Original Article

Factors influencing the prevalence of frailty in older adults with fractures: the association of nutritional status with frailty

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Background and Objectives: To investigate the association between frailty, malnutrition, comorbid medical conditions and activities of daily living (ADL) in older adult patients with fractures, and to analyse the influential factors of frailty. **Methods and Study Design:** The FRAIL scale including five components: fatigue, resistance, ambulation, illness, and loss of weight, was used to evaluate frailty. Participants were divided into frailty, pre-frailty and non-frailty groups. The ADL was assessed using the Barthel Index, while the nutrition risk screening tool, NRS-2002, was used to assess the nutritional risk, and the Global Leadership Initiative on Malnutrition diagnostic criteria were used to diagnose the nutritional status. Statistical analysis was performed using univariate and multivariate logistic regression to determine the factors associated with frailty. **Results:** A total of 166 patients were included in the study, and the incidences of frailty, pre-frailty and non-frailty were 39.2%, 33.1% and 27.7%, respectively. The severe dependence rate (ADL scale of <40) in the frailty, pre-frailty and non-frailty groups was 49.2%, 20.0% and 6.52%, respectively. The prevalence of nutritional risk was 33.7% (56/166), including 56.9% (31/65) in the frailty group and 32.7% (18/55) in the pre-frailty group. Of the 166 patients, 45 (27.1%) were diagnosed with malnutrition, including 47.7% (31/65) in the frailty group and 23.6% (13/55) in the pre-frailty group. **Conclusions:** Frailty in older adult patients with fractures is widespread, and the prevalence of malnutrition is high. The occurrence of frailty may be related to an advanced age, increased medical comorbidity and impairment in ADL.

Key Words: frailty, malnutrition, older adults, fractures, activities of daily living (ADL)

INTRODUCTION

Frailty is a state of heightened vulnerability characterised by a diminished physiological reserve across multiple domains that results in a reduced ability to maintain and restore homeostasis in the setting of acute stress.[1,2] The early detection of stages of frailty may provide a window of opportunity for timely preventive or therapeutic interventions, which may delay the progression of the condition and even reverse it.[3,4] Currently, frailty is known to be highly prevalent in older adults. Many researchers believe that frailty is a high predictor of falls, disabilities, fractures, hospitalisation and death in older adults and that it is associated with an increased risk of falls and fractures.[5] The functions of older adults' bodies gradually decline with age, and the body's metabolic capacity gradually becomes lower than the normal level, making it easy for fractures to occur.[6] The prognosis of treatment for older adults showing signs of frailty is poorer than that of young people, and many complications and adverse events can occur regularly, which makes it more difficult for medical personnel to provide care, and the burden on patients' families and society is increased. Over the past 20 years, geriatric-related literature has been pervaded by a proliferation of research focused on frailty.

Malnutrition is common in elderly patients, especially among those hospitalised for acute conditions. Studies have reported that frailty and malnutrition have overlapping physiological mechanisms and that they have a cause-and-effect relationship.[7-9] Furthermore, while malnutrition is associated with physical frailty and is considered to be the core of the frailty cycle, the two aspects are also believed to have fundamentally distinct pathologies.[8]

The present study used the frailty scale known as Fatigue, Resistance, Ambulation, Illness and Loss of Weight Index (FRAIL), which denotes fatigue, resistance, ambu-

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lation, illness and loss of weight,[10] and the Global Leadership Initiative on Malnutrition (GLIM) diagnostic criteria[11] to assess the prevalence of frailty and malnutrition in older adult patients hospitalised with fractures. Statistical methods were also adopted to explore the risk factors pertaining to frailty. This study provides a reference for clinical frailty interventions.

METHODS

Participants

A total of 166 older adult patients who were hospitalised in the orthopaedic ward of a tertiary hospital in Ningbo from September 2020 to June 2021 were selected. Based on the sample size estimation method for multivariate analysis, the sample size should be 10–20 times the number of independent variables. This study included nine variables, including various general sociodemographic and health status data. The ideal sample size of this study thus ranged from 90 to 180 patients, with the final sample size ideally ranging from 99 to 216 patients when accounting for a sample turnover rate of 10%–20%.[12,13] The inclusion criteria were as follows: (1) patients aged >60 years; (2) patients with clear consciousness or the ability to answer questions correctly and cooperate with the completion of all the assessments; and (3) patients who were willing to participate in this study, with consent forms signed by them or their family members. The exclusion criteria were as follows: (1) patients identified as having severe cognitive impairment according to the abbreviated mental test score cognitive scale;[14] (2) patients who were bedridden for more than 30 days;[15] (3) patients with malignancies or at the end stage of a disease; and (4) patients suffering multiple injuries with fractures at other sites, organ damage and/or pathological fractures.

The assessment of frailty included the following five aspects based on the FRAIL scale: (1) fatigue for all or most of the past four weeks; (2) increased resistance or decreased endurance, such as difficulty in walking up a flight of stairs without resting midway (without any aids or the help of others); (3) decreased free movement, for example, difficulty in walking a block (100 m) without any aids or the help of others; (4) underlying comorbid diseases, namely the presence of five or more of the following diseases: hypertension, diabetes, angina pectoris, stroke, malignancy (except microscopic skin cancer), congestive heart failure, asthma, arthritis, chronic lung disease and kidney disease; and (5) weight loss of >5% within one year or less. Based on the assessment results, meeting three or more of the above criteria was considered to indicate frailty, meeting one or two was considered to indicate pre-frailty and meeting none was considered to indicate non-frailty. Therefore, the study participants were divided into frailty, pre-frailty and non-frailty groups.

Ethics approval and consent to participate

This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Ningbo First Hospital, and all participants signed an informed consent form.

Study methods

General condition assessment

A basic condition questionnaire was used, which included gender, age, body mass index (BMI), education level, residence status, underlying disease and type of fracture.

Comparison of nutritional status and activities of daily living of patients in the frailty, pre-frailty and non-frailty groups

The nutritional status was assessed using GLIM criteria. If a patient met at least one phenotypical criterion and one etiological criterion, malnutrition was diagnosed.[11,16] The manifest indicators included involuntary weight loss (weight loss of >5% within six months or >10% over six months) and a BMI of <18.5 kg/m^2 and reduced muscle mass. The etiological indicators included reduced food intake, decreased absorption (food intake ≤50% of normal requirements for more than one week, any degree of reduced intake for more than two weeks or chronic gastrointestinal symptoms due to absorption disorders) and disease burden/inflammation. The performance rating index selected for this study did not include a muscle mass reduction item.[17]

The activities of daily living (ADL) were assessed using the Barthel Index.[18] The daily life ability scale is a 10-item scale comprised of eating, bathing, grooming, dressing, defecating, urinating, toileting, bed and chair transferring, walking and going up and down stairs. The total score of the 10 items ranges from 0 to 100 and is divided into three levels, with 61–100 denoting mildly dependent, 41–60 moderately dependent and 0–40 severely dependent.

The nutrition risk screening tool (nutritional risk screening 2002, NRS2002) comprises the impaired nutritional status score (0–3), the severity of illness score (0–3) and the age score. A total score of three or more indicates nutritional risk. The BMI was based on the standards of the Chinese Obesity Working Group, with the normal BMI of Chinese people being 24.0, more than the approximate BMI of 18.5.

Observation indexes

The observation indexes included the incidences of frailty, pre-frailty and non-frailty in older adult fracture patients, a comparison of the prevalence of malnutrition and ADL in frailty, pre-frailty and non-frailty patients, and an analysis of the factors influencing the occurrence of frailty in older adult fracture patients.

Quality control

A trained individual was responsible for the assessment of the data collection and double-entry data collection. Following data verification, the individual in charge reviewed the data to ensure that any abnormal values were found in a timely manner and corrected.

Statistical methods

The data analysis was conducted using SPSS 22.0 statistical software. The measurement data conforming to normal distribution were expressed in terms of mean and standard deviation ($x \pm s$), and a group t-test was used for intergroup comparisons. The measurement data not con-

forming to normal distribution were expressed in terms of the median (M [P25, P75]), and the rank-sum test was used for intergroup comparisons. The count data were expressed as numbers with percentages, with the χ^2 test used for intergroup comparisons. Multivariate logistic regression analysis was used to explore the factors influencing the occurrence of frailty in older adult patients with fractures. The difference was considered statistically significant at $p < 0.05$.

RESULTS

General information on the older adult fracture patients in the frailty, pre-frailty and non-frailty stages

Among the 166 older adult patients hospitalised, 65 (39.2%) were in the frailty group, 55 (33.1%) were in the pre-frailty group and 46 (27.7%) were in the non-frailty group. The proportions of the frailty and pre-frailty patients aged >70 years were 96.9% and 81.8%, respectively. The combination of multiple underlying diseases was common among the frailty and pre-frailty patients. Only 9.09% of the pre-frailty patients had no underlying diseases, while 19 patients (29.2%) in the frailty group had a combination of five or more underlying diseases. The univariate analysis based on frailty status indicated that the differences in age, BMI and the number of underlying comorbid diseases were statistically significant ($p < 0.05$). The incidences of hip fractures for the frailty, pre-frailty and non-frailty patients were 96.9%, 58.2% and 30.4%, respectively, with statistically significant differences ($p < 0.05$) (Table 1).

Nutritional risk and malnutrition in older adult fracture patients in the frailty, pre-frailty and non-frailty stages

Fifty-six cases had a total NRS-2002 score of >3. The overall prevalence of nutritional risk was 33.7%. The prevalence of nutritional risk for the frailty, pre-frailty and non-frailty patients was 56.9%, 32.7% and 2.17%, respectively. The overall GLIM diagnosis prevalence of malnutrition was 27.1%, with the prevalence of malnutrition for the frailty, pre-frailty and non-frailty patients being 47.7%, 23.6% and 2.17%, respectively, with statistically significant differences ($p < 0.05$) (Table 2 and Figure 1).

Activities of daily living assessment of older adult fracture patients in the frailty, pre-frailty and non-frailty stages

Among the 166 patients, the incidence of severe dependence (ADL score of <40) for the frailty, pre-frailty and non-frailty patients was 49.2%, 20.0% and 6.52%, respectively, with statistically significant differences ($p < 0.05$). Similarly, the proportion of patients with an ADL score of 40–60 was significantly different among the three groups ($p < 0.05$). The proportion of patients with an ADL score of >60 was the lowest in the frailty group, with only 6.15% (Table 3).

Multivariate logistic regression analysis of the factors influencing the occurrence of frailty in older adult inpatients

Age, BMI, the number of underlying comorbid diseases, the type of fracture, the ability to perform ADL, and malnutrition, statistically significant according to the univariate analysis of frailty status, were used as the independent variables. Frailty and pre-frailty in the subgroups were used as the response variables and included in the logistic regression equation. The results indicated that the patients with advanced age, more underlying diseases and higher dependence in ADL were more likely to be in the frailty group (odds ratio [OR] values of 1.135, 2.623 and 3.418, respectively; $p < 0.05$). In addition, the fracture type was an independent risk factor influencing the factor of frailty

Table 1. General information of elderly fracture patients and debilitating stage, pre-debilitating stage, and non-debilitating patients

	Frailty group (n=65)	Pre-frailty group (n=55)	Non-frailty group (n=46)	Statistics	*p*
Gender [n (%)]				χ^2=4.97	*p*=0.083
Male	16 (24.6)	24 (43.6)	17 (37.0)		
Female	49 (75.4)	31 (56.4)	29 (63.0)		
Age [n (%)]				*H*=67.2	*p*<0.001
60-69	3 (4.62)	10 (18.2)	28 (60.9)		
70-79	17 (26.2)	27 (49.1)	17 (37.0)		
80-89	45 (69.2)	18 (32.7)	1 (2.17)		
BMI [(mean±SD) kg/m^2]	20.7±3.24	22.8±3.17	25.6±3.22	*F*=17.1	*p*<0.001
Level of education [n (%)]				χ^2=6.89	*p*=0.548
Primary and below	48 (73.9)	39 (70.9)	35 (76.1)		
Junior high school and above	17 (26.2)	16 (20.1)	11 (23.9)		
Way of living [n (%)]				χ^2=4.79	*p*=0.091
Alone	12 (18.5)	8 (14.6)	2 (4.34)		
Not alone	53 (81.5)	47 (85.5)	44 (95.7)		
Basic diseases [n (%)]				*H*=42.4	*p*<0.001
0	0 (0)	5 (9.09)	15 (32.6)		
1~2	23 (35.4)	25 (45.5)	27 (58.7)		
3~4	23 (35.4)	18 (32.7)	4 (8.7)		
≥5	19 (29.2)	7 (12.7)	0 (0)		
The fracture types [n (%)]				χ^2=47.4	*p*<0.001
Hip fracture	63 (96.9)	32 (58.2)	14 (30.4)		
Other fracture	2 (3.08)	23 (41.8)	32 (69.6)		

Table 2. Nutritional risk and malnutrition in elderly patients with frailty, pre-frailty and non-frailty†

	Nutritional risk (NRS2002 ≥3)	Malnutrition (GLIM diagnosis)
Frailty group (n=65) [n (%)]	37 (56.9)	31 (47.7)
Pre-frailty group (n=55) [n (%)]	18 (32.7)	13 (23.6)
Non-frailty group (n=46) [n (%)]	1 (2.17)	1 (2.17)
Statistics	χ^2=36.2	χ^2=28.7
p	*p*<0.001	*p*<0.001

†*p*<0.05 indicates that the difference in incidence among the three groups was statistically significant by the chi-square test

Table 3. ADL assessment in elderly patients with frailty, pre-frailty and non-frailty†

	ADL		
	<40	40-60	>60
Frailty group (n=65) [n (%)]	32 (49.2)	29 (44.6)	4 (6.15)
Pre-frailty group (n=55) [n (%)]	11 (20.0)	31 (56.4)	13 (23.6)
Non-frailty group (n=46) [n (%)]	3 (6.52)	8 (17.4)	35 (76.1)
Statistics		*H*=65.2	
p		*p*<0.001	

†*p*<0.05 indicates that the difference in incidence among the three groups was statistically significant by the chi-square test

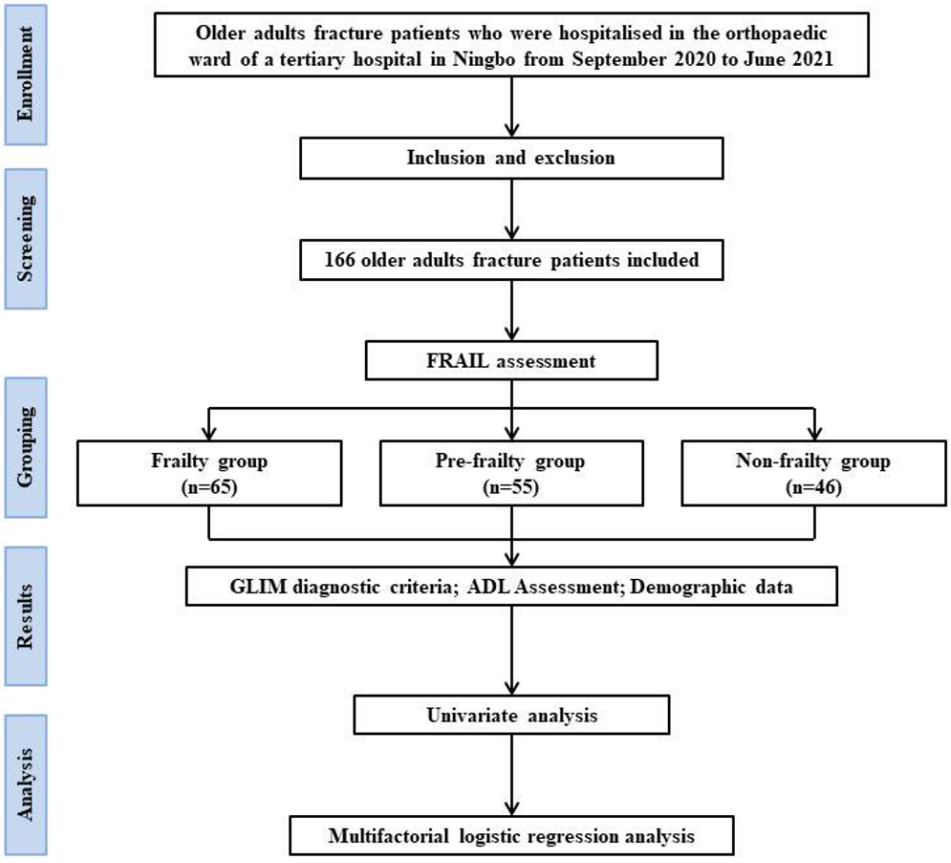

Figure 1. Flowchart of research design

in older adult patients hospitalised (OR = 0.340, $p = 0.01$) (Table 4).

DISCUSSION

This was a cross-sectional study. The univariate analysis indicated that age, BMI and the number of underlying comorbidities were significantly different ($p < 0.05$) across the frailty, pre-frailty and non-frailty groups. There was also a significant difference in the composition ratio of fracture types among the three groups ($p < 0.05$). The overall prevalence of nutritional risk in older adult fracture patients was 33.7%, and the overall GLIM-diagnosed malnutrition prevalence was 27.1%. There were differences in the incidence of nutritional risk and the prevalence of malnutrition among the three groups, and the differences were statistically significant ($p < 0.05$). There were also significant differences in the ADL assessment among the three groups of patients. The multivariate logistic regression analysis indicated that an older age, more underlying diseases and a high degree of depend-

Table 2. Nutritional risk and malnutrition in elderly patients with frailty, pre-frailty and non-frailty†

	Nutritional risk (NRS2002 ≥3)	Malnutrition (GLIM diagnosis)
Frailty group (n=65) [n (%)]	37 (56.92)	31 (47.69)
Pre-frailty group (n=55) [n (%)]	18 (32.73)	13 (23.64)
Non-frailty group (n=46) [n (%)]	1 (2.17)	1 (2.17)
Statistics	χ^2=36.157	χ^2=28.747
p	*p*<0.001	*p*<0.001

†*p*<0.05 indicates that the difference in incidence among the three groups was statistically significant by the chi-square test

Table 3. ADL assessment in elderly patients with frailty, pre-frailty and non-frailty†

	ADL		
	<40	40-60	>60
Frailty group (n=65) [n (%)]	32 (49.2)	29 (44.6)	4 (6.15)
Pre-frailty group (n=55) [n (%)]	11 (20.0)	31 (56.4)	13 (23.6)
Non-frailty group (n=46) [n (%)]	3 (6.52)	8 (17.4)	35 (76.1)
Statistics		*H*=65.194	
p		*p*<0.001	

†*p*<0.05 indicates that the difference in incidence among the three groups was statistically significant by the chi-square test

ence in daily life were independent risk factors for frailty in older adult fracture patients.

The prevalence of frailty and malnutrition is high in older adult patients with fractures. The frailty state of older adults experiencing fewer external stimuli may lead to a series of negative clinical events.[1] In this study, among the 166 older adult fracture patients, 65 were in the frailty group, and 55 were in the pre-frailty group, and the detection rates of frailty and pre-frailty were 39.2% and 33.1%, respectively. Sixty-three of the 109 hip fracture patients were in the frailty group, and 32 were in the pre-frailty group, and the detection rates of frailty and pre-frailty were 57.6% and 29.4%, respectively. This is consistent with the literature that reported the detection rate of frailty in fragility fractures of the hip as 33.3% to 53.3%.[19-25]

According to the present study, the multivariate logistic regression analysis suggested that a one-year increase in age was associated with a 1.137-fold increase in the risk of frailty, which implied that the risk of developing frailty increased with age in older adults and that people of advanced age were more prone to frailty. This may be related to the gradual decline in the functions of various tissues and organs, especially the degeneration of the motor system. A decrease in muscle mass and strength accelerates the progression of disability and muscle atrophy in older adults and causes an imbalance of various hormone levels in the body. This disrupts the homeostatic balance of the immune and neuroendocrine systems, which is consistent with previously reported results.[26] Therefore, it is extremely important to enhance early screening and intervention approaches for frailty in older adult patients. It is also suggested that healthcare professionals should develop individualised intervention plans for frailty prevention in older adult patients of different ages.

Older adults frequently experience age-related chronic diseases such as hypertension, diabetes, stroke and heart failure simultaneously, which can accelerate the deterioration of the physiological reserve function of multiple organ systems and promote the onset and development of frailty. In the current study, it was found that underlying chronic disease was an independent risk factor for frailty in older adult patients. For these patients, each additional underlying disease was associated with a 1.429-fold increased risk of frailty, which meant that with an increase in the number of diseases, the risk of frailty also increased.[27,28] This suggested that orthopaedic healthcare providers need to develop multidisciplinary collaborations based on the comorbidities of older adult patients such that optimal clinical decisions and therapeutic care can be developed to effectively manage chronic diseases, avoid the associated complications and positively improve the prognosis.

The fracture type and the ADL score were found to be

Table 4. ADL assessment in elderly patients with debilitating, pre-debilitating and non-debilitating fractures †

Factor	*z*	*p*-value	OR	OR 95% CI
Age	4.332	0.000	1.135	0.984 – 1.286
BMI	-1.594	0.111	0.879	0.750 – 1.030
Basic diseases	2.901	0.004	2.623	1.472 – 2.775
The fracture types	-2.560	0.010	0.340	0.149 – 0.777
Ability of daily living activities	1.578	0.000	3.418	3.269 – 3.567
Nutritional risk	0.237	0.812	1.209	0.253 – 5.783
Malnutrition	-0.082	0.934	0.937	0.199 – 4.413

BMI: Body mass index; OR: odds ratio; CI: confidence interval
†*p*<0.05 indicates that the variables were included in the model with statistical significance

associated with the frailty scores. The incidences of hip fractures were significantly higher among the frailty and pre-frailty patients than among the non-frailty patients. The rate of heavy dependence (ADL score of <40) was 49.2% for the frailty group and 20.0% for the pre-frailty group. The ADL score was significantly and negatively related to the frailty score, with each one-point increase in the ADL score decreasing the frailty score by 3.90%. It was clear that the risk of frailty decreased as the ability to perform ADL increased.

The nutritional status of older adult fracture patients is a matter of great concern. Malnutrition is mainly caused by protein deficiency and a relatively insufficient energy intake, which can easily lead to adverse consequences, such as decreased activity, decreased physiological metabolic rate, increased chance of infection, muscle atrophy and decreased muscle strength.[29] Current evidence suggests that frailty and malnutrition are two concepts that share common determinants and several pathophysiological pathways. Some of these include reduced body tissue, the presence of chronic inflammation, a pernicious sociodemographic background, impaired physical and cognitive functions as well as dependence in bodily functions.[30] Frailty is a geriatric syndrome of decreased physiologic reserve and resistance to stressors. Multi-system disorders are an important pathway for the occurrence of frailty, mainly manifested in hypothalamic-pituitary-adrenal disorders and neuroendocrine disorders, chronic inflammation and ageing of the immune system, cellular ageing, impaired energy metabolism, social environmental psychological factors and physical diseases.[31] At the molecular level, a recent study found 15 single nucleotide polymorphisms and 18 genes associated with faltering by screening for gene-related molecules.[32] Reduced nutrient intake, high consumption and reduced nutrient bioavailability are the core mechanisms and pathways of malnutrition in the elderly.[29] Recent studies have reported that the mTORC1-p38MAPK-p53 signalling pathway is the core regulatory pathway of intestinal villi senescence, which may be one of the pathogeneses of malnutrition. Physical frailty and malnutrition are closely associated (Figure 2).[33] Frailty can lead to malnutrition, and malnutrition can further weaken the immune defence function of the body, slow down the efficacy of drug absorption and reduce the self-repair ability, which can lead to hypofunction of multiple systems and a considerable increase in the chance of infection. Malnutrition will further aggravate frailty, thus creating a vicious circle.[28]

In this study, the overall nutritional risk and the prevalence of malnutrition were 33.7% and 27.1%, respectively, while the prevalence of nutritional risk was as high as 56.9% for the frailty group and 32.7% for the pre-frailty group. Meanwhile, the prevalence of malnutrition among the 166 patients was as high as 47.7% for the frailty group and 23.6% for the pre-frailty group. The BMI of the frailty and pre-frailty patients were also significantly lower than that of the non-frailty patients. The univariate analysis results indicated that the nutritional risk obtained via NRS-2002 screening, BMI and the GLIM diagnosis of malnutrition were associated with the development of frailty, while the multivariate regression analysis revealed that the GLIM, BMI and NRS-2002 scores did not affect the frailty score. This baseline status did not appear to directly lead to frailty. In fact, interference from external

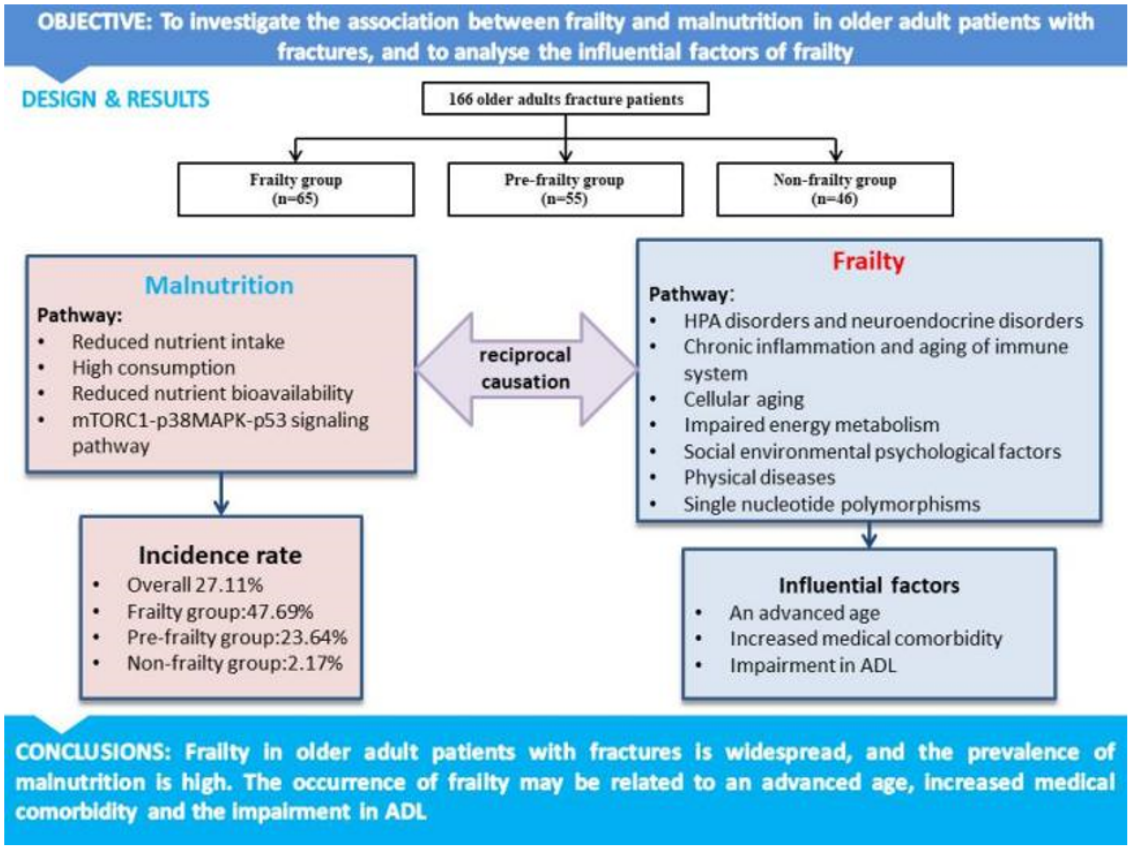

Figure 2. Graphical abstract

factors (e.g. hip fracture, reduced ADL or underlying comorbid diseases) were required for frailty to occur. Given the close relationship between malnutrition and frailty, it is important to prevent the risk of frailty by improving the nutritional status and immune system function, maintaining muscle function and improving self-care in older adult patients with fractures and malnutrition through reasonable nutritional supplementation and timely and appropriate nutritional interventions to fundamentally improve the baseline level.

A number of limitations were detected in this study. First, this was a single-centre cross-sectional study, and a multi-centre prospective intervention study is needed to further validate our findings. Second, the treatment of certain covariates was lacking in this study (e.g. nutrition-related laboratory indicators were not included), which means that confounding factors could have affected the study's conclusions. Third, this study only involved orthopaedic inpatients, meaning the results may be subject to some selection bias and may need to be validated by further sample collection.

Conclusion

Older adult fracture patients have a high prevalence of frailty, premature ageing and malnutrition, which requires early identification and intervention to improve patient outcomes. An advanced age, more underlying diseases and a higher dependence in daily living are independent risk factors for frailty in older adult patients with fractures.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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