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Associations between social support and frailty and the mediating role of mental and physical health: evidence from CHARLS

Li Mao[1†], Yu Tian[1†], Ling Zhang[2†], Fang Lei[3], Guoying Wang[1], Jinxing He[1], Lijin Lin[1,4*] and Defeng Peng[5*]

Abstract

Background Although studies have demonstrated associations between social support and frailty in older adults, the direction and underlying mechanisms of this relationship are yet to be better delineated. We aimed to investigate the association between different forms of social support and frailty, as well as the mediating role of physical and mental health in this association.

Methods Participants were adults aged ≥ 60 from the 2011 China Health and Retirement Longitudinal Study (CHARLS). Social support (including formal and informal support), physical health, and mental health were the main variables. Frailty was evaluated using the Physical Frailty Phenotype (PFP) scale, and the relationships among these variables were examined using a structural equation model (SEM).

Results The final analysis included 4,511 participants, with a median age of 66.0 years. And the prevalence of frailty was 7.7%. Frailty was found to be influenced by both formal (β = -0.221, $P < 0.001$) and informal social support (β = -0.221, $P < 0.001$). Moreover, formal and informal social support demonstrated positive associations with mental and physical health (β = 0.720, 0.347, 0.679, and 0.484, respectively, all $P < 0.001$). Mental and physical health were negatively associated with frailty (β = -0.374, -0.202, respectively, both $P < 0.001$).

Conclusions The relationship between social support and frailty appears to be mediated by mental and physical health, primarily through psychological pathways. Therefore, comprehensive interventions aimed at improving social support and mental and physical health are recommended to prevent frailty.

Keywords Social support, Frailty, Mental health, Physical health, Structural equation mode

†Li Mao, Yu Tian co-first authors.

Lijin Lin is the first corresponding author of this study and Defeng Peng is the second corresponding author of this study.

*Correspondence:
Lijin Lin
linlijin@whu.edu.cn
Defeng Peng
pengdefeng@hgyy.org.cn
[1] Gannan Innovation and Translational Medicine Research Institute, State Key Laboratory of New Drug Discovery and Development for Major Diseases, Gannan Medical University, Ganzhou, Jiangxi, China
[2] Department of Obstertrics, Huanggang Maternal and Child Health Hospital, Huanggang, Hubei, China
[3] Medical Science Research Center, Zhongnan Hospital of Wuhan University, Wuhan, Hubei, China
[4] Department of Cardiology, Renmin Hospital of Wuhan University, Wuhan, Hubei, China
[5] Department of Chinese Medicine, Huanggang Maternal and Child Health Hospital, Huanggang, Hubei, China

Introduction

Frailty, as a geriatric syndrome, is characterized by a decline in the functioning of multiple physiological systems and increased vulnerability to stressors. It is rapidly emerging as a global health burden [1–3]. Previous studies have revealed that frailty increases the risk of adverse health outcomes, such as falls, disability, cardiovascular disease, and death [4–6]. Nevertheless, recent evidence has demonstrated the dynamic nature of frailty and its potential for reversal through effective interventions [3, 7]. Thus, the identification of risk factors associated with frailty assumes great importance as it allows for targeted interventions and preventive measures to be implemented within a specific time-frame. Specifically, there is growing evidence that social factors are closely related to the health of older adults [8]. Positive social factors such as social support, social networks, and social participation can reduce the occurrence of frailty events [9, 10]. However, negative factors such as low perceived social support, social isolation, and loneliness can cause mental health problems, a decline in physical function, and an increase in chronic diseases [11–13]. Therefore, we need to pay more attention to social factors and reduce adverse health outcomes caused by unfavorable social factors.

Social support can be structurally categorized as formal or informal depending on the source of it [14]. Formal support is given by official organizations, and friends, neighbors, while informal support is given by colleagues, family, and relatives [15–17]. In previous literature, social support has been proven to increase the quality of life, significantly lower the risk for mortality, prevent diseases, minimize the impacts of stress from negative life events, and maintain good physical and mental health [4, 16, 18].

Previous studies have revealed a negative association between frailty and social support in older adults with diabetes and hypertension [19]. A cohort study in China showed that social support attenuated the risk of frailty in unmarried older persons [20]. In a Japanese cohort study, a negative association was also found between social support and frailty, with emotional and instrumental support from within and outside the family reducing future physical frailty in older adults [21]. None of the previous studies explored the potential mediating mechanisms between social support and frailty.

Health is a multi-dimensional concept that includes physical health and mental health [22]. There is research evidence that social support is beneficial to the mental and physical health of older adults, as well as the presence of health problems that are a factor in the increased risk of frailty [23–26]. Social support has the potential to promote physical and mental health, thereby reducing the prevalence of frailty. However, the role of mental and physical health in mediating the relationship between social support and frailty remains unclear. Therefore, in order to explore whether physical and mental health are an intermediate mechanism for the association between social support and frailty, we set two latent variables, physical health and mental health, as mediating variables. Elucidating the relationship between social support, physical and mental health, and the incidence of frailty may provide valuable insights into preventing frailty.

Thus, using a structural equation model, the current study aimed to explore the relationship between social support and frailty. In the meantime, we explored the mediating role of physical and mental health. Based on previous studies, we proposed 10 hypotheses (Table S1) and a theoretical model (Figure S1).

Methods

Study design and population

Our research constitutes a longitudinal study grounded in the datasets derived from the China Health and Retirement Longitudinal Study (CHARLS). The CHARLS is a comprehensive national survey conducted from 2008 to 2018, targeting residents aged 45 and above in China. This longitudinal study evaluates various facets, including demographic profiles, health conditions, functional abilities, social and economic statuses, and retirement details. Employing a multistage probability sampling method, the CHARLS research team conducted surveys on middle-aged and older adult residents in communities across 28 provinces in China [23]. This work has been approved by the Peking University Biomedical Ethics Review Committee (approval number: IRB00001052-11015). Each respondent provided their consent to continue after reading a statement that outlined the objectives of the study. The national baseline survey, including 17,708 participants, was conducted in 2011. In this cross-sectional study, we selected 7,209 older adults who were ≥ 60 years as the primary study subjects, excluding 2,698 individuals who had missing data on frailty and social support, resulting in the inclusion of 4,511 participants. The complete procedure for participant selection is illustrated in Figure S2.

Definitions of formal and informal social support

This study divided social support into formal and informal support, both of which were assumed to be independent variables. The data on formal support were sourced from the pension insurance, infrastructure, public facilities, lifestyle, and health behaviors sections of CHARLS 2011. Meanwhile, data on informal support were derived from the family and demographic background sections of CHARLS 2011. Table S2 demonstrates the coding of all the variables.

Formal support was examined using the variables pension amount, number of activity places and type of social activity [27–29]. Among these measures, the pension amount was assessed by inquiring about the annual pension income. The number of activity places was determined by asking whether the village/community had specific facilities, including basketball courts, swimming pools, outdoor exercise facilities, table tennis rooms, rooms for card games and chess, activity centers for older adults, and nursing homes. The type of social activity was gauged by asking about the frequency of attendance at social events in the past month.

Informal support comprised three indicators: frequency of contact with children, the number of living children, and living with a partner [14, 30]. The informal support was assessed by inquiring about the frequency of contact with children through phone calls, text messages, mail, or email, and by obtaining information on the number of children and marital status.

Assessment of frailty

In this study, we assessed frailty using the Physical Frailty Phenotype (PFP), a widely accepted scale that serves as a reference and provides guidance for frailty assessment across various populations [1]. The PFP comprised five components: weakness, slowness, exhaustion, inactivity, and shrinking. Table S3 demonstrates the coding of all the variables. Weakness was defined as a participant's maximum grip strength equal to or below the 20 th percentile, adjusted for gender and body mass index (BMI). Slowness was characterized by a walking pace at or below the 20 th percentile, adjusted for sex and height. We employed the residual method to adjust grip strength and step speed in order to determine cutoff points. Exhaustion was defined as participants self-reporting that everything they did was an effort sometimes or always. Inactivity was defined as participants self-reporting an inability to walk continuously for at least ten minutes or more during the week. Participants were classified as shrinking if their BMI was ≤ 18.5 kg/m^2 or if they self-reported a weight loss of at least 5 kg in the past year. Building on previous studies [31], we included participants who provided data on at least four factors. Participants meeting three or more criteria were classified as frailty, those meeting 1–2 criteria as pre-frailty, and those with none were considered non-frailty.

Mediators

We selected mental health and physical health as mediating variables (Table S4). The mental health includes episodic memory, cognitive ability, and depressive symptoms. A higher mental health score indicates better overall health [32]. There were 10 questions in the Center for Epidemiologic Studies-Depression (CES-D) that reflect the depression score of older adults. Cognitive scores were determined based on participants' responses to several cognitive questions across five dimensions, including reaction, calculation, drawing, naming, and language, to assess the cognitive abilities of older adults. Episodic memory score was divided into two dimensions: long-term word memory and short-term word memory, with ten questions in each dimension and one point for each correct answer.

Physical health consisted of activities of daily living (ADL), instrumental activities of daily living (IADL) and physical function (PF). The ADL was measured across six dimensions, including clothing, bathing, eating, getting in and out of bed, toileting, and bowel control. The IADL was evaluated in five aspects, including housework, preparing hot meals, purchasing daily necessities, managing money, and taking medication [33]. The PF was assessed based on participants' self-reported difficulty in completing seven activities, including climbing several flights of stairs without resting, bending, kneeling, or crouching and others [34]. The score was inversely proportional to the reported difficulty, with higher scores indicating better physical health.

Covariates

This study selected control variables from individual characteristics based on previous research on the factors affecting frailty [35]. The variables included age, gender, area type, education, chronic diseases and household income.

Statistical analyses

Baseline characteristics of the study population were compared by frailty status grouping (no frailty, pre-frailty, frailty) with a chi-square test for categorical variables and a Kruskal–Wallis test for continuous variables. The Confirmatory Factor Analysis (CFA) is employed to scrutinize the hypothesized measurement model by assessing the relationships between observed and latent variables. Structural Equation Modeling (SEM) is a flexible statistical technique that allows for the simultaneous analysis of complex relationships among both latent (unobserved) and observed variables [36]. While SEM is often associated with models in which both predictors and outcomes are latent variables, it is also suitable and widely used when the outcome variable is observed. In this study, SEM was developed to examine the relationship between formal and informal social support and frailty, with mental and physical health included as mediators. The model was tested using maximum likelihood estimation and bootstrap methods to evaluate the pathways and effects within the relationships.

To assess the goodness of fit of the model, the following indices were utilized in reference to previous studies: adjusted goodness of fit index (AGFI) >0.900, goodness of fit index (GFI) >0.900, a standardized root mean square residual (SRMR) ≤0.080, and root mean square error of approximation (RMSEA) ≤0.080.

Subgroup analysis of the model was conducted to investigate potential differences in path coefficients among key variables between the two groups. In the subgroup analysis, two groups were considered to be different if the difference in path coefficients from the "critical difference ratio" was equal to or greater than ± 1.96 [33].

In the sensitivity analysis, we assessed the stability of the model by incorporating individuals aged 45 years and above and employing alternative missing value imputation methods (K-Nearest Neighbors and mean imputation). Missing data were imputed using random forest as implemented in R. Detailed missing rates for the essential factors used in this study are provided in Table S5. All analyses were two-sided, and using IBM SPSS Statistics 20.0, AMOS software, and R 4.3.2, p-value <0.05 was deemed statistically significant.

Results

Characteristics of participants

The analytical sample consisted of 4,511 participants, with a median age of 66.0 [63.0;72.0] years. Among the respondents, 51.3% were males, 81.5% lived in a rural village, 82.6% were primary school or less, and 75.4% suffered from at least one chronic disease. Regarding the frailty status of the subjects, the highest proportion was observed among per-frailty older adults (56.7%), followed by older adults with no frailty (35.7%), and older adults with frailty (7.7%). Participants with frailty were predominantly older, resided in rural villages, had lower levels of education, had chronic diseases, had worse formal and informal social support, and had poorer mental and physical health (Table 1).

The associations between social support and frailty

The results of the correlation analysis among formal social support, informal social support, physical health, mental health, and frailty variables are detailed in Table S6. The results indicated that each observed variable was significantly correlated with the outcome indicators, but the correlation coefficients did not meet the criteria for a strong correlation. Based on the CFA results, the model demonstrated a good fit with the data and was deemed suitable for SEM analysis, as indicated by the goodness of fit tests yielding values of 0.990, 0.996, 0.022, and 0.035 for AGFI, GFI, SRMR, and RMSEA, respectively (Table S7 and Table S10). Subsequently, a total direct model was employed to assess the impact of social support on frailty in older adults. As presented in the Table S7 and Table S11, formal social support showed significant associations with three of its dimensions: pension amount (β =0.579, P< 0.001), number of activity places (β =0.414, P< 0.001) and type of social activity (β =0.332, P< 0.001). Similarly, informal social support exhibited significant associations with three its dimensions: living with partner (β =0.272, P< 0.001), number of living children (β =−0.414, P< 0.001), children contact frequency (β =0.568, P< 0.001). Frailty was found to be influenced by both formal social support (β =−0.221, P< 0.001) and informal social support (β =−0.221, P< 0.001). These findings provided support for Hypotheses1-2, indicating that both formal and informal social support contribute significantly to reducing frailty levels (Table S12).

The mediating role of mental and physical health between social support and frailty

We constructed a multiple mediation model to explore the relationships between social support, frailty, and physical and mental health mediators. The model displayed a good fit with the data well, as evidenced by AGFI, GFI, SRMR, and RMSEA values of 0.928, 0.952, 0.057, and 0.069, respectively (Table S7). Figure 1 and Table S13 present the final model, outlining the association and effect paths among the key variables.

As expected, formal social support exhibited a direct positive association with mental health and physical health (β =0.720, P< 0.001; β= 0.347, P< 0.001), while informal social support also showed a direct positive association with mental health and physical health (β =0.679, P< 0.001; β= 0.394, P< 0.001). Additionally, mental health and physical health were direct negatively associated with frailty (β =−0.374, P< 0.001; β=−0.202, P< 0.001). These results provided support for Hypotheses 3–8, indicating that both formal and informal social support positively influence mental and physical health, and that improved mental and physical health, in turn, contributes to lower levels of frailty. This underscores the interconnected role of social support and health in mitigating frailty (Table S12). Table 2 indicates that the indirect effects of social support on frailty are statistically significant, revealing the presence of mediating effects. The findings confirmed Hypotheses 9 and 10, demonstrating that mental and physical health serve as significant mediators in the relationship between both formal and informal social support and frailty. This implied that social support can reduce frailty not only directly but also indirectly by improving individuals'mental and physical health (Table S12).

Table 1 Description of the main variables and descriptive statistics of the sample

Characteristic	Total (*N* = 4511)	No frailty (*N* = 1609)	Pre-frailty (*N* = 2556)	Frailty (*N* = 346)	*P*-value
Age, median [IQR]	66.0 [63.0;72.0]	65.0 [62.0;69.0]	67.0 [63.0;72.0]	71.0 [65.2;76.0]	< 0.001
Gender, n (%)					< 0.001
Male	2314 (51.3%)	884 (54.9%)	1245 (48.7%)	185 (53.5%)	
Female	2197 (48.7%)	725 (45.1%)	1311 (51.3%)	161 (46.5%)	
Area type, n (%)					< 0.001
Rural Village	3678 (81.5%)	1215 (75.5%)	2161 (84.5%)	302 (87.3%)	
Urban	833 (18.5%)	394 (24.5%)	395 (15.5%)	44 (12.7%)	
Education, n (%)					< 0.001
Primary school or less	3727 (82.6%)	1237 (76.9%)	2176 (85.1%)	314 (90.8%)	
Middle school or above	784 (17.4%)	372 (23.1%)	380 (14.9%)	32 (9.2%)	
Smoking, n (%)					0.191
NO	2529 (56.1%)	878 (54.6%)	1463 (57.2%)	188 (54.3%)	
Yes	1982 (43.9%)	731 (45.4%)	1093 (42.8%)	158 (45.7%)	
Drinking, n (%)					< 0.001
NO	3102 (68.8%)	1038 (64.5%)	1797 (70.3%)	267 (77.2%)	
Yes	1409 (31.2%)	571 (35.5%)	759 (29.7%)	79 (22.8%)	
Chronic disease, n (%)					< 0.001
NO	1109 (24.6%)	477 (29.6%)	567 (22.2%)	65 (18.8%)	
Yes	3402 (75.4%)	1132 (70.4%)	1989 (77.8%)	281 (81.2%)	
Pension amount, median [IQR]	0.0 [0.0;960.0]	490.0 [0.0;7200.0]	0.0 [0.0;720.0]	0.0 [0.0;660.0]	< 0.001
Number of activity places, n (%)					< 0.001
NO	1552 (34.4%)	484 (30.1%)	941 (36.8%)	127 (36.7%)	
One to four	2385 (52.9%)	842 (52.3%)	1353 (52.9%)	190 (54.9%)	
Five or more	574 (12.7%)	283 (17.6%)	262 (10.3%)	29 (8.4%)	
Type of social activity, n (%)					< 0.001
NO	2297 (50.9%)	724 (45.0%)	1366 (53.4%)	207 (59.8%)	
One or two	2099 (46.5%)	815 (50.7%)	1147 (44.9%)	137 (39.6%)	
Three or more	115 (2.5%)	70 (4.4%)	43 (1.7%)	2 (0.6%)	
Children contact frequency, n (%)					< 0.001
Almost never and other or once a year	1785 (39.6%)	525 (32.6%)	1071 (41.9%)	189 (54.6%)	
Once a month	1437 (31.9%)	510 (31.7%)	827 (32.4%)	100 (28.9%)	
Once a week	1289 (28.6%)	574 (35.7%)	658 (25.7%)	57 (16.5%)	
Living with partner, n (%)					< 0.001
NO	1003 (22.2%)	292 (18.1%)	596 (23.3%)	115 (33.2%)	
Yes	3508 (77.8%)	1317 (81.9%)	1960 (76.7%)	231 (66.8%)	
Number of living children, median [IQR]	3.0 [3.0;4.0]	3.0 [2.0;4.0]	4.0 [3.0;5.0]	4.0 [3.0;5.0]	< 0.001
Depression score, median [IQR]	22.0 [17.0;26.0]	25.0 [22.0;28.0]	20.0 [15.0;24.0]	16.0 [11.0;21.0]	< 0.001
Cognitive score, median [IQR]	8.0 [6.0;10.0]	9.0 [6.0;11.0]	8.0 [5.0;10.0]	6.0 [4.0;9.0]	< 0.001
Episodic memory score, median [IQR]	6.0 [3.0;8.0]	7.0 [4.0;9.0]	5.0 [2.0;8.0]	4.0 [1.0;6.0]	< 0.001
ADL, median [IQR]	18.0 [17.0;18.0]	18.0 [18.0;18.0]	18.0 [17.0;18.0]	18.0 [15.0;18.0]	< 0.001
IADL, median [IQR]	15.0 [14.0;15.0]	15.0 [15.0;15.0]	15.0 [14.0;15.0]	14.0 [9.0;15.0]	< 0.001
PF, median [IQR]	4 [3,4]	4 [3,4]	3 [3,4]	3 [2,3]	< 0.001

Abbreviations: IQR Interquartile range, *ADL* Activities of daily living, *IADL* Instrumental activities of daily living, *PF* Physical function

Subgroup analysis

The results of subgroup analyses are presented in Table 3 and the model fit indices for each group are presented in Table S8. Within the age group stratification, significant differences were observed in the paths from formal social support to mental health (critical ratios for difference = 2.673) and from mental health to Frailty (critical ratios for difference = 3.882). For the gender group stratification, significant differences were noted in all paths except physical health to Frailty (critical ratios for difference

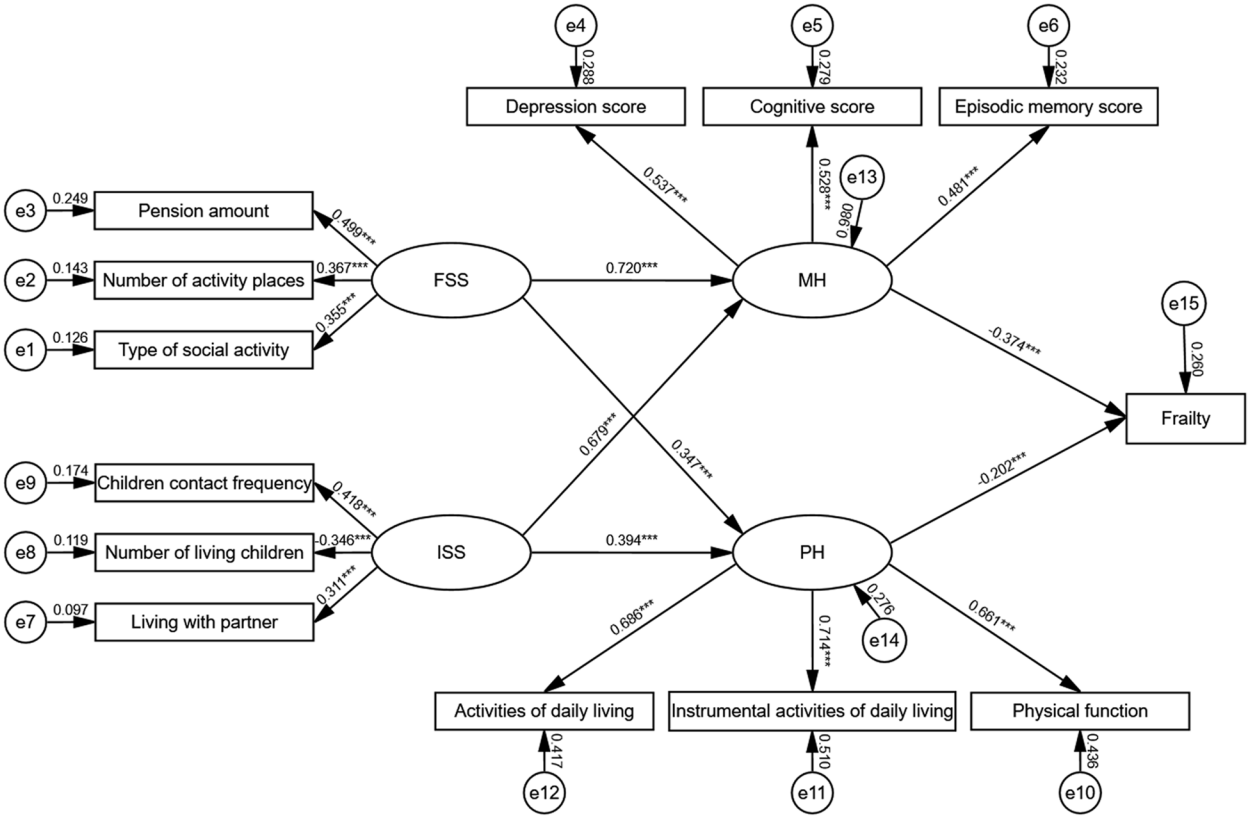

Fig. 1 Standardized coefficients for the full sample model. FSS, Formal social support; ISS, Informal social support; MH, Mental health; PH, Physical health

Table 2 The pathways from social support, mental health and physical health to frailty status

Path	Path coefficient (β)	95%CI
Direct effect		
FSS → MH	0.720***	(0.595, 0.909)
FSS → PH	0.347***	(0.222, 0.502)
ISS → MH	0.679***	(0.484, 0.861)
ISS → PH	0.394***	(0.223, 0.544)
MH → Frailty	−0.374***	(−0.429, −0.314)
PH → Frailty	−0.202***	(−0.257, −0.152)
Indirect effect		
FSS → MH → Frailty	−0.270***	(−0.363, −0.219)
FSS → PH → Frailty	−0.070***	(−0.105, −0.036)
ISS → MH → Frailty	−0.254***	(−0.366, −0.184)
ISS → PH → Frailty	−0.080***	(−0.114, −0.042)

Abbreviations: FSS Formal social support, *ISS* Informal social support, *MH* Mental health, *PH* Physical health, *CI* Confidence interval

*** $P < 0.001$

= −0.128). When considering area type group stratification, significant differences were identified in the paths from physical health to Frailty (critical ratios for difference = −2.011) and from mental health to Frailty (critical ratios for difference = 2.740). In the education group stratification, significant differences were observed in all paths except from mental health (critical ratios for difference = −1.117) and physical health (critical ratios for difference = −0.571) to Frailty. Within the chronic disease group stratification, significant differences were found in all paths except mental health to Frailty (critical ratios for difference = 1.923). Lastly, in the household income group stratification, significant differences were observed in all paths except from mental health (critical ratios for difference = −1.297) to Frailty.

Sensitivity analysis

Sensitivity analyses confirmed the robustness of the main results. First, we extended the inclusion criteria to people aged 45 years and older, and the results were generally similar to those in the main analysis (Table S14). Second, when employing alternative missing value filling methods such as K-Nearest Neighbors and mean imputation,

Table 3 Standardized regression coefficients (β) with *P*-values for the components of subgroup analyses

Path			Age			Gender		
			< 70 (*N* = 2978)	**≥ 70 (*N* = 1533)**	**Critical ratios for difference**	**Male (*N* = 2314)**	**Female (*N* = 2197)**	**Critical ratios for difference**
MH	←	FSS	0.588***	0.715***	2.673	0.614***	0.685***	2.386
PH	←	FSS	0.257***	0.258***	0.783	0.204***	0.342***	2.879
MH	←	ISS	0.889***	0.831***	0.442	0.875***	0.645***	−2.755
PH	←	ISS	0.490***	0.501***	0.700	0.538***	0.350***	−4.161
Frailty	←	PH	−0.104***	−0.157***	−0.435	−0.167***	−0.192***	−0.128
Frailty	←	MH	−0.482***	−0.367***	3.882	−0.418***	−0.396***	2.131
Path			**Area type**			**Education**		
			Rural Village (*N* = 3678)	**Urban (*N* = 833)**	**Critical ratios for difference**	**Primary school or less (*N* = 3727)**	**Middle school or above (*N* = 784)**	**Critical ratios for difference**
MH	←	FSS	0.930***	0.862**	0.864	0.922***	0.456***	−6.473
PH	←	FSS	0.573***	0.423**	−0.005	0.553***	0.147**	−7.335
MH	←	ISS	0.473***	0.546***	1.683	0.451***	0.949***	1.981
PH	←	ISS	0.266***	0.139*	−1.125	0.256***	0.457***	2.889
Frailty	←	PH	−0.061 (0.079)	−0.172***	−2.011	−0.075*	−0.106*	−0.571
Frailty	←	MH	−0.531***	−0.388***	2.740	−0.527***	−0.443***	−1.117
Path			**Chronic disease**			**Household income**		
			NO (*N* = 1109)	**Yes (*N* = 3402)**	**Critical ratios for difference**	**Low income (*N* = 2255)**	**High income (*N* = 2256)**	**Critical ratios for difference**
MH	←	FSS	0.556***	0.831***	2.633	0.970***	0.717***	−2.998
PH	←	FSS	0.271***	0.431***	3.023	0.579***	0.298***	3.933
MH	←	ISS	0.891***	0.519***	−3.299	0.449***	0.669***	3.790
PH	←	ISS	0.433***	0.286***	−2.528	0.209***	0.424***	−4.535
Frailty	←	PH	−0.075(0.109)	−0.223***	−2.311	−0.091**	−0.158***	2.678
Frailty	←	MH	−0.469***	−0.355***	1.923	−0.516***	−0.396***	−1.297

Abbreviations: FSS Formal social support, *ISS* Informal social support, *MH* Mental health, *PH* Physical health

*** $P < 0.001$. ** $P < 0.01$. * $P < 0.05$

the results remained generally consistent with the main analyses (Table S15 and Table S16). Third, we added the error terms of the latent variables of formal social support and informal social support. There were no significant changes in the research conclusions (Figure S3). Finally, we added a further analysis of the relationships between formal and informal social support, as well as mental health and physical health. There were no significant changes in the research conclusions (Figure S4). All sensitivity analysis models demonstrated good fits with the data (Table S9).

Discussion

This study, based on hypotheses 1–10, systematically explored the impact of social support on frailty among individuals aged 60 and above in China, with a particular focus on the mediating roles of mental and physical health. The findings support all hypotheses, indicating a significant negative correlation between social support and frailty, with mental and physical health serving as important mediators in this relationship. Our results indicate that enhancing social support can reduce frailty not only directly but also indirectly by improving mental and physical health, with the mediating effect of mental health being particularly prominent.

Social support is recognized as a crucial factor contributing to individuals' health and well-being by providing access to various tangible resources promoting health [37]. Social support is commonly classified into formal and informal social support based on its source [14, 38, 39]. Among the dimensions of social support, formal social support exhibited the strongest association with pensions, a component of social security that can enhance the older adults' self-care abilities, life satisfaction, and overall health while reducing depression and anxiety [40]. Creating community environments conducive to improving the overall health of the older adults is also essential [41]. The frequency of communication between children and their parents is particularly significant in informal social support, as older adults often experience declining physical function with age, leading to increased emotional needs [42]. Furthermore,

our study identified a negative association between the number of children and informal social support, which may be related to the fact that more children cause families to face more conflicts and economic tensions [14]. These results highlight the importance of evaluating and addressing social support for older adults as a modifiable factor impacting frailty.

To our knowledge, this study is the first to examine the mediating roles of mental and physical health between social support and frailty in older adults. Of particular note is the finding that mental health plays a primary role in the onset of frailty. Therefore, when assessing and treating frailty in the older adults, it is crucial to consider their mental health. The findings of these studies are valuable because they provide new insights into the planning and implementation of interventions for older adults who lack adequate social support.

While the physical dimension has traditionally received more emphasis, there is an increasing recognition that frailty is a multidimensional and complex syndrome that encompasses physical, cognitive, psychological, and social aspects [43, 44]. In essence, it is a "biopsychosocial" syndrome [45]. A significant portion of the prior study on frailty has focused on physical health [46, 47]. However, mental health, which includes cognitive abilities, sleep patterns, social interactions, and positive well-being, is equally important [48]. In our study, we discovered that both mental and physical health impact frailty, with psychological factors exerting a greater influence than physical factors. This finding is consistent with existing evidence, even in the absence of decreased physical function, older adults with poor psychological function have a high prevalence of frailty [49–51]. Our study also demonstrated that both formal and informal social support are associated with both mental health and physical health, with a greater impact on mental health than physical health. Therefore, we suggest that actively enhancing social support among the older adults to improve mental well-being is more conducive to preventing frailty.

Moreover, subgroup analyses showed that the moderating role of mental and physical health between social support and frailty was consistent across older adults of different age groups, genders, area types, education levels, chronic disease statuses and household income. Age subgroup results suggested that older adults over the age of 70 have a greater need for enhanced formal social support to promote mental health and slow the incidence of frailty. The gender subgroup results indicated that male mental health and physical health are comparatively more affected by informal social assistance. Previous findings suggested that while women may be more vulnerable to health problems, men have higher rates of adverse outcomes [52, 53]. This may be related to traditional socio-cultural contexts where men are often less inclined to express emotions and seek help, resulting in a relative lack of emotional support and social connections [54]. Therefore, we emphasize the importance of strengthening informal social support networks for men, providing them with more emotional support and a sense of belonging in their daily lives. This can not only improve their mental health but also reduce the risk of illness or worsening health conditions. The results of the area type subgroups showed that the role of mental health in frailty is more pronounced among older adult residents in rural areas. Compared to urban older adults, those in rural regions generally face lower levels of mental health, which may be closely related to inadequate social support [55, 56]. Social support is crucial for the mental well-being of the older adults, and rural seniors, due to limited access to social support networks, are more susceptible to mental health issues. Therefore, it is imperative to strengthen social support for older adult residents in rural areas, especially interventions targeting mental health. This not only helps improve their mental health but also enhances their overall life satisfaction [57]. Additionally, the subgroup analysis based on educational level revealed differences in the types of social support required by people with varying educational backgrounds. For older adults with lower educational levels, formal support is more crucial, likely because they have relatively weaker access to social resources and healthcare services, making them more dependent on formal assistance to ensure proper health management and basic living needs [51, 58]. On the other hand, those with higher educational levels, who may have more personal social resources and greater self-coping abilities, are more likely to derive psychological satisfaction and a sense of belonging from informal social support [59]. This distinction highlights the need to adopt different strategies based on population characteristics when designing and providing social support, ensuring effective allocation and utilization of resources. In the context of chronic diseases, the results showed that individuals with chronic illnesses require more formal social support than those without chronic conditions. This finding highlights the increased dependence of chronic disease patients on healthcare and caregiving services in their daily lives. A formal social support network can provide them with essential medical resources, long-term care, and financial assistance for accessing healthcare services [60]. In the income subgroup analysis, the results were similar to those for education level. People with lower household incomes are economically vulnerable and lack the resources to cope with health issues or life stress, thus

they rely more on formal support from the government and society to secure their livelihoods [58, 61]. In contrast, those with higher incomes have stronger financial capabilities, which makes it easier for them to participate in social activities and receive emotional support and a sense of belonging from their broad social networks, including family, friends, or the community [59]. Overall, these subgroup results reveal the complexity and differentiated needs of social support, emphasizing the importance of considering the unique needs of various groups when formulating social policies to more effectively improve the overall health of the older adults.

Strengths and limitations

The main strength of the present study is that we examined the association between the formal and informal social support and frailty in a nationally representative sample of older Chinese and evaluated the intermediary mechanism. Nevertheless, there are several limitations to this study. First, the cross-sectional design restricts the inferences we can make about causality. Therefore, causality needs to be verified in more prospective investigations. Second, because this study was carried out in China, variations in demographics, including race, may have caused the results to vary from those of other nations and areas. Furthermore, the selection of all variables was based on previous studies and databases, not our targeted questionnaire collection, resulting in some small factor loadings. And the $\chi 2/df$ ($\chi 2/df = 22.661$) for the main result was outside the accepted normal range ($\chi 2/df < 5$), but some research has explained $\chi 2/df$ was highly sensitive to large sample sizes [34, 62]. Finally, the study had some self-reported variables that could introduce recall bias, and given that the individuals were 60 years of age or older, there was also some selection bias.

Conclusion

Our study demonstrated that the onset of debilitating events is influenced by both formal and informal social support, with mental and physical health as intermediate mechanisms and mental health as the primary pathway. Thus, social support plays a crucial role in maintaining older adults' mental and physical well-being and postponing the onset of frailty. We advocate for greater social support for older adults to contribute positively to healthy aging.

Abbreviations

CHARLS	China Health and Retirement Longitudinal Study
PFP	Physical Frailty Phenotype
SEM	Structural Equation Model
BMI	Body Mass Index
CES-D	Center for Epidemiologic Studies-Depression
FSS	Formal Social Support
ISS	Informal Social Support
MH	Mental Health
PH	Physical Health
ADL	Activities of Daily Living
IADL	Instrumental Activities of Daily Living
PF	Physical Function
CFA	Confirmatory Factor Analysis
AGFI	Adjusted Goodness of Fit Index
GFI	Goodness of Fit Index
SRMR	Standardized Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation

Supplementary Information

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Supplementary Material 1: Figure 1. Theoretical hypothesis graph. FSS, Formal social support; ISS, Informal social support; MH, Mental health; PH, Physical health. Figure 2. The flow chart of participants through the study. CHARLS, China Health and Retirement Longitudinal Study. Figure 3. Standardized coefficients for the full sample model with error terms. FSS, Formal social support; ISS, Informal social support; MH, Mental health; PH, Physical health. ***$P < 0.001$. Figure 4. Sensitivity Analysis - The Relationships between FSS and ISS as well as MH and PH. FSS, Formal social support; ISS, Informal social support; MH, Mental health; PH, Physical health. ***$P < 0.001$.

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Authors' contributions

LM, YT, and LZ contributed to the study concept and design. FL, GW, JH contributed to the acquisition, analysis, and interpretation of data. LM, YT, and LZ drafted the manuscript. All authors contributed to critical revisions of the manuscript for important intellectual content. All authors have read and approved of the submission of this manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The data used in this study were retrieved from the CHARLS. This survey was endorsed by the Biomedical Ethics Committee of Peking University (NO.IRB 00001052–11015). All participants in the survey signed or marked (if illiterate) the informed consent forms. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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