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# Prevalence and risk factors of frailty among people in rural areas: a systematic review and meta-analysis

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## ABSTRACT

**Objective** Older people in rural areas are possibly more frail due to the limited medical resources and lower socioeconomic status. Given the negative healthy outcomes caused by frailty, knowing the epidemiology of frailty in rural areas is of great importance. We tried to synthesise the existing evidences for the prevalence and risk factors of frailty in rural areas.

**Design** A systematic review and meta-analysis.

**Data sources** PubMed, Embase, MEDLINE, Cochrane Library, Web of Science and Scopus were used to identify the articles from inception to 30 April 2019.

**Eligibility criteria** Observational studies providing cross-sectional data on the prevalence of frailty in rural elderly were extracted.

**Data extraction and synthesis** Two independent investigators selected studies, extracted data and assessed the methodological quality of included studies. The pool prevalence of frailty was calculated by the random effects model and the OR and 95% CI were used to calculate the risk factors.

**Results** The literature search yielded 2219 articles, of which 23 met the study criteria and were included in this analysis. The pooled prevalence of frailty and pre-frailty were 18% (95% CI 15% to 21%, $I^2$=98.5%, p<0.001) and 50% (95% CI 45% to 56%, $I^2$=98.4%, p<0.001), respectively. The pooled frailty prevalence was 15% for the Fried Phenotype, 18% for the Frailty Index and 23% for other criteria. The pooled prevalence of frailty was 17% for males and 26% for females. The pooled prevalence of frailty was 17% in developing countries and 23% in developed countries. Age, cognitive impairment, depressive symptom, risk of malnutrition, activity of daily living (ADL) disability and poor self-perception of health were associated with frailty. There was no publication bias.

**Conclusions** Frailty influences almost one in five older people in rural areas, and increasing age, cognitive impairment, depressive symptom, risk of malnutrition, ADL disability and poor self-perception of health were all risk factors for frailty. We should be cautious about the research results due to the heterogeneity between studies.

## Strengths and limitations of this study

- In this study, we conducted a comprehensive systematic literature search.
- This study focused on the frailty of older people in rural areas that are easily neglected.
- The data are mainly from Asia and North and South America, and lack of data from Europe.
- The main limitation is the heterogeneity among studies of this meta-analysis.
- Stratified meta-analyses cannot explain all sources of heterogeneity.

## INTRODUCTION

An ageing population is a common phenomenon experienced by all countries in the world,[1] which brings considerable challenges for the planning and delivery of healthcare services internationally. The most problematic manifestation of population ageing is frailty.[2] Frailty is an age-related medical syndrome, which is characterised by diminished strength, endurance and reduced physiological function that increases an individual's vulnerability for developing increased dependency and/or death.[3] Frailty has been proved to be associated with negative healthy outcomes, such as hospitalisation, institutionalisation/dependency and premature mortalities.[4] Ahmad[5] found that the transition towards greater frailty states were more likely (22.9%) than transition toward lesser frailty states (19.9%) during a 12-month follow-up through the survey of 2324 elderly and it proved that frailty was potential reversible and this reversibility made it a cornerstone to delay frailty progression. Pre-frailty is an intermediate state between frailty and robustness, which can predispose to the development of frailty and other adverse health and social care outcomes and it is necessary to identify the state of pre-frailty.[6]

With the continuous expansion of the study population, more and more researches begin to pay attention to the frail elderly in rural areas. From high-income countries to sub-Saharan Africa, under the guidance of city-oriented development path, the gap between urban and rural areas continues to expand.[7] The elderly person in the rural context, in addition to the peculiarities of the ageing

process,[8] shows a series of environment-related characteristics, such as limited educational resources, limited accessibility of healthcare services and resources, lower socioeconomic status, and all of these potential factors may cause the emergence or advancement of frailty.[9 10] Many countries have explored the prevalence of frailty in rural elderly and the results are quite different, for example the prevalence of frailty is 43.4% in Brazil,[8] 15.2% in Sri Lanka,[11] 38.8% in India,[12] 18.8% in France[13] and even in the same country, the prevalence of frailty varies greatly due to differences in assessment tools, research environments and so on. A recent meta-analysis on prevalence of frailty including 62 countries across the world reported the prevalence of frailty and pre-frailty were 12% and 46%, respectively, using the tool of Fried phenotype (FP).[14] However, the included people were from cities, towns and villages, and the data of rural areas is absent.

Hence, it is necessary to synthesise the existing body of evidence and offer a perspective on the prevalence of frailty in rural areas, which are critically important to developing strategies and disease prevention. The objectives of this systematic review were to synthesise the pooled prevalence and risk factors of frailty in rural areas through conducting a meta-analysis.

## METHODS

### Protocol

This review was conducted according to the MOOSE statement which was for the meta-analysis of observational studies in epidemiology.[15]

### Search strategy

We conducted a comprehensive search of the literature using six electronic databases. PubMed, Embase, MEDLINE, Cochrane Library, Web of Science and Scopus were searched from their dates of inception through 30 April 2020 with languages restricted to English. A combination of title/keyword/abstract and Medical Subject Headings were used and the following key words were used: “frailty”, “frail”, “frail*”, “rural”, “village”, “countryside” and “rural*”. Reference lists of relevant literatures were hand-searched for addition studies. The search strategy in PubMed is available in online supplemental table 1.

### Eligibility criteria

#### Condition

We considered studies reporting the prevalence (or enough data to compute this estimate) of frailty or pre-frailty. The measurement of frailty or pre-frailty was based on the assessment tools used. For example, the FP contained five components (weight loss, exhaustion, weakness, slowness and low physical activity) and subjects who were positive for three or more components were defined as frailty, those with one or two component(s) were defined as pre-frailty.[16] In the studies where frailty or pre-frailty were not defined using the FP, we considered the definition used by authors.

#### Context

We considered studies conducted in people living in the rural areas. We found that there is no unified definition of rural areas by reviewing the literature. Some studies think that rural areas are the places with the relatively backward economic development,[10] while others think that rural areas are far away from cities.[5] Therefore, we will include studies as long as it clearly points out that it conducts in rural contexts.

#### Population

We considered studies conducted in older adults (≥60 years). Studies that limited the study population to specific population such as lung cancer and kidney disease were excluded.

### Study design

Study designs were observational providing cross-sectional data on the prevalence of frailty or pre-frailty. Review, editorial, comment and conference abstract were excluded.

### Data extraction

Two investigators extracted data independently and disagreements were resolved by discussion. Data were recorded in the Microsoft Excel file format from each eligible study including the following variables: first author, year and country of publication, study design, sample size, mean or median age of the population, proportion of female, assessment tools of frailty, prevalence of frailty and pre-frailty and risk factors mentioned. We asked for the missing data by sending emails to the corresponding author of the included articles.

### Methodological quality assessment

All eligible articles were subjected to a quality assessment by two investigators independently through the criterion proposed by Loney *et al*[17] which was designed to critically assess studies about the prevalence. Each study was assigned a summative quality score ranging from 0 to 8, which was obtained by scoring a point for each of random sample or whole population, unbiased sampling frame (ie, census data), adequate sample size (>300 subjects), measures were the standard, outcomes measured by unbiased assessors, adequate response rate (70%), CIs, subgroup analysis and study subjects described. Only studies that scored three or above were deemed eligible for inclusion and studies which met more than four criteria were thought to have adequate quality.[18] A third author resolved quality disagreements.

### Statistical analysis

Heterogeneity among studies was tested using $\chi^2$ test and the $I^2$ statistic. Studies were considered to have significant heterogeneity if the p value was less than 0.1. The $I^2$ statistic was used to assess the degree of heterogeneity,

with $I^2$ values of 25%, 50% and 75% being considered to indicate low, moderate and high heterogeneity, respectively. Random-effects model was used to calculate the pooled prevalence of frailty if significant heterogeneity was present; otherwise a fixed-effects model was used. We tried to explore the potential reasons for heterogeneity by conducting stratified meta-analyses. In stratified meta-analyses, the literature data were divided into subgroups according to frailty criteria, gender and level of development, and pooled estimates of frailty prevalence with 95% CIs were calculated. The prevalence of frailty and pre-frailty were extracted from all included studies in order to calculate the pooled prevalence and the ORs and associated 95% CIs were extracted to assess the risk factors of frailty in rural elderly. Begg's test and Egger's test were used to assess publication bias.

Statistical analyses were conducted using Stata SE V.12.0 (Stata Corp, College Station, Texas, USA), and a p value <0.05 was considered significant.

### Patient and public involvement

There was no direct patient or public involvement in this study.

## RESULTS

### Study process

The systematic search of the six databases retrieved 2219 articles. After 1345 duplicate studies were excluded, a further 783 studies were excluded through screening the title and abstract. Of the 91 studies left, 68 were excluded from the full-text review due to non-data-based article (eg, editorial, commentary, review, conference abstract) (n=15), same sample (n=11), non-English (n=7), no data of frailty in rural elderly (n=25), sample from a specific population (eg, patients with cancer, disabled individuals) (n=6), one more form of frailty assessment (n=4). Finally, 23 published articles,[5 8–12 19–35] involving a total of 32 478 older adults in rural areas, were eligible and included in the meta-analysis (figure 1). Of all the studies included, 17 studies have adequate quality (score >4). The characteristics of studies were showed in table 1. One of these studies included data from four countries.[35]

### Prevalence of frailty and pre-frailty

The prevalence of frailty and pre-frailty in included studies range from 5.4% to 43.4%,[8 35] and from 23% to 67.8%,[22 23] respectively. Meta-analysis showed the pooled prevalence of frailty 18% (95% CI 15% to 21%, $I^2$=98.5%, p<0.001) in rural elderly, with the pooled prevalence of pre-frailty of 50% (95% CI 45% to 56%, $I^2$=98.4%, p<0.001) based on a random-effects model (figures 2 and 3). Heterogeneity statistics ($\chi^2$ test=1644.51; p<0.001; $I^2$=98.5%) indicated significant variability among studies. According to the results of Begg's test (Pr=0.659>0.05) and Egger's test (p=0.059>0.05), there was no evidence of publication bias.

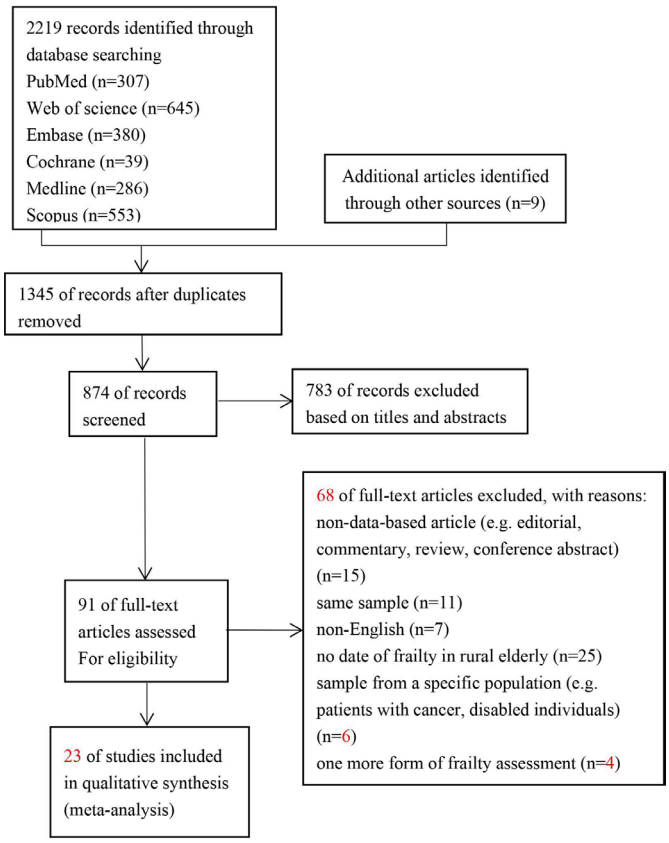


**Figure 1** Flow chart of systematic review.

### Stratified prevalence of frailty according to frailty criteria, gender and level of development

The pooled estimates of frailty prevalence based on the FP, FI and other criteria were 15%, 18% and 32%, respectively. The estimated pooled prevalence of frailty was 26% in females and 17% in males. The estimated pooled prevalence of frailty was 17% in developing countries and 23% in developed countries. Results of subgroup analyses are shown in table 2.

### Risk factors

We identified six potential risk factors including age, cognitive impairment, depressive symptom, risk of malnutrition, activity of daily living (ADL) disability and poor self-perception of health, which were associated with frailty in rural elderly for the pooled analysis (table 3).

## DISCUSSION

Based on 23 studies involving a total of 32 478 participants living in rural areas, the estimated pooled prevalence of frailty and pre-frailty of older people in rural areas are 18% and 50%, respectively. However, this result has to be cautiously interpreted because of the substantial heterogeneity between studies. When assessing potential risk factors associated with frailty in rural elderly, six factors including increasing age, cognitive impairment, depressive symptom, risk of malnutrition, ADL disability and poor self-perception of health were associated with frailty.

**Table 1** Characteristics of studies

| First author (year) | Country | Sample size | Study design | Mean or median age of the population | Proportion of female (%) | Frailty assessment | Prevalence (%) | | Risk factors assessed | Quality score |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Frail | Pre-frail | | |
| Llano *et al* 2019[8] | Brazil | 820 | Cross-sectional | – | 56.10 | FP | 43.4 | 37.1 | Income; education level; nutritional status, physical inactivity, cognitive deficit, poor self-perceived health | 6 |
| Manrique-Espinoza *et al* 2016[9] | Mexico | 558 | Cross-sectional | – | 47.50 | FP | 8.6 | 52.9 | ADL and IADL disability, depression symptom, educational level, self-reported health | 6 |
| Gu *et al* 2019[10] | China | 4323 | Cross-sectional | 70.2±7.0 | 58.50 | FP | 6.8 | 49.4 | Age, stroke history, vision decrease, anaemia | 6 |
| Siriwardhana *et al* 2019[11] | Sri Lanka | 746 | Cross-sectional | 68 | 53.20 | FP | 15.2 | 48.5 | Age, longest-held occupation | 4 |
| Dasgupta *et al* 2019[12] | India | 165 | Cross-sectional | 66.99±6.5 | 67.90 | TFI | 38.8 | – | Educational level, two chronic diseases | 4 |
| Ahmad *et al* 2018[5] | Malaysia | 2324 | Based on cohort | – | 62.10 | FP | 9.4 | 57.9 | – | 6 |
| Huang *et al* 2020[19] | China | 1014 | Cross-sectional | 78.7±8.0 | 66.30 | FP | 17.6 | 59.4 | Depressive symptoms; urinary incontinence; abnormal performance of TUG; malnutrition | 5 |
| Nguyen *et al* 2019[20] | Vietnam | 512 | Cross-sectional | – | 69.90 | FP | 21.7 | 65.6 | Age, marital status, occupation, comorbidities, cognitive impairment, history of fall in the last 12 months | 5 |
| Yoon *et al* 2018[21] | Korea | 104 | Cross-sectional | 73.5±5.43 | 76.90 | FP | 16.5 | 49.6 | – | 3 |
| Li *et al* 2018[22] | China | 3048 | Cross-sectional | 71.55±6.7 | 58.50 | FI | 15.8 | 67.8 | Self-neglect, age, sex and alcohol drinking | 5 |
| Del Brutto *et al* 2016[23] | Ecuador | 311 | Cross-sectional | 71±8 | 56.90 | EFS | 31 | 23 | – | 5 |
| Dent *et al* 2016[24] | Australia | 1501 | Cross-sectional | 75.9±7.9 | 54.90 | FI | 25 | – | Health service use | 6 |
| Çakmur *et al* 2015[25] | Turkey | 168 | Cross-sectional | 72.7±7.7 | 53.60 | FP | 7.1 | 47.3 | – | 4 |
| Kim *et al* 2019[26] | Korea | 808 | Cross-sectional | 74.58±6.26 | 59.00 | KYCL | 35.5 | – | Perceived neighbourhood walkability, environmental pollution | 6 |
| Boulos *et al* 2016[27] | Lebanon | 1120 | Cross-sectional | 75.7±7.1 | 59.40 | SOF | 36.4 | 30.4 | Marital status, education level, physical health status, mental health status | 6 |
| Zhu *et al* 2016[28] | China | 1478 | Cross-sectional | 75.3±3.9 | 53.00 | FP | 12 | 42.9 | High sensitivity C reactive protein | 6 |
| Curcio *et al* 2014[29] | Colombia | 1878 | Based on cohort | 70.9±7.4 | 52.20 | FP | 12.2 | 53 | Age, gender, health status variables, functional covariate variables, psychosocial variables | 4 |
| Ocampo-Chaparro *et al* 2019[30] | Colombia | 688 | Cross-sectional | – | 49.60 | FP | 20.6 | 64.4 | – | 6 |
| Wu *et al* 2017[31] | China | 3048 | Based on cohort | – | – | FP | 8.1 | 53.6 | – | 8 |
| Abe *et al* 2019[32] | Japan | 1576 | Cross-sectional | – | 55.50 | KYCL | 20.8 | – | – | 8 |
| Ma *et al* 2018[33] | China | 2353 | Cross-sectional | – | – | FI | 12.9 | – | – | 7 |
| Jung *et al* 2016[34] | Korea | 382 | Based on cohort | 74.4±6.5 | 56.30 | FP | 17.4 | 52.6 | – | 4 |
| Llibre Rodriguez *et al* 2018[35] | Peru | 552 | Cross-sectional | 74.2±7.3 | 53.4 | The modified FP | 16.8 | – | – | 7 |
| | Mexico | 1000 | | 74.1±6.7 | 60.2 | | 15.7 | | | |
| | China | 1002 | | 72.4±6.0 | 55.5 | | 5.4 | | | |
| | India | 999 | | 72.6±5.8 | 54.60 | | 15.4 | | | |

ADL, activity of daily living; EFS, Edmonton Frail Scale; FI, Frailty Index; FP, Fried phenotype; IADL, instrumental activity of daily living; KYCL, Kaigo-Yobo checklist; SOF, Study of Osteoporotic Fractures index; TFI, Tilburg Frailty Indicator; TUG, timed up-and-go.

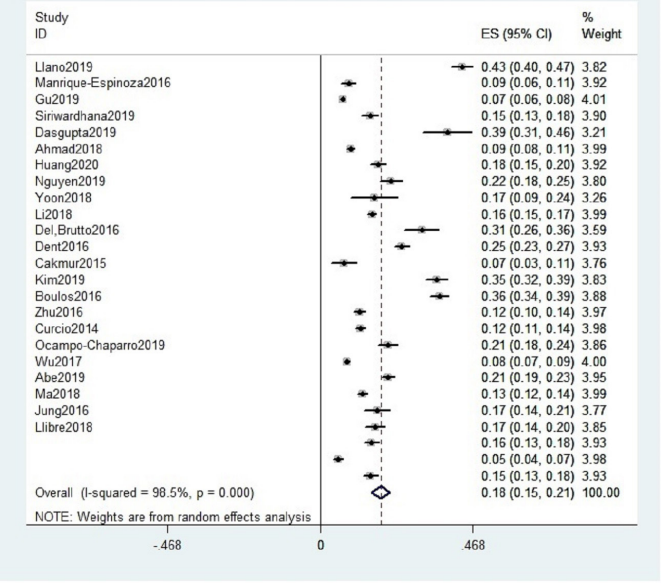


**Figure 2** Forest plot of prevalence of frailty.

The pooled prevalence of frailty in rural elderly from this meta-analysis was 18% (95% CI 15% to 21%), higher than the global estimate (10.7%; 95% CI 10.5% to 10.9%) which published in 2012.[36] Differences in frailty prevalence estimates between rural areas and the global average may be due to the characteristics of studies included. Most of the people included in the global study came from cities and towns, however the participants of our meta-analysis came from the rural areas. Frailty was more common among rural areas, which may be explained by these reasons: (1) lower socioeconomic status among residents living in rural communities, (2) limited accessibility of healthcare services and resources, (3) relatively unhealthy lifestyle and limited healthcare awareness.[19 20] Frailty has been proved to be associated with negative healthy outcomes,[4 37 38] and studies from Canada, China and Korea found that frail rural elderly have higher mortality than that in the city or town.[39–41] Besides, in the context of the COVID-19 pandemic, study found that frailty can predict disease outcomes better in a large population of patients with COVID-19 than age or comorbidity and it is also meaningful to know the frailty of older people in rural areas.[42] Hence, it is time to focus and improve the healthcare in rural areas, expect for improving the distribution of medical resources, strategies including support services, nutritional supplementation, exercise interventions and health education may also be useful to prevent and delay the occurrence and development of frailty.[34] The pooled prevalence of pre-frailty in this meta-analysis was found to be 50% (95% CI 45% to 56%). Pre-frailty is a transitional and potentially reversible risk state before the onset of frailty, and the fact that half of the rural elderly were pre-frail indicates that it is urgent to establish and implement early frailty prevention strategies among rural areas.

This analysis found that pooled prevalence of frailty varied based on the assessment tools used. In this

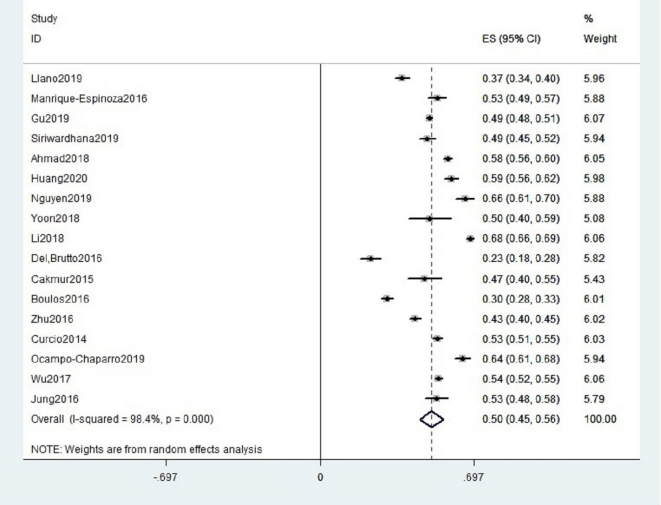


**Figure 3** Forest plot of prevalence of pre-frailty.

**Table 2** Subgroup analyses by frailty criteria, gender and level of development

| | Frailty | | | |
|---|---|---|---|---|
| **Subgroups** | **Prevalence (%)** | **95% CI** | **$I^2$ (%)** | **P value** |
| Frailty criteria | | | | |
| FP | 15 | 12% to 18% | 97.7 | <0.001 |
| FI | 18 | 12% to 24% | 97.6 | <0.001 |
| Other criteria | 32 | 24% to 40% | 96.4 | <0.001 |
| Gender | | | | |
| Female | 26 | 20% to 31% | 98.4 | <0.001 |
| Male | 17 | 13% to 22% | 97.4 | <0.001 |
| Level of development | | | | |
| Developing countries | 17 | 14% to 20% | 98.4 | <0.001 |
| Developed countries | 23 | 18% to 29% | 94.5 | <0.001 |

FI, Frailty Index; FP, Fried phenotype.

**Table 3** Pooled risk factors of frailty

| No. | Risk factors | OR | 95% CI | $I^2$ (%) | P value |
|---|---|---|---|---|---|
| 1 | Age | 1.05 | 1.03 to 1.08 | 0.0 | <0.001 |
| 2 | Cognitive impairment | 1.97 | 1.41 to 2.54 | 0.0 | <0.001 |
| 3 | Depressive symptom | 1.24 | 1.14 to 1.34 | 68.5 | <0.001 |
| 4 | Risk of malnutrition | 2.49 | 1.51 to 3.48 | 62.0 | <0.001 |
| 5 | ADL disability | 2.59 | 1.71 to 3.48 | 0.0 | <0.001 |
| 6 | Poor self-perception of health | 2.42 | 1.39 to 3.45 | 0.0 | <0.001 |

ADL, activity of daily living.

meta-analysis, studies using the FP reported lower prevalence of frailty than those using the Frailty Index (FI) and other criteria, consistent with many other studies,[14 36] and this suggests that researchers around the world recognised the definition of FP. The benefits of the FP include its relative ease of application, and another benefit is the minimal amount of data required for its calculation, making it a potential tool for screening.[43] However, the FP has its roots in Canadian population surveys, and it is better to verify its applicability or to make an adjustment when used in other populations. The FI is another commonly used criterion, based on a deficit accumulation model,[44] and study found that the the electronic FI (eFI) overestimates the frailty status of community-dwelling older people compared with the Clinical Frailty Scale which is a validated measure of frailty based on clinical presentation.[45] Hence, we need to consider carefully when using the FI and further work should also be conducted to identify a uniform scale that can be used to accurately identify frailty among populations.

Our stratified analysis of gender revealed that females were more likely to be frail than males among the older people in rural areas, which was consistent with previous reports.[14 36] Females have a longer life expectancy, and this survival effects may result in a greater accumulation of frailty-associated deficits over time.[46] Another possible explanation is that postmenopausal women have lower average amounts of lean body mass and muscle because of vitamin D deficiency,[47] and the relationship between frailty and sarcopenia has been confirmed in previous research.[48]

The result of our level of development-stratified analysis revealed that older people in rural areas from developed countries were more likely to be frail than older people from developing countries, and this is not consistent with another meta-analysis which found that the prevalence of frailty appeared higher in community-dwelling older adults in upper middle-income countries compared with high-income countries.[49] This may be because older rural people in developed countries live longer than those in developing countries and further work should also be conducted to identify the differences in the incidence of frailty in countries at different levels of development.

The potential risk factors associated with frailty estimated in rural elderly were increasing age, cognitive impairment, depressive symptom, risk of malnutrition, ADL disability and poor self-perception of health. Ageing can be conceptualised as a deficit accumulation process of each physiological system, taking place in different individuals in different ways, with a variety of rates for different organ systems, making it necessary to find out prevalence and associated factors of different age groups of the elderly in rural areas.[50] Limited data made it difficult to conduct a subgroup of age in this meta-analysis, but evidence from rural elderly in Sri Lanka had found the prevalence of frailty has almost doubled with the increasing of age (group: 75–79 years vs ≥80 years; RR(Relative Risk): 4.07 vs 7.02).[11] Park and Yu[51] found that different age groups had different risk factors of frailty by analysing the data of 22 868 elderly people, so targeted interventions for frailty prevention can reduce the pressure in rural areas with limited medical resources.

Cognitive impairment was associated with frailty in the rural elderly, consistent with results among the world that poor cognitive function is strongly closed associated with pre-frailty and frailty subgroups in older populations.[52] Many factors are involved in the relationship between cognitive function and frailty, such as neuropathology, cardiovascular disease, inflammation, hormonal changes, nutrition, social isolation, social vulnerability and so on.[53] As cognitive function contains several cognitive domains, it might be useful and necessary to determine which individual experienced cognitive deficits are most significantly associated with frailty scores.

Depression was associated with frailty among older people in rural areas, and this is due to that frailty and depression share the same pathophysiological mechanism.[54] Besides, individuals with depressive symptoms usually have less physical activity, which will increase the probability of frailty.[55] Risk of malnutrition was another risk factors associated with frailty, as weight loss, reduced intake of calorie and specific dietary pattern may change the body composition and physical function, which can increase the risk of frailty.[55]

ADL disability means the decreased ability of self-care, affecting eating ability and physical activity, further causing malnutrition and muscle decline, eventually leading to frailty.[56] Self-perception of health has been identified as a highly sensitive variable in elderly health estimations and a valid predictor of morbidity,[9] and Jylhä *et al*[57] found self-appraisal has biological and cognitive underpinnings, existing as a predictor of frailty. Actually, rural older persons are exposed to a greater inequitable and precarious socioeconomic and health conditions throughout their life courses, and as a result, perception of the elderly regarding adverse experiences may predispose them to frailty.

The strength of this study is to focus on the frailty of elderly in rural areas that are easily neglected. However, there are still several limitations. The main limitation is the heterogeneity among studies. Moreover, the included articles mainly from Asia, South and North America, lacking studies from Europe and Africa, perhaps due to the difference in number and distribution of rural population. Third, the quality of the studies included was moderate, and we should be careful with research results.

## CONCLUSION

The urban–rural gap is the main problem in the distribution of medical resources in various countries, and there are a large number of older people in rural areas who are the key populations to achieve equalisation of basic public health services. As a relatively neglected elderly group, a better insight of frailty and its risk factors will have wide-scale implications for healthcare policy and practice in

rural-dwelling populations. This meta-analysis found that the pooled prevalence of frailty of older people was 18% in rural areas and many factors were associated with frailty, including age, cognitive impairment, depressive symptom, risk of malnutrition, ADL disability and poor self-perception of health. Hence, it is time to focus the frailty of older people in rural areas. In order to prevent and reduce the frailty of the older adults in rural areas, we can try to establish a frailty screening mechanism for the elderly in rural areas, pay attention to the key groups, and establish nutrition, exercise, diet and other interventions.

**Contributors** QL and MZ conceived and designed the study strategy; RX and FG completed the work of the article search, article assessment, data extraction, quality assessment and data analysis independently; LZ participated in the discussion when there was disagreement; RX wrote the manuscript. The definitive manuscript was read and approved by all authors.

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## REFERENCES

1 Peel NM, McClure RJ, Bartlett HP. Behavioral determinants of healthy aging. *Am J Prev Med* 2005;28:298–304.
2 Strandberg TE, Pitkälä KH. Frailty in elderly people. *Lancet* 2007;369:1328–9.
3 Morley JE, Vellas B, van Kan GA, *et al*. Frailty consensus: a call to action. *J Am Med Dir Assoc* 2013;14:392–7.
4 Vermeiren S, Vella-Azzopardi R, Beckwée D, *et al*. Frailty and the prediction of negative health outcomes: a meta-analysis. *J Am Med Dir Assoc* 2016;17:1163.e1–e17.
5 Ahmad NS, Hairi NN, Said MA, *et al*. Prevalence, transitions and factors predicting transition between frailty states among rural community-dwelling older adults in Malaysia. *PLoS One* 2018;13:e0206445.
6 Sezgin D, Liew A, O'Donovan MR, *et al*. Pre-frailty as a multi-dimensional construct: a systematic review of definitions in the scientific literature. *Geriatr Nurs* 2020;41:139–46.
7 Chen ZG, Zhou YY, Fan SG. Rural revitalization from a global perspective. *Issues in Agricultural Economy* 2020:87–96.
8 Llano PMPde, Lange C, Sequeira CAdaC, *et al*. Factors associated with frailty syndrome in the rural elderly. *Rev Bras Enferm* 2019;72:14–21.
9 Manrique-Espinoza B, Salinas-Rodríguez A, Salgado de Snyder N, *et al*. Frailty and social vulnerability in Mexican deprived and rural settings. *J Aging Health* 2016;28:740–52.
10 Gu J, Chen H, Gu X, *et al*. Frailty and associated risk factors in elderly people with health examination in rural areas of China. *Iran J Public Health* 2019;48:1663–70.
11 Siriwardhana DD, Weerasinghe MC, Rait G, *et al*. Prevalence of frailty in rural community-dwelling older adults in Kegalle district of Sri Lanka: a population-based cross-sectional study. *BMJ Open* 2019;9:e026314.
12 Dasgupta A, Bandyopadhyay S, Bandyopadhyay L, *et al*. How frail are our elderly? An assessment with Tilburg frailty indicator (TFI) in a rural elderly population of West Bengal. *J Family Med Prim Care* 2019;8:2242–8.
13 Avila-Funes JA, Pelletier A, Meillon C, *et al*. Vascular cerebral damage in frail older adults: the AMImage study. *J Gerontol A Biol Sci Med Sci* 2017;72:971–7.
14 O'Caoimh R, Sezgin D, O'Donovan MR, *et al*. Prevalence of frailty in 62 countries across the world: a systematic review and meta-analysis of population-level studies. *Age Ageing* 2021;50:afaa219
15 Stroup DF, Berlin JA, Morton SC, *et al*. Meta-analysis of observational studies in epidemiology: a proposal for reporting. meta-analysis of observational studies in epidemiology (MOOSE) group. *JAMA* 2000;283:2008–12.
16 Fried LP, Tangen CM, Walston J, *et al*. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001;56:M146–57.
17 Loney PL, Chambers LW, Bennett KJ, *et al*. Critical appraisal of the health research literature: prevalence or incidence of a health problem. *Chronic Dis Can* 1998;19:170–6.
18 Isaacs AM, Riva-Cambrin J, Yavin D, *et al*. Age-specific global epidemiology of hydrocephalus: systematic review, metanalysis and global birth surveillance. *PLoS One* 2018;13:e0204926.
19 Huang C-Y, Lee W-J, Lin H-P, *et al*. Epidemiology of frailty and associated factors among older adults living in rural communities in Taiwan. *Arch Gerontol Geriatr* 2020;87:103986.
20 Nguyen AT, Nguyen LH, Nguyen TX, *et al*. Frailty prevalence and association with health-related quality of life impairment among rural community-dwelling older adults in Vietnam. *Int J Environ Res Public Health* 2019;16:3836.
21 Yoon DH, Hwang SS, Lee DW, *et al*. Physical frailty and cognitive functioning in Korea rural community-dwelling older adults. *J Clin Med* 2018;7:405.
22 Li J, Zhao D, Dong B, *et al*. Frailty index and its associations with self-neglect, social support and sociodemographic characteristics among older adults in rural China. *Geriatr Gerontol Int* 2018;18:987–96.
23 Del Brutto OH, Mera RM, Sedler MJ, *et al*. The effect of age in the association between frailty and poor sleep quality: a population-based study in Community-Dwellers (the Atahualpa project). *J Am Med Dir Assoc* 2016;17:269–71.
24 Dent E, Hoon E, Karnon J, *et al*. Frailty and health service use in rural South Australia. *Arch Gerontol Geriatr* 2016;62:53–8.
25 Çakmur H. Frailty among elderly adults in a rural area of Turkey. *Med Sci Monit* 2015;21:1232–42.
26 Kim M-J, Seo S-H, Seo A-R, *et al*. The association of perceived neighborhood Walkability and environmental pollution with frailty among community-dwelling older adults in Korean rural areas: a cross-sectional study. *J Prev Med Public Health* 2019;52:405–15.
27 Boulos C, Salameh P, Barberger-Gateau P. Malnutrition and frailty in community dwelling older adults living in a rural setting. *Clin Nutr* 2016;35:138–43.
28 Zhu Y, Liu Z, Wang Y, *et al*. C-reactive protein, frailty and overnight hospital admission in elderly individuals: a population-based study. *Arch Gerontol Geriatr* 2016;64:1–5.
29 Curcio C-L, Henao G-M, Gomez F. Frailty among rural elderly adults. *BMC Geriatr* 2014;14:2.
30 Ocampo-Chaparro JM, Reyes-Ortiz CA, Castro-Flórez X, *et al*. Frailty in older adults and their association with social determinants of health. The SABE Colombia study. *Colomb Med* 2019;50:89–101.
31 Wu C, Smit E, Xue Q-L, *et al*. Prevalence and correlates of frailty among community-dwelling Chinese older adults: the China health and retirement longitudinal study. *J Gerontol* 2018;73:102–8.
32 Abe T, Kitamura A, Seino S, *et al*. Differences in the prevalence of and factors associated with frailty in five Japanese residential areas. *Int J Environ Res Public Health* 2019;16:3974.
33 Ma L, Tang Z, Zhang L, *et al*. Prevalence of frailty and associated factors in the community-dwelling population of China. *J Am Geriatr Soc* 2018;66:559–64.
34 Jung H-W, Jang I-Y, Lee YS, *et al*. Prevalence of frailty and aging-related health conditions in older Koreans in rural communities: a cross-sectional analysis of the aging study of Pyeongchang rural area. *J Korean Med Sci* 2016;31:345–52.

35 Llibre Rodriguez JJ, Prina AM, Acosta D, *et al*. The prevalence and correlates of frailty in urban and rural populations in Latin America, China, and India: a 10/66 population-based survey. *J Am Med Dir Assoc* 2018;19:287–95.
36 Collard RM, Boter H, Schoevers RA, *et al*. Prevalence of frailty in community-dwelling older persons: a systematic review. *J Am Geriatr Soc* 2012;60:1487–92.
37 Hewitt J, Carter B, McCarthy K, *et al*. Frailty predicts mortality in all emergency surgical admissions regardless of age. An observational study. *Age Ageing* 2019;48:388–94.
38 Hewitt J, Long S, Carter B, *et al*. The prevalence of frailty and its association with clinical outcomes in general surgery: a systematic review and meta-analysis. *Age Ageing* 2018;47:793–800.
39 Song X, MacKnight C, Latta R, *et al*. Frailty and survival of rural and urban seniors: results from the Canadian study of health and aging. *Aging Clin Exp Res* 2007;19:145–53.
40 Yu P, Song X, Shi J, *et al*. Frailty and survival of older Chinese adults in urban and rural areas: results from the Beijing longitudinal study of aging. *Arch Gerontol Geriatr* 2012;54:3–8.
41 Jang I-Y, Jung H-W, Lee CK, *et al*. Rural and urban disparities in frailty and aging-related health conditions in Korea. *J Am Geriatr Soc* 2016;64:908–11.
42 Hewitt J, Carter B, Vilches-Moraga A, *et al*. The effect of frailty on survival in patients with COVID-19 (COPE): a multicentre, European, observational cohort study. *Lancet Public Health* 2020;5:e444–51.
43 Lewis EG, Coles S, Howorth K, *et al*. The prevalence and characteristics of frailty by frailty phenotype in rural Tanzania. *BMC Geriatr* 2018;18:283.
44 Rockwood K, Mitnitski A. Frailty in relation to the accumulation of deficits. *J Gerontol A Biol Sci Med Sci* 2007;62:722–7.
45 Broad A, Carter B, Mckelvie S, *et al*. The convergent validity of the electronic frailty index (eFI) with the clinical frailty scale (CFS). *Geriatrics* 2020;5:88.
46 Gordon EH, Peel NM, Samanta M, *et al*. Sex differences in frailty: a systematic review and meta-analysis. *Exp Gerontol* 2017;89:30–40.
47 Venning G. Recent developments in vitamin D deficiency and muscle weakness among elderly people. *BMJ* 2005;330:524–6.
48 Morley JE, Malmstrom TK, Rodriguez-Mañas L, *et al*. Frailty, sarcopenia and diabetes. *J Am Med Dir Assoc* 2014;15:853–9.
49 Siriwardhana DD, Hardoon S, Rait G, *et al*. Prevalence of frailty and prefrailty among community-dwelling older adults in low-income and middle-income countries: a systematic review and meta-analysis. *BMJ Open* 2018;8:e018195.
50 Fulop T, Larbi A, Witkowski JM, *et al*. Aging, frailty and age-related diseases. *Biogerontology* 2010;11:547–63.
51 Park E, Yu M. Frailty and its related factors in vulnerable elderly population by age groups. *J Korean Acad Nurs* 2016;46:848–57.
52 Furtado GE, Caldo A, Rieping T, *et al*. Physical frailty and cognitive status over-60 age populations: a systematic review with meta-analysis. *Arch Gerontol Geriatr* 2018;78:240–8.
53 Yun J-H, Ki S-K, Kim J, *et al*. Relationships between cognitive function and frailty in older Korean adults: the moderating effect of the number of teeth. *Arch Gerontol Geriatr* 2020;91:104213.
54 Kwan RYC, Leung AYM, Yee A, *et al*. Cognitive frailty and its association with nutrition and depression in community-dwelling older people. *J Nutr Health Aging* 2019;23:943–8.
55 Cruz-Jentoft AJ, Kiesswetter E, Drey M, *et al*. Nutrition, frailty, and sarcopenia. *Aging Clin Exp Res* 2017;29:43–8.
56 Perna S, Francis M, Bologna C, *et al*. Performance of Edmonton frail scale on frailty assessment: its association with multi-dimensional geriatric conditions assessed with specific screening tools. *BMC Geriatr* 2017;17:2.
57 Jylhä M, Volpato S, Guralnik JM. Self-rated health showed a graded association with frequently used biomarkers in a large population sample. *J Clin Epidemiol* 2006;59:465–71.