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RESEARCH

The relationship among socioeconomic status, social support and frailty: is there a gender difference?

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Abstract

Objective This study aimed to determine the relationship among socioeconomic status, social support and frailty, and its gender difference.

Methods Education and income were combined to indicate the socioeconomic status. The Social Support Rating Scale (SSRS) was used to measure the level of social support. Frailty was measured by the FRAIL Scale. Mediation effects were analyzed using the PROCESS 4.1 macro in SPSS version 26.0.

Results Among the 936 participants, socioeconomic status had a direct effect on frailty (effect = − 0.088, 95% *CI*: − 0.142, − 0.021). Social support was an indirect pathway for the relationship between socioeconomic status and frailty (effect = − 0.011, 95% *CI*: − 0.023, − 0.003), accounting for 11.11% of the total effect. Stratified by gender, we found that the total, direct and indirect effects of socioeconomic status on frailty were significant only in the female subsample.

Conclusion Overall, there was a significant association between socioeconomic status and frailty among the rural older adults, and social support mediated this relationship. However, there were gender differences in the association among socioeconomic status, social support and frailty. Specifically, the correlation between socioeconomic status and frailty and the mediating role of social support were found only in the female subsample. The public health sector should focus on the rural older adults with low socioeconomic status and lack of social support, taking targeted interventions to avoid and delay the occurrence and progress of frailty.

Keywords Socioeconomic status · Social support · Frailty · Gender difference · Older adults · Rurality

Introduction

At present, population aging has become an important public health problem in the world. It is projected that by 2050, the global population over the age of 65 will exceed 2 billion [1]. In recent years, the elderly population in China has been growing, accounting for 21.1% of the total [2], entering the accelerated stage of aging. Frailty is considered to be the most prominent health problem in the context of population aging [1]. It refers to the decreased function of multiple physiological systems of the human body, resulting in the increased susceptibility to stressors [3]. A recent study reported the prevalence of frailty among older adults in China reached 37.6% [4], and the prevalence was higher in rural areas than in urban areas [5]. Frailty is a predictor of many adverse health outcomes. It can not only increase the risk of physical health impairment, such as dementia, falls and death [6–8], but also threaten an individual's

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mental health, leading to loneliness, anxiety and depression [9–11]. At the same time, the burden of medical services will increase [12, 13]. Studies have shown that frailty was reversible, and the reversal rate was significantly higher in prefrailty than in frailty [14]. Prefrailty is the transition from health to frailty, which is more prevalent but poses less threat to the health of older adults [15]. Therefore, the early identification and intervention of frailty can be beneficial in avoiding and delaying the occurrence and progress of frailty, as well as facilitating the transition of frail and prefrail individuals to the healthy state.

Socioeconomic status is a comprehensive indicator with multiple dimensions, including education, income and occupation [16, 17]. The influence of socioeconomic status on an individual's health extends throughout his or her life cycle [18]. People with higher socioeconomic status are generally in better health [19]. For some patients, socioeconomic status also affects their quality of life and health by influencing the effective use of health resources and services [20]. Previous studies have shown that frailty was more likely to occur in groups with low socioeconomic status [21]. Higher levels of education and income can reduce the risk of frailty [22]. Although existing research has demonstrated the relationship between socioeconomic status and frailty. However, it is not clear which underlying mechanisms may contribute to greater frailty in older people with lower socioeconomic status, which requires further exploration.

As a key factor of active aging [23], social support is defined as the emotional, informational, and instrumental help that individuals can obtain from their own social network [24]. Good social support can buffer the stimulation of external pressure and play an important role in improving self-efficacy and promoting physical and mental health [25, 26]. Several studies have found a positive association between social support and socioeconomic status [27, 28]. Results from a Canadian survey suggested that high socioeconomic status may imply high levels of social support [29]. In addition, a longitudinal study involving middle-aged and elderly people in the Ruhr region of Germany by Nico Vonneilich et al. found that individuals with high socioeconomic status generally had more positive social relationships [30], whose functional aspect is exactly social support [31, 32]. Similar to socioeconomic status, frailty has also been reported to be significantly associated with social support [33, 34]. A 10-year epidemiological survey conducted in China discovered that the risk of frailty decreased with increasing levels of social support [35]. A study performed in Thailand came to a similar conclusion that inadequate social support increased the probability of frailty and prefrailty [36]. The clinical practice guidelines developed by the working group of the International Conference on Fragility and Sarcopenia Research (ICFSR) also mentioned that social support should be provided to all older adults with frailty according to need [37].

In conclusion, although a large body of evidence has proven that both socioeconomic status and social support have a direct impact on frailty, the specific potential mechanisms among the three have not yet been clarified. At the same time, previous studies have shown that there are gender differences in socioeconomic status [38]. Compared to males, inequality in socioeconomic status is higher and more strongly related with health status among females [39]. In addition, there is also a disparity in the size of social networks of males and females [40]. Spouses are generally the main social relationship that males rely on [41]. The difference is that, in addition to their spouses, females rely more than males on other relationships for social support, thus having larger social networks [42]. This may lead to more social support being accessed and utilized by females, resulting in a certain degree of gender difference in the link between social support and frailty. Currently, there is still a lack of effective measures to prevent and delay frailty in older adults. Understanding the relationship between socioeconomic status and frailty and its underlying mechanisms is of great value to help identify individuals at greater risk of frailty. Therefore, our study aimed to (1) investigate the relationship between socioeconomic status and frailty among rural older adults; (2) determine the mediating role of social support in the above relationship; (3) examine whether the relationship among socioeconomic status, social support and frailty differs by gender.

Methods

Study design and sample

The present study, was a cross-sectional survey conducted from September to December in 2023 in an eastern province of China. The details of the research program have been described in other articles [43]. In short, a certain number of residents from 216 villages or communities were selected for a questionnaire survey to identify our potential subjects. The eligible population included rural residents aged≥60 years who volunteered to participate in the study. We excluded older adults with severe physical and / or cognitive impairments. In addition, older adults with missing data on key variables in the questionnaire were also not included. The study complied with the principles of the Declaration of Helsinki and was approved by the Medical Ethics Committee of Weifang Medical University (2021YX-066). All participants were provided written informed consent before the survey. Finally, 936 participants were eligible for inclusion in this study.

Assessment of frailty

The FRAIL Scale was used to assess how frail the participants were [44]. This scale is a 5-point test that includes tests for fatigue, resistance, ambulation, illness and loss of weight. The higher the score, the more serious the frailty [45].

Assessment of socioeconomic status

With reference to previous studies [46–48], socioeconomic status is usually combined by three indicators: education, occupation and income. However, this study focused on the rural older adults, most of whom were in non-working state and engaged in agricultural production activities before retirement. Occupation was not a highly heterogeneous indicator. Therefore, it was not included. We used annual household income per person and educational attainment to evaluate participants' socioeconomic status. Quartiles were applied to divide annual household income per person (RMB) into four categories: < 2000 yuan = 1, 2000 − 4999 yuan = 2, 5000 − 9999 yuan = 3, ≥ 10,000 yuan = 4. We created three categories of educational attainment: primary and below = 1, middle school = 2, and high school and above = 3. The scores of the two indicators were added together to obtain the score of socioeconomic status, which ranges from 2 to 7. A high total score indicated high socioeconomic status.

Assessment of social support

Social support was measured based on the Social Support Scale (SSRS). The scale includes three dimensions: the objective and subjective support received and the utilization of the above support [49]. The total score is 66. The higher the score, the higher the level of social support [50].

Assessment of covariates

Covariates included gender (male, female), age (60–69 years, 70–79 years, ≥ 80 years), marital status (currently married, others), chronic disease (none, have), body mass index (BMI) and sleep quality. BMI is a commonly applied indicator for screening and diagnosing obesity, which is calculated by dividing weight (kg) by height squared (m^2) [51]. The Pittsburgh Sleep Quality Index Scale (PSQI) was employed to estimate the sleep quality of subjects during the latest month. Scores on this scale range from 0 to 21. The lower the score, the better the sleep quality [52].

Statistical analysis

First, we described the basic information of the total sample, the male subsample and the female subsample, respectively. Frequencies (n) and percentages (%) were used to represent categorical variables. Numerical variables were denoted as M (P_{25}, P_{75}) since they did not fit the normal distribution. Second, the associations among the main variables were examined by Spearman's correlation analysis. Finally, controlling for all covariates, Model 4 of the PROCESS 4.1 macro was used for mediation analysis: (1) linear regression analysis was performed to explore the association between socioeconomic status and frailty, (2) linear regression analysis was used to test the association between socioeconomic status and social support, and (3) the linear regression analysis was used to further explore the relationship between socioeconomic status and frailty when social support was included as a mediator. The bootstrap method based on 5000 samples was applied to test the total, direct and indirect effects. The significance of results was determined by not including 0 between the upper and lower limits of the 95% *CI*. All analyses were performed using SPSS version 26.0. Statistical significance was set at $P < 0.05$ (2-tailed).

Results

Characteristics of the participants

As shown in Table 1, the participants consisted of 359 males and 577 females. 91.7% were aged 60–79 years. 81.4% were currently married. 88.6% had at least one chronic disease. The median BMI and sleep quality were 24.97 and 7.00, respectively. The median socioeconomic status of males and females was equal at 4.00. However, compared to males, females had lower levels of social support (median = 41.00), more severe frailty (median = 1.00).

Correlation between study variables

Table 2 shows the correlation between socioeconomic status, social support, and frailty. We found that in the total sample, socioeconomic status was positively associated with social support ($r = 0.141$, $P < 0.001$) and negatively related to frailty ($r = -0.147$, $P < 0.001$). There was a significant negative correlation between social support and frailty ($r = -0.186$, $P < 0.001$). Stratified by gender, in the male subsample, frailty was negatively correlated with socioeconomic status ($r = -0.108$, $P < 0.05$) and social support ($r = -0.141$, $P < 0.01$). But there was no significant association between socioeconomic status and social support ($r = 0.100$, $P > 0.05$). In the female subsample,

Table 1 Participant characteristics

Variables	Total (n=936)	Males (n=359)	Females (n=577)
Age (years), n (%)			
60−69	427 (45.6)	168 (46.8)	259 (44.9)
70−79	431 (46.1)	157 (43.7)	274 (47.5)
≥80	78 (8.3)	34 (9.5)	44 (7.6)
Marital status, n (%)			
Currently married	762 (81.4)	308 (85.8)	454 (78.7)
Others[a]	174 (18.6)	51 (14.2)	123 (21.3)
Chronic disease, n (%)			
None	107 (11.4)	50 (13.9)	57 (9.9)
Have	829 (88.6)	309 (86.1)	520 (90.1)
BMI, M (P_{25}, P_{75})	24.97 (22.86, 27.34)	24.68 (22.86, 26.95)	25.39 (22.89, 27.34)
Sleep quality, M (P_{25}, P_{75})	7.00 (5.00, 10.00)	7.00 (5.00, 10.00)	7.00 (5.00, 9.00)
Socioeconomic status, M (P_{25}, P_{75})	4.00 (3.00, 5.00)	4.00 (3.00, 5.00)	4.00 (3.00, 5.00)
Social support, M (P_{25}, P_{75})	42.00 (37.00, 46.00)	42.00 (38.00, 47.00)	41.00 (37.00, 46.00)
Frailty, M (P_{25}, P_{75})	1.00 (0.00, 2.00)	0.00 (0.00, 2.00)	1.00 (0.00, 3.00)

[a] Others includes single, divorced and widowed

Table 2 Correlation between key variables

Variables	1.Socioeconomic status	2.Social support	3.Frailty
Total sample (n=936)			
1.Socioeconomic status	1.000		
2.Social support	0.141***	1.000	
3.Frailty	− 0.147***	− 0.186***	1.000
Male subsample (n=359)			
1.Socioeconomic status	1.000		
2.Social support	0.100	1.000	
3.Frailty	− 0.108*	− 0.141**	1.000
Female subsample (n=577)			
1.Socioeconomic status	1.000		
2.Social support	0.159***	1.000	
3.Frailty	− 0.129**	− 0.211***	1.000

***P−value<0.001,**P−value<0.01, *P−value<0.05

socioeconomic status was positively related to social support (r=0.159, P<0.001) and negatively associated with frailty (r=−0.129, P<0.01). Social support was negatively related with frailty (r=−0.211, P<0.001).

The mediating effect of social support

Table 3 displays the results of the mediation analysis for the total sample, male subsample and female subsample. In the total sample, Model 1 showed that higher socioeconomic status was significantly associated with lower frailty scores (β=−0.099, P<0.01). Model 2 showed that higher socioeconomic status was significantly related to higher levels of social support (β=0.082, P<0.01). When social support was included in Model 3 as a mediator, there was still a significant relationship between higher socioeconomic status and lower frailty scores (β=−0.088, P<0.01). Thus, social support partially mediated the link between socioeconomic status and frailty. We reached the same conclusion in the female subsample instead of the male subsample.

Table 4 presents that, in the total sample, the total effect of socioeconomic status on frailty was −0.099 (95% CI: − 0.153, − 0.032), and the indirect effect through social support was −0.011 (95% CI: − 0.023, − 0.003), accounting for 11.11% of the total effect. In the female subsample, the total effect of socioeconomic status on frailty was −0.101 (95% CI: − 0.181, − 0.018), and the indirect effect through social support was −0.016 (95% CI: − 0.033, − 0.002), accounting for 15.84% of the total effect. Nonetheless, we did not find significant total, direct and indirect effects of socioeconomic status on frailty among the male subsample. Figures 1, 2 and 3 present the mediation pathway models for the total sample, male subsample and female subsample, respectively.

Table 3 Association of socioeconomic status and social support with frailty

Variables	Model 1 (Frailty)		Model 2 (Social support)		Model 3 (Frailty)	
	β	t	β	t	β	t
Total sample (n = 936)						
Gender	0.128	3.930***	0.029	0.985	0.132	4.091***
Age	0.103	3.066**	− 0.036	− 1.180	0.098	2.932**
Marital status	− 0.050	− 1.502	0.427	14.121***	0.012	0.328
Chronic disease	0.116	3.639***	− 0.070	− 2.391*	0.106	3.341***
BMI	0.015	0.477	0.091	3.068**	0.028	0.884
Sleep quality	0.073	2.313*	0.004	0.143	0.074	2.351*
Socioeconomic status	− 0.099	− 2.992**	0.082	2.686**	− 0.088	− 2.650**
Social support					− 0.144	−4.047***
R^2	0.074		0.223		0.090	
F	10.586***		38.009***		11.463***	
Male subsample (n = 359)						
Age	0.077	1.424	− 0.014	− 0.297	0.075	1.401
Marital status	− 0.043	− 0.784	0.464	9.618***	0.005	0.078
Chronic disease	0.065	1.193	− 0.107	− 2.210*	0.054	0.988
BMI	− 0.044	− 0.811	0.131	2.759**	− 0.030	− 0.557
Sleep quality	0.046	0.879	− 0.083	− 1.794	0.038	0.715
Socioeconomic status	− 0.093	− 1.738	0.060	1.277	− 0.087	− 1.623
Social support					− 0.103	− 1.705
R^2	0.027		0.243		0.035	
F	1.655		18.874***		1.841	
Female subsample (n = 577)						
Age	0.120	2.689**	− 0.063	− 1.544	0.109	2.464*
Marital status	− 0.037	− 0.868	0.415	10.635***	0.037	0.795
Chronic disease	0.155	3.800***	− 0.058	− 1.555	0.145	3.584***
BMI	0.041	0.998	0.062	1.655	0.052	1.279
Sleep quality	0.094	2.308*	0.072	1.927	0.107	2.646**
Socioeconomic status	− 0.101	− 2.383*	0.088	2.293*	− 0.085	− 2.027*
Social support					− 0.178	−3.926***
R^2	0.073		0.231		0.097	
F	7.472***		28.530***		8.769***	

***P − value < 0.001, **P − value < 0.01, *P − value < 0.05

Table 4 Test of the mediating effect of social support

	Effect	SE	95% CI		Mediation (%)
			Lower	Upper	
Total sample (n = 936)					
Total effect	− 0.099	0.031	− 0.153	− 0.032	
Direct effect	− 0.088	0.031	− 0.142	− 0.021	
Indirect effect	− 0.011	0.005	− 0.023	− 0.003	11.11
Male subsample (n = 359)					
Total effect	− 0.093	0.046	− 0.169	0.010	
Direct effect	− 0.087	0.046	− 0.163	0.016	
Indirect effect	− 0.006	0.006	− 0.021	0.004	6.45
Female subsample (n = 577)					
Total effect	− 0.101	0.042	− 0.181	− 0.018	
Direct effect	− 0.085	0.041	− 0.165	− 0.003	
Indirect effect	− 0.016	0.008	− 0.033	− 0.002	15.84

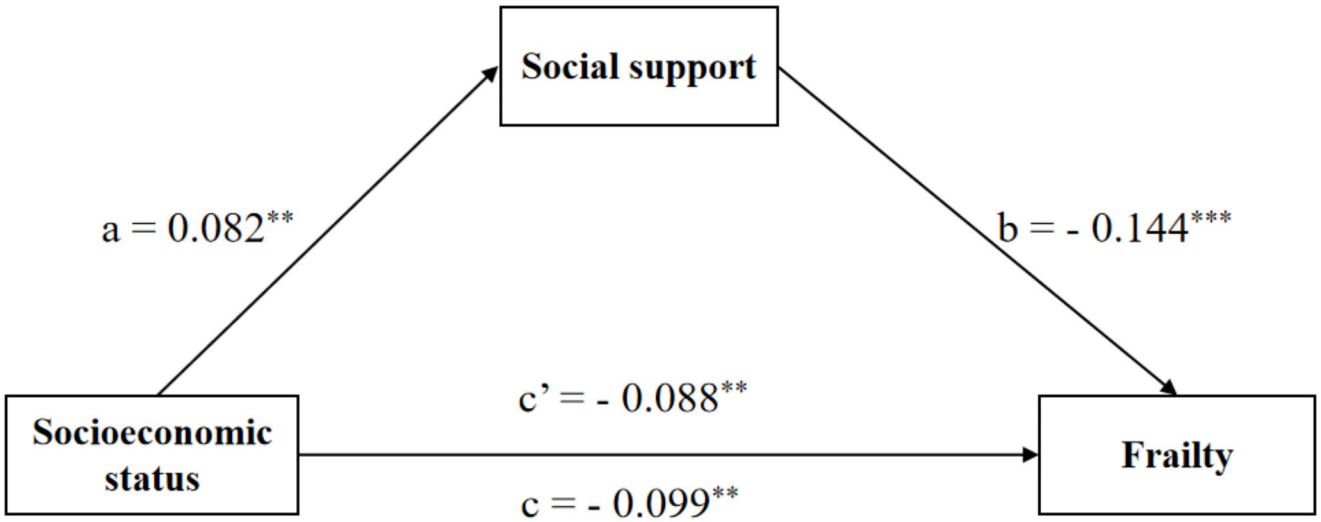

Fig. 1 Path diagram of the association between socioeconomic status and frailty with social support as a mediator in the total sample. *Notes*: ***P-value < 0.001, **P-value < 0.01. Models control for gender, age, marital status, chronic disease, BMI and sleep quality

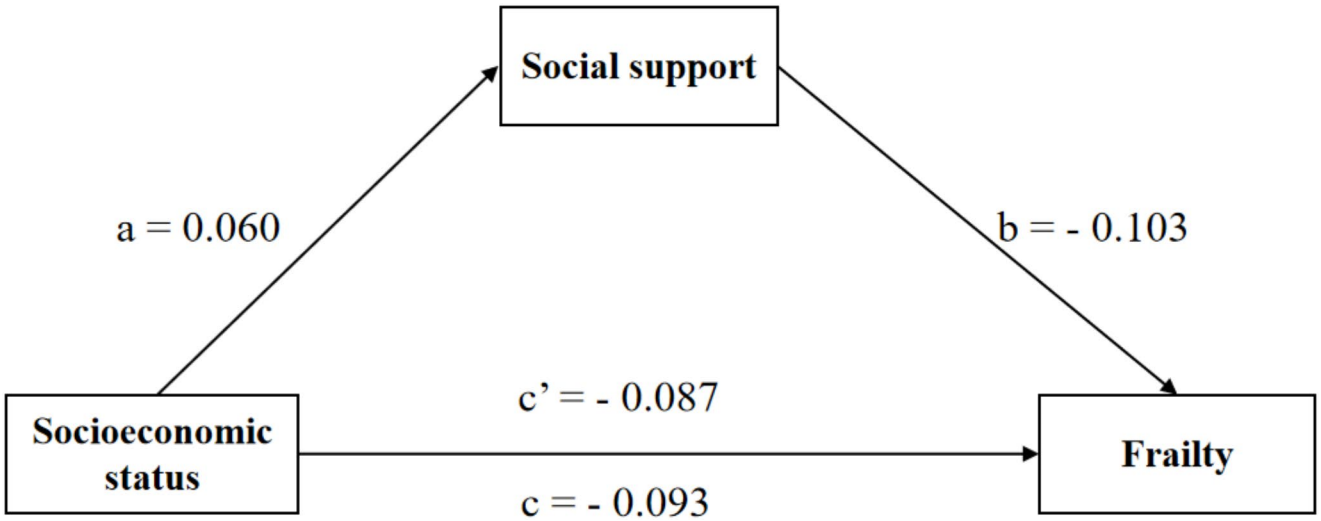

Fig. 2 Path diagram of the association between socioeconomic status and frailty with social support as a mediator in the male subsample. *Notes*: All paths are not significant. Models control for age, marital status, chronic disease, BMI and sleep quality

Discussion

The present study examined the relationship between socioeconomic status and frailty among rural older adults and for the first time explored the mediating role of social support in this relationship, as well as gender differences in the association among socioeconomic status, social support, and frailty. Our results revealed that there was a significant negative relationship between socioeconomic status and frailty among rural older adults. That said, those with low socioeconomic status were at higher risk of frailty. Meanwhile, we found that the effect of socioeconomic status on frailty was partially mediated through social support. The mediating effect of social support accounted for 11.11% of the total effect of socioeconomic status on frailty. An intriguing finding is that there were gender differences in the above results. Specifically, we discovered that, only in females, the relationship between socioeconomic status and frailty held and the mediating effect of social support was also significant.

Our finding that increased socioeconomic status was associated with decreased symptoms of frailty after adjusting for all covariates was in line with previous studies [53]. Individuals with higher socioeconomic status show higher compliance with interventions related to health promotion [54]. They tend to pay more attention to their own health, have a higher willingness to enrich health knowledge through various channels, and urge themselves to develop good living habits. Likewise, groups with higher

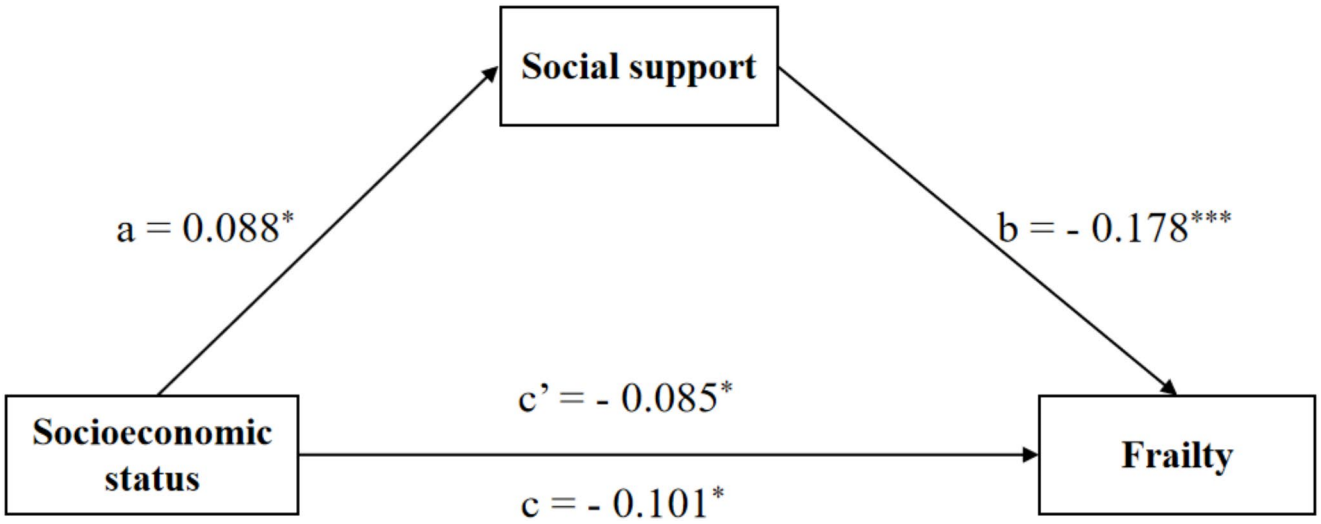

Fig. 3 Path diagram of the association between socioeconomic status and frailty with social support as a mediator in the female subsample. *Notes*: ***P-value < 0.001, *P-value < 0.05. Models control for age, marital status, chronic disease, BMI and sleep quality

socioeconomic status may have greater access to medical services and be at an advantage in obtaining more specialized and complex medical services [55]. All of these factors could be effective in reducing the occurrence of frailty or delaying its aggravation. Prior research has confirmed that socioeconomic status may also be linked to frailty through diet. Low socioeconomic status groups are more restricted in dietary choices and more difficult to achieve balanced nutrition, making them vulnerable to malnutrition [56]. It may also increase the level of inflammation in the blood [57, 58], thereby reducing bone mineral density and even leading to osteoporosis [59]. There is recent evidence that individuals with low socioeconomic status are more likely to drink alcohol [60], which can increase the risk of obesity [61, 62]. As we all know, obesity has been proven to be an independent risk factor for certain diseases [63–65]. It can also induce the pro-inflammatory state through the release of adipokines, accelerating muscle loss and altering the composition and quality of muscle [66], and ultimately promoting the onset and progress of frailty.

This study also analyzed the role of social support in the relationship between socioeconomic status and frailty. Our results suggested that social support could partially mediate the effect of socioeconomic status on frailty. This finding is new and additional evidence for existing related research. On one hand, groups with high socioeconomic status may receive more social support. This is because they are usually more connected to the outside world, have wider social networks, and thus can receive more social support from richer sources [67]. Moreover, the social networks of those are more stable [68]. Socioeconomic status can also influence social support through life events. This means that people with low socioeconomic status may experience more negative life events, leading to disrupted social relationships and reduced social support [69]. On the other hand, low levels of social support may increase the risk of frailty. Social support is an important driving force for health promotion behaviors for older adults. The material and spiritual help provided by members of the social network is conducive to reducing the burden of older adults, improving their ability to access health information and increasing their confidence in self-health management [70], thereby better improving their health level. In addition, adequate social support plays an important role in effectively relieving stress [71]. People with low levels of social support may feel more pressure and loneliness, have difficulty in resolving adverse emotions and be prone to a series of psychiatric problems or illnesses [72, 73], as well as potentially affecting sleep quality [74, 75], which can increases the risk of frailty. Additionally, previous research has indicated that low levels of social support and frailty could also be linked due to inflammation [76].

Our study also explored gender differences in the relationship among socioeconomic status, social support and frailty. The results showed that when stratified by gender, the relationship between socioeconomic status and frailty and the mediating effect of social support were significant only in the female subsample. There may be several reasons: Firstly, while the sensitivity to socioeconomic status is not inherently gender-specific, prior results have been found that females may be more sensitive to perceptions of socioeconomic status than males [77]. For example, females tend to show stronger emotional reactions when faced with changes in their economic situation [78], increasing the risk of mental and physical health problems. Secondly, the risk of frailty varies by gender [79, 80], which may imply the

results of the present study. Previous studies have shown that females have higher inflammatory levels and greater inflammatory activities, and that gradually declining estrogen level with age is significantly associated with adverse events such as decreased bone density and increased risk of cardiovascular disease, making them more susceptible to frailty [81]. Finally, compared with males, females are better at emotional expression and show more comfort in socializing [82], which makes it easier for them to establish and maintain close and lasting relationships with others, thus possibly gaining more social support. As an important protective factor against frailty, the higher level of social support has a significant effect on reducing susceptibility to frailty [35].

Of course, these causes do not ensure that the relationship among socioeconomic status, social support and frailty is not statistically significant in the male population. Our findings may be influenced by several factors. Previous studies have shown differences in the types of social support exchanged by males and females. Specifically, compared with males, females exchanged more emotional support with others in terms of receiving and giving [83]. Meanwhile, females tend to have more same-sex friends [84], which is beneficial to their higher levels of emotional social support. There is recent evidence that emotional social support is more strongly associated with frailty than instrumental social support among older adults [85]. This may serve as a substrate for the phenomenon that the current mediation model is not significant in the male subsample. Secondly, our results may also be affected by the insufficient sample size included, as a small sample size may reduce statistical power. In addition, it cannot be ignored that the measurement instrument used in this study may also have measurement invariance limitations concerning the gender dimension.

Our results have some implications for the prevention and intervention of frailty among older adults. To begin with, the government and other institutions should provide more policy support and social welfare for older people with low socioeconomic status to meet their basic needs for livelihood and health care services. Secondly, it is necessary to actively build social platforms and organize various community activities regularly to help older adults broaden their interpersonal network and maintain optimism. Besides, older adults should be encouraged to exercise consciously to enhance physical fitness, get rid of improper behaviors and cultivate healthy living habits, so as to prevent the occurrence of frailty. At last, public health departments should focus on older adults with low socioeconomic status and lack of social support. It is important to strengthen monitoring and screening for frailty and implement comprehensive interventions as early as possible for those who are already experiencing frailty or prefrailty to prevent the exacerbation of symptoms and facilitate the reversal to health.

This study also has several limitations. Firstly, as a cross-sectional study, it was not the ideal form for determining causality between variables. Secondly, the proportions of mediating effects in the total and female samples reflected the fact that other potential mechanisms may need further to be explored in the relationship between socioeconomic status and frailty. Thirdly, some of the data, such as frailty, social support and sleep quality, were obtained by self-report using well-established scales, which was inevitably subject to reporting bias and recall bias. Fourthly, the non-significant findings in the male subsample resulting from the present study were not completely established. Affected by some factors such as sample size and measurement limitations, our research is rather shallow in exploring the gender differences in the relationship among the three key variables, which suggests that more in-depth analyses are necessary in the future. Furthermore, future research should continue to explore other factors influencing frailty in both males and females, and use social support measures that capture gender-specific differences in the types and dynamics of support provided or received by both sexes. Finally, participants in this study were only from rural areas in an eastern province of China. In order to improve the generalizability of our findings, the scope and population of the study should be expanded in the future.

Conclusion

In conclusion, this study demonstrated that socioeconomic status was significantly associated with frailty among rural older adults, and that social support mediated this relationship. In addition, we found that there were gender differences in the relationship among socioeconomic status, social support and frailty. Specifically, the association between socioeconomic status and frailty and the mediating role of social support were statistically significant in the female subsample but not in the male subsample. These findings highlighted the importance of socioeconomic status and social support in improving the frailty of rural older adults, especially females. Additional studies need to be conducted in the future to explore other underlying pathways and temporal sequence between socioeconomic status and frailty.

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Author contributions P. D., X. Z., and W. Y.: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing - Original Draft Preparation, Writing - Review & Editing, Project Administration. Z. L., X. L., and M. G.: Investigation, Resources, Data Curation, Formal Analysis. Y. S., H. G., and Z. C.:

Conceptualization, Methodology, Supervision, Writing-Review & Editing, Project Administration. All authors have read and agreed to the published version of the manuscript.

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Data availability The datasets used and/or analyzed during the current study are available from corresponding authors on reasonable request.

Declarations

Ethics approval and consent to participate The study complied with the principles of the Declaration of Helsinki and was approved by the Medical Ethics Committee of Weifang Medical University (2021YX-066). All participants were provided written informed consent before the survey.

Competing interests The authors declare no competing interests.

Conflict of interest The authors report no conflicts of interest in this work.

References

1. Brivio P, Paladini MS, Racagni G, Riva MA, Calabrese F, Molteni R (2019) From healthy aging to frailty: in search of the underlying mechanisms. Curr Med Chem 26(20):3685–3701. https://doi.org/10.2174/0929867326666190717152739
2. National Bureau of Statistics of China Statistical communique of the People's Republic of China on the 2023 national economic and social development. [cited 2024 Sep 20]. Available from: https://www.stats.gov.cn/sj/zxfb/202402/t20240228_1947915.html
3. Hoogendijk EO, Afilalo J, Ensrud KE, Kowal P, Onder G, Fried LP (2019) Frailty: implications for clinical practice and public health. Lancet 394(10206):1365–1375. https://doi.org/10.1016/S0140-6736(19)31786-6
4. Dong YF, Ma HM, Sun H, Li YM, Li XF, Pan SQ et al (2024) Association of altitude and frailty in Chinese older adults: using a cumulative frailty index model. Front Public Health 12:1321580. https://doi.org/10.3389/fpubh.2024.1321580
5. Zhou Q, Li Y, Gao Q, Yuan HP, Sun L, Xi H et al (2023) Prevalence of frailty among Chinese Community-Dwelling older adults: A systematic review and Meta-Analysis. Int J Public Health 68:1605964. https://doi.org/10.3389/ijph.2023.1605964
6. Ward DD, Ranson JM, Wallace LMK, Llewellyn DJ, Rockwood K (2022) Frailty, lifestyle, genetics and dementia risk. J Neurol Neurosurg Psychiatry 93(4):343–350. https://doi.org/10.1136/jnnp-2021-327396
7. Bartosch PS, Kristensson J, McGuigan FE, Akesson KE (2020) Frailty and prediction of recurrent falls over 10 years in a community cohort of 75-year-old women. Aging Clin Exp Res 32(11):2241–2250. https://doi.org/10.1007/s40520-019-01467-1
8. Kojima G, Iliffe S, Walters K (2018) Frailty index as a predictor of mortality: a systematic review and meta-analysis. Age Ageing 47(2):193–200. https://doi.org/10.1093/ageing/afx162
9. Hoogendijk EO, Suanet B, Dent E, Deeg DJ, Aartsen MJ (2016) Adverse effects of frailty on social functioning in older adults: results from the longitudinal aging study Amsterdam. Maturitas 83:45–50. https://doi.org/10.1016/j.maturitas.2015.09.002
10. Tan M, Bhanu C, Frost R (2023) The association between frailty and anxiety: A systematic review. Int J Geriatr Psychiatry 38(5):e5918. https://doi.org/10.1002/gps.5918
11. Deng MG, Liu F, Liang YH, Wang K, Nie JQ, Liu JW (2023) Association between frailty and depression: A bidirectional Mendelian randomization study. Sci Adv 9(38):eadi3902. https://doi.org/10.1126/sciadv.adi3902
12. Ilinca S, Calciolari S (2015) The patterns of health care utilization by elderly Europeans: frailty and its implications for health systems. Health Serv Res 50(1):305–320. https://doi.org/10.1111/1475-6773.12211
13. Bock JO, König HH, Brenner H, Haefeli WE, Quinzler R, Matschinger H et al (2016) Associations of frailty with health care costs–results of the ESTHER cohort study. BMC Health Serv Res 16:128. https://doi.org/10.1186/s12913-016-1360-3
14. Ofori-Asenso R, Lee Chin K, Mazidi M, Zomer E, Ilomaki J, Ademi Z et al (2020) Natural regression of frailty among Community-Dwelling older adults: A systematic review and Meta-Analysis. Gerontologist 60(4):e286–e298. https://doi.org/10.1093/geront/gnz064
15. O'Caoimh R, Sezgin D, O'Donovan MR, Molloy DW, Clegg A, Rockwood K et al (2021) Pr-evalence of frailty in 62 countries across the world: a systematic review and meta-anal-ysis of population-level studies. Age Ageing 50(1):96–104. https://doi.org/10.1093/ageing/afaa219
16. Fu YJ, Zhang S, Guo XL, Lu ZL, Sun XJ (2023) Socioeconomic status and quality of life among older adults with hypertension in rural Shandong, China: a mediating effect of social capital. Front Public Health 11:1248291. https://doi.org/10.3389/fpubh.2023.1248291
17. Tousoulis D, Oikonomou E, Vogiatzi G, Vardas P (2020) Cardiovascular disease and socioeconomic status. Eur Heart J 41(34):3213–3214. https://doi.org/10.1093/eurheartj/ehaa405
18. Marmot MG, Kogevinas M, Elston MA (1987) Social/economic status and disease. Annu Rev Public Health 8:111–135. https://doi.org/10.1146/annurev.pu.08.050187.000551
19. Torres JM, Rizzo S, Wong R (2018) Lifetime socioeconomic status and Late-life health trajectories: longitudinal results from the Mexican health and aging study. J Gerontol B Psychol Sci Soc Sci 73(2):349–360. https://doi.org/10.1093/geronb/gbw048
20. Hwang J, Lyu B, Ballew S, Coresh J, Grams ME, Couper D et al (2023) The association between socioeconomic status and use of potentially inappropriate medications in older adults. J Am Geriatr Soc 71(4):1156–1166. https://doi.org/10.1111/jgs.18165
21. Poli S, Cella A, Puntoni M, Musacchio C, Pomata M, Torriglia D et al (2017) Frailty is associated with socioeconomic and lifestyle factors in community-dwelling older subjects. Aging Clin Exp Res 29(4):721–728. https://doi.org/10.1007/s40520-016-0623-5
22. Mello Ade C, Engstrom EM, Alves LC (2014) Health-related and socio-demographic factors associated with frailty in the elderly: a systematic literature review. Cad Saude Publica 30(6):1143–1168. https://doi.org/10.1590/0102-311x00148213

23. World Health Organization Active Ageing: A Policy Framework. [cited 2024 Sep 20]. Available from: http://whqlibdoc.who.int/hq/2002/WHO_NMH_NPH_02.8.pdf?ua=1
24. Fahmy C, Testa A (2021) Stress among older adults with an incarcerated family member: testing the buffering model of social support. J Gerontol B Psychol Sci Soc Sci 76(10):2057–2062. https://doi.org/10.1093/geronb/gbab117
25. Iwanowicz-Palus G, Zarajczyk M, Bień A, Korżyńska-Piętas M, Krysa J, Rahnama-Hezavah M et al (2021) The relationship between social support, Self-Efficacy and characteristics of women with diabetes during pregnancy. Int J Environ Res Public Health 19(1):304. https://doi.org/10.3390/ijerph19010304
26. Li DF, Li XL, Zeng Y (2022) The moderating effect of community environment on the association between social support and Chinese older adults' health: an empirical analysis study. Front Public Health 10:855310. https://doi.org/10.3389/fpubh.2022.855310
27. Rashidi Fakari F, Doulabi MA, Mahmoodi Z (2022) Predict marital satisfaction based on the variables of socioeconomic status (SES) and social support, mediated by mental health, in women of reproductive age: path analysis model. Brain Behav 12(3):e2482. https://doi.org/10.1002/brb3.2482
28. Pang ML, Wang JR, Tian TT, Zhao JF, Jiang XX, Li HX et al (2022) The mediating effect of social support on the association between socioeconomic status and self-reported oral health status among the migrant elderly following children in Weifang, China: a cross-sectional study. BMC Oral Health 22(1):619. https://doi.org/10.1186/s12903-022-02649-6
29. Gazzaz AZ, Carpiano RM, Aleksejuniene J (2021) Socioeconomic status, social support, and oral health-risk behaviors in Canadian adolescents. J Public Health Dent 81(4):316–326. https://doi.org/10.1111/jphd.12478
30. Vonneilich N, Jöckel KH, Erbel R, Klein J, Dragano N, Weyers S et al (2011) Does socioeconomic status affect the association of social relationships and health? A moderator analysis. Int J Equity Health 10:43. https://doi.org/10.1186/1475-9276-10-43
31. Kelly ME, Duff H, Kelly S, McHugh Power JE, Brennan S, Lawlor BA et al (2017) The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. Syst Rev 6(1):259. https://doi.org/10.1186/s13643-017-0632-2
32. Kuiper JS, Zuidersma M, Zuidema SU, Burgerhof JG, Stolk RP, Oude Voshaar RC et al (2016) Social relationships and cognitive decline: a systematic review and meta-analysis of longitudinal cohort studies. Int J Epidemiol 45(4):1169–1206. https://doi.org/10.1093/ije/dyw089
33. Hanlon P, Wightman H, Politis M, Kirkpatrick S, Jones C, Andrew MK et al (2024) The relationship between frailty and social vulnerability: a systematic review. Lancet Healthy Longev 5(3):e214–e226. https://doi.org/10.1016/S2666-7568(23)00263-5
34. Santos DGMD, Pallone JM, Manzini CSS, Zazzetta MS, Orlandi FS (2021) Relationship betw-een frailty, social support and family functionality of Hemodialysis patients: a cross-sect-ional study. Sao Paulo Med J 139(6):570–575. https://doi.org/10.1590/1516-3180.2021.0089.R1.0904221
35. Fan LJ, Wang SY, Xue H, Ding Y, Wang JW, Tian Y et al (2021) Social support and mortality in Community-Dwelling Chinese older adults: the mediating role of frailty. Risk Manag Healthc Policy 14:1583–1593. https://doi.org/10.2147/RMHP.S296018
36. Anantapong K, Wiwattanaworaset P, Sriplung H (2020) Association between social support and frailty among older people with depressive disorders. Clin Gerontol 43(4):400–410. https://doi.org/10.1080/07317115.2020.1728002
37. Dent E, Morley JE, Cruz-Jentoft AJ, Woodhouse L, Rodríguez-Mañas L, Fried LP et al (2019) Physical frailty: ICFSR international clinical practice guidelines for identification and management. J Nutr Health Aging 23(9):771–787. https://doi.org/10.1007/s12603-019-1273-z
38. Neufcourt L, Deguen S, Bayat S, Zins M, Grimaud O (2020) Gender differences in the assoc-iation between socioeconomic status and hypertension in France: A cross-sectional analy-sis of the CONSTANCES cohort. PLoS ONE 15(4):e0231878. https://doi.org/10.1371/journal.pone.0231878
39. Ma H, Liu FC, Li JX, Chen JC, Cao J, Chen SF et al (2023) Sex differences in associations between socioeconomic status and incident hypertension among Chinese adults. Hypertension 80(4):783–791. https://doi.org/10.1161/HYPERTENSIONAHA.122.20061
40. Campbell SB, Gray KE, Hoerster KD, Fortney JC, Simpson TL (2021) Differences in functional and structural social support among female and male veterans and civilians. Soc Psychiatry Psychiatr Epidemiol 56(3):375–386. https://doi.org/10.1007/s00127-020-01862-4
41. Kiecolt-Glaser JK, Newton TL (2001) Marriage and health: his and hers. Psychol Bull 127(4):472–503. https://doi.org/10.1037/0033-2909.127.4.472
42. Antonucci TC, Akiyama H (1987) An examination of sex differences in social support among older men and women. Sex Roles 17(11):737–749. https://doi.org/10.1007/s11199-023-01366-w
43. Gao M, Li XN, Shi YL, Li ZY, Dong P, Feng ZQ et al Influencing Factors for Medication Experience and Medication Adherence in Elderly Patients with Chronic Diseases. Chinese General Practice. [cited 2024 Sep 20]. Available from: http://kns.cnki.net/kcms/detail/13.1222.R.20240716.1703.004.html
44. Yamato Y, Kamiya K, Hamazaki N, Nozaki K, Ichikawa T, Yamashita M et al (2022) Utility of the fatigue, resistance, ambulation, illness, and loss of weight scale in older patients with cardiovascular disease. J Am Med Dir Assoc 23(12):1971–1976e2. https://doi.org/10.1016/j.jamda.2022.08.006
45. van Abellan G, Rolland Y, Bergman H, Morley JE, Kritchevsky SB, Vellas B (2008) The I.A.N.A task force on frailty assessment of older people in clinical practice. J Nutr Health Aging 12(1):29–37. https://doi.org/10.1007/BF02982161
46. Huang R, Grol-Prokopczyk H (2022) Health and health behaviors in China: anomalies in the SES-health gradient? SSM Popul Health 17:101069. https://doi.org/10.1016/j.ssmph.2022.101069
47. Liu Y, Liu ZR, Liang R, Luo YN (2022) The association between community-level socioeconomic status and depressive symptoms among middle-aged and older adults in China. BMC Psychiatry 22(1):297. https://doi.org/10.1186/s12888-022-03937-9
48. Duan Y, Liu ZH, Qi Q, Liu HQ, Zhang M (2024) Solid fuel use, socioeconomic status and depression: a cross-study of older adults in China. BMC Geriatr 24(1):115. https://doi.org/10.1186/s12877-024-04670-6
49. Ma WK, Kang DM, Song YP, Wei CY, Marley G, Ma W (2015) Social support and HIV/ST-Ds infections among a probability-based sample of rural married migrant women in Sh-andong Province, China. BMC Public Health 15:1170. https://doi.org/10.1186/s12889-015-2508-5
50. Bao J, Wang XY, Chen CH, Zou LT (2023) Relationship between primary caregivers' social support function, anxiety, and depression after interventional therapy for acute myocardial infarction patients. World J Psychiatry 13(11):919–928. https://doi.org/10.5498/wjp.v13.i11.919
51. Sweatt K, Garvey WT, Martins C (2024) Strengths and limitations of BMI in the diagnosis of obesity: what is the path forward?? Curr Obes Rep 13(3):584–595. https://doi.org/10.1007/s13679-024-00580-1
52. Hur S, Oh B, Kim H, Kwon O (2021) Associations of diet quality and sleep quality with obesity. Nutrients 13(9):3181. https://doi.org/10.3390/nu13093181

53. Etman A, Burdorf A, Van der Cammen TJ, Mackenbach JP, Van Lenthe FJ (2012) Socio-demographic determinants of worsening in frailty among community-dwelling older people in 11 European countries. J Epidemiol Community Health 66(12):1116–1121. https://doi.org/10.1136/jech-2011-200027
54. Bonaccio M, Di Castelnuovo A, Pounis G, Costanzo S, Persichillo M, Cerletti C et al (2017) High adherence to the mediterranean diet is associated with cardiovascular protection in higher but not in lower socioeconomic groups: prospective findings from the Moli-sani study. Int J Epidemiol 46(5):1478–1487. https://doi.org/10.1093/ije/dyx145
55. Filc D, Davidovich N, Novack L, Balicer RD (2014) Is socioeconomic status associated with utilization of health care services in a single-payer universal health care system? Int J Equity Health 13:115. https://doi.org/10.1186/s12939-014-0115-1
56. Lim HS, Park YH, Lee HH, Kim TH, Kim SK (2015) Comparison of calcium intake status by region and socioeconomic status in Korea: the 2011–2013 Korea National health and nutrition examination survey. J Bone Metab 22(3):119–126. https://doi.org/10.11005/jbm.2015.22.3.119
57. Richman AD (2018) Concurrent social disadvantages and chronic inflammation: the intersection of race and ethnicity, gender, and socioeconomic status. J Racial Ethn Health Disparities 5(4):787–797. https://doi.org/10.1007/s40615-017-0424-3
58. Tang YC, Peng B, Liu JM, Liu ZC, Xia YY, Geng B (2022) Systemic immune-inflammation index and bone mineral density in postmenopausal women: A cross-sectional study of the National health and nutrition examination survey (NHANES) 2007–2018. Front Immunol 13:975400. https://doi.org/10.3389/fimmu.2022.975400
59. Zhang Y, Tan C, Tan W (2023) BMI, socioeconomic status, and bone mineral density in U.S. Adults: mediation analysis in the NHANES. Front Nutr 10:1132234. https://doi.org/10.3389/fnut.2023.1132234
60. Allen L, Williams J, Townsend N, Mikkelsen B, Roberts N, Foster C et al (2017) Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. Lancet Glob Health 5(3):e277–e289. https://doi.org/10.1016/S2214-109X(17)30058-X
61. Ho CC, Lee PF, Xu S, Hung CT, Su YJ, Lin CF et al (2022) Associations between cigarette smoking status and health-related physical fitness performance in male Taiwanese adults. Front Public Health 10:880572. https://doi.org/10.3389/fpubh.2022.880572
62. Park KY, Park HK, Hwang HS (2017) Relationship between abdominal obesity and alcohol drinking pattern in normal-weight, middle-aged adults: the Korea National health and nutrition examination survey 2008–2013. Public Health Nutr 20(12):2192–2200. https://doi.org/10.1017/S1368980017001045
63. Seravalle G, Grassi G (2017) Obesity and hypertension. Pharmacol Res 122:1–7. https://doi.org/10.1016/j.phrs.2017.05.013
64. Bell JA, Kivimaki M, Hamer M (2014) Metabolically healthy obesity and risk of incident type 2 diabetes: a meta-analysis of prospective cohort studies. Obes Rev 15(6):504–515. https://doi.org/10.1111/obr.12157
65. Lin CJ, Chang YC, Cheng TY, Lo K, Liu SJ, Yeh TL (2020) The association between metabolically healthy obesity and risk of cancer: A systematic review and meta-analysis of prospective cohort studies. Obes Rev 21(10):e13049. https://doi.org/10.1111/obr.13049
66. García-Esquinas E, José García-García F, León-Muñoz LM, Carnicero JA, Guallar-Castillón P, Gonzalez-Colaço Harmand M et al (2015) Obesity, fat distribution, and risk of frailty in two population-based cohorts of older adults in Spain. Obes (Silver Spring) 23(4):847–855. https://doi.org/10.1002/oby.21013
67. Bishop JH (1980) Jobs, cash transfers and marital instability: a review and synthesis of the evidence. J Hum Resour 15(3):301–334. https://doi.org/10.2307/145286
68. Mirowsky J (2017) Education, social status, and health, 1st edn. Routledge, New York
69. Mickelson KD, Kubzansky LD (2003) Social distribution of social support: the mediating role of life events. Am J Community Psychol 32(3–4):265–281. https://doi.org/10.1023/b:ajcp.0000004747.99099.7e
70. Li LQ, Zhou H, Wang Q, Tan ZJ, Li L Influence of frailty on knowledge, attitude an-d behavior of rehabilitation in community elderly: The mediating role of social support. China Journal of Health Psychology. [cited 2024 Sep 20]. Available from: http://kns.cnki.net/kcms/detail/11.5257.r.20240816.1547.002.html
71. Dehghankar L, Valinezhad S, Amerzadeh M, Zarabadi Poor F, Hosseinkhani Z, Motalebi SA (2024) Relationship between perceived social support and disability with the mediating role of perceived stress among older adults. BMC Geriatr 24(1):276. https://doi.org/10.1186/s12877-024-04871-z
72. Fried EI, Nesse RM, Guille C, Sen S (2015) The differential influence of life stress on individual symptoms of depression. Acta Psychiatr Scand 131(6):465–471. https://doi.org/10.1111/acps.12395
73. Peng HN, Ma JJ, Hu J, Gan YQ (2024) Association of daily stress with daily anxiety and depression. Eur J Health Psychol 31(1):16–27
74. Seo S, Mattos MK (2024) The relationship between social support and sleep quality in older adults: A review of the evidence. Arch Gerontol Geriatr 117:105179. https://doi.org/10.1016/j.archger.2023.105179
75. Zhang J, Li XW, Tang ZX, Xiang SG, Hu WX et al (2024) Effects of stress on sleep quality: multiple mediating effects of rumination and social anxiety. Psicol Reflex Crit 37(1):10. https://doi.org/10.1186/s41155-024-00294-2
76. Coussons-Read ME, Okun ML, Nettles CD (2007) Psychosocial stress increases inflammatory markers and alters cytokine production across pregnancy. Brain Behav Immun 21(3):343–350. https://doi.org/10.1016/j.bbi.2006.08.006
77. Chen X, Woo J, Yu R, Chung GK, Yao W, Yeoh EK (2022) Subjective social status, area deprivation, and gender differences in health among Chinese older people. Int J Environ Res Public Health 19(16):9857. https://doi.org/10.3390/ijerph19169857
78. Lee H, Park S (2018) Gender differences in the trajectory classes of depressive symptoms in Korean older adults. Aging Ment Health 22(9):1162–1169. https://doi.org/10.1080/13607863.2017.1339776
79. Zeng XZ, Meng LB, Li YY, Jia N, Shi J, Zhang C et al (2023) Prevalence and factors associated with frailty and pre-frailty in the older adults in China: a National cross-sectional study. Front Public Health 11:1110648. https://doi.org/10.3389/fpubh.2023.1110648
80. Murayama H, Kobayashi E, Okamoto S, Fukaya T, Ishizaki T, Liang J et al (2020) National prevalence of frailty in the older Japanese population: Findings from a nationally repre-sentative survey. Arch Gerontol Geriatr.;91:104220. https://doi.org/10.1016/j.archg-er. 2020.104220
81. Zeidan RS, McElroy T, Rathor L, Martenson MS, Lin Y, Mankowski RT (2023) Sex differences in frailty among older adults. Exp Gerontol 184:112333. https://doi.org/10.1016/j.exger.2023.112333
82. Shangguan CY, Zhang LH, Wang YL, Wang W, Shan MX, Liu F (2022) Expressive flexibility and mental health: the mediating role of social support and gender differences. Int J Environ Res Public Health 19(1):456. https://doi.org/10.3390/ijerph19010456
83. Liebler CA, Sandefur GD (2002) Gender differences in the exchange of social support with friends, neighbors, and

co-workers at midlife. Soc Sci Res 31(3):364–391. https://doi.org/10.1016/S0049-089X(02)00006-6
84. Abu-Kaf S, Nakash O, Hayat T, Cohen M (2022) Social support and psychological distress among the bedouin Arab elderly in Israel: the moderating role of gender. Int J Environ Res Public Health 19(7):4358. https://doi.org/10.3390/ijerph19074358
85. Chu WM, Tange C, Nishita Y et al (2023) Effect of different types of social support on physical frailty development among community-dwelling older adults in Japan: evidence from a 10-year population-based cohort study. Arch Gerontol Geriatr 108:104928. https://doi.org/10.1016/j.archger.2023.104928