Qiu and Wang
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RESEARCH

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GLIM criteria-based identification of severe malnutrition and its relationship with the risk of mortality among older Chinese adults with arthritis or rheumatism

Wei Qiu[1] and Yilin Wang[2*]

Abstract

Background Malnutrition is a well-known risk factor for mortality among older adults. Arthritis and rheumatism are characterized by chronic inflammation and are also related to malnutrition as diagnosed using the Global Leadership Initiative on Malnutrition (GLIM) criteria. This study was thus developed to examine the associations linking malnutrition and all-cause death among older adults in China, employing the GLIM criteria to assess malnutrition.

Methods Two waves of the China Health and Retirement Longitudinal Study from 2013 and 2018 were used to conduct this study. Moderate malnutrition was defined as low BMI (< 18.5 and < 20 for individuals < 70 and 70 + years of age, respectively), an unintended 10–20% decrease in weight, or low muscle mass based on the sex-specific lowest 20% of the height-adjusted muscle mass as < 5.039 kg/m^2 in women and < 6.866 kg/m^2 in men. Severe malnutrition was defined as a > 20% unintended decrease in weight only or the combination of both low muscle mass and an unintended reduction of over 10% in weight. Associations between malnutrition and the risk of all-cause death were assessed through Cox regression analyses.

Results Overall, this study enrolled 1766 subjects 60 + years of age, of whom 57.36% (1033/1766) were female. Malnutrition was estimated to affect 418 (23.67%) of these individuals at baseline, with 21.06% and 2.60% affected by moderate and severe malnutrition, respectively. Over the 5-year follow-up, 189 of these individuals died. Covariate-adjusted Cox regression analyses confirmed a significant association between severe malnutrition and the risk of death in this cohort (HR = 2.196, 95%CI 1.125–4.286, $P = 0.021$).

Conclusions Severe malnutrition, identified through screening based on the GLIM criteria, was associated with an increased risk of all-cause death among older Chinese adults with arthritis or rheumatism.

Backgtound

More advanced age is associated with progression declines in physiological function, higher rates of comorbidities, and reduced access to healthy food, with malnutrition thus representing an important threat facing older populations [1]. An estimated one in four older adults is at risk of or currently suffers from malnutrition [2]. As populations age, corresponding increases in malnutrition incidence are forecast. Such malnutrition can expose older individuals to a greater risk of frailty, delirium,

*Correspondence:
Yilin Wang
wangyilinzg0321@163.com
[1] The Affiliated Chaohu Hospital of Anhui Medical University, Hefei, China
[2] The Zigong Affiliated Hospital of Southwest Medical University, Zigong Mental Health Center, Zigong, China

muscle wasting, osteoporosis, cognitive decline, impaired immune functionality, fluctuating moods, lower body temperatures, an overall reduction in quality of life, and the potential for premature death [3–9]. To prolong the human lifespan and contribute to overall improvements in well-being, it is vital that awareness regarding appropriate nutrition be raised and that reliable approaches to screening for and addressing malnutrition among elderly populations be established.

The malnutrition status of older populations has previously been evaluated using a range of indices, including the Controlling Nutritional Status (CONUT) score, the Prognostic Nutritional Index (PNI), the Nutritional Risk Index (NRI), the geriatric NRI (GNRI), and the Global Leadership Initiative on Malnutrition (GLIM) [10–12]. Among these indicators, CONUT, PNI, NRI, and GNRI rely on indicators from laboratory tests for calculation, presenting challenges to grassroots communities without access to laboratory testing and instrumentation.

The recently developed GLIM criteria are effective in the identification of malnutrition and prediction of negative health outcomes, such as pneumonia, sarcopenia, frailty, and mortality, in older adults [4, 13–16]. According to the GLIM criteria, malnutrition can be diagnosed based on the presence of at least one of three phenotypic findings (low BMI, unintended weight loss, reduced muscle mass) together with a minimum of one of two etiologic criteria (inflammation/disease burden or reductions in food intake or assimilation) [10]. Therefore, GLIM may be useful as a preliminary screening tool for malnutrition in grassroots communities lacking medical resources.

In China, people over the age of 60 are classified as older adults. A nationwide survey of older adults in China, namely, the China Health and Retirement Longitudinal Study (CHARLS), found that more than 30% of Chinese adults 60 + years of age are affected by arthritis or rheumatism. Adults suffering from arthritis or rheumatism experience various adverse health outcomes, including chronic inflammation, increased risk of Parkinson's disease [17], complications of cardiovascular disease and interstitial lung disease [18], radiological joint destruction, and mortality [19]. The GLIM criteria recognize a link between chronic inflammation, in particular, and the incidence of malnutrition. Thus, the use of the GLIM criteria has a greater probability of diagnosing malnutrition in older adults dealing with these health issues. Nevertheless, there is a lack of detailed information on the adverse health outcomes associated with the use of the GLIM criteria in this specific population.

Accordingly, the present study was undertaken with the goal of examining the validity of the GLIM criteria as an approach to detecting malnutrition and assessing the relationship between malnutrition and the likelihood of all-cause death in these older patient population with arthritis or rheumatism.

Methods

Data collection

The first national collection of the CHARLS dataset was conducted in 2011 (wave 1), with follow-ups in 2013 (wave 2), 2015 (wave 3), 2018 (wave 4), and 2020 (wave 5). Since the 2020 data were not available during the design of this study, data from 2011 to 2018 were used. Additionally, for comparing body weight, the baseline data from 2013 were selected, while the weight data from 2011 were used for comparison. As a result, the present study was based on data obtained from individuals 45 + years of age from the 2011–2018 waves of the CHARLS study, utilizing the data from individuals with baseline results obtained in 2013.

Participants were considered eligible if they (1) were 60 + years of age, (2) had self-reported rheumatism or arthritis, and (3) had available height and weight data. Participants were excluded if they did not meet these criteria, if any of the corresponding data were obviously incorrect, if they lacked weight data from CHARLS wave 1 (2011), or if they were lost to follow-up.

Evaluation of malnutrition

Based on the GLIM criteria [10], the diagnosis of malnutrition requires that subjects meet a minimum of one phenotypic and one etiological criterion. Phenotypic criteria include a > 5% unintended decrease in weight within a 6-month period or a > 10% decrease over more than 6 months, a BMI of < 18.5 kg/m^2 or < 20 kg/m^2 for Asian adults < 70 and 70 + years of age, respectively, or a reduction in muscle mass. Etiologic criteria include reduced food intake or assimilation, and the presence of inflammation or disease burden. As the present study focused solely on patients with rheumatism or arthritis, all of whom were considered to be in a state of persistent inflammation, all subjects were assumed to have met the etiological criteria necessary for the GLIM criteria-based diagnosis of malnutrition. Accordingly, those participants meeting at least one phenotypic criterion were considered to be malnourished.

Multiple investigations have demonstrated that appendicular skeletal muscle mass (ASM), as computed below, exhibits a strong concordance with the measurements obtained from dual-energy X-ray absorptiometry (DXA) [20–22]. The ASM was determined using validated anthropometric equations applicable to the Chinese population as: ASM = 0.193 * Weight (kg) + 0.107 * Height (cm)—4.157 *Sex (Males = 1 and Females = 2) − 0.037 * Age (years) − 2.631 [23]. With reference to previous studies, the threshold of classification of low muscle mass

was based on the lowest 20% of the sex-specific height-adjusted muscle mass (ASM/Ht2) within the study population [23]. In this study, the ASM/Ht2 values of < 6.8663 kg/m^2 for men and < 5.0386 kg/m^2 for women were regarded as low muscle mass.

Participants who exhibited an unintended decrease in body weight of > 10% relative to the CHARLS Wave 1 data, low BMI (as defined above), or low muscle mass were considered to be malnourished for the purposes of the study. Moderate malnutrition was defined by low BMI (as defined above), an unintended 10–20% decrease in weight, or low muscle mass based on the sex-specific lowest 20% of the height-adjusted muscle mass among the study population, with thresholds of < 5.039 kg/m^2 for women and < 6.866 kg/m^2 for men. Severe malnutrition was defined by > 20% unintended decrease in weight only, or the combination of both low muscle mass and unintended weight loss of over 10%.

Mortality outcomes

The five-year mortality outcome data for these patients were obtained from the 2018 sample information dataset.

Information on chronic diseases

To assess the prevalence of chronic conditions, the study inquired about participants' medical diagnoses of various conditions. The extensive checklist of chronic health issues encompassed hypertension, dyslipidemia, diabetes or hyperglycemia, cancer or malignant tumors (with the exception of minor skin cancers), chronic respiratory diseases such as chronic bronchitis and emphysema (excluding tumor- or cancer-related cases), liver disease (excluding fatty liver, tumors, and cancer), a spectrum of cardiovascular ailments including myocardial infarction, coronary heart disease, angina, congestive heart failure, and other heart-related disorders, cerebrovascular incidents or stroke, kidney disease (excluding tumor- or cancer-related conditions), gastrointestinal conditions such as stomach diseases (excluding tumor- or cancer-related conditions), and neurodegenerative disorders such as Alzheimer's disease, cerebral atrophy, and Parkinson's disease, as well as arthritis and rheumatism. Participants' responses regarding all chronic diseases were meticulously documented.

Covariates

The covariates analyzed in the CHARLS study included age, sex, BMI, sleep duration, location of residence (village or urban), marital status (married or cohabiting, separated or divorced, or widowed), education level (illiterate, primary school or lower, junior high school or higher), presence of physical disabilities, brain damage or mental retardation, visual impairments, auditory impairments, speech impediments, hypertension, dyslipidemia, diabetes, history of cancers or other malignancies, chronic lung conditions, liver disease, heart problems, history of stroke, kidney disease, digestive disorders, emotional or psychiatric issues, memory-related diseases, asthma, history of falls, smoking habits, and history of alcohol consumption.

Statistical analyses

Data were analyzed with SPSS 25.0, with a two-sided *P*-value < 0.05 being considered significant. Non-normally distributed survival data were reported as medians (P25, P75), while categorical data were reported as numbers with percentages. Baseline patient characteristics were compared using rank-sum and Pearson's chi-square tests.

Possible relationships between malnutrition and all-cause mortality risk among the enrolled subjects were explored with Cox regression analyses. Three models were generated, namely, Model 1 which was unadjusted, Model 2, adjusted for age, sex, BMI, marital status, vision problems, and hearing problems, and Model 3, adjusted as for Model 2 as well as for chronic diseases associated with chronic or recurrent mild-to-moderate inflammation, including hypertension, diabetes, chronic lung conditions, liver disease, heart problems, kidney disease, cancer or malignant tumors, and asthma.

Results

Figure 1 outlines the participant selection process. From an initial pool of 18,455 potentially eligible individuals, 12,677 were excluded due to the absence of rheumatism or arthritis, 2537 were under 60 years old, and an additional 1362 were omitted due to incomplete or erroneous weight data in either wave 1 or wave 2. Similarly, 8 participants had missing or incorrect height data in wave 2, and 105 were lost to follow-up. The final analysis cohort comprised 1,766 subjects, of which 57.36% (1033/1766) were female.

During the 5-year follow-up period, 189 participants passed away. Table 1 presents the baseline characteristics of the study subjects, categorized by their survival status at 5 years. A comparison between those who survived and those who did not revealed several significant differences. The median age of the non-survivors was greater (70 vs. 66 years, $P < 0.001$), with a greater proportion being male ($P = 0.001$). They also had a lower mean BMI ($P < 0.001$), were less likely to be married or cohabiting ($P < 0.001$), and had a higher prevalence of vision problems ($P = 0.001$). In addition, non-survivors were more likely to report hearing problems ($P = 0.032$) and have a diagnosis of chronic lung

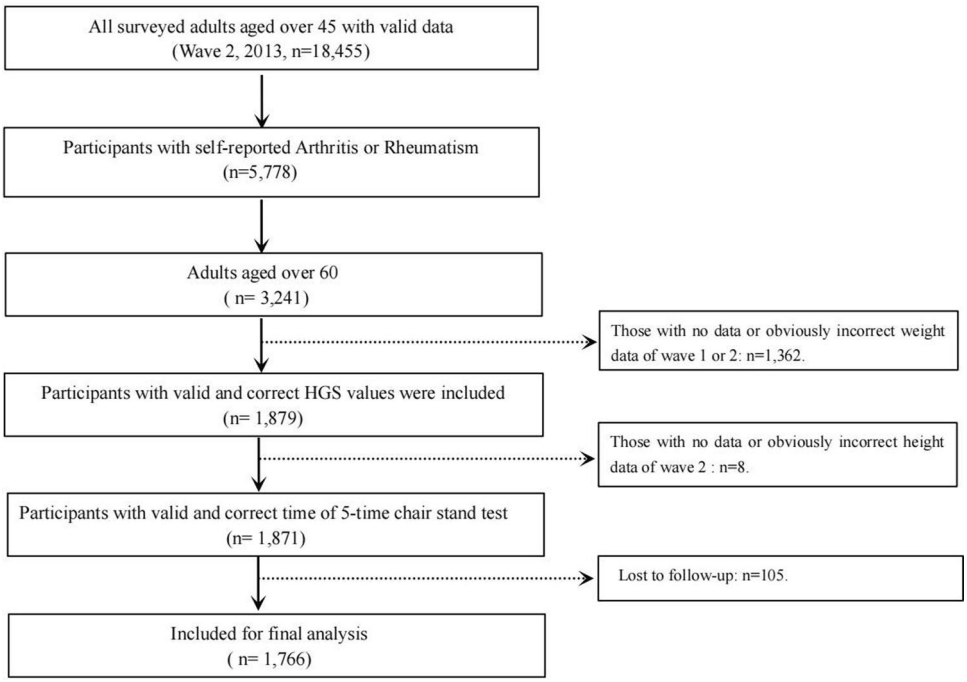

Fig. 1 Flowchart of the participant selection process. The number of participants excluded or included at each step is provided with reasons

diseases ($P=0.003$). The remaining covariates did not differ significantly between these groups.

Table 2 presents the results of the 5-year follow-up outcomes for these participants when stratified into malnourished (23.67%) and non-malnourished (76.33%) groups as per the GLIM criteria. Malnutrition was estimated to affect 418 (23.67%) of the study participants at baseline, with 372 (21.06%) and 46 (2.60%) affected by moderate and severe malnutrition, respectively. Over the course of the 5-year follow-up, 189 deaths were recorded, with mortality rates of 6.57%, 3.45%, and 0.68% for the non-malnourished, moderately malnourished, and severely malnourished groups, respectively, and significant differences between the groups ($P<0.001$, Table 2).

Table 3 shows the correlations between the malnutrition severity at baseline and 5-year all-cause mortality. Following adjustment of the models for possible covariates (age, BMI, marital status, sex, vision problems, hearing problems, hypertension, diabetes, chronic lung conditions, liver disease, heart problems, kidney disease, cancer or malignant tumor, and asthma), severe malnutrition was found to be associated with a significant increase in mortality risk among older adults affected by arthritis or rheumatism (HR = 2.196, 95%CI 1.125–4.286, $P=0.021$, Table 3).

Discussion

The present study is the first to examine the relationship between malnutrition status, as determined using the GLIM criteria, and all-cause mortality risk over a 5-year interval among Chinese adults 60 + years of age affected by arthritis or rheumatism. The analysis showed a significant association between severe malnutrition and increased risk of all-cause death in this population. Accordingly, these findings suggest that screening is warranted for any older individuals with arthritis or rheumatism who experience a > 20% drop in weight over 6 months or present with low muscle mass combined with a > 10% drop in weight over 6 months. By providing at-risk adults with appropriate monitoring and interventional management strategies, it may be possible to improve their quality of life and prolong their healthy lifespan.

An earlier study in Poland of 98 participants 60 + years of age with rheumatoid arthritis determined that 36.73% were at risk of malnutrition, while 6.12% were malnourished, according to the complete MNA® Mini Nutritional Assessment questionnaire [24]. A study in Spain focused on 76 patients with rheumatoid arthritis who were 65 + years of age, finding that the nutritional status of 31.5% was impaired, with 28.9% and 2.6% shown to be at risk of malnutrition and malnourishment, respectively,

Table 1 Baseline characteristics of participants according to the five years follow-up all-cause mortality

Variable		Survival, n = 1577	Died, n = 189	*P*-value
Demographic characteristics				
Age, year, median (P25,P75)		66 (63,71)	70 (65.25,75)	< 0.001
BMI, kg/m^2, median (P25,P75)		23.24 (20.95,25.85)	22.67 (19.90,24.96)	< 0.001
Sleeping time (h),median (P25,P75)		6 (4,7)	6 (4,7)	0.737
ASM/height^2, kg/m^2,median (P25,P75)		6.51 (5.61,7.37)	6.68 (5.78,7.37)	0.483
Residential area, n (%)	Rural	1114 (89.3)	133 (10.7)	0.937
	Urban	450 (89.5)	53(10.5)	
Education, n (%)	Illiterate	255 (86.7)	39(13.3)	0.174
	Primary school and below	292 (89.8)	33(10.2)	
	Junior high school and above	1,023 (90.5)	108 (9.5)	
Smoking history, n (%)	Yes	593 (89)	73 (11)	0.184
	No	950 (91)	94 (9)	
Drinking history, n (%)	Yes	623 (88.6)	80 (11.4)	0.466
	No	951 (89.7)	109 (10.3)	
Marital status, n (%)	Married/cohabiting	1253 (90.9)	126 (9.1)	< 0.001
	Divorced or Widowed or Single	324 (83.7)	63 (16.3)	
Sex, n (%)	Male	652 (86.6)	101 (13.4)	0.001
	Female	925 (91.3)	88 (8.7)	
Physical disabilities, n (%)	Yes	68 (85)	12 (15)	0.204
	No	1508 (89.5)	177 (10.5)	
Brain damage/mental retardation, n (%)	Yes	53 (89.8)	6 (10.2)	0.902
	No	1523 (89.3)	182 (10.7)	
Vision problems, n (%)	Yes	142 (82.1)	31 (17.9)	0.001
	No	1435 (90.1)	158 (9.9)	
Hearing problems, n (%)	Yes	210 (85.4)	36 (14.6)	0.032
	No	1364 (89.9)	153 (10.1)	
Speech impediment, n (%)	Yes	3 (75)	1 (25)	0.355
	No	1571 (89.3)	188 (10.7)	
Comorbidity				
Hypertension, n (%)	Yes	498 (87.7)	70 (12.3)	0.134
	No	1067 (90)	118 (10)	
Dyslipidemia, n (%)	Yes	165 (91.2)	16 (8.8)	0.402
	No	1361 (89.1)	166 (10.9)	
Diabetes, n (%)	Yes	102 (85)	18 (15)	0.122
	No	1454 (89.5)	170 (10.5)	
Cancer or malignant tumor, n (%)	Yes	20 (95.2)	1 (4.8)	0.374
	No	1543 (89.2)	187 (10.8)	
Chronic lung diseases, n (%)	Yes	258 (84.6)	47 (15.4)	0.003
	No	1311 (90.3)	141 (9.7)	
Liver disease, n (%)	Yes	82 (88.2)	11 (11.8)	0.709
	No	1476 (89.4)	175 (10.6)	
Heart problems, n (%)	Yes	268 (88.2)	36 (11.8)	0.452
	No	1295 (89.6)	150 (10.4)	
Stroke, n (%)	Yes	49 (84.5)	9 (15.5)	0.220
	No	1522 (89.5)	178 (10.5)	
Kidney disease, n (%)	Yes	160 (89.4)	19 (10.6)	0.998
	No	1399 (89.4)	166 (10.6)	
Stomach or other digestive disease, n (%)	Yes	547 (90.9)	55 (9.1)	0.120
	No	1018 (88.4)	133 (11.6)	

Table 1 (continued)

Variable		Survival, n = 1577	Died, n = 189	*P*-value
Emotional, nervous, or psychiatric problems, n (%)	Yes	22 (81.5)	5 (18.5)	0.180
	No	1542 (89.5)	181 (10.5)	
Memory-related disease, n (%)	Yes	33 (84.6)	6 (15.4)	0.334
	No	1534 (89.4)	181 (10.6)	
Asthma, n (%)	Yes	92 (91.1)	9 (8.9)	0.548
	No	1476 (89.2)	179 (10.8)	
Fallen down, n (%)	Yes	358 (90.6)	37 (9.4)	0.339
	No	1215 (88.9)	151 (11.1)	
Number of chronic diseases, n (%)	0	436 (91.2)	42 (8.8)	0.235
	1–2	825 (88.9)	103 (11.1)	
	≥ 3	315 (87.7)	44 (12.3)	

Table 2 Comparison of five years follow-up all-cause mortality between malnourished and non-malnourished populations diagnosed using GLIM criteria

Variable	Survival, n = 1577	Died, n = 189	*P*-value
Non-malnourished, n (%)	1232 (78.1)	116 (61.4)	< 0.001
Stage 1/moderate malnutrition, n (%)	311 (19.7)	61 (32.3)	
Stage 2/severe malnutrition, n (%)	34 (2.2)	12 (6.3)	

GLIM = the Global Leadership Initiative on Malnutrition

Table 3 Correlations between malnutrition and five-year follow-up mortality

Variable	Model 1		Model 2		Model 3	
	P-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)
Normal control	–	Reference	–	Reference	–	Reference
Stage 1/moderate malnutrition	< 0.001	1.944 (1.426,2.651)	0.071	1.473 (0.968,2.242)	0.142	1.376 (0.898,2.107)
Stage 2/severe malnutrition	< 0.001	3.230 (1.783,5.853)	0.039	2.012 (1.036,3.909)	0.021	2.196 (1.125,4.286)

Model 1: unadjusted model; Model 2: adjusting for age, BMI, marital status, sex, vision problems, hearing problems; Model 3: adjusting for Model 2 and hypertension, diabetes, chronic lung conditions, liver disease, heart problems, kidney disease, cancer or malignant tumor, and asthma

using the Mini Nutritional Assessment Short Form (MNA-SF) analysis [25]. Here, 418 of the study subjects (23.67%) were found to be malnourished, of whom 21.06% and 2.60% exhibited moderate and severe malnutrition, respectively. These discrepancies in findings may be related to the vulnerability of older adults to malnutrition and that the assessment of malnutrition may vary according to the diagnostic tool used and the comorbidities affecting these patients [1, 13, 14, 26–28]. Moreover, regional differences in quality of life and development may also contribute to these differences.

The validity of the GLIM criteria has been demonstrated for assessing nutritional status and predicting the risk of mortality. For instance, a previous study conducted in Australia reported that severe malnutrition, as defined by the GLIM criteria, was significantly associated with the risk of 1-year mortality in ambulatory cancer patients receiving in-chair intravenous therapy [29]. Rosato et al. reported that malnutrition, as determined by the GLIM criteria, was a significant risk factor for the composite endpoint of mortality in patients with systemic sclerosis over a 4-year follow-up period [30]. Additionally, a Belgian study found that malnutrition, diagnosed according to the GLIM criteria, was correlated with the 4-year risk of mortality in older adults [16]. The present study reinforces these findings, showing a robust correlation between severe malnutrition and the 5-year all-cause mortality risk among older Chinese adults with arthritis, as per the GLIM criteria, emphasizing the critical importance of identifying severe malnutrition in this population. Although the screening approach for detecting and assessing the severity of malnutrition in elderly

patients with arthritis deviated from the strict application of the GLIM criteria, relying instead on weight loss, muscle mass (estimated from height, weight, and age), and BMI, the results still provide valuable insights for screening initiatives. Notably, the simplicity of our criteria allows for their straightforward implementation in primary care settings, especially in resource-limited communities where tools for muscle mass measurement may be scarce and in households facing challenging circumstances.

The current analysis is subject to several limitations. Firstly, the sample size was modest, with only 46 subjects identified as being severely malnourished. Although an increased risk of all-cause mortality over a 5-year period was noted, the area under the curve (AUC) of the model was 0.6, which is considered insufficient for predictive purposes. Consequently, the findings would benefit from verification with a larger sample size to establish a robust correlation. Secondly, the presence of arthritis or rheumatism at baseline was determined solely through self-reporting, without independent verification of these diagnoses or evaluation of the inflammatory profiles of the patients. This approach could introduce additional bias into the study. Furthermore, the absence of data on inflammation precludes the use of etiological criteria for the classification of malnutrition, which is an important aspect of the GLIM diagnostic framework. Thirdly, detailed information on the prevalence and specifics of arthritis or rheumatism, including the duration of the disease and specific treatments, was not available in the original dataset. This gap in information precluded more in-depth analysis that could have affected the accuracy of the results. Fourthly, muscle mass was determined by calculation using the ASM index, with a threshold of 20% of ASM/height [2] indicative of low muscle mass. While this threshold may be relevant for the studied cohort, it may not be universally applicable due to variations across different populations. Moreover, the study did not further differentiate individuals with low BMI due to the absence of specific BMI thresholds for identifying severe malnutrition in Asian populations. Lastly, since the cohort study concluded in 2018, none of the participants had a history of COVID-19, necessitating further verification to ascertain the applicability of the findings to elderly individuals with arthritis or rheumatism who experienced COVID-19. Future research should aim to overcome these limitations and provide additional verification for the current findings.

Conclusions

The results of this study demonstrated that severe malnutrition, as classified according to the GLIM criteria, was strongly correlated with the risk of all-cause death among older Chinese adults suffering from arthritis or rheumatism.

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Author contributions
QW contributed to the data collection, first writing and revision of this article; WYL contributed to the guidance, analysis the data and revision of this article.

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Availability of data and materials
The online repository contains the datasets used in this study. The repository name and access number can be found at http://charls.pku.edu.cn/en.

Declarations

Ethics approval and consent to participate
The Biomedical Ethics Review Committee of Peking University approved the CHARLS study (IRB00001052–11015), and the need for informed consent for the present study was waived by the Ethics Committee of Zigong Psychiatric Research Center due to the publically accessible nature of these data (IRB number: 2023041002).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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