BMC Geriatrics

RESEARCH

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Associated factors of frailty among community-dwelling older adults with multimorbidity from a health ecological perspective: a cross-sectional study

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Abstract

Background As the global aging process accelerates, the older population is increasing annually, with the majority suffering from one or more chronic diseases. Due to the influence of chronic disease comorbidity, frailty among the older is widespread. Therefore, early identification of frailty in older adults with comorbidities from a comprehensive perspective, along with proactive measures for prevention and timely intervention, becomes an inevitable requirement for healthy aging. This study aimed to identify the entry point of frailty management in the older with multimorbidity in the community and clarify the focus of frailty management.

Methods A national cross-sectional survey of 1056 older adults with comorbidities in 148 cities across China was conducted. Frailty was assessed using the Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight (FRAIL) scale. Based on the health ecological model, the factors which may influence frailty were collected from five levels. Univariate and multivariate analysis were utilized to determine the factors influencing frailty. The STROBE checklist was used preparing the manuscript**.**

Results A total of 417 patients (39.5%) reported having frailty, while 613 patients (58.0%) were in the pre-frail state. Multivariate logistic regression analysis indicate that compared with robust patients, number of comorbidities, self-efficacy, sleep quality and perceived social support are associated with frailty in older patients with comorbidities ($P < 0.05$). Compared to pre-frail group, factors such as number of comorbidities, gender (female), cognitive status of diseases, anxiety, having four or more comorbidities, smoking, eating habits, taking three or more different types of medication and perceived social support are associated with frailty ($P < 0.05$).

Conclusions The prevalence of frailty among older adults with comorbidities is exceptionally high, influenced by various dimensions from health ecology perspective. Psychological care and daily behavior management should be strengthened for the frail older with multimorbidity. Precise and individualized care interventions need to be developed to help promote healthy aging.

Keywords Frailty, Older adults, Multimorbidity, Health ecological model, Risk factors

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Background

The aging of the population is accelerating rapidly and is gradually becoming a global phenomenon. By 2050, the world's population of people aged 60 years and older will double (2.1 billion) [1]. China is the country with the largest older population in the world and the fastest aging. By the end of 2023, the number of people over 60 reached 297 million, accounting for 21.1% of the population. By 2040, the proportion of the population aged 60 and above will rise to 28% [2].The coexistence of two or more chronic diseases is commonly referred to as multimorbidity, a prevalent phenomenon within the older population [3]. Moreover, the prevalence of multimorbidity significantly escalates with advancing age [4]. The prevalence of multimorbidity in Chinese people aged 60 years and older is between 6.4% and 76.5% [5]. The incidence of frailty also increases with the occurrence of comorbidity [6–9]. Frailty is a biological syndrome of decreased reserve and resistance to stressors, resulting from a cumulative decline in multiple physiological systems and leading to vulnerability to adverse outcomes [6]. Frailty is recognized as an emerging public health priority, with a prevalence of roughly between 12—24% [4].

Frailty can happen to adults at any age, especially those with chronic disease [8], and the risk is even higher for those with several chronic conditions [6, 10, 11]. From a clinical perspective, there is a continuum between multimorbidity and frailty in the older. They progress from having chronic diseases to developing multimorbidity, and eventually become frail. Degenerative changes associated with aging play a crucial role in this progression [12]. older adults with compromised health status have a markedly increased risk of frailty. Multimorbidity can precipitate adverse conditions such as diminished exercise tolerance, reduced gait speed, and medication dependence, all of which contribute to the development of frailty. Additionally, there is a common characteristic between frailty and multimorbidity: both originate from the accumulation of health deficits in the individual [6]. These factors elevate the likelihood of diminished quality of life and poorer disease prognosis in older adults, thereby increasing the risk of adverse health outcomes, including hospitalization, disability, and mortality. Therefore, older adults with comorbidities and frailty are more likely to incur high medical costs and substantial economic burdens.

Frailty is a multifactorial syndrome that results from the complex interactions between an individual, their interpersonal network, and the broader social environment, and it should be identified from multiple aspects. Variables such as gender, age, and physical condition [4, 13–15] are closely linked to an individual's innate physiological traits. These factors contribute to the direct decline in the function of various organs and systems, triggering a series of pathophysiological changes associated with frailty, thereby leading to individual differences in frailty status [13]. Furthermore, behavioral and psychological factors, such as physical exercise, sleep, diet, and loneliness [15, 16], may further increase inflammatory biomarker levels on the basis of the loss of physiological reserves in older adults, causing environmental imbalances and nutrient losses in the body [6], which in turn affect muscle mass, function, and strength, and induce frailty. Interpersonal networks play a crucial role in the development of frailty through social influence. Poor interpersonal relationships may decrease dietary quality and willingness to engage in activities, thereby accelerating the onset of frailty [17]. Moreover, there is substantial evidence indicating that living and working conditions such as educational level, career status, and monthly income [18, 19], along with policy support [17] can influence the progression of frailty in older adults through various mechanisms, including the promotion of health behaviors, increased social participation, and enhanced economic resources. However, the factors influencing frailty in older adults with multimorbidity remain insufficiently understood. Previous studies on this topic often lack a robust theoretical framework, resulting in fragmented, inconsistent, and difficult-to-integrate conclusions.

Frailty is dynamic and reversible process and can prevent or delay the onset of frailty and improve [8, 20]. Both the National Institute for Health and Care Excellence (NICE) and the British Geriatric Society emphasize the importance of timely identifying frailty in older adults with multimorbidity to mitigate the adverse consequences of frailty [21]. In this context, the present study, as the first nationwide survey in China, aims to assess the prevalence of frailty among 1,056 community-dwelling older adults with multimorbidity, thereby filling a gap in the existing data. By analyzing the risk factors associated with frailty, this study seeks to provide insights into the management of frailty in older adults with multimorbidity, ultimately helping to reduce the excessive demand for healthcare resources.

This study aimed to assess the prevalence of frailty among older adults with comorbidities, and explore the multidimensional factors that influence frailty within the study population from a health ecology perspective.

Theoretical framework

In recent years, health ecological model has emerged as an influential theoretical framework in health practice, particularly in the management of chronic diseases [22, 23]. Chen et al. [24] utilized this theory to investigate the causes of comorbidities in older adults, and their

findings demonstrated that this theory provides a more comprehensive framework for analyzing the influencing factors. This model views individual health as a complex "human ecosystem" interacting with the environment, positing that health outcomes are shaped by multiple, interrelated factors. It emphasizes five key levels of influence, ranging from individual traits, personal behaviors and psychological, interpersonal networks, living and working conditions, and macro policy [25]. Health ecological model provides a broad and comprehensive logical framework that highlights the multi-layered impact of the social environment on individuals. This aligns well with the multifactorial interactions that characterize frailty. To address the limitations of previous studies, this research adopts a health ecological perspective, offering theoretical support for precision care and personalized interventions for older adults with multimorbidity. It also provides valuable insights into the growing diversity of frailty management needs within the context of healthy aging.

Methods

Study design

This was a cross-sectional study, The data used in this study were sourced from the Psychology and Behavior Investigation of Chinese Residents (PBICR). A survey was conducted from 20 June 2022 to 31 August 2022, using stratified sampling and quota sampling methods in 148 cities, 202 districts and counties, 390 townships / towns /streets, and 780 communities / villages (excluding Hong Kong, Macao, and Taiwan) from 23 provinces, 5 autonomous regions, and 4 municipalities directly under the central government in China. The sampling ratio was determined based on the population proportion provided by the seventh national census data (the quota attributes are sex, age, and urban–rural distribution).The survey protocol has been published [26]. We used the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist to report the findings of our research (see File 1).

Participants

Initially, of 30,505 collected questionnaires, 21,916 remained after adjustment using quota sampling based on Chinese demographic characteristics. Of these 21,916 questionnaires, 36 were disregarded because the respondents had been outside mainland China for the past 3 months, 17,529 were disregarded because the respondents were younger than 60 years old, and 3,161 were disregarded because they did not meet the diagnosis of multimorbidity (defined as the co-occurrence of at least 2 chronic diseases in the same individual). After performing logical checks, those who meet the qualification criteria are included in the final statistical analysis, including a total of 1056 data points (Fig. 1).

Inclusion criteria: (a)Aged 60 years or over (The Chinese Medical Association stipulates that the age of 60 years or older is considered to be older adults); (b) Diagnosis of 2 or more chronic diseases according to the 9 chronic diseases specified in the Eleventh Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-11); (c)Chinese nationality; (d)China's permanent resident (out of country for no more than 1 month per year); (e)Participated in the study and signed an informed consent form voluntarily; (f)Participants can complete the questionnaire survey by themselves or with the help of investigators; (g)Participants can understand the meaning of each item in the questionnaire.

The exclusion criteria: (a)Having cognitive or mental impairment; (b)Participation in other similar research projects.

Data collection

The survey was carried out through the network Wenjuanxing platform, the most popular survey software in China (https://www.wjx.cn/), by trained investigators issuing questionnaires to residents one-on-one and face-to-face. The participants signed the informed consent form and answered the questionnaires by clicking on the link, and the investigators input the questionnaire number. If the respondent had the ability to think but did not have enough action ability to answer the questionnaire, the investigator would conduct a one-to-one interview and then answer the questions on his or her behalf.

The study questionnaires were composed of self-made questionnaires and a series of standardized scales, focusing on the health-ecological factors related to the frailty of the older with multimorbidity in 5 key levels: (a)Individual trait level(Age, Gender, BMI, Nationality, Religion, Number of comorbidity, Self-efficacy, Personality traits), (b)Behavioral and psychological level(Smoking, Drinking, Exercise, Sleeping, Eating, Fall, Anxiety, Depression, Loneliness, Taking medicine, Health literacy, Cognitive status of diseases, Self-rated health), (c)Interpersonal network level(marital status, Number of offspring, Living arrangement, Family health, Perceived social support), (d)Living and working condition level(educational level, Career status, Social status, Household monthly income, Place of residence, Primary health care institutions), (e) Macro policy level(Region, National or local subsidy policy, Medical insurance type) (Fig. 2). The study questionnaire underwent 38 expert consultations and 3 pre-surveys to guarantee the results' validity.

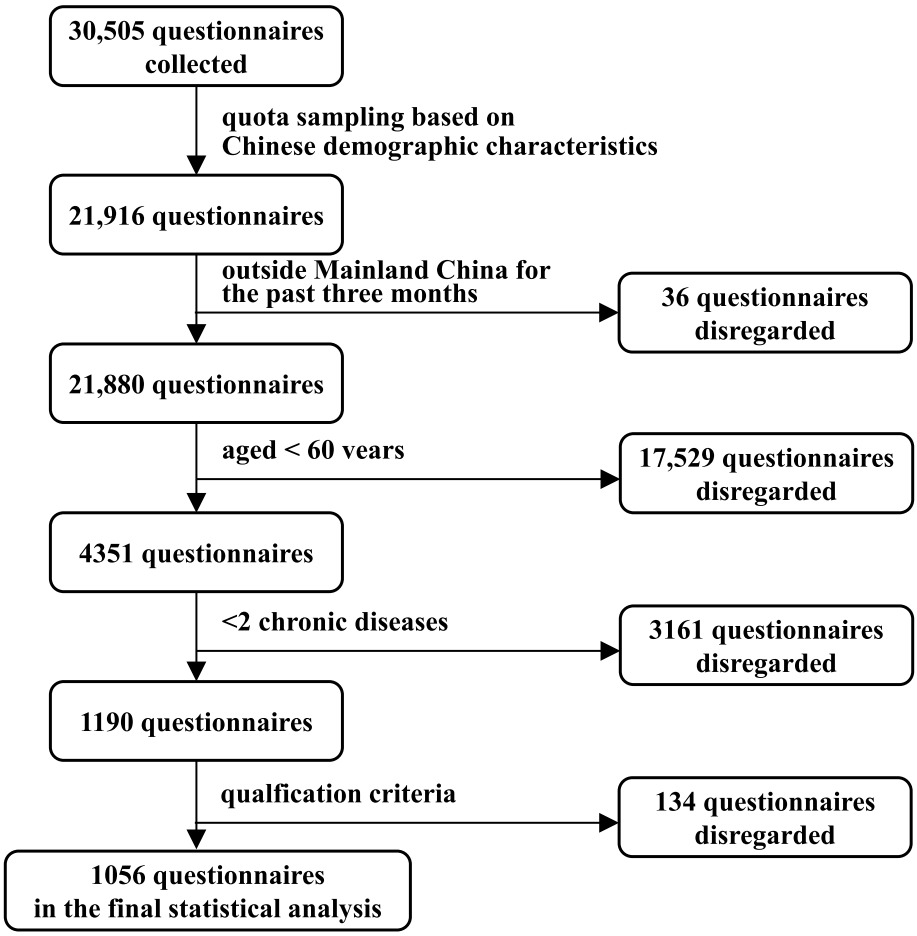


Fig. 1 Flow Chart for Inclusion of Study Participants

Assessments

Frailty assessment

Frailty was assessed using the Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight (FRAIL) scale [6], which has been validated in older Chinese populations. We assessed the presence of fatigue and loss of body weight by participants responding "yes" to the following items in the self-reported questionnaire: "Were you tired most of last week?" and "Have you experienced an unexplained loss of more than 5% of your body weight in the last year?" The presence of resistance and ambulation problems were assessed by a "yes" answer to the following questions: "Can you go up a staircase?" and "Can you walk a block (500 m) away?" Illness was assessed based on the total number of chronic diseases that participants had (at least 5 diseases had to be present), and the number was then dichotomized into a binary variable. All the abovementioned 5 variables were coded as 0 ("no") or 1 ("yes"), with 1 indicating the presence of deficits. The total deficits were summed to calculate a frailty score that ranged from 0 to 5. On the basis of previous studies, participants who scored 0 were defined as robust, those who scored 1 or 2 were defined as prefrail, and those who scored ≥ 3 were defined as frail [11, 27, 28].

Other variables measured

The 2022 PBICR collected data regarding individual sociodemographic characteristics, personal health, behaviors and psychologic, social environments. The self-made questionnaires included the general demographic characteristics of residents such as age, gender, body mass index (BMI), number of comorbidity, health behaviors (included smoking, alcohol intake, physical exercise, sleep, diet and medicine), as well as their basic family information such as family structure and family finances. The questionnaire information is shown in Wang's study. [26] And the variables rated using specific scales are as follows: self-efficacy, personality traits, health literacy, status of disease perception, anxiety symptoms, depression, loneliness, family health and perceived social support. The scales corresponding to the independent variables are presented in Table 1.

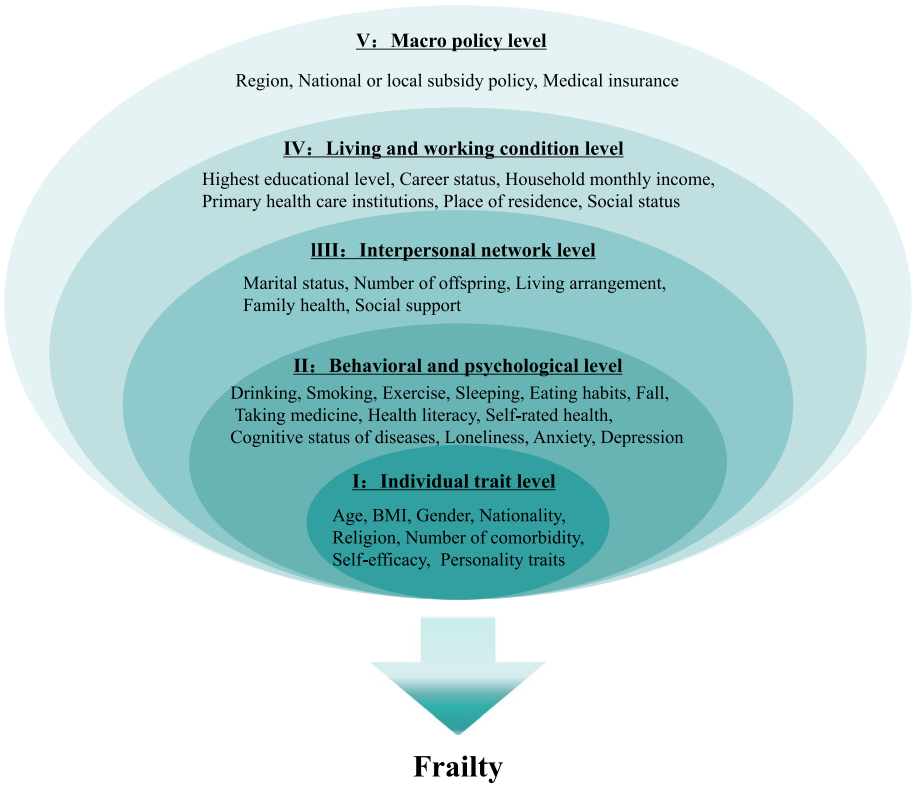


Fig. 2 Health ecological model of frailty

Table 1 Scale used for partial independent variables

Independent Variable	Scale	Abbreviation	Level	Item
Self-efficacy(SE)	The New General Self-Efficacy Scale [29]	*NGSES-SF3*	Individual trait level	3
Personality traits	The Ten-Item Big Five Personality Inventory [30, 31]	*BFI-10*	Individual trait level	10
Health literacy(HL)	The New Health Literacy Scale-Short Form-12 [32]	*HLS-SF12*	Behavioral and psychological level	12
Status of disease perception	The Brief Illness Perception Questionnaire [33]	*BIPQ*	Behavioral and psychological level	9
Anxiety	The Generalized Anxiety Disorder-7 [34]	*GAD-7*	Behavioral and psychological level	7
Depression	The Patient Health Questionnaire-9 [35]	*PHQ-9*	Behavioral and psychological level	9
Loneliness	The Three-Item Loneliness Scale [36]	*T-ILS*	Behavioral and psychological level	3
Family health	the Family Health Scale-Short Form [37]	*FHS-SF*	Interpersonal network level	10
Perceived social support	The Perceived Social Support Scale [38]	*PSSS*	Interpersonal network level	12

Data Analysis

We divided the participants into three groups: robust, pre-frail, and frail. Descriptive statistics of the demographic and clinical characteristics were presented for each group. The continuous data of normal distribution were described by mean and standard deviation, while those of non-normal distribution were described by median and interquartile range. Categorical variables were described using counts and percentages. The dependent variables were the FRAIL scale score. Then, we compared participants' characteristics according to frailty level using Chi-square tests, analysis of variance, or non-parametric tests (the Kruskal–Wallis H test). To determine the risk factors that were associated with frailty, and to estimate their 95% confidence intervals (CI), independent variables with a P value < 0.05 (set at a stringent level) on univariate analysis as described above were entered into a multivariate logistic regression model analysis. All data were analyzed using the

SPSS 25.0 software (IBM Corp., Armonk, NY, USA) and a P value < 0.05 was considered statistically significant.

Results

This study recruited a total of 1056 older adults with comorbidities, with an average age of 71.95 years. The majority were female (52.3%), and people age range 70 to 79 years old accounted for the most proportion (49.1%) with 519 people. The mean score of the Body Mass Index was 22.10. Regarding the number of comorbidities, 606 individuals (57.4%) had two types of comorbidities, 275 individuals (26.0%) had three types of comorbidities, and 175 individuals (16.6%) had four types or more.

Current status and univariate analysis of frailty in older adults with comorbidities.

A total of 417 comorbid older adults were diagnosed as frail, with a prevalence rate of 39.5%, while 613 were diagnosed as prefrail (58%). Based on the health ecological model, compared with the robust and prefrail group, gender, number of chronic diseases, and self-efficacy (SE) were identified as influencing factors at the individual trait level for the prefrail group ($P<0.05$). At the second level of the model, behaviors and psychological factors play a crucial role in frailty, the occurrence of frailty is associated with smoking status, sleep quality, eating habits, number of drug types, health literacy (HL), self-rated health (SRH), cognitive status of diseases, loneliness, anxiety and depression ($P<0.05$). Most of the older (40.8%) in the frail group took one or two drugs, and the health literacy (HL) in the frail group was significantly lower than that in the Prefrail and robust groups, detailed scores are shown in Table 2.

As for the interpersonal network in the third level, no significant difference was found for marital status, number of offspring, living arrangement (whether living alone) ($P>0.05$), but family health and perceived social support have a correlation with the occurrence of frailty. At the fourth level of the model, which pertains to living and working conditions, patients residing in rural environments are more likely to be frailty ($P<0.05$). No significant differences were found in education, career status, household per capita monthly income, grassroots medical and health institutions, social status ($P>0.05$). In the fifth level of macro policy, within the scope of this study, the proportion of frail individuals was higher in Eastern China than in Western China and Central China (44.6% vs. 31.4% vs. 24%). Nearly all older adults were covered by public insurance (96.5%). Univariate analysis revealed that the presence of subsidy policies is correlated with the occurrence of frailty ($P<0.05$), as seen in Table 2.

Multivariate analysis of frailty in older adults with comorbidities

Based on the five levels of the Health Ecological Model, the results of our multivariate analysis are presented in Table 3. We found that variables at the individual trait level, behaviors and psychological level, and interpersonal network level were associated with the occurrence of frailty. As described in Table 3, the multivariate logistic regression analysis showed that compared with robust patients, older adults with higher self-efficacy(SE) (OR = 1.412, 95% CI: 1.099–1.812, $P=0.007$), bad sleep quality(ref. very good)(OR = 33.684, 95% CI: 3.236–350.592, $P=0.003$), or good sleep quality(ref. very good) (OR = 2.883, 95% CI: 1.031–8.067, $P=0.044$)were the influencing factors of frailty in older adults with comorbidities. Furthermore, had three types of comorbidities (ref. had four types or more types of comorbidities) (OR = 0.171, 95% CI:0.038–0.767, $P=0.021$) and perceived social support(OR = 0.822, 95% CI:0.679–0.994, $P=0.043$)were identified as protective factors against frailty.

Lastly, the researchers conducted further analysis to identify the independent factors influencing frailty, using the pre-frailty group as the control. The results revealed that compared to Prefrail, with each incremental unit increase in disease cognition score, there is a corresponding 1.022-fold increase in the risk of frailty (95% CI: 1.006–1.039, $P=0.017$). Similarly, with each incremental unit increase in the anxiety score, there is a corresponding 1.163-fold increase in the risk of physical frailty (95% CI: 1.038–1.303, $P=0.009$). Perceived social support and daily breakfast consumption were identified as protective factors against frailty (OR = 0.926, 95% CI: 0.868–0.987; OR = 0.683, 95% CI: 0.482–0.966). Female gender and smoking were identified as risk factors for frailty (OR = 1.486, 95% CI: 1.092–2.022; OR = 1.742, 95% CI: 1.157–2.623). Moreover, compared to having two chronic diseases, older adults with more than four chronic diseases had a greater risk of frailty (OR = 5.660, 95% CI: 3.611–8.872), and the risk of frailty for older adults taking three or more medications was 1.830 times that of those not taking medications (95% CI: 1.122–2.985). The specific results are presented in Table 4.

Discussion

Our cross-sectional survey presented the current levels of frailty among older adults with multimorbidity in Chinese communities. Using the health ecological model to categorize the influencing factors, we found that, at the individual trait level, the number of comorbidities and self-efficacy; at the behavioral and psychological level, sleep quality; and at the interpersonal network

Table 2 Univariate analysis of general demographic characteristics and frailty from the health ecology perspective

	Robust (*n* = 26)2.5%	Prefrail (*n* = 613)58%	Frail (*n* = 417)39.5%	Total (*n* = 1056)	F/χ^2/H	*P*
Individual trait level						
Age	71.58 ± 5.35	71.63 ± 6.47	72.45 ± 6.56	71.95 ± 6.49	2.036	0.131
BMI[kg/m^2]	23.03 ± 3.15	22.17 ± 3.41	21.95 ± 3.28	22.10 ± 3.36	1.576	0.207
Gender, n (%)					6.149	**0.046***
Female	16 (61.5%)	301 (49.1%)	235 (56.4%)	552 (52.3%)		
Male	10 (38.5%)	312 (50.9%)	182 (43.6%)	504 (47.7%)		
Nationality, n (%)					0.029	0.985
Han nationality	24 (92.3%)	560 (91.4%)	381 (91.4%)	965 (91.4%)		
Other nationality	2 (7.7%)	53 (8.6%)	36 (8.6%)	91 (8.6%)		
Religion, n (%)					1.232	0.541
No	24 (92.3%)	556 (90.7%)	370 (88.7%)	950 (90.0%)		
Other religion	2 (7.7%)	57 (9.3%)	47 (11.3%)	106 (10.0%)		
Number of comorbidity, n (%)					57.325	**0.000***
2	11 (42.3%)	400 (65.3%)	195 (46.8%)	606 (57.4%)		
3	12 (46.2%)	163 (26.6%)	100 (24%)	275 (26.0%)		
≥4	3 (11.5%)	50 (8.2%)	122 (29.3%)	175 (16.6%)		
Self-efficacy(SE)[score]	9.00 (9.00,10.25)	11.00 (9.00,12.00)	9.00 (8.00,12.00)	10.00 (9.00,12.00)	60.730	**0.000***
Personality traits[score]						
Extraversion	0.00 (−1.00,1.00)	0.00 (−1.00,1.00)	0.00 (−1.00,1.00)	0.00 (−1.00,1.00)	20.836	**0.000***
Agreeableness	9.00 (−1.00,1.25)	1.00 (0.00,2.00)	1.00 (0.00,2.00)	1.00 (0.00,2.00)	20.641	**0.000***
Conscientiousness	0.96 ± 1.399	1.38 ± 1.502	0.87 ± 1.538	1.17 ± 1.533	14.476	**0.000***
Neuroticism	−0.31 ± 1.715	−0.54 ± 1.511	−0.13 ± 1.475	−0.37 ± 1.513	9.220	**0.000***
Openness	0.00 (−1.00,0.25)	0.00 (−1.00,0.00)	0.00 (−1.00,1.00)	0.00 (−1.00,1.00)	0.944	0.624
Behavioral and psychological level						
Alcohol intake, n (%)					0.542	0.752
Yes	3 (11.5%)	99 (16.2%)	63 (15.1%)	165 (15.6%)		
No	23 (88.5%)	514 (83.8%)	354 (84.9%)	891 (84.4%)		
Smoking status, n (%)					26.640	**0.000***
Yes	4 (15.4%)	79 (12.9%)	106 (25.4%)	189 (17.9%)		
No	22 (84.6%)	534 (87.1%)	311 (74.6%)	867 (82.1%)		
Physical exercise, n (%)					0.951	0.623
< 150 min/w	5 (19.2%)	106 (17.3%)	82 (19.7%)	193 (18.3%)		
≥ 150 min/w	21 (80.8%)	507 (82.7%)	335 (80.3%)	863 (81.7%)		
Sleep quality, n (%)					23.441	**0.000***
very bad	2 (7.7%)	16 (2.6%)	22 (5.3%)	40 (3.8%)		

Table 2 (continued)

	Robust (*n* = 26)2.5%	Prefrail (*n* = 613)58%	Frail (*n* = 417)39.5%	Total (*n* = 1056)	F/χ^2/H	*P*
bad	1 (3.8%)	109 (17.8%)	115 (27.6%)	225 (21.3%)		
good	12 (46.2%)	370 (60.4%)	215 (51.6%)	597 (56.5%)		
very good	11 (42.3%)	118 (19.2%)	65 (15.6%)	194 (18.4%)		
Eating habits, n (%)					36.734	**0.000***
Eating breakfast daily	20 (76.9%)	487 (79.4%)	260 (62.4%)	767 (72.6%)		
Irregular Eating breakfast	6 (23.1%)	126 (20.6%)	157 (37.6%)	289 (27.4%)		
Fall, n (%)					4.859	0.088
Yes	6 (23.1%)	123 (20.1%)	108 (25.9%)	237 (22.4%)		
No	20 (76.9%)	490 (79.9%)	309 (74.1%)	819 (77.6%)		
Number of drug types, n (%)					13.223	**0.001***
0	14 (53.8%)	262 (42.7%)	156 (37.4%)	432 (40.9%)		
1 ~ 2	10 (38.5%)	286 (46.7%)	170 (40.8%)	466 (44.1%)		
≥ 3	2 (7.7%)	65 (10.6%)	91 (21.8%)	158 (15.0%)		
Health literacy(HL)[score]	15.04 ± 3.84	15.76 ± 5.14	13.89 ± 5.28	15.00 ± 5.25	16.176	**0.000***
Self-rated health(SRH)[score]	58.54 ± 22.84	69.54 ± 18.16	61.90 ± 18.13	66.26 ± 18.67	24.076	**0.000***
Cognitive status of diseases[score]	52.00 (42.50,60.50)	50.00 (43.00,57.00)	52.00 (46.50,57.00)	51.00 (44.00,57.00)	5.543	**0.004***
Loneliness[score]	6.00 (4.75,6.00)	4.00 (3.00,6.00)	5.00 (4.00,6.00)	5.00 (3.00,6.00)	36.041	**0.000***
Anxiety[score]	6.50 (1.00,10.25)	3.00 (0.00,7.00)	6.00 (4.00,8.00)	5.00 (1.00,7.00)	87.014	**0.000***
Depression[score]	8.50 (4.00,11.50)	5.00 (2.00,9.00)	8.00 (6.00,11.00)	6.00 (3.00,10.00)	89.741	**0.000***
Interpersonal network level						
Marital status, n (%)					5.894	0.053
Married	19 (73.1%)	509 (83.0%)	323 (77.5%)	851 (80.6%)		
Single/Divorced/Widowed	7 (26.9%)	104 (17.0%)	94 (22.5%)	205 (19.4%)		
Number of offspring, n (%)					2.956	0.228
0	4 (15.4%)	30 (4.9%)	42 (10.1%)	76 (7.2%)		
1	3 (11.5%)	162 (26.4%)	104 (24.9%)	269 (25.5%)		
≥ 2	19 (73.1%)	421 (68.7%)	271 (65%)	711 (67.3%)		
Living arrangement, n (%)					1.316	0.529
Living alone	5 (19.2%)	82 (13.4%)	64 (15.3%)	151 (14.3%)		
Living with others	21 (80.8%)	531 (86.6%)	353 (84.7%)	905 (85.7%)		
Family health[score]	37.00 (31.75,40.00)	36.00 (32.00,38.00)	34.00 (30.00,37.00)	35.00 (31.00,38.00)	32.587	**0.000***
Perceived social support[score]	14.00 (12.00,17.25)	15.00 (13.00,18.00)	13.00 (11.00,16.00)	15.00 (12.00,18.00)	71.856	**0.000***
Living and working condition level						
Highest educational level, n (%)					4.304	0.116

Table 2 (continued)

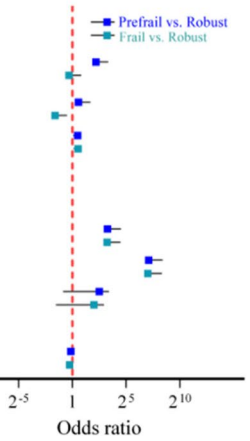
	Robust (*n* = 26)2.5%	Prefrail (*n* = 613)58%	Frail (*n* = 417)39.5%	Total (*n* = 1056)	F/χ^2/H	*P*
Primary school and below	16 (61.5%)	310 (50.6%)	237 (56.8%)	563 (53.3%)		
Junior high school&high school	5 (19.2%)	234 (38.2%)	143 (34.3%)	382 (36.2%)		
Junior college and above	5 (19.2%)	69 (11.3%)	37 (8.9%)	111 (10.5%)		
Career status, n (%)					1.234	0.584
Retired	22 (84.6%)	555 (90.5%)	380 (91.1%)	957 (90.6%)		
Employed	4 (15.4%)	58 (9.5%)	37 (8.9%)	99 (9.4%)		
Household per capita monthly income (yuan), n (%)					2.733	0.255
≤ 3000	16 (61.5%)	282 (46.0%)	190 (45.6%)	488 (46.2%)		
3001 ~ 6000	8 (30.8%)	242 (39.5%)	164 (39.3%)	414 (39.2%)		
≥ 6001	2 (7.7%)	89 (14.5%)	63 (15.1%)	154 (14.6%)		
Grassroots medical and health institutions, n (%)					1.197	0.555
Yes	25 (96.2%)	588 (96.0%)	394 (94.5%)	1007 (95.4%)		
No	1 (3.8%)	25 (4.1%)	23 (5.5%)	49 (4.6%)		
Place of residence, n (%)					21.453	**0.000***
Urban	9 (34.6%)	365 (59.5%)	193 (46.3%)	567 (53.7%)		
Rural	17 (65.4%)	248 (40.5%)	224 (53.7%)	489 (46.3%)		
Social status	4.00 (3.00,6.00)	4.00 (4.00,5.00)	4.00 (4.00,5.00)	4.00 (4.00,5.00)	2.182	0.336
Macro policy level						
Region, n (%)					1.816	0.770
Eastern China	11 (42.3%)	248 (40.5%)	186 (44.6%)	445 (42.1%)		
Central China	6 (23.1%)	158 (25.8%)	100 (24%)	264 (25.0%)		
Western China	9 (34.6%)	207 (33.8%)	131 (31.4%)	347 (32.9%)		
Subsidy policy, n (%)					14.265	**0.001***
Yes	11 (42.3%)	219 (35.7%)	198 (47.5%)	428 (40.5%)		
No	15 (57.7%)	394 (64.3%)	219 (52.5%)	628 (59.5%)		
Public insurance coverage, n (%)					5.159	0.379
Not covered	3 (11.5%)	21 (3.4%)	13 (3.1%)	37 (3.5%)		
Covered	23 (88.5%)	592 (96.6%)	404 (96.9%)	1019 (96.5%)		

Note: *Values in bold indicate if a P-value < 0.05, denoting statistical significance. And a *P*-value > 0.05, denoting statistical not significance

Table 3 Multivariate analysis of factors influencing frailty from the health ecology perspective

	Prefrail vs. robust 58%（n=613）				Frail vs. robust 39.5%（n=417）			
	B	p	OR	95% CI	B	p	OR	95% CI
Individual trait level								
Number of comorbidity（ref. ≥4）								
comorbidity=2	0.85	0.279	2.339	0.501-10.909	-0.887	0.255	0.412	0.090-1.897
comorbidity=3	-0.266	0.73	0.767	0.170-3.467	-1.764	0.021	0.171	0.038-0.767
Self-efficacy	0.316	**0.012**	1.372	1.072-1.756	0.345	**0.007**	1.412	1.099-1.812
Behavioral and psychological level								
Sleep quality（ref. very good）								
very bad	1.23	0.223	3.423	0.473-24.774	1.188	0.243	3.281	0.446-24.136
bad	3.576	**0.003**	35.724	3.451-369.825	3.517	**0.003**	33.684	3.236-350.592
good	1.406	**0.006**	4.081	1.483-11.228	1.059	**0.044**	2.883	1.031-8.067
Interpersonal network level								
Perceived social	-0.116	0.23	0.891	0.737-1.076	-0.196	**0.043**	0.822	0.679-0.994

Note: OR= odds ratio; CI=confidence interval



level, perceived social support, all had significant impacts on the prevalence of frailty among older adults with multimorbidity.

Our cross-sectional survey revealed a frailty prevalence of 39.5% and a prefrailty prevalence of 58% among Chinese older adults with comorbidities, which surpassed the reported rates in the United Kingdom (29.6%, 53.8%) [39], Norway(10.3%, 47.6%) [40], and Singapore (8.3%, 43.0%) [28]. Compared to other studies conducted in China, several reported similar or higher rates. Liu [41] measured the prevalence of frailty among community-dwelling older adults with hypertension and diabetes using the Tilburg Frailty Indicator (TFI) scale, which was found to be 42.4%. In brief, the variation in frailty prevalence rates is attributed to differing national conditions, specific policies, frailty assessment tools, and fundamental concepts of frailty. Compared to developed countries, the frailty status of older adults with multimorbidity in Chinese community is concerning, potentially linked to the earlier commencement of frailty research in developed nations and the proactive adoption of effective preventive measures by their residents [19]. This underscores the need for our country to enhance the promotion of frailty screening and prevention initiatives for the older.

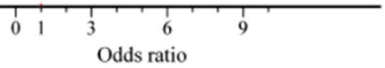
Initially, at the first level of health ecological model, which pertains to individual traits, the number of comorbidities and self-efficacy were significantly associated with frailty. These factors are closely linked to an individual's genetic makeup and physiological differences, which directly influence health outcomes. In this study, compared to individuals with four or more chronic conditions, those with three chronic diseases appear to have a lower risk of developing frailty. This finding aligns with the results of Hanlon et al. [42], where the prevalence of frailty increases as the number of chronic conditions rises in older adults. This may be attributed to degenerative physiological changes and the influence of various complex diseases in older adults [8–10, 43–46]. Elevated blood levels of pro-inflammatory markers, such as IL-6, significantly contribute to inflammation, which is a primary risk factor with comorbid. In this context, inflammation disrupts the ongoing maintenance and repair processes in all tissues, leading to the accumulation of damage and frailty [47]. Additionally, older patients with comorbidities exhibit diminished resistance to invasive factors, leading to an increased disease burden, they are more susceptible to developing symptoms of frailty [48, 49]. However, there is no significant difference in frailty risk between individuals with two chronic conditions and those with four or more. Given the complexity of multimorbidity and frailty, we hypothesize that the risk of frailty is not only determined by the number of chronic diseases but also by the specific nature, severity, disease course, and combinations. For instance, neuropsychiatric-sensory and cardiometabolic multimorbidity patterns may further increase the risk of frailty [50]. In conclusion, when managing older adults with multimorbidity, it is crucial to closely monitor the health status of those with a higher number of chronic conditions and more complex multimorbidity patterns, to prevent rapid progression to frailty due to the deterioration of their multimorbidity.

Furthermore, self-efficacy (SE) was found to be an independent risk factor for frailty in community-dwelling older adults with multimorbidity. This finding contrasts with the negative association between self-efficacy

Table 4 Multivariate analysis of factors influencing frailty from the health ecology perspective (Frail vs. Prefrail)

	Frail vs. Prefrail 39.5%(n=417) vs. 58%（n=613）			
	B	p	OR	95%CI
Individual trait level				
Number of comorbidity（ref. =2）				
comorbidity≥4	1.734	**0.000**	5.66	3.611-8.872
comorbidity=3	0.244	0.174	1.276	0.898-1.812
Gender（ref. Male）				
Female	0.396	**0.012**	1.486	1.092-2.022
Behavioral and psychological level				
Cognitive status of diseases	0.022	**0.007**	1.022	1.006-1.039
Anxiety	0.151	**0.009**	1.163	1.038-1.303
Smoking status（ref. No）				
Smoking	0.555	**0.008**	1.742	1.157-2.623
Eating habits（ref. No）				
Eating breakfast daily	-0.382	**0.031**	0.683	0.482-0.966
Number of drug types（ref. =0）				
types≥3	0.604	**0.015**	1.83	1.122-2.985
types1~2	0.337	0.055	1.401	0.993-1.977
Interpersonal network level				
Perceived social support	-0.077	**0.018**	0.926	0.868-0.987

Note: OR= odds ratio; CI=confidence interval



and frailty found in previous research [46]. In this study, researchers contend that the manifestation of diseases among older adults in the frail group is more pronounced compared to the robust group. Consequently, individuals in the frail group often establish higher levels of self-efficacy to facilitate rational health behaviors aimed at ameliorating symptoms such as fatigue and weight loss. This endeavor is pursued with the objective of mitigating the progression of frailty. Previous research has confirmed that high levels of self-efficacy may partially buffer the detrimental effects of frailty and also yield beneficial motivational effects, thereby leading to more positive emotions and ultimately better coping with frailty [51]. However, the mechanism for this need to be further investigated. Moreover, self-efficacy is subject to variability under the influence of environmental factors, stress, and physical ailments. Li's research conducted on hospitalized older adults reveals a significant association between diminished self-efficacy and the occurrence of frailty among older patients with chronic illnesses [46]. This reduced self-efficacy may be temporary and situational, as the psychological manifestations of older chronic adults vary depending on the environment. Therefore, the researchers of this study suggest that future research should focus on exploring the causal relationship between frailty and self-efficacy under different situations, providing a more detailed description of the correlation between the two.

At the second level of the model, the individual behavioral factor of sleep quality significantly influences the development of frailty in community-dwelling older adults with multimorbidity. Such factors exert their effects over time and as individuals mature, indirectly impacting health with a cumulative effect. In this study, older adults in the frail group generally exhibited poor sleep quality (with 84.4% reporting sleep quality as not very good), and older adults experiencing bad sleep quality face a remarkably elevated risk, 33.684 times higher, of developing frailty compared to individuals with excellent sleep quality. Prior studies have confirmed that [15, 43, 52]. All systems of the human body undergo restoration during sleep, and poor sleep quality accelerates the decline in function and reserves [15], hastening the progression of frailty. However, frailty is also reversible and can be delayed [20, 47]. Longitudinal studies [53]have shown that individuals experiencing sleep difficulties exhibit an accelerated rate of frailty progression, whereas those with improved sleep patterns show a slower rate of

frailty development. While further research is needed to elucidate the pathways linking sleep quality and frailty, improving sleep may help older adults increase physical and social activities [54], and these interventions can ultimately improve frailty. Therefore, health management for older patients with multimorbidity should emphasize sleep management to promote healthy aging.

At the third level of the model, which pertains to interpersonal network, higher perceived social support is significantly associated with a lower risk of frailty, and it has been shown to be an independent protective factor against frailty. Increased perceived social support leads to a reduced risk of debilitation, and we consider the following reasons: Perceived social support is related to the living environment, with different living environments associated with varying degrees of frailty. A survey on frailty among community-dwelling older adults [55] showed that individuals residing in poorer communities facing a higher risk of frailty. The better living environment enhances the perceived social support, thereby mitigating the risk of frailty among older adults with multimorbidity. older adults residing in communities with a high density of older adults are more likely to receive substantial social support, which contributes to delaying the progression of frailty [17]. Aging communities are often characterized by a more comprehensive social security and welfare infrastructure, precise healthcare services, well-developed healthcare facilities, and an abundance of resources and social interactions specifically tailored to address the challenges associated with aging [41]. Furthermore, older adults with frailty and multimorbidity influenced by declining physiological reserves and functional limitations, exhibit symptoms such as decreased activity capacity and reduced walking speed, these symptoms ultimately lead to limited social interactions, which is another reason for their reduced perception of social support [56]. Notably, some older adults with multimorbidity perceive their illnesses as imposing a substantial burden on their families, which can result in the exacerbation of negative psychological states and a diminished perception of social support. It is clear that strengthening care and support for older persons experiencing multimorbidity and frailty is essential, and it is recommended to improve community and family resources and provide them with critical medical, life management and emotional assistance [57].

Besides, the living and working conditions, along with policy factors, represent the macro socioeconomic and material environment, which are fundamental determinants of population health. These are often referred to as "upstream factors" [58] and can indirectly affect health by influencing individual behaviors, psychological factors, interpersonal networks, and innate biological conditions. While this study did not establish a statistically significant influence of the factors at this level on frailty among older adults with multimorbidity in the community, it was observed that the coverage of public health insurance and residential location were associated with the occurrence of frailty. This suggests that these macro-level factors may have an impact on health outcomes, and further research is needed to explore their specific effects on individual frailty. And it is recommended to implement a government-led health promotion strategy to establish a comprehensive model for managing multimorbidity and frailty in older adults.

Prefrailty is an intermediate state between frailty and robustness, characterized by a heightened risk of progressing to frailty [9]. To investigate the potential factors contributing to the transition from prefrailty to frailty, our study used the prefrail group as a reference and conducted a more detailed analysis of the factors associated with frailty. We have found that at the individual trait, behavioral and psychological levels, besides the correlation between the number of comorbidities and frailty, older patients with frailty are more likely to be female, smokers, and have three or more types of comorbidities compared to pre-frail individuals. Cognitive status of diseases and anxiety also increase the risk of frailty occurrence. Having healthy eating habits (eating breakfast daily) can reduce the risk of frailty. This is consistent with previous research conclusions, as many studies have shown that women may have a higher risk of frailty than men due to factors such as low muscle strength [7], vitamin D deficiency [9], or other pathophysiological factors [52]. While the accumulation of behavioral factors, such as smoking and unhealthy eating habits, can contribute to the development or progression of frailty [8, 59, 60], research indicated that lifestyle modifications through intervention and prevention strategies can be effective [8]. By modifying these unhealthy habits and empowering patients with better self-management skills, it is possible to attenuate the advancement of frailty.

The challenge of frailty significantly impacts the quality of life and treatment outcomes for older adults with multimorbidity, posing a considerable economic burden on both families and society. Therefore, it is crucial to go beyond mere understanding of physiological and pathological mechanisms of frailty, such as chronic inflammation, and comprehensively elucidate individual characteristics, behaviors, psychological factors, social environments, and other factors relevant to frailty. It is imperative to implement timely and targeted interventions across multiple dimensions within a comprehensive theoretical framework to effectively manage frailty in older adults with multimorbidity. This study identified the primary influencing factors of frailty

among older patients with comorbidities from health ecology perspective. Compared to previous research, our study has a solid theoretical foundation. Our study offers insights into frailty assessment in clinical practice, which holds significant practical implications.

Furthermore, this study is the first nationwide survey in China to assess the prevalence of frailty among older adults with multimorbidity in community settings, thereby addressing the existing data gap. We have also demonstrated the prevalence of frailty and prefrailty among older adults with multimorbidity in China, underscoring the importance of screening for frailty and implementing timely management strategies for older adults residing in the community. Our study lays the foundation for future research on precise care and personalized interventions targeting older adults with multimorbidity, and it aids in addressing the increasingly diverse needs in frailty management within the framework of healthy aging.

Limitations

Admittedly, this study still has some limitations. Firstly, the study exclusively focused on community-dwelling older adults and assessed frailty solely based on the FRAIL scale, without incorporating relevant clinical or laboratory indicators. Secondly, the questionnaire used in this study relied on self-reporting, which introduces the possibility of recall bias. Thirdly, due to the cross-sectional design of our study, we only investigated the prevalence of frailty without to explore its trajectory over time as in longitudinal studies. Consequently, we cannot ascertain causal relationships between risk factors and frailty. Therefore, future research could involve long-term follow-up studies to explore the progression of frailty in community-dwelling older adults with comorbidities, and to understand the impact of frailty on their prognosis.

Conclusion

This study draws the following conclusions: the higher prevalence of frailty and prefrailty among community-dwelling older adults with comorbidities is influenced by various factors in different dimensions under the health ecology perspective. Older adults with four or more comorbidities, high self-efficacy, poor sleep quality and low perceived social support warrant particular attention. Furthermore, it is imperative to enhance health behavior management among the older, including adherence to medication and dietary habits, while simultaneously addressing their psychological well-being.

Relevance to clinical practice

This study provides valuable insights into the management of frailty among community-dwelling older adults with comorbidities. It is recommended to incorporate frailty screening into the management of comorbidities in the community, along with strengthening the daily behavioral and psychological management of older adults. Healthcare providers should approach frailty management for community-dwelling older adults with comorbidities from a psychological perspective to enhance their sense of happiness and gratification, thereby preventing frailty. For individuals at risk of or in the early stages of frailty, alongside psychological care, emphasis should be placed on daily living management. This involves assisting them in correcting unhealthy life concept and modifying detrimental habits as much as possible to delay the progression of frailty.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05777-0.

Supplementary Material 1.

Acknowledgements

Thanks to all the participants and researchers involved in this study.

Authors' contributions

Yunqiu Che and Hanjia Xin contributed equally to this work and co-first authors. Yunqiu Che and Hanjia Xin conceptualized the idea. Hanjia Xin designed the study with input from Yingying Gu, Xiuxiu Ma, Ziying Xiang organized and collected the data, Yunqiu Che analyzed the data and drafted the manuscript. Chaozhu He overseeed the progress and quality management of the article. All authors of this paper have read and approved the final version submitted.

Funding

This study received funding support from the *Chronic Disease Virtual Simulation System Development* Project (HX202305080003).

Data availability

Data are not publicly available but may be obtained from the corresponding author upon reasonable request. Data used in this study were extracted from the Psychology and Behaviour Investigation of Chinese Residents (PBICR).

Declarations

Ethics approval and consent to participate:

This study has been officially registered in the China Clinical Trial Registry (Registration No.: ChiCTR2200061046, Registration Date: 2022/06/15), approved by the Medical Ethics Committee of The Second Xiangya Hospital of Central South University (No.2022-K050) and conducted in strict accordance with the Declaration of Helsinki. Informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 18 June 2024 Accepted: 10 February 2025
Published online: 14 March 2025

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