension of the factors potentially impacting our central explanatory variable. The conceptual framework guiding our research is illustrated in Fig. 2. The definition of all variables is shown in Supplementary Table S2.

2.3.4. *Statistical analysis*

All descriptive analyses were conducted using STATA version 17.0 software, with a significance level of $P < 0.05$. The data delineating the descriptive statistics of this study are presented in Table 1.

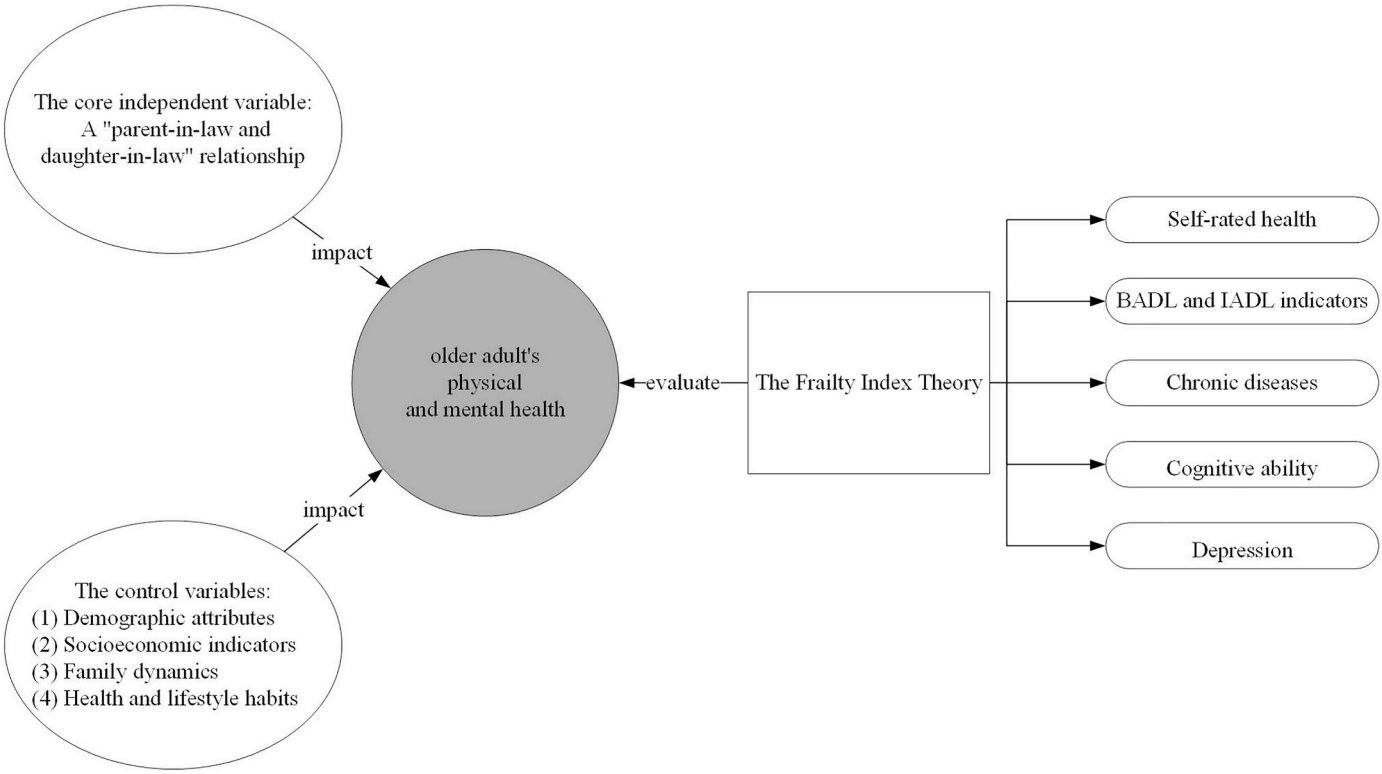

Fig. 2. The analysis framework.

Table 1
The descriptive statistics of all variables.

Variables	Total (n = 6024) n (%)	With in-law relationship (n = 1218) n (%)	Without in-law relationship (n = 4806) n (%)	P Value*
Dependent variable (2018)				
Frailty Index of Elderly, mean (SD)	0.13 (0.07)	0.14 (0.08)	0.13 (0.07)	<0.01
Control Variables (2016)				
Gender				<0.01
Female	2926 (48.57)	649 (53.28)	2277 (47.38)	
Male	3098 (51.43)	569 (46.72)	2529 (52.62)	
Age, mean (SD)	69.25 (7.00)	70.63 (7.61)	68.60 (6.80)	<0.01
Residence				<0.01
Rural	2334 (38.75)	525 (43.10)	1809 (37.64)	
Urban	3690 (61.25)	693 (56.90)	2997 (62.36)	
Married				<0.01
Without spouse	1561 (25.91)	511 (41.95)	1050 (21.85)	
With spouse	4463 (74.09)	707 (58.05)	3756 (78.15)	
Education				<0.01
Illiterate	1698 (28.19)	422 (34.65)	1276 (26.55)	
Literate	4326 (71.81)	796 (65.35)	3530 (73.45)	
Employment status				<0.01
No	5250 (87.15)	1092 (89.66)	4158 (86.52)	
Yes	774 (12.85)	126 (10.34)	648 (13.48)	
Pension				0.64
No	1517 (25.18)	313 (25.70)	1204 (25.05)	
Yes	4507 (74.82)	905 (74.30)	3602 (74.95)	
Properties, mean (SD)	0.99 (0.398)	0.91 (0.540)	1.00 (0.351)	<0.01
Number of living children, mean (SD)	2.48 (1.36)	2.83 (1.35)	2.39 (1.35)	<0.01
The frequency of contact with children, mean (SD)	5.43 (3.70)	7.04 (3.83)	5.03 (3.56)	<0.01
Financial assistance from children				0.01
No	883 (14.66)	151 (12.40)	732 (15.23)	
Yes	5141 (85.34)	1067 (87.60)	4074 (84.77)	
Financial assistance to children				0.06
No	3864 (64.14)	809 (66.42)	3055 (63.57)	
Yes	2160 (35.86)	409 (33.58)	1751 (36.43)	
Sleep Quality				0.31
Poor	534 (8.86)	99 (8.13)	435 (9.05)	
Fair	2813 (46.70)	564 (46.31)	2249 (46.80)	
Good	2677 (44.44)	555 (45.57)	2122 (44.15)	
Smoking history				0.01
No	4188 (69.52)	882 (72.41)	3306 (68.79)	
Yes	1836 (30.48)	336 (27.59)	1500 (31.21)	
Social network, mean (SD)	0.49 (0.18)	0.53 (0.19)	0.47 (0.18)	<0.01

Notes: S.D. standard deviation; *t-test.

3. Results

3.1. OLS regression

As delineated in Table 2, we conduct a stepwise regression analysis of the frailty index for older adults, concentrating on the mother (father)-in-law and daughter-in-law relationships. Sequentially, from Model 1 to Model 4, we adjust for variables including demographic characteristics, socioeconomic features, familial attributes, health status, and lifestyle routines of older adults. The frailty index spans from 0 to 1, where higher scores represent more severe health deficits. A positive regression coefficient signifies that the corresponding variable exacerbates the health burden for older adults. In contrast, a negative coefficient indicates a protective effect on health. The regression results reveal a significant positive correlation between the co-residence relationship and the frailty index. As we incrementally control for more variables, this effect decreases and escalates. For instance, in Model 4, the frailty index increases by 0.088 for older adults co-residing with a daughter-in-law compared to those not co-residing, a difference significant at the 1% level (β=0.0088, $P < 0.001$). This suggests that co-residence with a daughter-in-law augments the health burden for older adults.

Concerning demographic characteristics, the factors of gender (β=−0.0047, $P < 0.05$), age (β=0.0024, $P < 0.001$), place of residence (β=−0.0088, $P < 0.001$), and marital status (β=−0.0093, $P < 0.001$) are all significant, at least at the 5% level. Notably, gender, habitation, and marital status show a significant negative correlation with the frailty index, indicating that urban-dwelling married males exhibit superior health conditions than solitary females residing in rural areas. Examining socioeconomic aspects, we find that a lower level of education is associated with more pronounced health deficits in older adults, whereas adequate employment contributes to maintaining good health (β=−0.0061, $P < 0.05$). Regarding family characteristics, the coefficient for the number of live children is positive (β=0.0027, P=0.001), suggesting that elderly individuals with more children tend to have inferior health status. The frequency of contact with children, although not significant at the 10% level, reveals a negative coefficient, implying that more frequent interactions can offer older adults more daily support and emotional solace, thus aiding their physical and mental health. Both receiving financial aid from children and supplying it to them demonstrate a negative correlation with the frailty index, but only the latter is significant at the 5% level (β=−0.0055, $P < 0.01$). This indicates that intergenerational economic exchanges can support health preservation in old age, alleviating children's economic burdens and having a more evidently favorable effect on geriatric health.

Compared to Model 3, Model 4 witnesses an approximate 35.38% increase in the regression coefficient of the primary explanatory variable (β=0.0088, $P < 0.001$). This increase suggests that neglecting older adults' health status and lifestyle behaviors could potentially undervalue the negative health impact of co-residence with a daughter-in-law. Further, by incorporating variables associated with health status and lifestyle behaviors, the model's explanatory power has improved by 15.7%, highlighting the crucial role of lifestyle in the correlation between living arrangements and health. The regression findings indicate that excellent sleep significantly reduces frailty (β=−0.0265, $P < 0.001$), and more frequent social interactions correspond to improved health

Table 2
Stepwise O.L.S. regression of the impact of co-residence with a daughter-in-law on the frailty index.

Variables	Model 1	Model 2	Model 3	Model 4
	β (S.E.)	β (S.E.)	β (S.E.)	β (S.E.)
Independent variable				
Daughter-in-law relationship	0.0073*** (0.00210)	0.0065** (0.00209)	0.0065** (0.00213)	0.0088*** (0.00213)
Demographic attributes				
Gender (Ref. = female)	−0.0070*** (0.00170)	−0.0053** (0.00171)	−0.0049** (0.00171)	−0.0047** (0.00179)
Age	0.0028*** (0.00012)	0.0026*** (0.00013)	0.0024*** (0.00014)	0.0024*** (0.00013)
Residence (Ref. = rural)	−0.0134*** (0.00170)	−0.0109*** (0.00177)	−0.0093*** (0.00181)	−0.0088*** (0.00180)
Married (Ref. = without spouse)	−0.0120*** (0.00204)	−0.0111*** (0.00204)	−0.0112*** (0.00204)	−0.0093*** (0.00202)
Socioeconomic indicators				
Education (Ref. = illiterate)		−0.0138*** (0.00193)	−0.0130*** (0.00194)	−0.0131*** (0.00192)
Employment status (Ref. = no)		−0.0073** (0.00249)	−0.0067** (0.00250)	−0.0061* (0.00247)
Pension (Ref. = no)		0.0014 (0.00193)	0.0015 (0.00193)	0.0031 (0.00194)
Properties		−0.0023 (0.00210)	−0.0016 (0.00210)	−0.0013 (0.00208)
Family dynamics				
Number of living children			0.0026** (0.00085)	0.0027*** (0.00084)
The frequency of contact with children			−0.0004 (0.00029)	−0.0003 (0.00029)
Financial assistance from children (Ref. = no)			0.0006 (0.00241)	0.0024 (0.00240)
Financial assistance to children (Ref. = no)			−0.0046** (0.00177)	−0.0055** (0.00176)
Health and lifestyle habits				
Sleep quality (Ref. = poor)				
Fair				−0.0137*** (0.00298)
Good				−0.0265*** (0.00300)
Smoking history (Ref. = no)				−0.0004 (0.00189)
Social network				−0.0273*** (0.00462)
Constant	−0.0469*** (0.00913)	−0.0233* (0.00980)	−0.0186 (0.01000)	0.0119 (0.01043)
R^2	0.120	0.130	0.132	0.151
Observations	6024	6024	6024	6024

Notes: *P<0.05, **P<0.01, ***P<0.001; β: regression coefficient; S.E. standard error.

among older adults (β=−0.0273, P < 0.001). Model 4 also suggests that elderly individuals co-residing with a daughter-in-law experience increased health deficits, possibly resulting from alterations to their initial lifestyle. In everyday life, the likelihood of discord and disagreement between parents-in-law and daughters-in-law escalates, leading to increased concerns and limitations on activities. Concurrently, the quantity of leisure time for discretionary activities diminishes. Such lifestyle adjustments and emotional fluctuations might intensify the health burden on older adults in the short term.

3.2. Quantile regression

The results of the quantile regression analysis are presented in Table 3. These findings align with the OLS regression results in demonstrating a positive coefficient for the relationship between parents-in-law and daughters-in-law, impacting older adults' frailty index. However, this effect differs across various percentiles of the frailty index. In the quantile regression, the adverse health effects of co-residence with a daughter-in-law initially decrease, then increase, exhibiting a positive U-shaped trend across diverse frailty levels in the older adult population. The smallest regression coefficient occurs at the 25% percentile (β=0.0043, P < 0.05), while the largest is seen at the 90% percentile (β=0.0137, P < 0.05). All five percentiles satisfy the significance test at a minimum of the 10% level (P < 0.05). The quantile regression results indicate that the adverse health impact of co-residing with a daughter-in-law is more pronounced for older adults with weaker health conditions compared to their healthier counterparts. Thus, the detrimental effects of co-residence with a daughter-in-law on older adult health cannot be universally applied; their impact is nonlinear across various frailty levels in the older adult population. Consequently, Hypothesis 2 is confirmed.

3.3. Robustness analysis

3.3.1. Changes in living patterns and frailty index

Supplementary Table S3 displays that, in the complete sample, elderly individuals in the "Always co-reside" and "Not co-reside → Co-reside" categories exhibit significantly higher frailty indices compared to "Never co-reside." This suggests that co-residence with a daughter-in-law can indeed escalate the health burden for older adults. In the sub-sample models, persistent co-residence with a daughter-in-law markedly exacerbates the health burden for elderly males (β=0.0127, P < 0.001), urban dwellers (β=0.0156, P < 0.001), and those aged over 75 (β = 0.0223, P < 0.001). The detrimental health effects of transitioning from non-co-residence to co-residence are particularly pronounced in the 70–74 (β=0.0235, P < 0.001) and over 75 age brackets (β=0.0427, P < 0.001). These regression results, essentially consistent with our expectations, corroborate the earlier conclusions. Interestingly, the "Always co-reside" category demonstrates a negative coefficient within the sub-sample of rural elderly. This implies that the parent-in-law and daughter-in-law relationship might have a moderately favorable impact on the health status of rural elderly individuals.

3.3.2. Propensity score matching

As indicated in Table 4, our validation exclusively employs the complete sample data. Initially, we utilized the Radius Matching method, reducing the standard deviation of most feature variables to less than 5%. Concurrently, our *t*-test statistics demonstrate the inability to reject the null hypothesis of a zero difference in covariates between older adults who do and those who do not cohabit with a daughter-in-law. This indicates a practical mirroring effect and signifies surviving the balance test. Variables affecting living arrangements do not exhibit systematic disparities, effectively mirroring the outcome of a randomized experiment and thus mitigating self-selection issues. The standard deviations before and after matching are shown in Supplementary Fig. S4, indicating that the differences decreased between the "With in-law relationship" group and the "Without in-law relationship" group after matching.

As depicted in Supplementary Table S5, once we control for self-selection issues, the difference in frailty indices between the intervention and control groups can be construed as the net impact of living arrangements on health. This study employs Radius Matching and Kernel Matching techniques to estimate the frailty indices of aged

Table 3
Quantile regression of the impact of co-residence with a daughter-in-law on the frailty index.

Variables	Dependent variable: Frailty Index of Older Adults				
	10th	25th	50th	75th	90th
Daughter-in-law relationship	0.0067** (0.00255)	0.0043* (0.00191)	0.0044* (0.00218)	0.0063* (0.00302)	0.0137* (0.00650)
Gender (Ref. = female)	−0.0077*** (0.00234)	−0.0064*** (0.00149)	−0.0041* (0.00207)	−0.0057* (0.00266)	−0.0046 (0.00421)
Age	0.0014*** (0.00016)	0.0015*** (0.00015)	0.0018*** (0.00015)	0.0026*** (0.00021)	0.0037*** (0.00043)
Residence (Ref. = rural)	−0.0091*** (0.00221)	−0.0079*** (0.00207)	−0.0100*** (0.00229)	−0.0094*** (0.00254)	−0.0057 (0.00483)
Married (Ref. = without spouse)	−0.0090*** (0.00226)	−0.0085*** (0.00196)	−0.0109*** (0.00225)	−0.0127*** (0.00271)	−0.0104 (0.00586)
Education (Ref. = illiterate)	−0.0141*** (0.00200)	−0.0142*** (0.00193)	−0.0124*** (0.00225)	−0.0115*** (0.00262)	−0.0124* (0.00577)
Employment status (Ref. = no)	−0.0050 (0.00295)	−0.0065* (0.00275)	−0.0063* (0.00287)	−0.0077* (0.00381)	−0.0078 (0.00595)
Pension (Ref. = no)	−0.0010 (0.00245)	−0.0006 (0.00217)	0.0017 (0.00208)	0.0056* (0.00257)	0.0029 (0.00534)
Properties	−0.0081*** (0.00212)	−0.0094*** (0.00273)	−0.0056* (0.00256)	−0.0012 (0.00291)	0.0093 (0.00692)
Number of living children	0.0035** (0.00131)	0.0039*** (0.00082)	0.0035*** (0.00104)	0.0018 (0.00135)	0.0033 (0.00264)
The frequency of contact with children	−0.0009* (0.00038)	−0.0008* (0.00032)	−0.0008* (0.00034)	−0.0001 (0.00040)	0.0001 (0.00081)
Financial assistance from children (Ref. = no)	−0.0007 (0.00332)	−0.0006 (0.00232)	0.0002 (0.00258)	0.0029 (0.00355)	0.0077 (0.00516)
Financial assistance to children (Ref. = no)	−0.0010 (0.00257)	0.0003 (0.00184)	−0.0049** (0.00184)	−0.0061* (0.00240)	−0.0072 (0.00461)
Sleep quality (Ref. = poor)					
Fair	−0.0113*** (0.00332)	−0.0107*** (0.00300)	−0.0090* (0.00391)	−0.0139** (0.00448)	−0.0251** (0.00905)
Good	−0.0203*** (0.00357)	−0.0220*** (0.00306)	−0.0214*** (0.00385)	−0.0261*** (0.00455)	−0.0387*** (0.00912)
Smoking history (Ref. = no)	0.0068** (0.00245)	0.0064*** (0.00187)	0.0009 (0.00173)	−0.0024 (0.00284)	−0.0033 (0.00433)
Social network	−0.0098 (0.00628)	−0.0099* (0.00487)	−0.0155** (0.00503)	−0.0329** (0.00656)	−0.0520*** (0.01308)
Constant	0.0119 (0.01253)	0.0294** (0.01131)	0.0404** (0.01286)	0.0346* (0.01657)	−0.0018 (0.03676)
Pseudo R^2	0.0764	0.0738	0.0745	0.0879	0.1104
Observations	6024	6024	6024	6024	6024

Notes: *P<0.05, **P<0.01, ***P<0.001; standardized coefficients are reported; standard errors in parentheses; the number of resampling times is 100.

Table 4
The balancing assumption test before and after propensity score matching.

Variables	Type	With in-law relationship (n = 1218)	Without an in-law relationship (n = 4806)	Standard Deviation (%)	t value	P>|t|
Gender	Before matching	0.4672	0.5262	−11.8	−3.69	0.000
	After matching	0.4672	0.4735	−1.3	−0.31	0.756
Residence	Before matching	0.5690	0.6236	−11.1	−3.50	0.000
	After matching	0.5690	0.5718	−0.6	−0.14	0.888
Education	Before matching	0.6535	0.7345	−17.6	−5.62	0.000
	After matching	0.6535	0.6532	0.1	0.02	0.985
The frequency of contact with children	Before matching	7.0353	5.0287	54.3	17.32	0.000
	After matching	7.0353	6.8355	5.4	1.28	0.199
Financial assistance from children	Before matching	0.8760	0.8477	8.2	2.50	0.013
	After matching	0.8760	0.8819	−1.7	−0.44	0.657
Financial assistance to children	Before matching	0.3358	0.3643	−6.0	−1.86	0.064
	After matching	0.3358	0.3431	−1.5	−0.38	0.704

Notes: Before matching, the Ps R2, L.R., chi2, mean error, and median error were 0.049, 297, 0.000, 18.2, and 11.5, respectively; after matching, the corresponding statistics were 0.001, 2.06, 0.914, 1.8, and 1.4 respectively.

individuals under two distinct living conditions and their average treatment effect on the treated (ATT). Considering the results obtained via Radius Matching, the ATT prior to matching is 0.01572. This signifies that co-residence with a daughter-in-law correlates with a net increase in the frailty index by 1.572%. After adjusting for selection bias, this net effect reduces to 1.030%, implying a significant rise in the frailty index due to co-residence with a daughter-in-law.

Moreover, the ATT obtained from the robustness assessment using Kernel Matching is 0.00985, aligning closely with the Radius Matching estimate. This consistency underscores the robustness of the Propensity Score Matching estimates. It also suggests that failure to address endogeneity issues resulting from selection bias could result in overestimating the deleterious influence of co-residence with a daughter-in-law on geriatric infirmity. Importantly, this confirms that even after controlling for self-selection in living arrangements, the parent-in-law and daughter-in-law relationship continues to intensify the health burden on older adults.

3.3.3. Heterogeneity analysis

The previous regression analysis reveals the average impact of

having or not having a relationship with a daughter-in-law on the frailty index of the overall geriatric population. However, this effect may vary across distinct groups, warranting a subsample heterogeneity test. As displayed in Table 5, co-residing with a daughter-in-law increases the frailty index for older adults at most quantiles. This effect obtains statistical significance for specific samples, at least at the 10% level ($P < 0.05$).

In gender-segregated samples, the regression coefficient reflecting the impact of co-residence with a daughter-in-law is substantially more significant for male seniors than female seniors, with an evident trend of this coefficient increasing as frailty intensifies. This highlights the differential impact of "mother-in-law and daughter-in-law" and "father-in-law and daughter-in-law" relationships on the health of elderly individuals. Notably, compared to their female counterparts, geriatric males experience more detrimental health effects from co-residing with a daughter-in-law.

Within urban and rural subgroups, co-residence with a daughter-in-law uniquely impacts the health of the geriatric population. A distinct quantile effect is observed for urban residents, demonstrating a positive U-shaped trend that initially diminishes slowly and then escalates significantly. Apart from the 75% quantile, all other quantiles satisfy the significance test at a 1% level ($P < 0.001$). Conversely, for older adults residing in rural areas, the health implications of co-residing with a daughter-in-law are not substantially detrimental and, in some instances, might even ameliorate their frailty status, as indicated by a negative regression coefficient. However, this does not satisfy the significance test at the 10% level ($P > 0.05$). This finding implies that in rural contexts, compared to urban ones, the relationship between parents-in-law and a daughter-in-law may contribute more positively to the overall well-being of older adults.

In the age-specific subsamples, geriatric individuals' first three age categories present negative regression coefficients. However, only the 60–64 and 70–74 age categories' 10% quantiles survive the significance test at the 10% level ($P < 0.05$). Still, the coefficients' trend exhibits a positive U-shape, initially decreasing before increasing. Significantly, for individuals over 75 years old, the influence of this co-residence arrangement on all health levels progressively intensifies, potentially attributed to this age group's initially inferior health status.

To sum up, for seniors at differing levels of frailty, the adverse health implications of relationships with daughters-in-law diverge across various genders, urban and rural residences, and age groups. This observation substantiates our third hypothesis. The trend variations in the quantile regression coefficients for the comprehensive sample and individual subgroups are depicted in Fig. 3.

Table 5
The quantile regression results for each subsample.

Subsample	Dependent variable: Frailty Index of Older Adults				
	90th	25th	50th	75th	90th
Gender					
Male (n = 3098)	0.0103**	0.0081**	0.0070*	0.0097*	0.0207*
	(0.00393)	(0.00313)	(0.00302)	(0.00434)	(0.01022)
Pseudo R^2	0.0566	0.0654	0.0663	0.0838	0.1071
Female (n = 2926)	0.0011	0.0009	0.0028	0.0041	0.0072
	(0.00388)	(0.00245)	(0.00339)	(0.00447)	(0.00905)
Pseudo R^2	0.0967	0.0806	0.0785	0.0893	0.1186
Residence					
Urban (n = 3690)	0.0154***	0.0085***	0.0107***	0.0079	0.0265***
	(0.00348)	(0.00241)	(0.00291)	(0.00457)	(0.00776)
Pseudo R^2	0.0927	0.079	0.0729	0.0902	0.1234
Rural (n = 2334)	−0.0038	−0.0031	−0.0050	0.0016	−0.0034
	(0.00427)	(0.00367)	(0.00333)	(0.00429)	(0.00729)
Pseudo R^2	0.0547	0.0615	0.0694	0.0832	0.1083
Age					
60-64 (n = 1843)	0.0078	0.0078*	0.0024	−0.0001	0.0041
	(0.00545)	(0.00351)	(0.00440)	(0.00518)	(0.00721)
Pseudo R^2	0.0728	0.0576	0.0416	0.0426	0.042
65-69 (n = 1683)	0.0064	−0.0022	−0.0037	−0.0032	0.0054
	(0.00419)	(0.00387)	(0.00425)	(0.00519)	(0.01022)
Pseudo R^2	0.0633	0.0588	0.0435	0.0414	0.0441
70-74 (n = 1140)	0.0137*	0.0050	0.0074	0.0023	−0.0078
	(0.00659)	(0.00394)	(0.00382)	(0.00567)	(0.01182)
Pseudo R^2	0.0646	0.0632	0.0583	0.0409	0.0461
75+ (n = 1358)	0.0011	0.0054	0.0107*	0.0243**	0.0517***
	(0.00589)	(0.00458)	(0.00504)	(0.00910)	(0.01505)
Pseudo R^2	0.0469	0.0456	0.0611	0.0784	0.0993

Notes: *P<0.05, **P<0.01, ***P<0.001; standardized coefficients are reported; standard errors in parentheses; control variables are the same as those in the quantile regression section of Table 4; the number of resampling times is 100.

4. Discussion and conclusions

4.1. Main conclusions

Firstly, the health of older adults can be substantially impacted by the relationship dynamics between in-laws, particularly those of parents-in-law and daughters-in-law. Living in close quarters with daughters-in-law has adversely affected seniors' health. This may be attributed to generational differences in thought patterns and lifestyle routines, which can contribute to frequent family conflicts and negatively impact older adults' emotional well-being (Du, 2022). Moreover, the seniors residing with their daughters-in-law often share the responsibility of looking after their grandchildren. This additional family obligation could hinder older adults from engaging in social activities and genuinely appreciating their retirement, inadvertently exacerbating their health burdens (Imamura et al., 2020).

Secondly, it is essential to observe that the effects of familial living arrangements on geriatric health cannot be generalized. The negative impact of residing with a daughter-in-law presents itself differently across various geriatric populations, particularly those with varying degrees of infirmity. Elderly individuals in poor health, despite their heightened need for care, often find residing with their daughters-in-law inconvenient. Compared to their healthier counterparts, these individuals experience a more significant detrimental effect from such living arrangements. The older adult population is diverse, and the negative ramifications of living with daughters-in-law differ across various demographics. This disparity is evident across gender, urban or rural locations, and age distinctions. A sub-sample of the data reveals a more harmonious "mother-daughter-in-law relationship" in rural, younger geriatric families, which is more conducive to their physical and mental health than the "father-daughter-in-law relationship" found in older, urban families.

Lastly, while in-law relationships undeniably influence older adults' health, these impacts might be mediated by other factors related to living arrangements. For instance, alterations in intergenerational economic interactions and lifestyle patterns could also influence the seniors' health. Overemphasis on the health implications of specific living arrangements while disregarding the underlying critical factors associated with these arrangements could lead to a superficial application of various home care models. Consequently, the health and welfare of older adults might remain precarious in their twilight years.

4.2. Implications for theory and practice

Our research emphasizes the significant role companionship plays in bolstering the health of geriatric individuals, substantiating the health benefits of having a life partner in old age. This parallels the findings of Yang et al. (2016) in China and Gopinathan et al. (2023) in India. Socioeconomically, we observe that health deficits in later years intensify with diminishing education levels among older adults, corroborating Marden et al. (2017) assertion that socioeconomic status functions as a health shield in old age. Moreover, our results underscore the positive influence of intergenerational economic interactions on preserving older adult health. Considering the current retirement age in China is 60 for men and 55 for women, and our study participants were 60 years of age

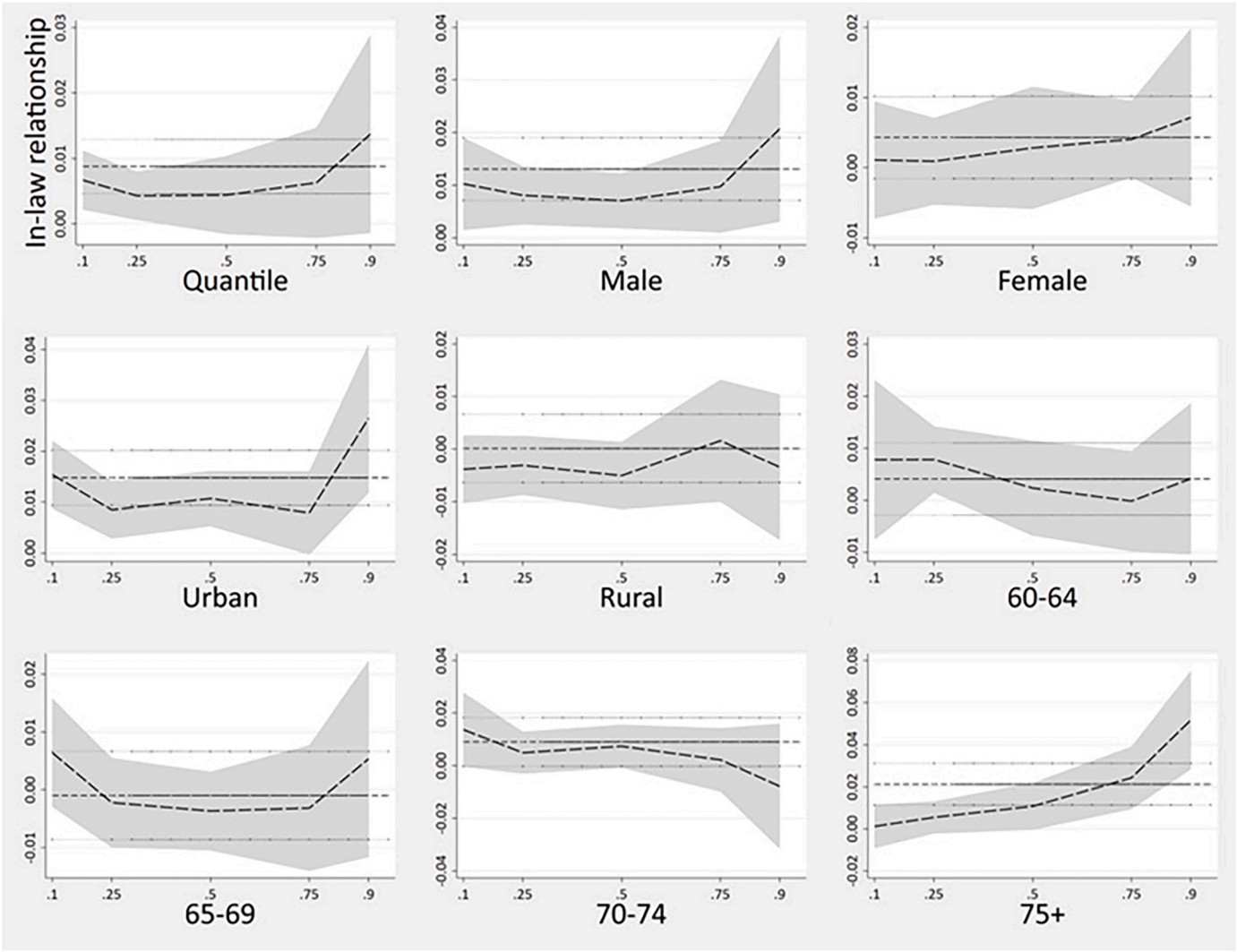

Fig. 3. Trend chart of quantile regression coefficients.

and older, transitioning from professional to domestic life can pose potential health challenges for seniors. However, adopting a "retirement without inactivity" lifestyle may offer physical and mental health protection, aligning with Huang Qian et al.'s conclusions (Huang & Yu, 2019).

In geriatric health research, numerous econometric methodologies regulate the endogenous influence on health and living patterns. However, an irreversible trend of health deterioration due to pathological factors is inevitable. Hence, our objective should be to control risk factors that may amplify the health burden for older adults, thereby delaying health deterioration. A healthy lifestyle is essential for seniors, irrespective of their living accommodations, and includes reducing smoking, ensuring appropriate sleep, and engaging in social activities. When circumstances permit, seniors might contemplate a "live-near-but-not-with" home care model. In this arrangement, older adults and their offspring reside nearby, nurturing regular economic assistance, caregiving, and emotional solace. This arrangement not only intensifies contact frequency between (grand) children and seniors, mitigating the risk of "empty nest"-related depression, but also curtails the negative health impacts linked to family strife and domestic duties. For the younger population and their spouses, increased attentiveness to seniors, respect for their lifestyle routines, and mitigation of intergenerational conflicts is crucial. On the societal and national front, initiatives should target enhancing social security systems, improving seniors' economic status, and reducing health disparities across urban-rural and income divides. Lastly, government agencies should offer customized assistance and care to seniors based on their health circumstances, ensuring residences become genuine sanctuaries in their twilight.

4.3. Limitations and future research

This investigation, while comprehensive, acknowledges several limitations. Firstly, the health status of older adults was self-reported, which could introduce discrepancies between the gathered data and actual conditions. Secondly, this study also disregarded certain lifestyle variables, such as exercise frequency, dietary preferences, and alcohol consumption, despite their significant correlation with the initial health status of seniors. Unfortunately, these characteristics were not addressed in the CLASS data. Thirdly, our exploration focused solely on the influence of having a daughter-in-law in the household on the health of older adults, neglecting the potential effects of households with multiple daughters-in-law.

Furthermore, the distinctive position and impact of sons-in-law were not considered. In the future, our research will broaden its scope to assess the influence of families with multiple daughters-in-law and other non-blood relatives, like sons-in-law, on geriatric well-being. This revision will contribute to a more nuanced comprehension of the complex dynamics of multigenerational households and geriatric health.

Ethical statement

This study has been reviewed and approved by the Academic Ethics Committee of Shanghai University of Engineering Science. The CLASS data had already been reviewed and approved by the Renmin University of China Academic Ethics Committee, and our study utilized a publicly accessible secondary dataset containing de-identified information. All procedures performed in the study involving human participants followed the institutional and national research committee's ethical standards and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The survey was also conducted within articles 38, 39, and 40 of the Constitution of the People's Republic of China and the legal framework governed by Chapter I, Article 9 from the statistics law of the People's Republic of China. Verbal informed consent was obtained from all individual participants included in the study. The design of this survey was within articles 38, 39, and 40 of the Constitution of the People's Republic of China and the legal framework governed by Chapter I, Article 9 from the statistics law of the People's Republic of China. Verbal informed consent was acceptable and was reviewed by the ethics committee. Moreover, the interviewer also documented more detailed information on obtaining informed consent, which included whether to agree to attend this study, the time of agreeing to attend this study, and the reasons for disagreeing to attend this study. Details of informed consent was stored by the Institute of Gerontology and National Survey Research Center at Renmin University of China. This study does not contain any studies with animals performed by any of the authors.

Consent to publish

Not applicable.

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CRediT authorship contribution statement

Juan Luo: Funding acquisition, Project administration. **Ben Li:** Writing – original draft, Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Jiarong Li:** Validation. **Zhenpeng Ren:** Supervision.

Declaration of generative AI and AI-assisted technologies in the writing process

Not applicable.

Declaration of competing interest

The author(s) declare no competing interests.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2024.101649.

Abbreviations

CLASS	China Longitudinal Aging Social Survey
F.I.	Frailty Index
BADL	Basic Activity of Daily Living
IADL	Instrumental Activity of Daily Living
CES-D	Center for Epidemiological Studies Depression Scale
LSNS	Lubben Social Network Scale
O.L.S.	Ordinary Least Squares Regression
P.S.M.	Propensity Score Matching
SD	Standard Deviation
S.E.	Standard Error
Ref	The reference category

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