BMJ Open

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters in Chinese geriatric inpatients: a multicenter, cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022993
Article Type:	Research
Date Submitted by the Author:	16-Mar-2018
Complete List of Authors:	Miao, Jian-Ping; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics Quan, Xiao-Qing; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics Zhang, Cun-Tai; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics Mei, Qi-Jian; General Hospital of the Yangtze River Shipping Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics Li, Shu-Guo; First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital, Department of Geriatrics Zhou, Hong-Lian; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics
Keywords:	malnutrition risk, NRS2002, MNA, elderly

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters in Chinese geriatric inpatients: a multicenter, cross-sectional study

Jian-Ping Miao[1], Xiao-Qing Quan[1], Cun-Tai Zhang[1], Hong Zhu[2], Mei Ye[3], Li-Ya Shen[4], Qiu-Hui Guo[4], Gang-Yan Zhu[5], Qi-Jian Mei[6], Yan-Xia Wu[7], Shu-Guo Li[8], Hong-Lian Zhou[1]

Running title: Malnutrition risk screening in Chinese geriatric inpatients

1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Hubei, China
2. Department of Geriatrics, the Central Hospital of Wuhan University, Hubei, China
3. Department of Geriatrics, Zhongnan Hospital of Wuhan University, Hubei, China
4. Department of Geriatrics, Wuhan No. 6 Hospital, Hubei, China
5. Department of Geriatrics, Hubei General Hospital, Hubei, China
6. Department of Geriatrics, General Hospital of the Yangtze River Shipping, Hubei, China
7. Department of Geriatrics, Wuhan No 1 Hospital, Hubei, China
8. Department of Geriatrics, First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital, Hubei, China

JPM and XQQ contributed equally.

Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com

ABSTRACT

Objectives: The aim of this study was to assess malnutrition risk in Chinese geriatric inpatients with Nutritional Risk Screening (NRS2002) and Mini-Nutritional Assessment (MNA), and to identify the most appropriate nutritional screening tool for these patients.

Design: Cross-sectional study.

Setting: Eight medical centers in Hubei province, China.

Participants: A total of 425 inpatients aged ≥70 years were enrolled in this study between December 2014 and May 2016.

Primary and secondary outcome measures: Nutritional status was assessed by NRS2002, MNA, anthropometric measurements and biochemical parameters within 24 hours of admission. Comorbidities and length of hospitalization were recorded. Nutritional parameters and length of hospital stay were used to compare MNA and NRS2002. Besides, Kappa analysis was used to evaluate the consistency of the two tools.

Results: The average age was 81.16±5.89 years (range, 70-98). The prevalence of undernutrition classified by NRS2002 and MNA was 40.94% and 58.59%, respectively. Patients with malnutrition had lower BMI, hemoglobin, albumin and prealbumin (P<0.05), and longer length of hospital stay (LOS) (P<0.05). The NRS2002 showed moderate agreement (κ=0.521, P<0.001) with MNA. Both tools showed significant correlation with age, BMI and laboratory parameters (P<0.001). In addition, a significant association between both tools and LOS was found (P<0.05).

Conclusions: The results show a relatively high prevalence of malnutrition risk in our sample cohort. We found NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients.

Strengths and limitations of this study

- ► This study assessed the risk of malnutrition among Chinese elderly inpatients with two different tools (NRS2002 and MNA).
- ► The study provides useful information to assess the risk of malnutrition among Chinese elderly inpatients.
- ► Because of the lack of a gold standard for malnutrition diagnosing, we could only compare two assessment scores with BMI and biochemical parameters.
- ► The small sample size of women may limit the power of data analysis.

Keywords: Malnutrition risk, NRS2002, MNA, Elderly

INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.[1] It is highly associated with many adverse outcomes including frailty,[2] muscle wasting,[3] weakened immune system,[4] longer hospitalization,[5] increased morbidity[6] and mortality.[7, 8] These outcomes contribute to large increases in medical expenditures.[9] Early identification and treatment of malnutrition can lead to better quality of life[10] and improved outcomes[11] in elderly inpatients. Therefore, the application of appropriate tools to assess the risk of malnutrition in geriatric inpatients is essential.

Nutritional risk screening and nutritional assessment tools are readily available nowadays.[12] These tools are used to identify patients with nutritional risk or nutritional deficiencies and to determine if intervention is needed. There are a variety of nutritional risk screening methods,[13] mainly involving anthropometric and biochemical parameters. However, to date, no single tool can be considered as the universal gold standard for the assessment of nutritional risk among the elderly inpatients.

The Nutritional Risk Screening (NRS2002) is recommended for hospitalized patients by the European Society of Parenteral and Enteral Nutrition (ESPEN).[14] It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.[15, 16] However, NRS2002 use excludes patients who cannot be weighed or have problems of communication and the tool isn't specifically

developed for elderly inpatients.

The Mini-Nutritional Assessment (MNA) is established for the nutritional screening and assessment in the geriatrics settings.[1] The ESPEN recommends the use of this tool for elderly populations.[17] It has been shown to predict outcomes, functional status, mortality, number of hospital visits and the related healthcare costs.[7, 17-21] In contrast to the NRS2002, the MNA is more time consuming.[22] The NRS2002 and MNA have not been compared in their ability to predict nutritional biochemical parameters and length of hospitalization together among Chinese elderly inpatients.

A number of studies suggested serum proteins are associated with malnutrition, but the nature of this association is controversial.[23-25] Hemoglobin and total lymphocyte count were also proposed as useful indicators of nutritional status.[24, 26] The aim of our study was to assess the risk of malnutrition among Chinese elderly inpatients with two different tools (NRS2002 and MNA), to compare them in terms of nutritional biochemical parameters and length of hospital stay (LOS), and to determine the most appropriate tool for these inpatients.

METHODS

Study subjects

This study included 425 patients older than 70 years of age who attended geriatric department of eight hospitals in Hubei Province from December 2014 to May 2016. The eight hospitals are as follows: (1) Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, (2) The Central Hospital of Wuhan University, (3) Zhongnan Hospital of Wuhan University, (4) Wuhan No. 6 Hospital, Affiliated Hospital of Jianghan University, (5) Hubei General Hospital, (6) General Hospital of The Yangtze River Shipping, (7) Wuhan No. 1 Hospital, (8) The First College of Clinical Medical Science, Three Gorges University and Yichang Central People's Hospital.

This cross-sectional study received approval from the institutional Ethics Committee and all subjects signed written informed consent before participation. Inclusion criteria were: (1) age 70 years or older, (2) the patients themselves or their proxies were able to clearly answer study questions, (3) hospital stay was longer than 24 hours and (4) patients were willing to cooperate with the study. Exclusion criteria included: (1) refusal to participate in the study, (2) younger than 70 years old and (3) patients was unconscious or refused to participate in the study.

Comorbidities and length of hospitalization were obtained from medical records. Body height and weight were measured within 24 hours after admission. The body

mass index (BMI) was then calculated as weight/height squared (kg/m^2).

Blood samples were also obtained within 24 hours after admission. Nutritional biochemical parameters: serum hemoglobin (Hb), total lymphocyte count (TLC), albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical chemistry laboratory. Malnutrition was determined when the value of Hb was <120 g/L for males and <110 g/L for females. The cutoff value of ALB was 35 g/L (normal range 35-55 g/L), PAB was 200mg/L (normal range 200-400 mg/L), TLC was 1.1×10^9/L (normal range $1.1\text{-}3.2\times10^9$/L) for both genders for malnutrition.[27] Moreover, based on previous research, the cutoff value of BMI was set at 20.5 kg/m^2 for malnutrition.[26]

Nutritional risk screening 2002 (NRS2002)

The NRS2002 consists of the following parameters: the severity of acute illness, BMI, patient appetite, accidental weight loss and patient age.[15] The total score ranges from 0 to 7.[16] For investigational purposes, patients were categorized into two groups: a total score ≥3 indicates under-nourished (at nutritional risk/malnourished), 0-2 indicates normal nutrition status.[14, 28] A nutritional care plan was initiated for patients with a score ≥3.[28]

Mini-Nutritional Assessment (MNA)

The MNA consists of four parts: anthropometric assessment (0-8 points), general

assessment (0-9 points), dietetic habits evaluation (0-9 points) and self-assessment of the nutrition and health status (0-4 points).[29] A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.[1]

Statistical analysis

The statistical analyses were conducted using SPSS 19.0. Data were presented as mean ± standard deviation and ranges in blanket. The chi-square test or student's *t*-test was used according to the data type. One-way analysis of variance was applied for multigroup comparisons. Correlation analysis was qualified by the spearman correlation test. Agreement between the two screening tools was achieved by the kappa (κ) statistic. The results were interpreted as follows: <0, no agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate agreement; 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.[26] The level of significance was set at $P<0.05$.

RESULTS

Over the study period, a total of 425 individuals from the Department of Geriatrics of eight hospitals in Hubei Province met the eligibility criteria and completed a nutrition assessment within 24 hours of admission. The average age was 81.16±5.89 years (range, 70-98) and 31.1% were females. The average body mass index was 23.22±3.73 kg/m^2 (range, 11.09-34.14). The average length of hospitalization was 21.86±13.75 days (range, 4-133). The most frequent cause of hospitalization were cardiac disease, followed by pulmonary infection, hypertension, cerebrovascular diseases, digestive disease and malignancies, while the most frequent comorbidities were hypertension, diabetes mellitus, cardiac disease and cerebrovascular disease. Characteristics of study participants are shown in table 1.

According to the NRS2002, about 174 patients (40.94%) were under-nourished, 251 patients (59.06%) were at normal nutritional status. The MNA showed that 99 patients (23.29%) were malnourished, 150 patients (35.29%) were at risk of malnutrition and 176 patients (41.41%) had a normal nutritional status (table 1).

Table 2 shows the risk of undernutrition, varying from 23.66% to 58.59%, according to the different methods employed in our study. The risk of under-nourished participants classified by NRS2002, MNA, BMI, ALB, PAB, Hb, TLC were 40.94%, 58.59%, 23.66%, 28.71%, 47.30%, 36.75%, 35.90%, respectively. The risk of

malnutrition was higher in men than that of women according to hemoglobin (41.72% vs 25.58%, respectively).

Although both instruments were closely related to each other (P<0.001), they showed substantial differences. Table 3 shows the cross-classification of MNA and NRS2002 regarding two nutritional categories. The MNA classified more patients as under-nourished than the NRS2002 (249 vs 174, respectively). Of the 249 patients classified as under-nourished by the MNA, the NRS2002 coincidently categorized 159 as malnourished, and 90 as well-nourished.

The NRS2002, on the other hand, classified 174 patients as under-nourished. Within this group of participants, the MNA classified 159 patients as under-nourished and 15 as well-nourished. What's more, a participant considered by the MNA to be well-nourished can be classified as under-nourished using the NRS2002. The individual categorization of nutritional status showed moderate agreement between MNA and NRS2002 (κ=0.521, P<0.001).

Data of Hb, TLC, ALB and PAB concentrations are listed in tables 1 and 2. There were significant decrease of ALB, PAB, Hb and TLC in the three groups of MNA scores (P<0.001 and P=0.023, figure 1a). Specifically, the group with the lowest MNA score <17 (n=99), indicating a poor nutritional state, had an average serum albumin of 33.34±4.81 g/L (range, 22.8-43.2), an average prealbumin of 140.82±81.72 mg/L (range, 12-339) and an average hemoglobin of 109.04±20.82 mg/L (range, 57-150.2), an average lymphocyte count of 1.53±1.21 10^9/L (range, 0.31-6.58). In the risk of malnutrition group with an MNA score of 17-23.5 (n=150),

average serum albumin was 37.87±5.61 g/L (range, 21.6-70), average prealbumin 192.25±61.78 mg/L (range, 8-380) and average hemoglobin 120.16±22.01 mg/L (range, 55-181), an average lymphocyte count of 1.29±0.56 10^9/L (range, 0.20-2.92). The group with MNA≥24 (n=180) had an average serum albumin concentration of 39.84±3.83 g/L (range, 29.3-54), an average prealbumin of 216.74±54.42 mg/L (range, 25-337) and an average hemoglobin of 127.59±15.32 mg/L (range, 81-173), an average lymphocyte count of 1.51±0.69 10^9/L (range, 0.28-4.30; figure 1a).

Similarly, ALB, PAB and Hb gradually declined with increasing risk of malnutrition according to NRS2002 results (P<0.001, figure 1b). In under-nourished patients (NRS2002: 3-7, n=174), average serum albumin was 35.13±5.58 g/L (range, 21.6-50.2), average prealbumin 148.51±79.25 mg/L (range, 17-339) and average hemoglobin 113.27±23.64 mg/L (range, 55-181). In the normal nutritional state group (NRS2002: 0-2, n=251), the results were: albumin 39.36±4.47 g/L (range, 26.4-70), prealbumin 210.19±56.08 mg/L (range, 8-380) and hemoglobin 125.80±16.16 mg/L (range, 72-173). In contrast, no difference in lymphocyte count was found in both groups (P=0.089, figure 1b).

Table 4 showed the Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated negatively with malnutrition scores of NRS2002, while correlated positively with the MNA scores (P<0.001). There was an inverse correlation between age and the two tools (P<0.001). Besides, a significant association between both tools and LOS was demonstrated (P<0.05). No correlation was found between TLC and the two tools.

DISCUSSION

Based on the current study, the nutritional health of elderly inpatients were assessed using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. We found the overall prevalence of malnutrition risk for the enrolled elderly patients ranged from 23.66% to 58.59%. The highest prevalence of malnutrition risk was detected by MNA and the lowest by BMI. These results illustrated the differences in nutritional risk detected by different screening tools.

Biochemical markers have many advantages in assessing the nutritional status, such as fast application, low cost. They can also be incorporated into the routine of clinical application. Albumin, the most abundant plasmatic protein, is commonly used in the assessment of malnutrition.[30] In several of studies, low serum ALB correlated with longer hospitalization, medical complications, and increased mortality.[30-32] Nevertheless, its value is limited by the long half-life (14-20 days), inflammation, the impairment of hepatic or renal, and possibly aging itself.[24] In the present study, prevalence of malnutrition detected by ALB is lower than MNA and NRS2002, which suggest that ALB was not suitable for assessing malnutrition in our patients. In contrast, a study by Covinsky *et al*[33] showed ALB is highly sensitive but low specific in the diagnosis of malnutrition in the hospitalized elderly.

Prealbumin has been regarded as a more sensitive marker than albumin for acute

nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in nutritional screening and mortality prediction are controversial.[34-37] In our study, prealbumin levels showed a great decline with deteriorating nutrition status assessed by both NRS2002 and MNA. The correlation between serum prealbumin and MNA consistent with one study,[38] but in contrast with another report.[36] This latter study had a small sample size (23 elderly patients), which may explain the discrepancies. Similar to serum albumin, the usage of prealbumin in predicting malnutrition is limited due to systemic inflammatory diseases.[35, 39]

Hemoglobin has been shown to decrease with progressive malnutrition.[40, 41] This relationship, consistent with a recent analysis performed in Northern China,[26] is found in our study. Total lymphocyte count was assumed to be suitable in screening test for assessing malnutrition and being an indicator of a poor prognosis.[24] In agreement with Lei *et al*,[42] we found a significant correlation between TLC and MNA. However, no correlation was found between NRS2002 and TLC, coincidence with a previous study.[26]

The prevalence of malnutrition diagnosed by BMI was far below that detected by MNA. Consistent with findings from another study,[43] this study suggest malnutrition is also under diagnosed when using BMI as the sole criteria. The reason is most likely related to water-sodium retention in patients, leading to an overestimation of their true weight.[44] In spite of this, low BMI was significantly associated with mortality.[45]

Our study revealed that NRS2002 and MNA, in moderate agreement with each other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless,

the MNA identified more patients with or at risk of malnutrition than did the NRS2002. The lower percentage of malnutrition classified by NRS2002 may be explained in several ways. First, the NRS2002 mainly consider the influence of acute diseases to nutritional status, while the MNA take chronic long-term condition into account, such as psychological factors and the BMI. Psychological factors may play a large role in the nutritional status of elderly inpatients. In addition, we categorized undernutrition as NRS2002 ≥3, while patients with a score of 1-2 indicates low risk of malnutrition.[46] This may have underestimated the percentage of malnutrition. Moreover, our study subjects were internal medical patients, of which the proportion of overweight and obesity was high. The NRS2002 take BMI <18.5 kg/m^2 as one of the criteria, which leads to a lower proportion of malnutrition with NRS2002 than that of MNA. Our results are in agreement with findings from Raslan *et al*,[5] but differ from the study conducted by Drescher *et al*.[46] The latter study was conducted in elderly patients with acute disease, which may explain the difference.

Norman *et al* suggested that there is a close relationship between the degree of malnutrition and LOS.[47] In the present study, we found a positive relationship between NRS2002 scores and LOS. Our findings corroborated those of the study by Bauer *et al*,[48] which showed longer hospital stay was associated with malnutrition assessed by the MNA. We conclude, therefore, that in Chinese geriatric inpatients, the NRS2002 and MNA might reflect malnutrition or the studied biochemical parameters, as well as predicting the length of hospitalization, however, the MNA was available for identifying most of the patients with or at risk of malnutrition.

Limitations

Our study has some limitations. First, because of the lack of a gold standard for malnutrition diagnosing, we could only compare two assessment scores with BMI and biochemical parameters.[49] In addition, the small sample size of women may limit the power of data analysis.

CONCLUSION

In summary, the results of the present study show a high prevalence of malnutrition risk in Chinese geriatric hospitalized patients. Although the diagnosis of nutritional status varied depending on the method used, both NRS2002 and MNA correlated with each other and with age, BMI and laboratory parameters. Besides, both tools were found to be a good predictor of the length of hospitalization. Therefore, this study suggests NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients. We recommend one of them to be used in admission.

Acknowledgements Thanks to the participating volunteer patients, the local research ethics committee and the individual researchers, clinicians and nurses for their participation in the data collection.

Contributors JPM, XQQ and HLZ are main contributors to the design of the present study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ took part in the discussion and modification of the design and the questionnaire. XQQ, HZ, MY, LYS, QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of data. JPM and XQQ contributed to the drafting of the manuscript. JPM participated in data gathering, analysis and interpretation. HLZ and CTZ were involved in the critical revision. All authors have seen and agreed to the submission of the final manuscript.

Funding This project was funded by the National Natural Science Foundation of China (Grant No. 81400255).

Competing interests None declared.

Ethics approval Ethics Review Board of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-C20141112).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legend

Figure 1 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

REFERENCES

1. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? *J Nutr Health Aging*. 2006;10:466-85; discussion 485-7.
2. Chang SF. Frailty Is a Major Related Factor for at Risk of Malnutrition in Community-Dwelling Older Adults. *J Nurs Scholarsh*. 2017;49:63-72.
3. Lumale S. [Nutritional management of elderly people, everyone's concern]. *Rev Infirm*. 2017;66:25-26.
4. Lesourd B. Nutritional factors and immunological ageing. *Proc Nutr Soc*. 2006;65:319-25.
5. Raslan M, Gonzalez MC, Dias MC, *et al.* Comparison of nutritional risk screening tools for predicting clinical outcomes in hospitalized patients. *Nutrition*. 2010;26:721-6.
6. Ehwerhemuepha L, Bendig D, Steele C, *et al.* The Effect of Malnutrition on the Risk of Unplanned 7-Day Readmission in Pediatrics. *Hosp Pediatr*. 2018.
7. Ahmed N, Choe Y, Mustad VA, et al. Impact of malnutrition on survival and healthcare utilization in Medicare beneficiaries with diabetes: a retrospective cohort analysis. BMJ Open Diabetes Res Care. 2018;6:e000471.
8. Sharma Y, Miller M, Kaambwa B, *et al.* Malnutrition and its association with readmission and death within 7 days and 8-180 days postdischarge in older patients: a prospective observational study. *BMJ Open*. 2017;7:e018443.
9. Khalatbari-Soltani S,Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN*. 2015;10:e89-e94.
10. Bouillanne O, Curis E, Hamon-Vilcot B, *et al.* Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: a randomized controlled trial. *Clin Nutr*. 2013;32:186-92.
11. Ballesteros-Pomar MD, Martinez Llinas D, Goates S, *et al.* Cost-Effectiveness of a Specialized Oral Nutritional Supplementation for Malnourished Older Adult Patients in Spain. *Nutrients*. 2018;10.
12. Racic M, Ivkovic N,Kusmuk S. [Screening of Nutritional Status among Elderly People at Family Medicine]. *Acta Med Croatica*. 2015;69:347-56.
13. Abd Aziz NAS, Teng N, Abdul Hamid MR, *et al.* Assessing the nutritional status of hospitalized elderly. *Clin Interv Aging*. 2017;12:1615-1625.
14. Elia M,Stratton R. On the ESPEN guidelines for nutritional screening 2002. *Clin Nutr*. 2004;23:131-2.
15. Kondrup J, Rasmussen HH, Hamberg O, *et al.* Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22:321-36.
16. Kondrup J, Allison SP, Elia M, *et al.* ESPEN guidelines for nutrition screening 2002. *Clin Nutr*. 2003;22:415-21.
17. Bleda MJ, Bolibar I, Pares R, *et al.* Reliability of the mini nutritional assessment (MNA) in institutionalized elderly people. *J Nutr Health Aging*. 2002;6:134-7.
18. Bollwein J, Volkert D, Diekmann R, *et al.* Nutritional status according to the mini nutritional assessment (MNA(R)) and frailty in community dwelling older persons: a close relationship. *J Nutr Health Aging*. 2013;17:351-6.
19. Dent E, Visvanathan R, Piantadosi C, *et al.* Use of the Mini Nutritional Assessment to detect frailty in hospitalised older people. *J Nutr Health Aging*. 2012;16:764-7.
20. Cabre M, Ferreiro C, Arus M, *et al.* Evaluation of CONUT for Clinical Malnutrition Detection and

Short-Term Prognostic Assessment in Hospitalized Elderly People. *J Nutr Health Aging*. 2015;19:729-33.

21. Chavarro-Carvajal D, Reyes-Ortiz C, Samper-Ternent R, *et al.* Nutritional assessment and factors associated to malnutrition in older adults: a cross-sectional study in Bogota, Colombia. *J Aging Health*. 2015;27:304-19.
22. Kyle UG, Kossovsky MP, Karsegard VL, *et al.* Comparison of tools for nutritional assessment and screening at hospital admission: a population study. *Clin Nutr*. 2006;25:409-17.
23. Sergi G, Coin A, Enzi G, *et al.* Role of visceral proteins in detecting malnutrition in the elderly. *Eur J Clin Nutr*. 2006;60:203-9.
24. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. *Nutrition*. 2000;16:131-40.
25. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools. *Nutrition*. 2000;16:50-63.
26. Zhou J, Wang M, Wang H, *et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
27. Blackburn GL, Bistrian BR, Maini BS, *et al.* Nutritional and metabolic assessment of the hospitalized patient. *JPEN J Parenter Enteral Nutr*. 1977;1:11-22.
28. Thoresen L, Frykholm G, Lydersen S, *et al.* Nutritional status, cachexia and survival in patients with advanced colorectal carcinoma. Different assessment criteria for nutritional status provide unequal results. *Clin Nutr*. 2013;32:65-72.
29. Jacobsen EL, Brovold T, Bergland A, *et al.* Prevalence of factors associated with malnutrition among acute geriatric patients in Norway: a cross-sectional study. *BMJ Open*. 2016;6:e011512.
30. Cabrerizo S, Cuadras D, Gomez-Busto F, *et al.* Serum albumin and health in older people: Review and meta analysis. *Maturitas*. 2015;81:17-27.
31. O'Daly BJ, Walsh JC, Quinlan JF, *et al.* Serum albumin and total lymphocyte count as predictors of outcome in hip fractures. *Clin Nutr*. 2010;29:89-93.
32. Chiu PF, Tsai CC, Wu CL, *et al.* Trajectories of Serum Albumin Predict Survival of Peritoneal Dialysis Patients: A 15-year Follow-Up Study. *Medicine (Baltimore)*. 2016;95:e3202.
33. Covinsky KE, Covinsky MH, Palmer RM, *et al.* Serum albumin concentration and clinical assessments of nutritional status in hospitalized older people: different sides of different coins? *Journal of the American Geriatrics Society*. 2002;50:631-7.
34. Carriere I, Dupuy AM, Lacroux A, *et al.* Biomarkers of inflammation and malnutrition associated with early death in healthy elderly people. *Journal of the American Geriatrics Society*. 2008;56:840-6.
35. Devoto G, Gallo F, Marchello C, *et al.* Prealbumin serum concentrations as a useful tool in the assessment of malnutrition in hospitalized patients. *Clinical chemistry*. 2006;52:2281-5.
36. Langkamp-Henken B, Hudgens J, Stechmiller JK, *et al.* Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *J Am Diet Assoc*. 2005;105:1590-6.
37. Kanda M, Mizuno A, Tanaka C, *et al.* Nutritional predictors for postoperative short-term and long-term outcomes of patients with gastric cancer. *Medicine (Baltimore)*. 2016;95:e3781.
38. Vellas B, Guigoz Y, Baumgartner M, *et al.* Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. *Journal of the American Geriatrics Society*. 2000;48:1300-9.

39. Lopez-Hellin J, Baena-Fustegueras JA, Schwartz-Riera S, *et al.* Usefulness of short-lived proteins as nutritional indicators surgical patients. *Clin Nutr*. 2002;21:119-25.
40. Wham CA, Teh RO, Robinson M, *et al.* What is associated with nutrition risk in very old age? *J Nutr Health Aging*. 2011;15:247-51.
41. Weng CH, Hsu CW, Hu CC, *et al.* Association Between Hemodiafiltration and Hypoalbuminemia in Middle-Age Hemodialysis Patients. *Medicine (Baltimore)*. 2016;95:e3334.
42. Lei Z, Qingyi D, Feng G, *et al.* Clinical study of mini-nutritional assessment for older Chinese inpatients. *J Nutr Health Aging*. 2009;13:871-5.
43. Antaki F, French MM, Moonka DK, *et al.* Bioelectrical impedance analysis for the evaluation of hepatic fibrosis in patients with chronic hepatitis C infection. *Dig Dis Sci*. 2008;53:1957-60.
44. Roongpisuthipong C, Sobhonslidsuk A, Nantiruj K, *et al.* Nutritional assessment in various stages of liver cirrhosis. *Nutrition*. 2001;17:761-5.
45. Akinyemiju T, Meng Q,Vin-Raviv N. Association between body mass index and in-hospital outcomes: Analysis of the nationwide inpatient database. *Medicine (Baltimore)*. 2016;95:e4189.
46. Drescher T, Singler K, Ulrich A, *et al.* Comparison of two malnutrition risk screening methods (MNA and NRS 2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. *Eur J Clin Nutr*. 2010;64:887-93.
47. Norman K, Pichard C, Lochs H, *et al.* Prognostic impact of disease-related malnutrition. *Clin Nutr*. 2008;27:5-15.
48. Bauer JM, Vogl T, Wicklein S, *et al.* Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients. *Z Gerontol Geriatr*. 2005;38:322-7.
49. Soeters PB, Reijven PL, van Bokhorst-de van der Schueren MA, *et al.* A rational approach to nutritional assessment. *Clin Nutr*. 2008;27:706-16.

Table 1 Characteristic of study participants

Variable	All subjects（n=425）
Age (year)	81.16±5.89 (70-98)
Gender	
Male	68.9% (293)
Female	31.1% (132)
Height (m)	1.64±0.08 (1.42-1.82)
Weight (kg)	62.89±11.51 (28.4-92.0)
Body mass index (kg/m^2)	23.22±3.73 (11.09-34.14)
Length of hospital stay (day)	21.86±13.75 (4-133)
Primary cause of admission to hospital	
Cardiac disease	160 (37.65%)
Pulmonary infection	84 (19.77%)
Hypertension	76 (17.88%)
Cerebrovascular disease	45 (10.59%)
Digestive disease	25 (5.88%)
Malignancy	19 (4.47%)
Others	16 (3.76%)
Comorbidities	
Hypertension	210 (49.41%)
Diabetes mellitus	101 (23.76%)
Cardiac disease (including atrial fibrillation)	94 (22.12%)
Cerebrovascular disease	30 (7.06%)
NRS2002 score	2.44±1.34 (0-7)
0-2 points (normal nutritional status)	59.06% (251)
3–7 points (under-nourished)	40.94% (174)
MNA score	20.79±5.94 (3.5-29.0)
<17 points (malnutrition)	23.29% (99)
17–23.5 points (at risk for malnutrition)	35.29% (150)
≥24 points (well-nourished)	41.41% (176)
Laboratory analysis	
Hemoglobin (g/L)	120.71±20.47 (55-181)
Lymphocyte count (10^9/L)	1.44±0.81 (0.20-6.58)
Albumin (g/L)	37.63±5.37 (21.6-70.0)
Prealbumin (mg/L)	193.94±68.39 (8-380)

MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002. Values are mean ± standard deviation (with ranges in brackets) or % (numbers), respectively.

Table 2 Nutritional status (%, n) of 425 patients classified by NRS2002, MNA, BMI and serum parameters

	Under-nourished	Well-nourished
NRS2002	40.94% (174)	59.06% (251)
MNA	58.59% (249)	41.41% (176)
BMI	23.66% (93)	76.34% (300)
ALB	28.71% (122)	71.29% (303)
PAB	47.30% (70)	52.70% (78)
Hb	36.75%(154)	63.25%(265)
Hb (male)	41.72%(121)	58.28%(169)
Hb (female)	25.58% (33)	74.42% (96)
TLC	35.90% (149)	64.10%(266)

ALB = albumin, BMI = Body mass index, Hb = hemoglobin, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count. Under-nourished (malnourished + at risk of malnutrition).

Table 3 Cross-classification

MNA	NRS2002		Total
	Under-nourished	Well-nourished	
Under-nourished	159	90	249
Well-nourished	15	161	176
Total	174	251	425
Kappa	0.521		
P	<0.001		

Number of patients classified into two categories according to MNA and NRS, respectively. MNA = Mini-Nutritional assessment, NRS2002 = Nutritional risk score 2002. Under-nourished: malnutrition + at risk of malnutrition.

Table 4 Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS

	MNA		NRS2002	
	rs	***p***	***rs***	***p***
Age	-0.239	＜0.001	0.238	＜0.001
BMI	0.578	＜0.001	-0.347	＜0.001
Hb	0.387	＜0.001	-0.321	＜0.001
TLC	-0.002	0.966	0.011	0.819
ALB	0.501	＜0.001	-0.383	＜0.001
PAB	0.481	＜0.001	-0.332	＜0.001
LOS	-0.109	0.048	0.178	0.001
NRS2002	-0.640	＜0.001	—	—

ALB = albumin, BMI = body mass index, Hb = hemoglobin, LOS = length of hospital stay, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count.

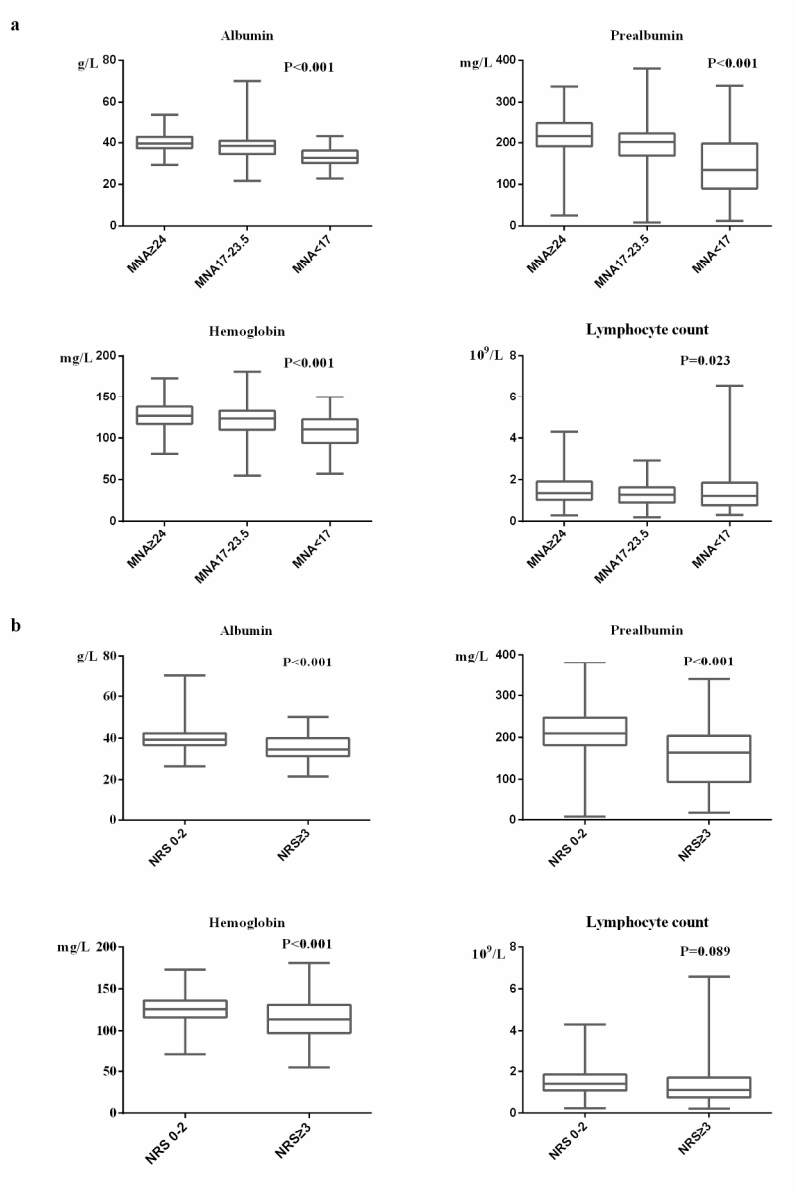

Figure 1 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

175x262mm (300 x 300 DPI)

BMJ Open

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022993.R1
Article Type:	Research
Date Submitted by the Author:	12-Jun-2018
Complete List of Authors:	Miao, Jian-Ping; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Quan, Xiao-Qing; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhang, Cun-Tai; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics Mei, Qi-Jian; General Hospital of the Yangtze River Shipping Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics Li, Shu-Guo; First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital, Department of Geriatrics Zhou, Hong-Lian; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	malnutrition risk, NRS2002, MNA, older patients

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Jian-Ping Miao[1, 2, 3], Xiao-Qing Quan[1, 2, 3], Cun-Tai Zhang[1, 2, 3], Hong Zhu[4], Mei Ye[5], Li-Ya Shen[6], Qiu-Hui Guo[6], Gang-Yan Zhu[7], Qi-Jian Mei[8], Yan-Xia Wu[9], Shu-Guo Li[10], Hong-Lian Zhou [1, 2, 3]*

Running title: Malnutrition screening in Chinese geriatric patients

1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology;

2. Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province

3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ Dysfunction in Wuhan

4. Department of Geriatrics, the Central Hospital of Wuhan University;

5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;

6. Department of Geriatrics, Wuhan No. 6 Hospital;

7. Department of Geriatrics, Hubei General Hospital;

8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;

9. Department of Geriatrics, Wuhan No 1 Hospital;

10. Department of Geriatrics, First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital.

JPM and XQQ contributed equally.

Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com

ABSTRACT

Objectives: The aim of this study was to assess malnutrition risk in Chinese geriatric inpatients with Nutritional Risk Screening (NRS2002) and Mini-Nutritional Assessment (MNA), and to identify the most appropriate nutritional screening tool for these patients.

Design: Cross-sectional study.

Setting: Eight medical centers in Hubei province, China.

Participants: A total of 425 inpatients aged ≥70 years were consecutively recruited between December 2014 and May 2016.

Primary and secondary outcome measures: Nutritional risk was assessed by NRS2002, MNA, anthropometric measurements and biochemical parameters within 24 hours of admission. Comorbidities and length of hospitalization were recorded. Nutritional parameters, BMI and length of hospital stay were used to compare MNA and NRS2002. Besides, Kappa analysis was used to evaluate the consistency of the two tools.

Results: The average age was 81.2±5.9 years (range, 70-98). The prevalence of undernutrition classified by NRS2002 and MNA was 40.9% and 58.6%, respectively. Patients with malnutrition had lower BMI, hemoglobin, albumin and prealbumin (P<0.05), and longer length of hospital stay (LOS) (P<0.05). The NRS2002 showed moderate agreement (κ=0.521, P<0.001) with MNA. Both tools showed significant correlation with age, BMI and laboratory parameters (P<0.001). In addition, a significant association between both tools and LOS was found (P<0.05).

Conclusions: The results show a relatively high prevalence of malnutrition risk in our sample cohort. We found NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients.

Strengths and limitations of this study

- ► This study assessed the risk of malnutrition among Chinese elderly inpatients with two different tools (NRS2002 and MNA).
- ► The study provides useful information to assess the risk of malnutrition among Chinese elderly inpatients.
- ► The consensus statement with diagnostic criteria for malnutrition was proposed in 2015 after our study initiated, thus it was not utilized in our study.
- ► The small sample size of women may limit the generalizability of the results.
- ► Regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined.

Keywords: malnutrition risk; NRS2002; MNA; older patients

INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.[1] It is highly associated with many adverse outcomes including frailty,[2] muscle wasting[3], weakened immune system[4], longer hospitalization,[5] increased morbidity[6] and mortality.[7, 8] These outcomes contribute to large increases in medical expenditures.[9] Early identification and treatment of malnutrition can lead to better quality of life[10] and improved outcomes[11] in older inpatients. Therefore, the application of appropriate tools to assess the risk of malnutrition in geriatric patients is essential.

Nutritional risk screening and nutritional assessment tools are readily available nowadays.[12] These tools are used to identify patients with nutritional risk or nutritional deficiencies and to determine if intervention is needed. There are a variety of nutritional risk screening methods,[13] mainly involving anthropometric and biochemical parameters. However, to date, no single tool can be considered as the universal gold standard for the assessment of nutritional risk among the older inpatients.

The Nutritional Risk Screening (NRS2002) is recommended for hospitalized patients by the European Society of Parenteral and Enteral Nutrition (ESPEN).[14] It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.[15, 16] However, NRS2002 use excludes patients who cannot be weighed or have problems of communication and the tool isn't specifically

developed for older patients.

The Mini-Nutritional Assessment (MNA) is established for the nutritional screening and assessment in the geriatrics settings.[1, 17] The ESPEN recommends the use of this tool for elderly populations.[18] The MNA was validated against a clinical evaluations of two geriatrics, including biochemical parameters (nutritional parameters, C-reactive protein, cholesterol, vitamins), anthropometry (BMI, brachial circumference, calf circumference, skinfold width of the triceps and subscapular muscles), dietary components and functional assessment outcomes.[19] It has been shown to predict outcomes, functional status, mortality, number of hospital visits and the related healthcare costs.[18, 20-23] In contrast to the NRS2002, the MNA is more time consuming.[24] Hence, two short forms of the MNA has been developed and validated, the most recently the revised MNA-SF by Kaiser *et al*[25], which is nowadays the recommended version of the MNA for clinical use. This instrument only incorporates 6 of the original 18 items and takes approximately 5 minutes to perform.

A number of studies suggested serum proteins are associated with malnutrition, but the nature of this association is controversial.[26-28] Hemoglobin and total lymphocyte count were also proposed as useful indicators of nutritional status.[27, 29] The aim of our study was to assess the risk of malnutrition among Chinese older participants with two different tools (NRS2002 and MNA), to compare them in terms of nutritional biochemical parameters and length of hospital stay (LOS), and to determine the most appropriate tool for these patients. We hypothesized that both tools were suitable for the study population.

METHODS

Study subjects

This study consecutively recruited patients older than 70 years of age who attended internal medicine of geriatrics department of eight large size Tertiary comprehensive hospitals in Hubei Province from December 2014 to May 2016. The eight hospitals are as follows: (1) Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, (2) The Central Hospital of Wuhan University, (3) Zhongnan Hospital of Wuhan University, (4) Wuhan No. 6 Hospital, Affiliated Hospital of Jianghan University, (5) Hubei General Hospital, (6) General Hospital of The Yangtze River Shipping, (7) Wuhan No. 1 Hospital, (8) The First College of Clinical Medical Science, Three Gorges University and Yichang Central People's Hospital.

This cross-sectional study received approval from the institutional Ethics Committee and all subjects signed written informed consent before participation. Inclusion criteria were: (1) age 70 years or older, (2) the patients themselves or their proxies were able to clearly answer study questions, (3) hospital stay was longer than 24 hours and (4) patients were willing to cooperate with the study. Exclusion criteria included: (1) younger than 70 years old, (2) refusal to participate in the study and (3) patients was unconscious or unable to answer the study questions (Figure 1).

Nutritional risk screening 2002 (NRS2002)

The NRS2002 consists of the following parameters: the severity of acute illness, BMI, patient appetite, accidental weight loss and patient age.[15] The total score ranges from 0 to 7.[16] For investigational purposes, patients were categorized into two groups: a total score ≥3 indicates under-nourished (at nutritional risk/malnourished), 0-2 indicates normal nutrition status.[14, 30] A nutritional care plan was initiated for patients with a score ≥3.[31]

Mini-Nutritional Assessment (MNA)

The MNA consists of four parts: anthropometric assessment (0-8 points), general assessment (0-9 points), dietetic habits evaluation (0-9 points) and self-assessment of the nutrition and health status (0-4 points).[32] A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.[33] A nutritional care plan was initiated for patients with a score <17.[31]

Data Collecting

Each hospital had 2 researchers trained before the study started. The main contents were about how to interpret the questions in the instruments (MNA and NRS2002) and how to perform the measurements. The patients were evaluated with both MNA and NRS2002 by two trained researchers on the first day of admission or

early morning of the next day.

Comorbidities and length of hospitalization were obtained from medical records. Patients were diagnosed by their bedside clinician and superior clinicians. Two trained researchers of each hospital verified the diagnoses and acquired data. Body height and weight were measured at 6-8 am within 24 hours after admission. Patients were asked to be fasting, only wearing ward clothes and taking off shoes before measurement. Height was measured with a calibrated scale (corrected to ±0.5 cm). The actual body mass was measured with a calibrated scale (corrected to ±0.2 kg). The body mass index (BMI) was then calculated as weight/height squared (kg/m^2).

Blood samples were also obtained within 24 hours after admission. Nutritional biochemical parameters: serum hemoglobin (Hb), total lymphocyte count (TLC), albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical chemistry laboratory. Malnutrition was determined when the value of Hb was <120 g/L for males and <110 g/L for females. The cutoff value of ALB was 35 g/L (normal range 35-55 g/L), PAB was 200mg/L (normal range 200-400 mg/L), TLC was 1.1×10^9/L (normal range $1.1\text{-}3.2\times10^9$/L) for both genders for malnutrition.[34] Moreover, based on previous research, the cutoff value of BMI was set at 20.5 kg/m^2 for malnutrition according to the epidemiological study in China.[35]

Patient and public involvement

Through the cross-sectional study, the older adults were recruited in eight hospitals.

After obtaining informed consent, the two trained researchers in each hospital were responsible for investigating the subjects, and the results of measurements would be disseminated to participants immediately after the investigation.

Statistical analysis

The statistical analyses were conducted using SPSS 19.0. Data were presented as mean ± standard deviation and ranges in blanket. The chi-square test or student's *t*-test was used according to the data type. One-way analysis of variance was applied for multigroup comparisons. Correlation analysis was qualified by the Pearson correlation test. The simple linear regression analysis was used to estimate the relationship between both instruments (MNA/NRS2002) and LOS. Agreement between the two screening tools was achieved by the kappa (κ) statistic. The results were interpreted as follows: <0, no agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate agreement; 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.[29] The level of significance was set at $P<0.05$.

RESULTS

Over the study period, a total of 425 individuals from the Department of Geriatrics of eight hospitals in Hubei Province met the eligibility criteria and completed a nutrition assessment within 24 hours of admission (Figure 1). The average age was 81.2±5.9 years (range, 70-98) and 31.1% were females. The average body mass index was 23.2±3.7 kg/m^2 (range, 11.1-34.1). The average length of hospitalization was 21.9±13.7 days (range, 4-133). The most frequent cause of hospitalization were cardiac disease, followed by pulmonary infection, hypertension, cerebrovascular diseases, digestive disease and malignancies, while the most frequent comorbidities were hypertension, diabetes mellitus, cardiac disease and cerebrovascular disease. Characteristics of study participants are shown in table 1.

According to the NRS2002, about 174 patients (40.9%) were under-nourished, 251 patients (59.1%) were at normal nutritional status. The MNA showed that 99 patients (23.3%) were malnourished, 150 patients (35.3%) were at risk of malnutrition and 176 patients (41.4%) had a normal nutritional status.

Table 2 shows the risk of undernutrition, varying from 23.7% to 58.6%, according to the different methods employed in our study. The risk of under-nourished participants classified by NRS2002, MNA, BMI, ALB, PAB, TLC were 40.9%, 58.6%, 23.7%, 28.7%, 47.3%, 35.9%, respectively. The risk of malnutrition was

higher in men than that of women according to hemoglobin (41.7% vs 25.6%, respectively).

Although both instruments were closely related to each other (P<0.001), they showed substantial differences. Table 3 shows the cross-classification of MNA and NRS2002 regarding two nutritional categories. The MNA classified more patients as under-nourished than the NRS2002 (249 vs 174, respectively). Of the 249 patients classified as under-nourished by the MNA, the NRS2002 coincidently categorized 159 as malnourished, and 90 as well-nourished. The NRS2002, on the other hand, classified 174 patients as under-nourished. Within this group of participants, the MNA classified 159 patients as under-nourished and 15 as well-nourished. What's more, a participant considered by the MNA to be well-nourished can be classified as under-nourished using the NRS2002. The individual categorization of nutritional status showed moderate agreement between MNA and NRS2002 (κ=0.521, P<0.001).

Data of Hb, TLC, ALB and PAB concentrations are listed in table 2 and additional table 1. There were significant decrease of ALB, PAB, Hb and TLC in the three groups of MNA scores (P<0.001 and P=0.023, figure 2a). Specifically, the group with the lowest MNA score <17 (n=99), indicating a poor nutritional state, had an average serum albumin of 33.3±4.8 g/L (range, 22.8-43.2), an average prealbumin of 140.8±81.7 mg/L (range, 12-339) and an average hemoglobin of 109.0±20.8 mg/L (range, 57-150.2), an average lymphocyte count of 1.5±1.2 10^9/L (range, 0.3-6.6). In the risk of malnutrition group with an MNA score of 17-23.5 (n=150), average serum albumin was 37.9±5.6 g/L (range, 21.6-70), average prealbumin 192.3±61.8 mg/L

(range, 8-380) and average hemoglobin 120.2±22.0 mg/L (range, 55-181), an average lymphocyte count of 1.3±0.56 10^9/L (range, 0.2-2.9). The group with MNA≥24 (n=180) had an average serum albumin concentration of 39.8±3.8 g/L (range, 29.3-54), an average prealbumin of 216.7±54.4 mg/L (range, 25-337) and an average hemoglobin of 127.6±15.3 mg/L (range, 81-173), an average lymphocyte count of 1.5±0.7 10^9/L (range, 0.3-4.3; figure 2a, additional table 1).

Similarly, ALB, PAB and Hb gradually declined with increasing risk of malnutrition according to NRS2002 results (P<0.001, figure 2b). In under-nourished patients (NRS2002: 3-7, n=174), average serum albumin was 35.1±5.6 g/L (range, 21.6-50.2), average prealbumin 148.5±79.3 mg/L (range, 17-339) and average hemoglobin 113.3±23.6 mg/L (range, 55-181). In the normal nutritional state group (NRS2002: 0-2, n=251), the results were: albumin 39.4±4.5 g/L (range, 26.4-70), prealbumin 210.2±56.1 mg/L (range, 8-380) and hemoglobin 125.8±16.2 mg/L (range, 72-173). In contrast, no difference in lymphocyte count was found in both groups (P=0.089, figure 2b, additional table 1).

Table 4 showed the Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated negatively with malnutrition scores of NRS2002, while correlated positively with the MNA scores (P<0.001). There was an inverse correlation between age and the two tools (P<0.001). Besides, a significant association between both tools and LOS was demonstrated (P<0.05). No correlation was found between TLC and the two tools.

Table 5 showed the simple linear regression of LOS. There was a linear

correlation between the MNA scores and LOS (P<0.05), so was the NRS2002 scores (P<0.01).

DISCUSSION

Based on the current study, the nutritional health of older inpatients were assessed using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. We found the overall prevalence of malnutrition risk for the enrolled older patients ranged from 23.7% to 58.6%. The highest prevalence of malnutrition risk was detected by MNA and the lowest by BMI. These results illustrated the differences in nutritional risk detected by different screening tools.

Biochemical markers have many advantages in assessing the nutritional status, such as fast application, low cost. They can also be incorporated into the routine of clinical application. Albumin, the most abundant plasmatic protein, is commonly used in the assessment of malnutrition.[36] In several of studies, low serum ALB correlated with longer hospitalization, medical complications, and increased mortality.[36-38] Nevertheless, its value is limited by the long half-life (14-20 days), inflammation, the impairment of hepatic or renal, and possibly aging itself.[27] In the present study, prevalence of malnutrition detected by ALB is lower than MNA and NRS2002, which suggest that ALB was not suitable for assessing malnutrition in our patients. The reason may be its long half-life to make it insensitive to malnutrition. In contrast, a

study by Covinsky *et al*[39] showed ALB is highly sensitive but low specific in the diagnosis of malnutrition in the hospitalized older adults.

Prealbumin has been regarded as a more sensitive marker than albumin for acute nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in nutritional screening and mortality prediction are controversial.[40-43] In our study, prealbumin levels showed a great decline with deteriorating nutrition status assessed by both NRS2002 and MNA. The correlation between serum prealbumin and MNA consistent with one study[44], but in contrast with another report.[42] This latter study had a small sample size (23 older patients), which may explain the discrepancies. Similar to serum albumin, the usage of prealbumin in predicting malnutrition is limited due to systemic inflammatory diseases.[41, 45]

Hemoglobin has been shown to decrease with progressive malnutrition.[46, 47] This relationship, consistent with a recent analysis performed in Northern China[29], is found in our study. Total lymphocyte count was assumed to be suitable in screening test for assessing malnutrition and being an indicator of a poor prognosis.[27] In agreement with Lei *et al*[48], we found a significant correlation between TLC and MNA. However, no correlation was found between NRS2002 and TLC, coincidence with a previous study.[29]

The prevalence of malnutrition diagnosed by BMI was far below that detected by MNA. Consistent with findings from another study[49], this study suggest malnutrition is also under diagnosed when using BMI as the sole criteria. The reason is most likely related to water-sodium retention in patients, leading to an overestimation of their true

weight.[50] In spite of this, low BMI was significantly associated with mortality.[51]

Our study revealed that NRS2002 and MNA, in moderate agreement with each other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless, the MNA identified more patients with or at risk of malnutrition than did the NRS2002. The lower percentage of malnutrition classified by NRS2002 may be explained in several ways. First, the NRS2002 mainly consider the influence of acute diseases to nutritional status, while the MNA take chronic long-term condition into account, such as psychological factors and the BMI. Psychological factors may play a large role in the nutritional status of older inpatients. In addition, we categorized undernutrition as NRS2002≥3, while patients with a score of 1-2 indicates low risk of malnutrition.[52] This may have underestimated the percentage of malnutrition. Moreover, our study subjects were internal medical patients, of which the proportion of overweight and obesity was high. The NRS2002 take BMI < 18.5 kg/m^2 as one of the criteria, which leads to a lower proportion of malnutrition with NRS2002 than that of MNA. Our results are in agreement with findings from Raslan *et al,*[5] but differ from the study conducted by Drescher *et al*.[52] The latter study was conducted in older patients with acute disease, which may explain the difference.

Norman *et al* suggested that there is a close relationship between the degree of malnutrition and LOS.[53] In the present study, we found the linear relation between both instruments (MNA and NRS2002) and LOS. Our findings corroborated those of the study by Bauer *et al,*[54] which showed longer hospital stay was associated with malnutrition assessed by the MNA. We conclude, therefore, that in Chinese geriatric

inpatients, the NRS2002 and MNA might reflect malnutrition or the studied biochemical parameters, as well as predicting the length of hospitalization, however, the MNA was available for identifying most of the patients with or at risk of malnutrition.

Limitations

Our study has some limitations. First, a consensus statement with diagnostic criteria for malnutrition was proposed in 2015[55] after our study initiated, thus it was not utilized in our study. Second, BMI and age were part of the screening tools, therefore already correlated with the MNA and NRS-2002 assessment. In addition, the small sample size of women may limit the generalizability of the results. Finally, regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined, this may contribute to the low Kappa value between the two instruments.

CONCLUSION

In summary, the results of the present study show a high prevalence of malnutrition risk in Chinese geriatric hospitalized patients. Although the nutritional risk varied depending on the method used, both NRS2002 and MNA correlated with each other and with age, BMI and laboratory parameters. Besides, both tools were found to be a good predictor of the length of hospitalization. Therefore, this study suggests NRS2002 and MNA both were suitable to screen malnutrition risk among

Chinese geriatric inpatients. We recommend one of them to be used in admission.

Acknowledgements Thanks to the participating volunteer patients, the local research ethics committee and the individual researchers, clinicians and nurses for their participation in the data collection.

Contributors JPM, XQQ and HLZ are main contributors to the design of the present study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ, took part in the discussion and modification of the study design. HZ, MY, LYS, QHG, GYZ, QJM, YXW, and SGL contributed to the study conception. XQQ, HZ, MY, LYS, QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of data. JPM and XQQ contributed to the drafting of the manuscript. HLZ and CTZ were involved in the critical revision. All the authors were involved in the analysis and interpretation of the data and gave their final approval.

Funding This project was funded by the National Natural Science Foundation of China (Grant No. 81400255).

Competing interests None declared.

Ethics approval Ethics Review Board of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-C20141112).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legend

Figure 1 Flow diagram of participant inclusion and exclusion.

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

REFERENCES

1. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? *J Nutr Health Aging*. 2006;10:466-85; discussion 485-7.
2. Chang SF. Frailty Is a Major Related Factor for at Risk of Malnutrition in Community-Dwelling Older Adults. *J Nurs Scholarsh*. 2017;49:63-72.
3. Lumale S. [Nutritional management of elderly people, everyone's concern]. *Rev Infirm*. 2017;66:25-26.
4. Lesourd B. Nutritional factors and immunological ageing. *Proc Nutr Soc*. 2006;65:319-25.
5. Raslan M, Gonzalez MC, Dias MC*, et al.* Comparison of nutritional risk screening tools for predicting clinical outcomes in hospitalized patients. *Nutrition*. 2010;26:721-6.
6. Ehwerhemuepha L, Bendig D, Steele C*, et al.* The Effect of Malnutrition on the Risk of Unplanned 7-Day Readmission in Pediatrics. *Hosp Pediatr*. 2018.
7. Ahmed N, Choe Y, Mustad VA*, et al.* Impact of malnutrition on survival and healthcare utilization in Medicare beneficiaries with diabetes: a retrospective cohort analysis. *BMJ Open Diabetes Res Care*. 2018;6:e000471.
8. Sharma Y, Miller M, Kaambwa B*, et al.* Malnutrition and its association with readmission and death within 7 days and 8-180 days postdischarge in older patients: a prospective observational study. *BMJ Open*. 2017;7:e018443.
9. Khalatbari-Soltani S,Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN*. 2015;10:e89-e94.
10. Bouillanne O, Curis E, Hamon-Vilcot B*, et al.* Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: a randomized controlled trial. *Clin Nutr*. 2013;32:186-92.
11. Ballesteros-Pomar MD, Martinez Llinas D, Goates S*, et al.* Cost-Effectiveness of a Specialized Oral Nutritional Supplementation for Malnourished Older Adult Patients in Spain. *Nutrients*. 2018;10.
12. Racic M, Ivkovic N,Kusmuk S. [Screening of Nutritional Status among Elderly People at Family Medicine]. *Acta Med Croatica*. 2015;69:347-56.
13. Abd Aziz NAS, Teng N, Abdul Hamid MR*, et al.* Assessing the nutritional status of hospitalized elderly. *Clin Interv Aging*. 2017;12:1615-1625.
14. Elia M,Stratton R. On the ESPEN guidelines for nutritional screening 2002. *Clin Nutr*. 2004;23:131-2.
15. Kondrup J, Rasmussen HH, Hamberg O*, et al.* Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22:321-36.
16. Kondrup J, Allison SP, Elia M*, et al.* ESPEN guidelines for nutrition screening 2002. *Clin Nutr*. 2003;22:415-21.
17. Guigoz Y, Vellas B,Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr Rev*. 1996;54:S59-65.
18. Bleda MJ, Bolibar I, Pares R*, et al.* Reliability of the mini nutritional assessment

(MNA) in institutionalized elderly people. *J Nutr Health Aging*. 2002;6:134-7.
19. Bauer JM, Kaiser MJ, Anthony P*, et al.* The Mini Nutritional Assessment--its history, today's practice, and future perspectives. *Nutr Clin Pract*. 2008;23:388-96.
20. Soderstrom L, Rosenblad A, Adolfsson ET*, et al.* Nutritional status predicts preterm death in older people: a prospective cohort study. *Clin Nutr*. 2014;33:354-9.
21. Dent E, Visvanathan R, Piantadosi C*, et al.* Use of the Mini Nutritional Assessment to detect frailty in hospitalised older people. *J Nutr Health Aging*. 2012;16:764-7.
22. Cabre M, Ferreiro C, Arus M*, et al.* Evaluation of CONUT for Clinical Malnutrition Detection and Short-Term Prognostic Assessment in Hospitalized Elderly People. *J Nutr Health Aging*. 2015;19:729-33.
23. Chavarro-Carvajal D, Reyes-Ortiz C, Samper-Ternent R*, et al.* Nutritional assessment and factors associated to malnutrition in older adults: a cross-sectional study in Bogota, Colombia. *J Aging Health*. 2015;27:304-19.
24. Kyle UG, Kossovsky MP, Karsegard VL*, et al.* Comparison of tools for nutritional assessment and screening at hospital admission: a population study. *Clin Nutr*. 2006;25:409-17.
25. Kaiser MJ, Bauer JM, Ramsch C*, et al.* Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging*. 2009;13:782-8.
26. Sergi G, Coin A, Enzi G*, et al.* Role of visceral proteins in detecting malnutrition in the elderly. *Eur J Clin Nutr*. 2006;60:203-9.
27. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. *Nutrition*. 2000;16:131-40.
28. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools. *Nutrition*. 2000;16:50-63.
29. Zhou J, Wang M, Wang H*, et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
30. Thoresen L, Frykholm G, Lydersen S*, et al.* Nutritional status, cachexia and survival in patients with advanced colorectal carcinoma. Different assessment criteria for nutritional status provide unequal results. *Clin Nutr*. 2013;32:65-72.
31. Wei J, Chen W, Zhu M*, et al.* Guidelines for parenteral and enteral nutrition support in geriatric patients in China. *Asia Pac J Clin Nutr*. 2015;24:336-46.
32. Jacobsen EL, Brovold T, Bergland A*, et al.* Prevalence of factors associated with malnutrition among acute geriatric patients in Norway: a cross-sectional study. *BMJ Open*. 2016;6:e011512.
33. Guigoz Y,Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. *Nestle Nutr Workshop Ser Clin Perform Programme*. 1999;1:3-11; discussion 11-2.
34. Blackburn GL, Bistrian BR, Maini BS*, et al.* Nutritional and metabolic

assessment of the hospitalized patient. *JPEN J Parenter Enteral Nutr*. 1977;1:11-22.

35. Cooperative Meta-Analysis Group of the Working Group on Obesity in China. International life sciences institute, focal point in China: the recommendation of Chinese adult body mass index classification. Zhonghua Yu Fang Yi Xue Za Zhi. 2001;35:349–50.
36. Cabrerizo S, Cuadras D, Gomez-Busto F*, et al.* Serum albumin and health in older people: Review and meta analysis. *Maturitas*. 2015;81:17-27.
37. O'Daly BJ, Walsh JC, Quinlan JF*, et al.* Serum albumin and total lymphocyte count as predictors of outcome in hip fractures. *Clin Nutr*. 2010;29:89-93.
38. Chiu PF, Tsai CC, Wu CL*, et al.* Trajectories of Serum Albumin Predict Survival of Peritoneal Dialysis Patients: A 15-year Follow-Up Study. *Medicine (Baltimore)*. 2016;95:e3202.
39. Covinsky KE, Covinsky MH, Palmer RM*, et al.* Serum albumin concentration and clinical assessments of nutritional status in hospitalized older people: different sides of different coins? *Journal of the American Geriatrics Society*. 2002;50:631-7.
40. Carriere I, Dupuy AM, Lacroux A*, et al.* Biomarkers of inflammation and malnutrition associated with early death in healthy elderly people. *Journal of the American Geriatrics Society*. 2008;56:840-6.
41. Devoto G, Gallo F, Marchello C*, et al.* Prealbumin serum concentrations as a useful tool in the assessment of malnutrition in hospitalized patients. *Clinical chemistry*. 2006;52:2281-5.
42. Langkamp-Henken B, Hudgens J, Stechmiller JK*, et al.* Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *J Am Diet Assoc*. 2005;105:1590-6.
43. Kanda M, Mizuno A, Tanaka C*, et al.* Nutritional predictors for postoperative short-term and long-term outcomes of patients with gastric cancer. *Medicine (Baltimore)*. 2016;95:e3781.
44. Vellas B, Guigoz Y, Baumgartner M*, et al.* Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. *Journal of the American Geriatrics Society*. 2000;48:1300-9.
45. Lopez-Hellin J, Baena-Fustegueras JA, Schwartz-Riera S*, et al.* Usefulness of short-lived proteins as nutritional indicators surgical patients. *Clin Nutr*. 2002;21:119-25.
46. Wham CA, Teh RO, Robinson M*, et al.* What is associated with nutrition risk in very old age? *J Nutr Health Aging*. 2011;15:247-51.
47. Weng CH, Hsu CW, Hu CC*, et al.* Association Between Hemodiafiltration and Hypoalbuminemia in Middle-Age Hemodialysis Patients. *Medicine (Baltimore)*. 2016;95:e3334.
48. Lei Z, Qingyi D, Feng G*, et al.* Clinical study of mini-nutritional assessment for older Chinese inpatients. *J Nutr Health Aging*. 2009;13:871-5.
49. Antaki F, French MM, Moonka DK*, et al.* Bioelectrical impedance analysis for the evaluation of hepatic fibrosis in patients with chronic hepatitis C infection.

Dig Dis Sci. 2008;53:1957-60.
50. Roongpisuthipong C, Sobhonslidsuk A, Nantiruj K*, et al.* Nutritional assessment in various stages of liver cirrhosis. *Nutrition*. 2001;17:761-5.
51. Akinyemiju T, Meng Q,Vin-Raviv N. Association between body mass index and in-hospital outcomes: Analysis of the nationwide inpatient database. *Medicine (Baltimore)*. 2016;95:e4189.
52. Drescher T, Singler K, Ulrich A*, et al.* Comparison of two malnutrition risk screening methods (MNA and NRS 2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. *Eur J Clin Nutr*. 2010;64:887-93.
53. Norman K, Pichard C, Lochs H*, et al.* Prognostic impact of disease-related malnutrition. *Clin Nutr*. 2008;27:5-15.
54. Bauer JM, Vogl T, Wicklein S*, et al.* Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients. *Z Gerontol Geriatr*. 2005;38:322-7.
55. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr. 2015;34:335-40.

Table 1 Characteristic of study participants

Variable	All subjects（n=425）
Age (year)	81.2±5.9 (70-98)
Gender	
Male	68.9% (293)
Female	31.1% (132)
Height (m)	1.6±0.1 (1.4-1.8)
Weight (kg)	62.9±11.5 (28.4-92.0)
Body mass index (kg/m^2)	23.2±3.7 (11.1-34.1)
Length of hospital stay (day)	21.9±13.8 (4-133)
Primary cause of admission to hospital	
Cardiac disease	160 (37.6%)
Pulmonary infection	84 (19.8%)
Hypertension	76 (17.9%)
Cerebrovascular disease	45 (10.6%)
Digestive disease	25 (5.9%)
Malignancy	19 (4.5%)
Others	16 (3.8%)
Comorbidities	
Hypertension	210 (49.4%)
Diabetes mellitus	101 (23.8%)
Cardiac disease (including atrial fibrillation)	94 (22.1%)
Cerebrovascular disease	30 (7.1%)

Values are mean ± standard deviation (with ranges in brackets) or % (numbers), respectively.

Table 2 Nutritional status (%, n) of 425 patients classified by NRS2002, MNA, BMI and serum parameters

	Under-nourished	Well-nourished
NRS2002	40.9% (174)	59.1% (251)
MNA	58.6% (249)	41.4% (176)
BMI	23.7% (93)	76.3% (300)
ALB	28.7% (122)	71.3% (303)
PAB	47.3% (70)	52.7% (78)
Hb (male)	41.7% (121)	58.3% (169)
Hb (female)	25.6% (33)	74.4% (96)
TLC	35.9% (149)	64.1% (266)

ALB = albumin, BMI = Body mass index, Hb = hemoglobin, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count. Under-nourished (malnourished + at risk of malnutrition).

Table 3 Cross-classification

MNA	NRS2002		Total
	Under-nourished	Well-nourished	
Under-nourished	159	90	249
Well-nourished	15	161	176
Total	174	251	425
Kappa	0.521		
P	<0.001		

Number of patients classified into two categories according to MNA and NRS, respectively. MNA = Mini-Nutritional assessment, NRS2002 = Nutritional risk score 2002. Under-nourished: malnutrition + at risk of malnutrition.

Table 4 Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS

	MNA		NRS2002	
	r	***p***	***r***	***p***
Age	-0.239	＜0.001	0.238	＜0.001
BMI	0.578	＜0.001	-0.347	＜0.001
Hb	0.387	＜0.001	-0.321	＜0.001
TLC	-0.002	0.966	0.011	0.819
ALB	0.501	＜0.001	-0.383	＜0.001
PAB	0.481	＜0.001	-0.332	＜0.001
LOS	-0.109	0.048	0.178	0.001
NRS2002	-0.640	＜0.001	—	—

ALB = albumin, BMI = body mass index, Hb = hemoglobin, LOS = length of hospital stay, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count.

Table 5 The simple linear regression analysis of LOS

	B	SE	β	t	*P*	95%CI	R^2	F
MNA	-0.261	0.131	-0.109	-1.987	<0.05	-0.519,-0.003	0.012	3.949
NRS2002	1.891	0.575	0.178	3.291	<0.01	0.761,3.022	0.032	10.834

LOS = length of hospital stay, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002.

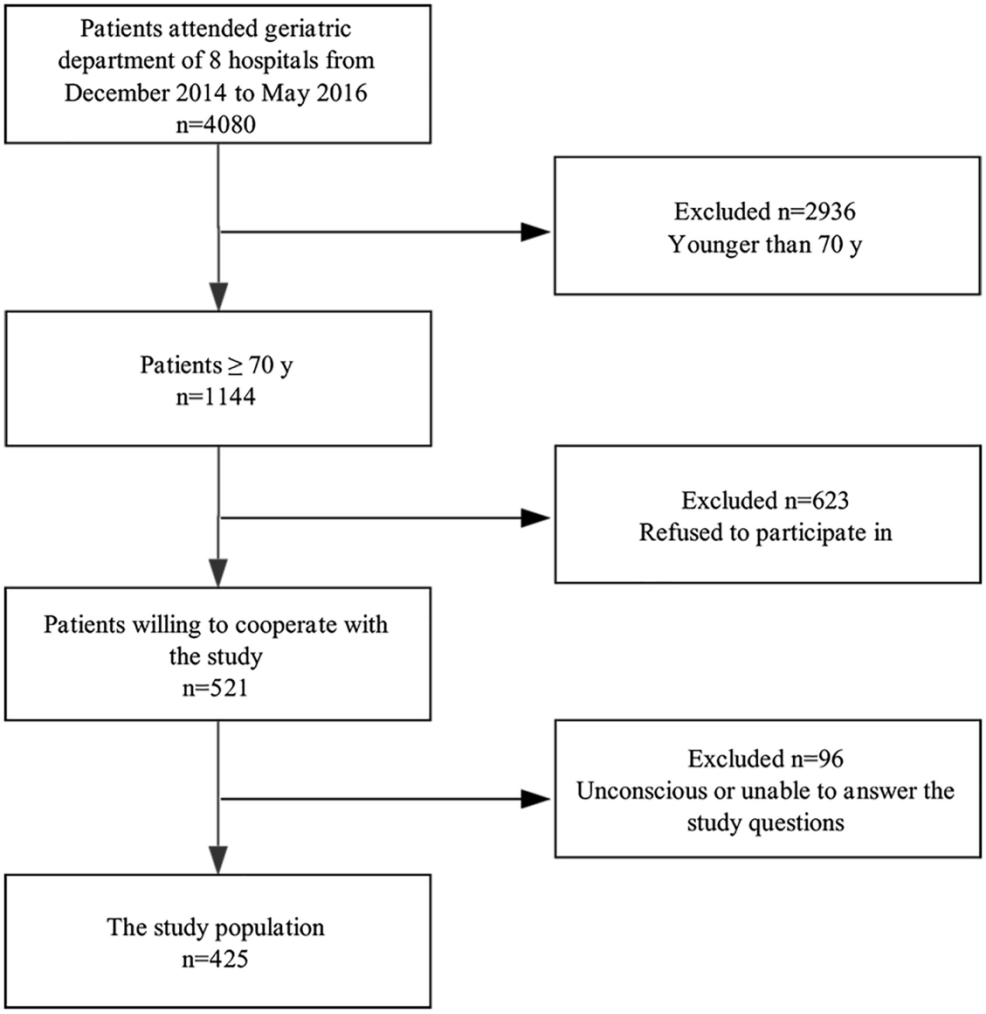

Figure 1 Flow diagram of participant inclusion and exclusion.

167x172mm (300 x 300 DPI)

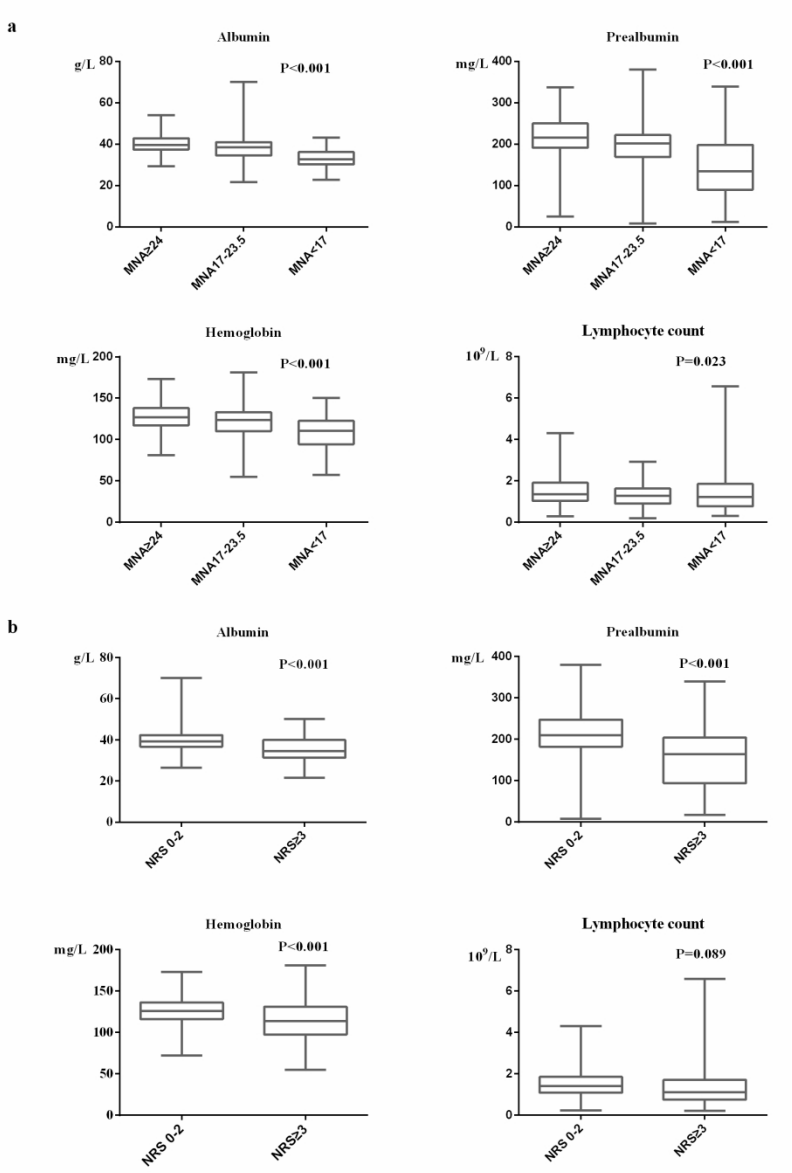

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

175x262mm (300 x 300 DPI)

Additional table 1 Nutritional parameters of study participants classified by MNA and NRS2002

	ALB (g/L)	PAB (mg/L)	Hb (g/L)	TLC (10^9/L)
MNA				
<17	33.3±4.8 (22.8-43.2)	140.8±81.7 (12-339)	109.0±20.8 (57-150.2)	1.5±1.2 (0.3-6.6)
17-23.5	37.9±5.6 (21.6-70)	192.3±61.8 (8-380)	120.2±22.0 (55-181)	1.3±0.6 (0.2-2.9)
≥24	39.8±3.8 (29.3-54)	216.7±54.4 (25-337)	127.6±15.3 (81-173)	1.5±0.7 (0.3-4.3)
NRS2002				
≥3	35.1±5.6 (21.6-50.2)	148.5±79.3 (17-339)	113.3±23.6 (55-181)	1.4±1.0 (0.2-6.6)
0-2	39.4±4.5 (26.4-70)	210.2±56.1 (8-380)	125.8±16.2 (72-173)	1.5±0.6 (0.2-4.3)

ALB = albumin, PAB = prealbumin, Hb = hemoglobin, TLC = total lymphocyte count, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002. Values are mean ± standard deviation (with ranges in brackets)

BMJ Open

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022993.R2
Article Type:	Research
Date Submitted by the Author:	28-Aug-2018
Complete List of Authors:	Miao, Jian-Ping; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Quan, Xiao-Qing; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhang, Cun-Tai; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics Mei, Qi-Jian; General Hospital of the Yangtze River Shipping Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics Li, Shu-Guo; First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital, Department of Geriatrics Zhou, Hong-Lian; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	malnutrition risk, NRS2002, MNA, older patients

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Jian-Ping Miao[1, 2, 3], Xiao-Qing Quan[1, 2, 3], Cun-Tai Zhang[1, 2, 3], Hong Zhu[4], Mei Ye[5], Li-Ya Shen[6], Qiu-Hui Guo[6], Gang-Yan Zhu[7], Qi-Jian Mei[8], Yan-Xia Wu[9], Shu-Guo Li[10], Hong-Lian Zhou [1, 2, 3]*

Running title: Malnutrition screening in Chinese geriatric patients

1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology;

2. Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province

3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ Dysfunction in Wuhan

4. Department of Geriatrics, the Central Hospital of Wuhan University;

5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;

6. Department of Geriatrics, Wuhan No. 6 Hospital;

7. Department of Geriatrics, Hubei General Hospital;

8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;

9. Department of Geriatrics, Wuhan No 1 Hospital;

10. Department of Geriatrics, First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital.

JPM and XQQ contributed equally.

Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com

ABSTRACT

Objectives: The aim of this study was to assess malnutrition risk in Chinese geriatric inpatients with Nutritional Risk Screening (NRS2002) and Mini-Nutritional Assessment (MNA), and to identify the most appropriate nutritional screening tool for these patients.

Design: Cross-sectional study.

Setting: Eight medical centers in Hubei province, China.

Participants: A total of 425 inpatients aged ≥70 years were consecutively recruited between December 2014 and May 2016.

Primary and secondary outcome measures: Nutritional risk was assessed using NRS2002, MNA, anthropometric measurements and biochemical parameters within 24 hours of admission. Comorbidities and length of hospitalization were recorded. Nutritional parameters, BMI and length of hospital stay were employed to compare MNA and NRS2002. Besides, Kappa analysis was used to evaluate the consistency of the two tools.

Results: The average age was 81.2±5.9 years (range, 70-98). The prevalence of undernutrition classified by NRS2002 and MNA was 40.9% and 58.6%, respectively. Patients undergoing malnutrition had lower BMI, hemoglobin, albumin and prealbumin (P<0.05), and longer length of hospital stay (LOS) (P<0.05). The NRS2002 showed moderate agreement (κ=0.521, P<0.001) with MNA. Both tools presented significant correlation with age, BMI and laboratory parameters (P<0.001). In addition, a significant association between both tools and LOS was found (P<0.05).

Besides, the NRS2002 was not different from MNA for predicting nutritional risk in terms of the area under receiver operating characteristic curve (P>0.05).

Conclusions: The results show a relatively high prevalence of malnutrition risk in our sample cohort. We found that NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients.

Strengths and limitations of this study

- ► This study assessed the risk of malnutrition among Chinese elderly inpatients with two different tools (NRS2002 and MNA).
- ► The study provides useful information to assess the risk of malnutrition among Chinese elderly inpatients.
- ► The consensus statement with diagnostic criteria for malnutrition was proposed in 2015 after our study initiated, and thus it was not utilized in our study.
- ► Regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined.
- ► In addition to nutritional status, LOS could also be influenced by age, financial situation, comorbidities and so on, which may explain the low R^2 regarding simple linear regression analysis.

Keywords: malnutrition risk; NRS2002; MNA; older patients

INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.[1] It is highly associated with numerous adverse outcomes including frailty,[2] muscle wasting[3], weakened immune system[4], longer hospitalization,[5] increased morbidity[6] and mortality.[7, 8] These outcomes contribute to large increases in medical expenditures.[9] Early identification and treatment of malnutrition can lead to better quality of life[10] and improved outcomes[11] in older inpatients. Therefore, it is essential to apply appropriate tools to assess the risk of malnutrition in geriatric patients.

Nutritional risk screening and nutritional assessment tools are readily available nowadays.[12] These tools are used to identify patients with nutritional risk or nutritional deficiencies and to determine if intervention is needed. There are a variety of nutritional risk screening methods,[13] mainly involving anthropometric and biochemical parameters. However, to date, no single tool has been considered as the universal gold standard for the assessment of nutritional risk among the older inpatients.

The Nutritional Risk Screening (NRS2002) is recommended for hospitalized patients by the European Society of Parenteral and Enteral Nutrition (ESPEN).[14] It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.[15, 16] However, the use of NRS2002 excludes patients who cannot be weighed or have problems of communication and the tool is

not specifically developed for older patients.

The Mini-Nutritional Assessment (MNA) is established for the nutritional screening and assessment in the geriatrics settings.[1, 17] The ESPEN recommends using this tool for elderly populations.[18] The MNA was validated against a clinical evaluations of two geriatrics, including biochemical parameters (nutritional parameters, C-reactive protein, cholesterol, vitamins), anthropometry (BMI, brachial circumference, calf circumference, skinfold width of the triceps and subscapular muscles), dietary components and functional assessment outcomes.[19] It has been shown to predict outcomes, functional status, mortality, number of hospital visits and the related healthcare costs.[18, 20-23] In comparison with the NRS2002, the MNA is more time consuming.[24] Hence, two short forms of the MNA have been developed and validated, the most recently the revised MNA-SF by Kaiser *et al*[25], which is currently the recommended version of the MNA for clinical use. This instrument only incorporates 6 of the original 18 items and takes approximately 5 minutes to perform.

Although a number of studies suggested that serum proteins are associated with malnutrition, the nature of this association is controversial.[26-28] In addition, hemoglobin and total lymphocyte count were also proposed as useful indicators of nutritional status.[27, 29] The aim of our study was to assess the risk of malnutrition among Chinese older participants with two different tools (NRS2002 and MNA), to compare them in terms of nutritional biochemical parameters and length of hospital stay (LOS), and determine the most appropriate tool for these patients. We hypothesized that both tools were suitable for the study population.

METHODS

Study subjects

This study consecutively recruited patients older than 70 years of age who attended internal medicine of geriatrics department of eight large size Tertiary comprehensive hospitals in Hubei Province from December 2014 to May 2016. The eight hospitals are as follows: (1) Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, (2) The Central Hospital of Wuhan University, (3) Zhongnan Hospital of Wuhan University, (4) Wuhan No. 6 Hospital, Affiliated Hospital of Jianghan University, (5) Hubei General Hospital, (6) General Hospital of The Yangtze River Shipping, (7) Wuhan No. 1 Hospital, (8) The First College of Clinical Medical Science, Three Gorges University and Yichang Central People's Hospital.

This cross-sectional study received approval from the institutional Ethics Committee and all subjects signed written informed consent before participation. Inclusion criteria were: (1) age 70 years or older, (2) the patients themselves or their proxies could clearly answer study questions, (3) hospital stay was longer than 24 hours and (4) patients were willing to cooperate with the study. Exclusion criteria included: (1) younger than 70 years old, (2) refusal to participate in the study and (3) patients was unconscious or unable to answer the study questions (Figure 1).

Nutritional risk screening 2002 (NRS2002)

The NRS2002 consists of the following parameters: the severity of acute illness, BMI, patient appetite, accidental weight loss and patient age.[15] The total score ranges from 0 to 7.[16] For investigational purposes, patients were categorized into two groups: a total score ≥3 indicates under-nourished (at nutritional risk/malnourished) and 0-2 indicates normal nutrition status.[14, 30] A nutritional care plan was initiated for patients with a score ≥3.[31]

Mini-Nutritional Assessment (MNA)

The MNA is consisted of four parts: anthropometric assessment (0-8 points), general assessment (0-9 points), dietetic habits evaluation (0-9 points) and self-assessment of the nutrition and health status (0-4 points).[32] A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.[33] In addition, a nutritional care plan was initiated for patients with a score <17.[31]

Data Collecting

Each hospital had 2 researchers trained before the start of the study. The main contents were about how to interpret the questions in the instruments (MNA and NRS2002) and how to perform the measurements. The patients were evaluated with

both MNA and NRS2002 by two trained researchers on the first day of admission or early morning of the next day.

Comorbidities and length of hospitalization were obtained from medical records. Patients were diagnosed by their bedside clinician and superior clinicians. Two trained researchers of each hospital verified the diagnoses and acquired data. Both body height and weight were measured at 6-8 am within 24 hours after admission. Patients were asked to be fasting, only wearing ward clothes and taking off shoes before measurement. Besides, height was measured with a calibrated scale (corrected to ±0.5 cm). The actual body mass was measured with a calibrated scale (corrected to ±0.2 kg). Then, the body mass index (BMI) was calculated as weight/height squared (kg/m^2).

Blood samples were also obtained within 24 hours after admission. Nutritional biochemical parameters including serum hemoglobin (Hb), total lymphocyte count (TLC), albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical chemistry laboratory. Malnutrition was determined when the value of Hb was <120 g/L for males and <110 g/L for females. The cutoff value of ALB was 35 g/L (normal range 35-55 g/L), PAB was 200mg/L (normal range 200-400 mg/L) and TLC was 1.1×10^9/L (normal range $1.1\text{-}3.2\times10^9$/L) for both genders for malnutrition.[34] Moreover, based on previous research[35], the cutoff value of BMI was set at 20.5 kg/m^2 for malnutrition.

Patient and public involvement

Patients did not participate in the design and conception of the proposed study. No patients were asked to advice on interpretation or writing up of results. Besides, the results of measurements would be disseminated to participants immediately after the investigation.

Statistical analysis

The statistical analyses were conducted using SPSS 19.0. Data were presented as mean ± standard deviation and ranges in blanket. The chi-square test or student's *t*-test was used according to the data type. One-way analysis of variance was applied for multigroup comparisons and correlation analysis was qualified by the Pearson correlation test. The simple linear regression analysis was used to estimate the relationship between both instruments (MNA/NRS2002) and LOS. Agreement between the two screening tools was achieved by the kappa (κ) statistic. The results were interpreted as follows: <0, no agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate agreement; 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.[29] In addition, the receiver operating characteristic (ROC) curve was applied to compare MNA and NRS2002 separately with nutritional parameters using Medcalc 18.6. The level of significance was set at $P<0.05$.

RESULTS

Over the study period, a total of 425 individuals from the Department of Geriatrics of eight hospitals in Hubei Province met the eligibility criteria and completed a nutrition assessment within 24 hours of admission (Figure 1). The average age was 81.2±5.9 years (range, 70-98) and 31.1% were females. The average body mass index was 23.2±3.7 kg/m^2 (range, 11.1-34.1). The average length of hospitalization was 21.9±13.8 days (range, 4-133). The most frequent cause of hospitalization was cardiac disease, followed by pulmonary infection, hypertension, cerebrovascular diseases, digestive disease and malignancies. However, the most frequent comorbidities were hypertension, diabetes mellitus, cardiac disease and cerebrovascular disease. Characteristics of study participants are shown in Table 1.

According to the NRS2002, approximately 174 patients (40.9%) were under-nourished and 251 patients (59.1%) were at normal nutritional status. The MNA demonstrated that 99 patients (23.3%) were malnourished, 150 patients (35.3%) were at risk of malnutrition and 176 patients (41.4%) had a normal nutritional status.

Table 2 showed the risk of undernutrition, varying from 23.7% to 58.6%, according to the different methods employed in the current work. The risk of under-nourished participants classified by NRS2002, MNA, BMI, ALB, PAB, TLC were 40.9%, 58.6%, 23.7%, 28.7%, 47.3%, 35.9%, respectively. The risk of malnutrition was higher in men than that in women according to hemoglobin (41.7% vs 25.6%, respectively).

Although both instruments were closely related to each other (P<0.001), they

showed substantial differences. Table 3 showed the cross-classification of MNA and NRS2002 regarding two nutritional categories. The MNA classified more patients as under-nourished than the NRS2002 (249 vs 174, respectively). Among the 249 patients classified as under-nourished by the MNA, the NRS2002 coincidently categorized 159 as malnourished, and 90 as well-nourished. The NRS2002, on the other hand, classified 174 patients as under-nourished. Within this group of participants, the MNA classified 159 patients as under-nourished and 15 as well-nourished. What's more, a participant considered by the MNA to be well-nourished can be classified as under-nourished using the NRS2002. The individual categorization of nutritional status presented moderate agreement between MNA and NRS2002 (κ=0.521, P<0.001).

Data of Hb, TLC, ALB and PAB concentrations are listed in Table 2 and additional Table 1. There existed significant decrease of ALB, PAB, Hb and TLC in the three groups of MNA scores (P<0.001 and P=0.023, Figure 2a). Specifically, the group with the lowest MNA score <17 (n=99), indicating a poor nutritional state, had an average serum albumin of 33.3±4.8 g/L (range, 22.8-43.2), an average prealbumin of 140.8±81.7 mg/L (range, 12-339) and an average hemoglobin of 109.0±20.8 g/L (range, 57-150.2) as well as an average lymphocyte count of 1.5±1.2 10^9/L (range, 0.3-6.6). In the risk of malnutrition group with an MNA score of 17-23.5 (n=150), average serum albumin was 37.9±5.6 g/L (range, 21.6-70), average prealbumin 192.3±61.8 mg/L (range, 8-380), average hemoglobin 120.2±22.0 g/L (range, 55-181) and an average lymphocyte count of 1.3±0.56 10^9/L (range, 0.2-2.9). The group with

MNA≥24 (n=180) had an average serum albumin concentration of 39.8±3.8 g/L (range, 29.3-54), an average prealbumin of 216.7±54.4 mg/L (range, 25-337), an average hemoglobin of 127.6±15.3 g/L (range, 81-173) and an average lymphocyte count of 1.5±0.7 10^9/L (range, 0.3-4.3; Figure 2a, additional Table 1).

Similarly, ALB, PAB and Hb gradually declined with increasing risk of malnutrition according to NRS2002 results (P<0.001, figure 2b). In under-nourished patients (NRS2002: 3-7, n=174), average serum albumin was 35.1±5.6 g/L (range, 21.6-50.2), average prealbumin 148.5±79.3 mg/L (range, 17-339) and average hemoglobin 113.3±23.6 g/L (range, 55-181). In the normal nutritional state group (NRS2002: 0-2, n=251), the results were as follows: albumin 39.4±4.5 g/L (range, 26.4-70), prealbumin 210.2±56.1 mg/L (range, 8-380) and hemoglobin 125.8±16.2 g/L (range, 72-173). By contrast, no difference in lymphocyte count was found in both groups (P=0.089, Figure 2b, additional Table 1).

Table 4 showed the Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated negatively with malnutrition scores of NRS2002, while showed positive correlation with the MNA scores (P<0.001). There existed an inverse correlation between age and the two tools (P<0.001). Besides, a significant association between both tools and LOS was demonstrated (P<0.05). No correlation was found between TLC and the two tools.

Table 5 showed the simple linear regression of LOS. There was a linear correlation between the MNA scores and LOS (P<0.05) and so was the NRS2002

scores (P<0.01).

Figure 3 showed the ROC curve analysis of the sensitivities and specificities of MNA and NRS2002 for predicting nutritional risk. The comparison between MNA and NRS2002 in those patients revealed the area under ROC curve (AUC) values for MNA (0.794, ALB; 0.704, PAB; 0.702, Hb; 0.581, TLC) and NRS2002 (0.761, ALB; 0.616, PAB; 0.677, Hb; 0.586, TLC). Besides, the comparison between the AUC showed that NRS2002 was not different from MNA for predicting nutritional risk (P=0.191, ALB; P=0.063, PAB; P=0.299, Hb; P=0.866, TLC).

DISCUSSION

Based on the current study, the nutritional health of older inpatients was assessed using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. The results showed that the overall prevalence of malnutrition risk for the enrolled older patients ranged from 23.7% to 58.6%. The highest prevalence of malnutrition risk was detected by MNA and the lowest by BMI. These results illustrated the differences in nutritional risk detected by different screening tools.

Biochemical markers possess many advantages in assessing the nutritional status, such as fast application and low cost. In addition, they can also be incorporated into the routine of clinical application. As the most abundant plasmatic protein, albumin is commonly used in the assessment of malnutrition.[36] In several of studies, low serum ALB correlated with longer hospitalization, medical complications, and increased

mortality.[36-38] Nevertheless, its value is still limited by the long half-life (14-20 days), inflammation, the impairment of hepatic or renal, and possibly aging itself.[27] Due to the reasons above, the prevalence of malnutrition detected by ALB is lower than MNA and NRS2002 in our study. Comparatively, a study by Covinsky *et al*[39] showed ALB is highly sensitive yet low specific in the diagnosis of malnutrition in the hospitalized older adults.

Prealbumin has been regarded as a more sensitive marker than albumin for acute nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in nutritional screening and mortality prediction remain controversial.[40-43] In our study, prealbumin levels showed a great decline with deteriorating nutrition status assessed by both NRS2002 and MNA. The correlation between serum prealbumin and MNA is consistent with one study[44], yet is in contrast with another report.[42] This latter study had a small sample size (23 older patients), which may account for the discrepancies. Similar to serum albumin, the usage of prealbumin in predicting malnutrition is limited due to systemic inflammatory diseases.[41, 45]

Hemoglobin has been demonstrated to decrease with progressive malnutrition.[46, 47] This relationship, consistent with a recent analysis performed in Northern China[29], is found in the proposed study. Total lymphocyte count was assumed to be suitable in screening test for assessing malnutrition and being an indicator of a poor prognosis.[27] In agreement with Lei *et al*[48], we also found a significant correlation between TLC and MNA. However, no correlation was found between NRS2002 and TLC, which was consistent with a previous study.[29]

The prevalence of malnutrition diagnosed by BMI was far below that detected by MNA. Consistent with findings from another study[49], this study suggested that malnutrition was also under diagnosed when using BMI as the sole criteria. The reason is most possibly related to water-sodium retention in patients, leading to an overestimation of their true weight.[50] In spite of this, low BMI was significantly associated with mortality.[51]

Our study revealed that NRS2002 and MNA, in moderate agreement with each other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless, the MNA identified more patients with or at risk of malnutrition than the NRS2002 did. The lower percentage of malnutrition classified by NRS2002 may be explained in several ways. First, the NRS2002 mainly consider the influence of acute diseases on nutritional status, while the MNA take chronic long-term condition into consideration, such as psychological factors and the BMI. Psychological factors may play a large role in the nutritional status of older inpatients. In addition, we categorized undernutrition as NRS2002≥3, while patients with a score of 1-2 indicates low risk of malnutrition.[52] This may have underestimated the percentage of malnutrition. Moreover, our study subjects were internal medical patients, among which the proportion of overweight and obesity was high. The NRS2002 takes BMI < 18.5 kg/m^2 as one of the criteria, leading to a lower proportion of malnutrition with NRS2002 than that of MNA. Our results agree with findings from Raslan *et al,*[5] yet differ from the study conducted by Drescher *et al*.[52] The latter study was conducted in older patients with acute disease, which may explain the difference.

Norman *et al* suggested that there exists a close relationship between the degree of malnutrition and LOS.[53] In the present study, we found the linear relation between both instruments (MNA and NRS2002) and LOS. Our findings corroborated those of the study conducted by Bauer *et al,*[54] showing longer hospital stay was associated with malnutrition assessed by the MNA. Comparison of the MNA and NRS 2002 and their ability to predict nutritional risk according to different standards showed that MNA and NRS 2002 were the both suitable screening tools, in terms of the ROC curve area. Therefore, we conclude, that in Chinese geriatric inpatients, the NRS2002 and MNA might reflect malnutrition or the studied biochemical parameters, as well as predict the length of hospitalization. However, the MNA was available for identifying most of the patients with or at risk of malnutrition.

Limitations

Our study still has some limitations. First, a consensus statement with diagnostic criteria for malnutrition was proposed in 2015[55] after our study initiated and thus it was not utilized in our study. Second, BMI and age were parts of the screening tools, therefore already correlated with the MNA and NRS-2002 assessment. Besides, in addition to nutritional status, LOS could also be influenced by age, financial situation, comorbidities and so on, which may explain the low R^2 between both instruments and LOS. Finally, regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined, which may contribute to the low Kappa value between the two instruments.

CONCLUSION

To conclude, the results of the present study show a high prevalence of malnutrition risk in Chinese geriatric hospitalized patients. Although the nutritional risk varied depending on the applied method, both NRS2002 and MNA correlated with each other and with age, BMI and laboratory parameters. Besides, both tools were proved to be a good predictor of the length of hospitalization. Moreover, the NRS2002 was not different from MNA for predicting nutritional risk according to the AUC. Therefore, this study suggested NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients. We recommend using one of them in admission.

Acknowledgements We are appreciated for the participating volunteer patients, the local research ethics committee and the individual researchers, clinicians and nurses for their participation in the data collection.

Contributors JPM, XQQ and HLZ are main contributors to the design of the present study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ, took part in the discussion and modification of the study design. HZ, MY, LYS, QHG, GYZ, QJM, YXW, and SGL contributed to the study conception. XQQ, HZ, MY, LYS, QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of data. JPM and

XQQ made contributions to the drafting of the manuscript. HLZ and CTZ were involved in the critical revision. All the authors were involved in the analysis and interpretation of the data and gave their final approval.

Funding This project was funded by the National Natural Science Foundation of China (Grant No. 81400255).

Competing interests None declared.

Ethics approval Ethics Review Board of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-C20141112).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legend

Figure 1 Flow diagram of participant inclusion and exclusion.

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

REFERENCES

1. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? *J Nutr Health Aging*. 2006;10:466-85; discussion 485-7.
2. Chang SF. Frailty Is a Major Related Factor for at Risk of Malnutrition in Community-Dwelling Older Adults. *J Nurs Scholarsh*. 2017;49:63-72.
3. Lumale S. [Nutritional management of elderly people, everyone's concern]. *Rev Infirm*. 2017;66:25-26.
4. Lesourd B. Nutritional factors and immunological ageing. *Proc Nutr Soc*. 2006;65:319-25.
5. Raslan M, Gonzalez MC, Dias MC, *et al.* Comparison of nutritional risk screening tools for predicting clinical outcomes in hospitalized patients. *Nutrition*. 2010;26:721-6.
6. Ehwerhemuepha L, Bendig D, Steele C, *et al.* The Effect of Malnutrition on the Risk of Unplanned 7-Day Readmission in Pediatrics. *Hosp Pediatr*. 2018.
7. Ahmed N, Choe Y, Mustad VA, *et al.* Impact of malnutrition on survival and healthcare utilization in Medicare beneficiaries with diabetes: a retrospective cohort analysis. *BMJ Open Diabetes Res Care*. 2018;6:e000471.
8. Sharma Y, Miller M, Kaambwa B, *et al.* Malnutrition and its association with readmission and death within 7 days and 8-180 days postdischarge in older patients: a prospective observational study. *BMJ Open*. 2017;7:e018443.
9. Khalatbari-Soltani S,Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN*. 2015;10:e89-e94.
10. Bouillanne O, Curis E, Hamon-Vilcot B, *et al.* Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: a randomized controlled trial. *Clin Nutr*. 2013;32:186-92.
11. Ballesteros-Pomar MD, Martinez Llinas D, Goates S, *et al.* Cost-Effectiveness of a Specialized Oral Nutritional Supplementation for Malnourished Older Adult Patients in Spain. *Nutrients*. 2018;10.
12. Racic M, Ivkovic N,Kusmuk S. [Screening of Nutritional Status among Elderly People at Family Medicine]. *Acta Med Croatica*. 2015;69:347-56.
13. Abd Aziz NAS, Teng N, Abdul Hamid MR, *et al.* Assessing the nutritional status of hospitalized elderly. *Clin Interv Aging*. 2017;12:1615-1625.
14. Elia M,Stratton R. On the ESPEN guidelines for nutritional screening 2002. *Clin Nutr*. 2004;23:131-2.
15. Kondrup J, Rasmussen HH, Hamberg O, *et al.* Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22:321-36.
16. Kondrup J, Allison SP, Elia M, *et al.* ESPEN guidelines for nutrition screening 2002. *Clin Nutr*. 2003;22:415-21.
17. Guigoz Y, Vellas B,Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr Rev*. 1996;54:S59-65.
18. Bleda MJ, Bolibar I, Pares R, *et al.* Reliability of the mini nutritional assessment

(MNA) in institutionalized elderly people. *J Nutr Health Aging*. 2002;6:134-7.
19. Bauer JM, Kaiser MJ, Anthony P, *et al.* The Mini Nutritional Assessment--its history, today's practice, and future perspectives. *Nutr Clin Pract*. 2008;23:388-96.
20. Soderstrom L, Rosenblad A, Adolfsson ET, *et al.* Nutritional status predicts preterm death in older people: a prospective cohort study. *Clin Nutr*. 2014;33:354-9.
21. Dent E, Visvanathan R, Piantadosi C, *et al.* Use of the Mini Nutritional Assessment to detect frailty in hospitalised older people. *J Nutr Health Aging*. 2012;16:764-7.
22. Cabre M, Ferreiro C, Arus M, *et al.* Evaluation of CONUT for Clinical Malnutrition Detection and Short-Term Prognostic Assessment in Hospitalized Elderly People. *J Nutr Health Aging*. 2015;19:729-33.
23. Chavarro-Carvajal D, Reyes-Ortiz C, Samper-Ternent R, *et al.* Nutritional assessment and factors associated to malnutrition in older adults: a cross-sectional study in Bogota, Colombia. *J Aging Health*. 2015;27:304-19.
24. Kyle UG, Kossovsky MP, Karsegard VL, *et al.* Comparison of tools for nutritional assessment and screening at hospital admission: a population study. *Clin Nutr*. 2006;25:409-17.
25. Kaiser MJ, Bauer JM, Ramsch C, *et al.* Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging*. 2009;13:782-8.
26. Sergi G, Coin A, Enzi G, *et al.* Role of visceral proteins in detecting malnutrition in the elderly. *Eur J Clin Nutr*. 2006;60:203-9.
27. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. *Nutrition*. 2000;16:131-40.
28. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools. *Nutrition*. 2000;16:50-63.
29. Zhou J, Wang M, Wang H, *et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
30. Thoresen L, Frykholm G, Lydersen S, *et al.* Nutritional status, cachexia and survival in patients with advanced colorectal carcinoma. Different assessment criteria for nutritional status provide unequal results. *Clin Nutr*. 2013;32:65-72.
31. Wei J, Chen W, Zhu M, *et al.* Guidelines for parenteral and enteral nutrition support in geriatric patients in China. *Asia Pac J Clin Nutr*. 2015;24:336-46.
32. Jacobsen EL, Brovold T, Bergland A, *et al.* Prevalence of factors associated with malnutrition among acute geriatric patients in Norway: a cross-sectional study. *BMJ Open*. 2016;6:e011512.
33. Guigoz Y,Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. *Nestle Nutr Workshop Ser Clin Perform Programme*. 1999;1:3-11; discussion 11-2.
34. Blackburn GL, Bistrian BR, Maini BS, *et al.* Nutritional and metabolic

assessment of the hospitalized patient. *JPEN J Parenter Enteral Nutr*. 1977;1:11-22.

35. Zhou J, Wang M, Wang H, *et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
36. Cabrerizo S, Cuadras D, Gomez-Busto F, *et al.* Serum albumin and health in older people: Review and meta analysis. *Maturitas*. 2015;81:17-27.
37. O'Daly BJ, Walsh JC, Quinlan JF, *et al.* Serum albumin and total lymphocyte count as predictors of outcome in hip fractures. *Clin Nutr*. 2010;29:89-93.
38. Chiu PF, Tsai CC, Wu CL, *et al.* Trajectories of Serum Albumin Predict Survival of Peritoneal Dialysis Patients: A 15-year Follow-Up Study. *Medicine (Baltimore)*. 2016;95:e3202.
39. Covinsky KE, Covinsky MH, Palmer RM, *et al.* Serum albumin concentration and clinical assessments of nutritional status in hospitalized older people: different sides of different coins? *Journal of the American Geriatrics Society*. 2002;50:631-7.
40. Carriere I, Dupuy AM, Lacroux A, *et al.* Biomarkers of inflammation and malnutrition associated with early death in healthy elderly people. *Journal of the American Geriatrics Society*. 2008;56:840-6.
41. Devoto G, Gallo F, Marchello C, *et al.* Prealbumin serum concentrations as a useful tool in the assessment of malnutrition in hospitalized patients. *Clinical chemistry*. 2006;52:2281-5.
42. Langkamp-Henken B, Hudgens J, Stechmiller JK, *et al.* Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *J Am Diet Assoc*. 2005;105:1590-6.
43. Kanda M, Mizuno A, Tanaka C, *et al.* Nutritional predictors for postoperative short-term and long-term outcomes of patients with gastric cancer. *Medicine (Baltimore)*. 2016;95:e3781.
44. Vellas B, Guigoz Y, Baumgartner M, *et al.* Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. *Journal of the American Geriatrics Society*. 2000;48:1300-9.
45. Lopez-Hellin J, Baena-Fustegueras JA, Schwartz-Riera S, *et al.* Usefulness of short-lived proteins as nutritional indicators surgical patients. *Clin Nutr*. 2002;21:119-25.
46. Wham CA, Teh RO, Robinson M, *et al.* What is associated with nutrition risk in very old age? *J Nutr Health Aging*. 2011;15:247-51.
47. Weng CH, Hsu CW, Hu CC, *et al.* Association Between Hemodiafiltration and Hypoalbuminemia in Middle-Age Hemodialysis Patients. *Medicine (Baltimore)*. 2016;95:e3334.
48. Lei Z, Qingyi D, Feng G, *et al.* Clinical study of mini-nutritional assessment for older Chinese inpatients. *J Nutr Health Aging*. 2009;13:871-5.
49. Antaki F, French MM, Moonka DK, *et al.* Bioelectrical impedance analysis for the evaluation of hepatic fibrosis in patients with chronic hepatitis C infection. *Dig Dis Sci*. 2008;53:1957-60.
50. Roongpisuthipong C, Sobhonslidsuk A, Nantiruj K, *et al.* Nutritional assessment

in various stages of liver cirrhosis. *Nutrition*. 2001;17:761-5.
51. Akinyemiju T, Meng Q,Vin-Raviv N. Association between body mass index and in-hospital outcomes: Analysis of the nationwide inpatient database. *Medicine (Baltimore)*. 2016;95:e4189.
52. Drescher T, Singler K, Ulrich A, *et al.* Comparison of two malnutrition risk screening methods (MNA and NRS 2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. *Eur J Clin Nutr*. 2010;64:887-93.
53. Norman K, Pichard C, Lochs H, *et al.* Prognostic impact of disease-related malnutrition. *Clin Nutr*. 2008;27:5-15.
54. Bauer JM, Vogl T, Wicklein S, *et al.* Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients. *Z Gerontol Geriatr*. 2005;38:322-7.
55. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr. 2015;34:335-40.

Table 1 Characteristic of study participants

Variable	All subjects（n=425）
Age (year)	81.2±5.9 (70-98)
Gender	
Male	68.9% (293)
Female	31.1% (132)
Height (m)	1.6±0.1 (1.4-1.8)
Weight (kg)	62.9±11.5 (28.4-92.0)
Body mass index (kg/m^2)	23.2±3.7 (11.1-34.1)
Length of hospital stay (day)	21.9±13.8 (4-133)
Primary cause of admission to hospital	
Cardiac disease	160 (37.6%)
Pulmonary infection	84 (19.8%)
Hypertension	76 (17.9%)
Cerebrovascular disease	45 (10.6%)
Digestive disease	25 (5.9%)
Malignancy	19 (4.5%)
Others	16 (3.8%)
Comorbidities	
Hypertension	210 (49.4%)
Diabetes mellitus	101 (23.8%)
Cardiac disease (including atrial fibrillation)	94 (22.1%)
Cerebrovascular disease	30 (7.1%)

Values are mean ± standard deviation (with ranges in brackets) or % (numbers), respectively.

Table 2 Nutritional status (%, n) of 425 patients classified by NRS2002, MNA, BMI and serum parameters

	Under-nourished	Well-nourished
NRS2002	40.9% (174)	59.1% (251)
MNA	58.6% (249)	41.4% (176)
BMI	23.7% (93)	76.3% (300)
ALB	28.7% (122)	71.3% (303)
PAB	47.3% (70)	52.7% (78)
Hb (male)	41.7% (121)	58.3% (169)
Hb (female)	25.6% (33)	74.4% (96)
TLC	35.9% (149)	64.1% (266)

ALB = albumin, BMI = Body mass index, Hb = hemoglobin, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count. Under-nourished (malnourished + at risk of malnutrition).

Table 3 Cross-classification

MNA	NRS2002		Total
	Under-nourished	Well-nourished	
Under-nourished	159	90	249
Well-nourished	15	161	176
Total	174	251	425
Kappa	0.521		
P	<0.001		

Number of patients classified into two categories according to MNA and NRS, respectively. MNA = Mini-Nutritional assessment, NRS2002 = Nutritional risk score 2002. Under-nourished: malnutrition + at risk of malnutrition.

Table 4 Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS

	MNA		NRS2002	
	r	***p***	***r***	***p***
Age	-0.239	<0.001	0.238	<0.001
BMI	0.578	<0.001	-0.347	<0.001
Hb	0.387	<0.001	-0.321	<0.001
TLC	-0.002	0.966	0.011	0.819
ALB	0.501	<0.001	-0.383	<0.001
PAB	0.481	<0.001	-0.332	<0.001
LOS	-0.109	0.048	0.178	0.001
NRS2002	-0.640	<0.001	—	—

ALB = albumin, BMI = body mass index, Hb = hemoglobin, LOS = length of hospital stay, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count.

Table 5 The simple linear regression analysis of LOS

	B	SE	β	t	*P*	95%CI	R^2	F
MNA	-0.261	0.131	-0.109	-1.987	<0.05	-0.519,-0.003	0.012	3.949
NRS2002	1.891	0.575	0.178	3.291	<0.01	0.761,3.022	0.032	10.834

LOS = length of hospital stay, CI = confidence interval, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002.

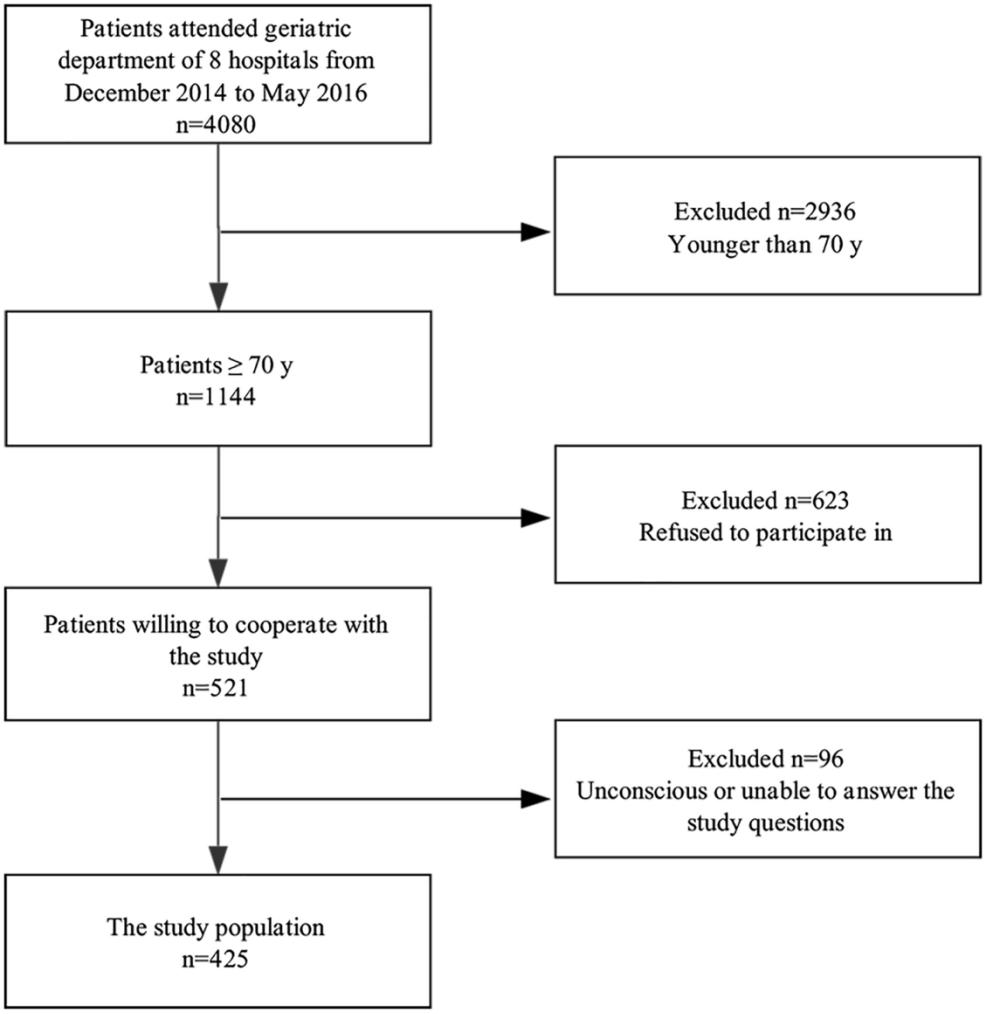

Figure 1 Flow diagram of participant inclusion and exclusion.

167x172mm (300 x 300 DPI)

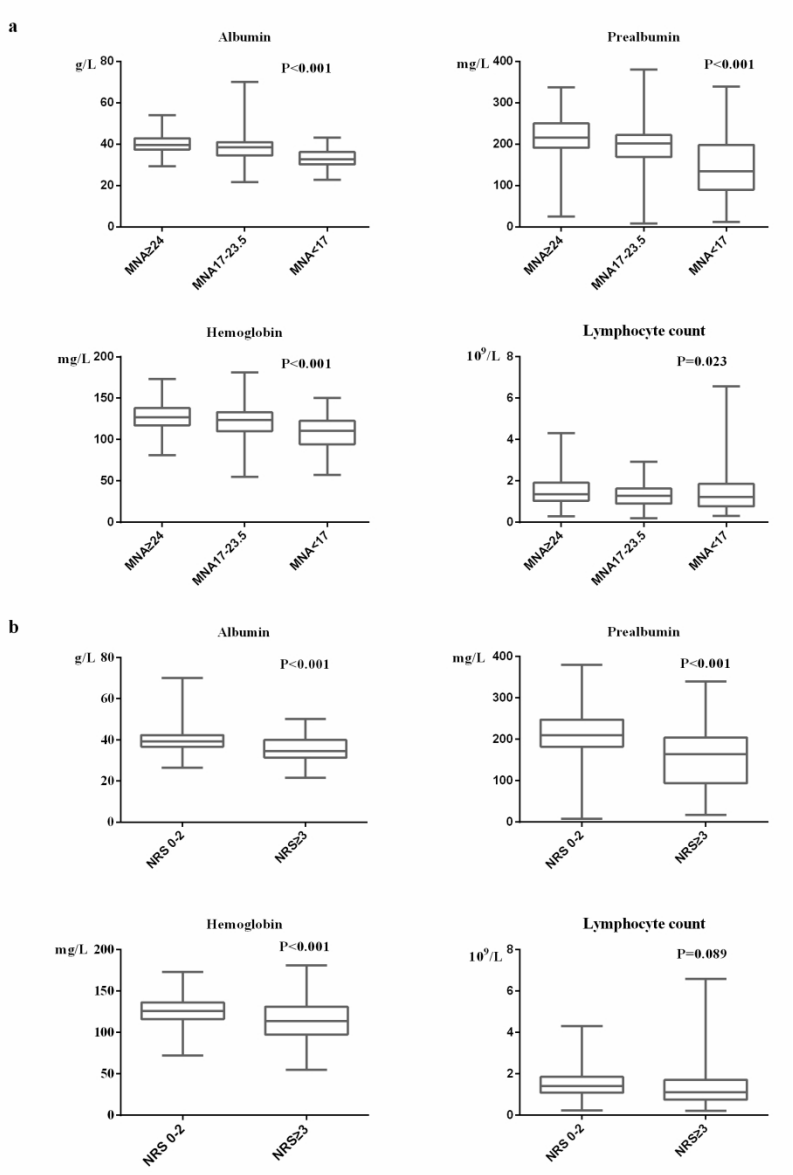

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

175x262mm (300 x 300 DPI)

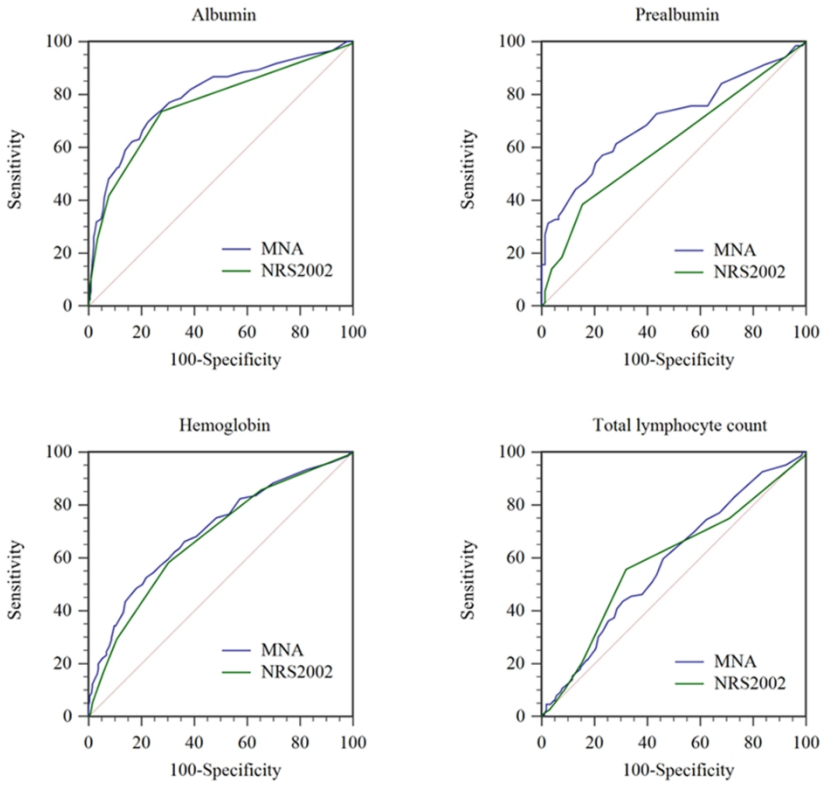

Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

170x139mm (300 x 300 DPI)

Additional Table 1 Nutritional parameters of study participants classified by MNA and NRS2002

	ALB (g/L)	PAB (mg/L)	Hb (g/L)	TLC (10^9/L)
MNA				
<17	33.3±4.8 (22.8-43.2)	140.8±81.7 (12-339)	109.0±20.8 (57-150.2)	1.5±1.2 (0.3-6.6)
17-23.5	37.9±5.6 (21.6-70)	192.3±61.8 (8-380)	120.2±22.0 (55-181)	1.3±0.6 (0.2-2.9)
≥24	39.8±3.8 (29.3-54)	216.7±54.4 (25-337)	127.6±15.3 (81-173)	1.5±0.7 (0.3-4.3)
NRS2002				
≥3	35.1±5.6 (21.6-50.2)	148.5±79.3 (17-339)	113.3±23.6 (55-181)	1.4±1.0 (0.2-6.6)
0-2	39.4±4.5 (26.4-70)	210.2±56.1 (8-380)	125.8±16.2 (72-173)	1.5±0.6 (0.2-4.3)

ALB = albumin, PAB = prealbumin, Hb = hemoglobin, TLC = total lymphocyte count, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002. Values are mean ± standard deviation (with ranges in brackets)

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-022993.R3
Article Type:	Research
Date Submitted by the Author:	21-Oct-2018
Complete List of Authors:	Miao, Jian-Ping; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Quan, Xiao-Qing; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhang, Cun-Tai; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics Mei, Qi-Jian; General Hospital of the Yangtze River Shipping Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics Li, Shu-Guo; First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital, Department of Geriatrics Zhou, Hong-Lian; Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Department of Geriatrics; Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	malnutrition risk, NRS2002, MNA, older patients

Comparison of two malnutrition risk screening tools with nutritional biochemical parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter, cross-sectional study

Jian-Ping Miao[1, 2, 3], Xiao-Qing Quan[1, 2, 3], Cun-Tai Zhang[1, 2, 3], Hong Zhu[4], Mei Ye[5], Li-Ya Shen[6], Qiu-Hui Guo[6], Gang-Yan Zhu[7], Qi-Jian Mei[8], Yan-Xia Wu[9], Shu-Guo Li[10], Hong-Lian Zhou [1, 2, 3]*

Running title: Malnutrition screening in Chinese geriatric patients

1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology;

2. Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine in Hubei Province

3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ Dysfunction in Wuhan

4. Department of Geriatrics, the Central Hospital of Wuhan University;

5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;

6. Department of Geriatrics, Wuhan No. 6 Hospital;

7. Department of Geriatrics, Hubei General Hospital;

8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;

9. Department of Geriatrics, Wuhan No 1 Hospital;

10. Department of Geriatrics, First Clinical Medical College, Three Gorges University & Yichang Central People's Hospital.

JPM and XQQ contributed equally.

Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com

ABSTRACT

Objectives: The aim of this study was to assess malnutrition risk in Chinese geriatric inpatients with Nutritional Risk Screening (NRS2002) and Mini-Nutritional Assessment (MNA), and to identify the most appropriate nutritional screening tool for these patients.

Design: Cross-sectional study.

Setting: Eight medical centers in Hubei province, China.

Participants: A total of 425 inpatients aged ≥70 years were consecutively recruited between December 2014 and May 2016.

Primary and secondary outcome measures: Nutritional risk was assessed using NRS2002, MNA, anthropometric measurements and biochemical parameters within 24 hours of admission. Comorbidities and length of hospitalization were recorded. Nutritional parameters, BMI and length of hospital stay were employed to compare MNA and NRS2002. Besides, Kappa analysis was used to evaluate the consistency of the two tools.

Results: The average age was 81.2±5.9 years (range, 70-98). The prevalence of undernutrition classified by NRS2002 and MNA was 40.9% and 58.6%, respectively. Patients undergoing malnutrition had lower BMI, hemoglobin, albumin and prealbumin (P<0.05), and longer length of hospital stay (LOS) (P<0.05). The NRS2002 showed moderate agreement (κ=0.521, P<0.001) with MNA. Both tools presented significant correlation with age, BMI and laboratory parameters (P<0.001). In addition, a significant association between both tools and LOS was found (P<0.05). Besides, the NRS2002 was not different from MNA for predicting nutritional risk in terms of the area under receiver

operating characteristic curve (P>0.05).

Conclusions: The results show a relatively high prevalence of malnutrition risk in our sample cohort. We found that NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients.

Strengths and limitations of this study

- ► This study assessed the risk of malnutrition among Chinese elderly inpatients with two different tools (NRS2002 and MNA).
- ► The study provides useful information to assess the risk of malnutrition among Chinese elderly inpatients.
- ► The consensus statement with diagnostic criteria for malnutrition was proposed in 2015 after our study initiated, and thus it was not utilized in our study.
- ► Regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined.
- ► In addition to nutritional status, LOS could also be influenced by age, financial situation, comorbidities and so on, which may explain the low R^2 regarding simple linear regression analysis.

Keywords: malnutrition risk; NRS2002; MNA; older patients

INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.[1] It is highly associated with numerous adverse outcomes including frailty,[2] muscle wasting[3], weakened immune system[4], longer hospitalization,[5] increased morbidity[6] and mortality.[7, 8] These outcomes contribute to large increases in medical expenditures.[9] Early identification and treatment of malnutrition can lead to better quality of life[10] and improved outcomes[11] in older inpatients. Therefore, it is essential to apply appropriate tools to assess the risk of malnutrition in geriatric patients.

Nutritional risk screening and nutritional assessment tools are readily available nowadays.[12] These tools are used to identify patients with nutritional risk or nutritional deficiencies and to determine if intervention is needed. There are a variety of nutritional risk screening methods,[13] mainly involving anthropometric and biochemical parameters. However, to date, no single tool has been considered as the universal gold standard for the assessment of nutritional risk among the older inpatients.

The Nutritional Risk Screening (NRS2002) is recommended for hospitalized patients by the European Society of Parenteral and Enteral Nutrition (ESPEN).[14] It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.[15, 16] However, the use of NRS2002 excludes patients who cannot be weighed or have problems of communication and the tool is not specifically developed for older patients.

The Mini-Nutritional Assessment (MNA) is established for the nutritional screening and assessment in the geriatrics settings.[1, 17] The ESPEN recommends using this tool for elderly populations.[18] The MNA was validated against a clinical evaluations of two geriatrics, including biochemical parameters (nutritional parameters, C-reactive protein, cholesterol, vitamins), anthropometry (BMI, brachial circumference, calf circumference, skinfold width of the triceps and subscapular muscles), dietary components and functional assessment outcomes.[19] It has been shown to predict outcomes, functional status, mortality, number of hospital visits and the related healthcare costs.[18, 20-23] In comparison with the NRS2002, the MNA is more time consuming.[24] Hence, two short forms of the MNA have been developed and validated, the most recently the revised MNA-SF by Kaiser *et al*[25], which is currently the recommended version of the MNA for clinical use. This instrument only incorporates 6 of the original 18 items and takes approximately 5 minutes to perform.

Although a number of studies suggested that serum proteins are associated with malnutrition, the nature of this association is controversial.[26-28] In addition, hemoglobin and total lymphocyte count were also proposed as useful indicators of nutritional status.[27, 29] The aim of our study was to assess the risk of malnutrition among Chinese older participants with two different tools (NRS2002 and MNA), to compare them in terms of nutritional biochemical parameters and length of hospital stay (LOS), and determine the most appropriate tool for these patients. We hypothesized that both tools were suitable for the study population.

METHODS

Study subjects

This study consecutively recruited patients older than 70 years of age who attended internal medicine of geriatrics department of eight large size Tertiary comprehensive hospitals in Hubei Province from December 2014 to May 2016. The eight hospitals are as follows: (1) Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, (2) The Central Hospital of Wuhan University, (3) Zhongnan Hospital of Wuhan University, (4) Wuhan No. 6 Hospital, Affiliated Hospital of Jianghan University, (5) Hubei General Hospital, (6) General Hospital of The Yangtze River Shipping, (7) Wuhan No. 1 Hospital, (8) The First College of Clinical Medical Science, Three Gorges University and Yichang Central People's Hospital.

This cross-sectional study received approval from the institutional Ethics Committee and all subjects signed written informed consent before participation. Inclusion criteria were: (1) age 70 years or older, (2) the patients themselves or their proxies could clearly answer study questions, (3) hospital stay was longer than 24 hours and (4) patients were willing to cooperate with the study. Exclusion criteria included: (1) younger than 70 years old, (2) refusal to participate in the study and (3) patients was unconscious or unable to answer the study questions (Figure 1).

Nutritional risk screening 2002 (NRS2002)

The NRS2002 consists of the following parameters: the severity of acute illness, BMI, patient appetite, accidental weight loss and patient age.[15] The total score ranges from 0 to 7.[16] For investigational purposes, patients were categorized into two groups: a total score ≥3 indicates under-nourished (at nutritional risk/malnourished) and 0-2 indicates normal nutrition status.[14, 30] A nutritional care plan was initiated for patients with a score ≥3.[31]

Mini-Nutritional Assessment (MNA)

The MNA is consisted of four parts: anthropometric assessment (0-8 points), general assessment (0-9 points), dietetic habits evaluation (0-9 points) and self-assessment of the nutrition and health status (0-4 points).[32] A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.[33] In addition, a nutritional care plan was initiated for patients with a score <17.[31]

Data Collecting

Each hospital had 2 researchers trained before the start of the study. The main contents were about how to interpret the questions in the instruments (MNA and NRS2002) and how to perform the measurements. The patients were evaluated with both MNA and NRS2002 by two trained researchers on the first day of admission or early morning of the

next day.

Comorbidities and length of hospitalization were obtained from medical records. Patients were diagnosed by their bedside clinician and superior clinicians. Two trained researchers of each hospital verified the diagnoses and acquired data. Both body height and weight were measured at 6-8 am within 24 hours after admission. Patients were asked to be fasting, only wearing ward clothes and taking off shoes before measurement. Besides, height was measured with a calibrated scale (corrected to ±0.5 cm). The actual body mass was measured with a calibrated scale (corrected to ±0.2 kg). Then, the body mass index (BMI) was calculated as weight/height squared (kg/m^2).

Blood samples were also obtained within 24 hours after admission. Nutritional biochemical parameters including serum hemoglobin (Hb), total lymphocyte count (TLC), albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical chemistry laboratory. Malnutrition was determined when the value of Hb was <120 g/L for males and <110 g/L for females. The cutoff value of ALB was 35 g/L (normal range 35-55 g/L), PAB was 200mg/L (normal range 200-400 mg/L) and TLC was 1.1×10^9/L (normal range 1.1-3.2×10^9/L) for both genders for malnutrition.[34] Moreover, based on previous research[35], the cutoff value of BMI was set at 20.5 kg/m^2 for malnutrition.

Patient and public involvement

Patients did not participate in the design and conception of the proposed study. No

patients were asked to advice on interpretation or writing up of results. Besides, the results of measurements would be disseminated to participants immediately after the investigation.

Statistical analysis

The statistical analyses were conducted using SPSS 19.0. Data were presented as mean ± standard deviation and ranges in blanket. The chi-square test or student's *t*-test was used according to the data type. One-way analysis of variance was applied for multigroup comparisons and correlation analysis was qualified by the Pearson correlation test. The simple linear regression analysis was used to estimate the relationship between both instruments (MNA/NRS2002) and LOS. Agreement between the two screening tools was achieved by the kappa (κ) statistic. The results were interpreted as follows: <0, no agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate agreement; 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.[29] In addition, the receiver operating characteristic (ROC) curve was applied to compare MNA and NRS2002 separately with nutritional parameters using Medcalc 18.6. The level of significance was set at $P<0.05$.

RESULTS

Over the study period, a total of 425 individuals from the Department of Geriatrics of

eight hospitals in Hubei Province met the eligibility criteria and completed a nutrition assessment within 24 hours of admission (Figure 1). The average age was 81.2±5.9 years (range, 70-98) and 31.1% were females. The average body mass index was 23.2±3.7 kg/m^2 (range, 11.1-34.1). The average length of hospitalization was 21.9±13.8 days (range, 4-133). The most frequent cause of hospitalization was cardiac disease, followed by pulmonary infection, hypertension, cerebrovascular diseases, digestive disease and malignancies. However, the most frequent comorbidities were hypertension, diabetes mellitus, cardiac disease and cerebrovascular disease. Characteristics of study participants are shown in Table 1.

According to the NRS2002, approximately 174 patients (40.9%) were under-nourished and 251 patients (59.1%) were at normal nutritional status. The MNA demonstrated that 99 patients (23.3%) were malnourished, 150 patients (35.3%) were at risk of malnutrition and 176 patients (41.4%) had a normal nutritional status.

Table 2 showed the risk of undernutrition, varying from 23.7% to 58.6%, according to the different methods employed in the current work. The risk of under-nourished participants classified by NRS2002, MNA, BMI, ALB, PAB, TLC were 40.9%, 58.6%, 23.7%, 28.7%, 47.3%, 35.9%, respectively. The risk of malnutrition was higher in men than that in women according to hemoglobin (41.7% vs 25.6%, respectively).

Although both instruments were closely related to each other (P<0.001), they showed substantial differences. Table 3 showed the cross-classification of MNA and NRS2002

regarding two nutritional categories. The MNA classified more patients as under-nourished than the NRS2002 (249 vs 174, respectively). Among the 249 patients classified as under-nourished by the MNA, the NRS2002 coincidently categorized 159 as malnourished, and 90 as well-nourished. The NRS2002, on the other hand, classified 174 patients as under-nourished. Within this group of participants, the MNA classified 159 patients as under-nourished and 15 as well-nourished. What's more, a participant considered by the MNA to be well-nourished can be classified as under-nourished using the NRS2002. The individual categorization of nutritional status presented moderate agreement between MNA and NRS2002 (κ=0.521, P<0.001).

Data of Hb, TLC, ALB and PAB concentrations are listed in Table 2 and additional Table 1. There existed significant decrease of ALB, PAB, Hb and TLC in the three groups of MNA scores (P<0.001 and P=0.023, Figure 2a). Specifically, the group with the lowest MNA score <17 (n=99), indicating a poor nutritional state, had an average serum albumin of 33.3±4.8 g/L (range, 22.8-43.2), an average prealbumin of 140.8±81.7 mg/L (range, 12-339) and an average hemoglobin of 109.0±20.8 g/L (range, 57-150.2) as well as an average lymphocyte count of 1.5±1.2 10^9/L (range, 0.3-6.6). In the risk of malnutrition group with an MNA score of 17-23.5 (n=150), average serum albumin was 37.9±5.6 g/L (range, 21.6-70), average prealbumin 192.3±61.8 mg/L (range, 8-380), average hemoglobin 120.2±22.0 g/L (range, 55-181) and an average lymphocyte count of 1.3±0.56 10^9/L (range, 0.2-2.9). The group with MNA≥24 (n=180) had an average serum albumin concentration of 39.8±3.8 g/L (range, 29.3-54), an average prealbumin of 216.7±54.4 mg/L (range, 25-337),

an average hemoglobin of 127.6±15.3 g/L (range, 81-173) and an average lymphocyte count of 1.5±0.7 10^9/L (range, 0.3-4.3; Figure 2a, additional Table 1).

Similarly, ALB, PAB and Hb gradually declined with increasing risk of malnutrition according to NRS2002 results (P<0.001, figure 2b). In under-nourished patients (NRS2002: 3-7, n=174), average serum albumin was 35.1±5.6 g/L (range, 21.6-50.2), average prealbumin 148.5±79.3 mg/L (range, 17-339) and average hemoglobin 113.3±23.6 g/L (range, 55-181). In the normal nutritional state group (NRS2002: 0-2, n=251), the results were as follows: albumin 39.4±4.5 g/L (range, 26.4-70), prealbumin 210.2±56.1 mg/L (range, 8-380) and hemoglobin 125.8±16.2 g/L (range, 72-173). By contrast, no difference in lymphocyte count was found in both groups (P=0.089, Figure 2b, additional Table 1).

Table 4 showed the Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated negatively with malnutrition scores of NRS2002, while showed positive correlation with the MNA scores (P<0.001). There existed an inverse correlation between age and the two tools (P<0.001). Besides, a significant association between both tools and LOS was demonstrated (P<0.05). No correlation was found between TLC and the two tools.

Table 5 showed the simple linear regression of LOS. There was a linear correlation between the MNA scores and LOS (P<0.05) and so was the NRS2002 scores (P<0.01).

Figure 3 showed the ROC curve analysis of the sensitivities and specificities of MNA and NRS2002 for predicting nutritional risk. The comparison between MNA and NRS2002 in those patients revealed the area under ROC curve (AUC) values for MNA (0.794, ALB;

0.704, PAB; 0.702, Hb; 0.581, TLC) and NRS2002 (0.761, ALB; 0.616, PAB; 0.677, Hb; 0.586, TLC). Besides, the comparison between the AUC showed that NRS2002 was not different from MNA for predicting nutritional risk (*P*=0.191, ALB; *P*=0.063, PAB; *P*=0.299, Hb; *P*=0.866, TLC).

DISCUSSION

Based on the current study, the nutritional health of older inpatients was assessed using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. The results showed that the overall prevalence of malnutrition risk for the enrolled older patients ranged from 23.7% to 58.6%. The highest prevalence of malnutrition risk was detected by MNA and the lowest by BMI. These results illustrated the differences in nutritional risk detected by different screening tools.

Biochemical markers possess many advantages in assessing the nutritional status, such as fast application and low cost. In addition, they can also be incorporated into the routine of clinical application. As the most abundant plasmatic protein, albumin is commonly used in the assessment of malnutrition.[36] In several of studies, low serum ALB correlated with longer hospitalization, medical complications, and increased mortality.[36-38] Nevertheless, its value is still limited by the long half-life (14-20 days), inflammation, the impairment of hepatic or renal, and possibly aging itself.[27] Due to the reasons above, the prevalence of malnutrition detected by ALB is lower than MNA and NRS2002 in our study.

Comparatively, a study by Covinsky *et al*[39] showed ALB is highly sensitive yet low specific in the diagnosis of malnutrition in the hospitalized older adults.

Prealbumin has been regarded as a more sensitive marker than albumin for acute nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in nutritional screening and mortality prediction remain controversial.[40-43] In our study, prealbumin levels showed a great decline with deteriorating nutrition status assessed by both NRS2002 and MNA. The correlation between serum prealbumin and MNA is consistent with one study[44], yet is in contrast with another report.[42] This latter study had a small sample size (23 older patients), which may account for the discrepancies. Similar to serum albumin, the usage of prealbumin in predicting malnutrition is limited due to systemic inflammatory diseases.[41, 45]

Hemoglobin has been demonstrated to decrease with progressive malnutrition.[46, 47] This relationship, consistent with a recent analysis performed in Northern China[29], is found in the proposed study. Total lymphocyte count was assumed to be suitable in screening test for assessing malnutrition and being an indicator of a poor prognosis.[27] In agreement with Lei *et al*[48], we also found a significant correlation between TLC and MNA. However, no correlation was found between NRS2002 and TLC, which was consistent with a previous study.[29]

The prevalence of malnutrition diagnosed by BMI was far below that detected by MNA. Consistent with findings from another study[49], this study suggested that malnutrition was also under diagnosed when using BMI as the sole criteria. The reason is most possibly

related to water-sodium retention in patients, leading to an overestimation of their true weight.[50] In spite of this, low BMI was significantly associated with mortality.[51]

Our study revealed that NRS2002 and MNA, in moderate agreement with each other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless, the MNA identified more patients with or at risk of malnutrition than the NRS2002 did. The lower percentage of malnutrition classified by NRS2002 may be explained in several ways. First, the NRS2002 mainly consider the influence of acute diseases on nutritional status, while the MNA take chronic long-term condition into consideration, such as psychological factors and the BMI. Psychological factors may play a large role in the nutritional status of older inpatients. In addition, we categorized undernutrition as NRS2002≥3, while patients with a score of 1-2 indicates low risk of malnutrition.[52] This may have underestimated the percentage of malnutrition. Moreover, our study subjects were internal medical patients, among which the proportion of overweight and obesity was high. The NRS2002 takes BMI < 18.5 kg/m^2 as one of the criteria, leading to a lower proportion of malnutrition with NRS2002 than that of MNA. Our results agree with findings from Raslan *et al,*[5] yet differ from the study conducted by Drescher *et al*.[52] The latter study was conducted in older patients with acute disease, which may explain the difference.

Norman *et al* suggested that there exists a close relationship between the degree of malnutrition and LOS.[53] In the present study, we found the linear relation between both instruments (MNA and NRS2002) and LOS. Our findings corroborated those of the study conducted by Bauer *et al,*[54] showing longer hospital stay was associated with malnutrition

assessed by the MNA. Comparison of the MNA and NRS2002 and their ability to predict nutritional risk according to different standards showed that MNA and NRS2002 were the both suitable screening tools, in terms of the ROC curve area. Therefore, we conclude, that in Chinese geriatric inpatients, the NRS2002 and MNA might reflect malnutrition or the studied biochemical parameters, as well as predict the length of hospitalization. However, the MNA was available for identifying most of the patients with or at risk of malnutrition.

Limitations

Our study still has some limitations. First, a consensus statement with diagnostic criteria for malnutrition was proposed in 2015[55] after our study initiated and thus it was not utilized in our study. Second, BMI and age were parts of the screening tools, therefore already correlated with the MNA and NRS2002 assessment. Besides, in addition to nutritional status, LOS could also be influenced by age, financial situation, comorbidities and so on, which may explain the low R^2 between both instruments and LOS. Finally, regarding the cross-classification of MNA, more patients will be categorized as at risk since the two groups malnourished and at risk are combined, which may contribute to the low Kappa value between the two instruments.

CONCLUSION

To conclude, the results of the present study show a high prevalence of malnutrition risk in Chinese geriatric hospitalized patients. Although the nutritional risk varied

depending on the applied method, both NRS2002 and MNA correlated with each other and with age, BMI and laboratory parameters. Besides, both tools were proved to be a good predictor of the length of hospitalization. Moreover, the NRS2002 was not different from MNA for predicting nutritional risk according to the AUC. Therefore, this study suggested NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric inpatients. We recommend using one of them in admission.

Acknowledgements We are appreciated for the participating volunteer patients, the local research ethics committee and the individual researchers, clinicians and nurses for their participation in the data collection.

Contributors JPM, XQQ and HLZ are main contributors to the design of the present study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ, took part in the discussion and modification of the study design. HZ, MY, LYS, QHG, GYZ, QJM, YXW, and SGL contributed to the study conception. XQQ, HZ, MY, LYS, QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of data. JPM and XQQ made contributions to the drafting of the manuscript. HLZ and CTZ were involved in the critical revision. All the authors were involved in the analysis and interpretation of the data and gave their final approval.

Funding This project was funded by the National Natural Science Foundation of China (Grant No. 81400255).

Competing interests None declared.

Ethics approval Ethics Review Board of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-C20141112).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Figure legend

Figure 1 Flow diagram of participant inclusion and exclusion.

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

REFERENCES

1. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? *J Nutr Health Aging*. 2006;10:466-85; discussion 485-7.
2. Chang SF. Frailty Is a Major Related Factor for at Risk of Malnutrition in Community-Dwelling Older Adults. *J Nurs Scholarsh*. 2017;49:63-72.
3. Lumale S. [Nutritional management of elderly people, everyone's concern]. *Rev Infirm*. 2017;66:25-26.
4. Lesourd B. Nutritional factors and immunological ageing. *Proc Nutr Soc*. 2006;65:319-25.
5. Raslan M, Gonzalez MC, Dias MC*, et al.* Comparison of nutritional risk screening tools for predicting clinical outcomes in hospitalized patients. *Nutrition*. 2010;26:721-6.
6. Ehwerhemuepha L, Bendig D, Steele C*, et al.* The Effect of Malnutrition on the Risk of Unplanned 7-Day Readmission in Pediatrics. *Hosp Pediatr*. 2018.
7. Ahmed N, Choe Y, Mustad VA*, et al.* Impact of malnutrition on survival and healthcare utilization in Medicare beneficiaries with diabetes: a retrospective cohort analysis. *BMJ Open Diabetes Res Care*. 2018;6:e000471.
8. Sharma Y, Miller M, Kaambwa B*, et al.* Malnutrition and its association with readmission and death within 7 days and 8-180 days postdischarge in older patients: a prospective observational study. *BMJ Open*. 2017;7:e018443.
9. Khalatbari-Soltani S,Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN*. 2015;10:e89-e94.
10. Bouillanne O, Curis E, Hamon-Vilcot B*, et al.* Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: a randomized controlled trial. *Clin Nutr*. 2013;32:186-92.
11. Ballesteros-Pomar MD, Martinez Llinas D, Goates S*, et al.* Cost-Effectiveness of a Specialized Oral Nutritional Supplementation for Malnourished Older Adult Patients in Spain. *Nutrients*. 2018;10.
12. Racic M, Ivkovic N,Kusmuk S. [Screening of Nutritional Status among Elderly People at Family Medicine]. *Acta Med Croatica*. 2015;69:347-56.
13. Abd Aziz NAS, Teng N, Abdul Hamid MR*, et al.* Assessing the nutritional status of hospitalized elderly. *Clin Interv Aging*. 2017;12:1615-1625.
14. Elia M,Stratton R. On the ESPEN guidelines for nutritional screening 2002. *Clin Nutr*. 2004;23:131-2.
15. Kondrup J, Rasmussen HH, Hamberg O*, et al.* Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22:321-36.
16. Kondrup J, Allison SP, Elia M*, et al.* ESPEN guidelines for nutrition screening 2002. *Clin Nutr*. 2003;22:415-21.
17. Guigoz Y, Vellas B,Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr Rev*. 1996;54:S59-65.

18. Bleda MJ, Bolibar I, Pares R, *et al.* Reliability of the mini nutritional assessment (MNA) in institutionalized elderly people. *J Nutr Health Aging*. 2002;6:134-7.
19. Bauer JM, Kaiser MJ, Anthony P, *et al.* The Mini Nutritional Assessment--its history, today's practice, and future perspectives. *Nutr Clin Pract*. 2008;23:388-96.
20. Soderstrom L, Rosenblad A, Adolfsson ET, *et al.* Nutritional status predicts preterm death in older people: a prospective cohort study. *Clin Nutr*. 2014;33:354-9.
21. Dent E, Visvanathan R, Piantadosi C, *et al.* Use of the Mini Nutritional Assessment to detect frailty in hospitalised older people. *J Nutr Health Aging*. 2012;16:764-7.
22. Cabre M, Ferreiro C, Arus M, *et al.* Evaluation of CONUT for Clinical Malnutrition Detection and Short-Term Prognostic Assessment in Hospitalized Elderly People. *J Nutr Health Aging*. 2015;19:729-33.
23. Chavarro-Carvajal D, Reyes-Ortiz C, Samper-Ternent R, *et al.* Nutritional assessment and factors associated to malnutrition in older adults: a cross-sectional study in Bogota, Colombia. *J Aging Health*. 2015;27:304-19.
24. Kyle UG, Kossovsky MP, Karsegard VL, *et al.* Comparison of tools for nutritional assessment and screening at hospital admission: a population study. *Clin Nutr*. 2006;25:409-17.
25. Kaiser MJ, Bauer JM, Ramsch C, *et al.* Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging*. 2009;13:782-8.
26. Sergi G, Coin A, Enzi G, *et al.* Role of visceral proteins in detecting malnutrition in the elderly. *Eur J Clin Nutr*. 2006;60:203-9.
27. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. *Nutrition*. 2000;16:131-40.
28. Omran ML,Morley JE. Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools. *Nutrition*. 2000;16:50-63.
29. Zhou J, Wang M, Wang H, *et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
30. Thoresen L, Frykholm G, Lydersen S, *et al.* Nutritional status, cachexia and survival in patients with advanced colorectal carcinoma. Different assessment criteria for nutritional status provide unequal results. *Clin Nutr*. 2013;32:65-72.
31. Wei J, Chen W, Zhu M, *et al.* Guidelines for parenteral and enteral nutrition support in geriatric patients in China. *Asia Pac J Clin Nutr*. 2015;24:336-46.
32. Jacobsen EL, Brovold T, Bergland A, *et al.* Prevalence of factors associated with malnutrition among acute geriatric patients in Norway: a cross-sectional study. *BMJ Open*. 2016;6:e011512.
33. Guigoz Y,Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. *Nestle Nutr Workshop Ser Clin Perform Programme*. 1999;1:3-11; discussion 11-2.
34. Blackburn GL, Bistrian BR, Maini BS, *et al.* Nutritional and metabolic assessment of

the hospitalized patient. *JPEN J Parenter Enteral Nutr*. 1977;1:11-22.
35. Zhou J, Wang M, Wang H, *et al.* Comparison of two nutrition assessment tools in surgical elderly inpatients in Northern China. *Nutr J*. 2015;14:68.
36. Cabrerizo S, Cuadras D, Gomez-Busto F, *et al.* Serum albumin and health in older people: Review and meta analysis. *Maturitas*. 2015;81:17-27.
37. O'Daly BJ, Walsh JC, Quinlan JF, *et al.* Serum albumin and total lymphocyte count as predictors of outcome in hip fractures. *Clin Nutr*. 2010;29:89-93.
38. Chiu PF, Tsai CC, Wu CL, *et al.* Trajectories of Serum Albumin Predict Survival of Peritoneal Dialysis Patients: A 15-year Follow-Up Study. *Medicine (Baltimore)*. 2016;95:e3202.
39. Covinsky KE, Covinsky MH, Palmer RM, *et al.* Serum albumin concentration and clinical assessments of nutritional status in hospitalized older people: different sides of different coins? *Journal of the American Geriatrics Society*. 2002;50:631-7.
40. Carriere I, Dupuy AM, Lacroux A, *et al.* Biomarkers of inflammation and malnutrition associated with early death in healthy elderly people. *Journal of the American Geriatrics Society*. 2008;56:840-6.
41. Devoto G, Gallo F, Marchello C, *et al.* Prealbumin serum concentrations as a useful tool in the assessment of malnutrition in hospitalized patients. *Clinical chemistry*. 2006;52:2281-5.
42. Langkamp-Henken B, Hudgens J, Stechmiller JK, *et al.* Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *J Am Diet Assoc*. 2005;105:1590-6.
43. Kanda M, Mizuno A, Tanaka C, *et al.* Nutritional predictors for postoperative short-term and long-term outcomes of patients with gastric cancer. *Medicine (Baltimore)*. 2016;95:e3781.
44. Vellas B, Guigoz Y, Baumgartner M, *et al.* Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. *Journal of the American Geriatrics Society*. 2000;48:1300-9.
45. Lopez-Hellin J, Baena-Fustegueras JA, Schwartz-Riera S, *et al.* Usefulness of short-lived proteins as nutritional indicators surgical patients. *Clin Nutr*. 2002;21:119-25.
46. Wham CA, Teh RO, Robinson M, *et al.* What is associated with nutrition risk in very old age? *J Nutr Health Aging*. 2011;15:247-51.
47. Weng CH, Hsu CW, Hu CC, *et al.* Association Between Hemodiafiltration and Hypoalbuminemia in Middle-Age Hemodialysis Patients. *Medicine (Baltimore)*. 2016;95:e3334.
48. Lei Z, Qingyi D, Feng G, *et al.* Clinical study of mini-nutritional assessment for older Chinese inpatients. *J Nutr Health Aging*. 2009;13:871-5.
49. Antaki F, French MM, Moonka DK, *et al.* Bioelectrical impedance analysis for the evaluation of hepatic fibrosis in patients with chronic hepatitis C infection. *Dig Dis Sci*. 2008;53:1957-60.
50. Roongpisuthipong C, Sobhonslidsuk A, Nantiruj K, *et al.* Nutritional assessment in

various stages of liver cirrhosis. *Nutrition*. 2001;17:761-5.

51. Akinyemiju T, Meng Q,Vin-Raviv N. Association between body mass index and in-hospital outcomes: Analysis of the nationwide inpatient database. *Medicine (Baltimore)*. 2016;95:e4189.
52. Drescher T, Singler K, Ulrich A*, et al.* Comparison of two malnutrition risk screening methods (MNA and NRS2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. *Eur J Clin Nutr*. 2010;64:887-93.
53. Norman K, Pichard C, Lochs H*, et al.* Prognostic impact of disease-related malnutrition. *Clin Nutr*. 2008;27:5-15.
54. Bauer JM, Vogl T, Wicklein S*, et al.* Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients. *Z Gerontol Geriatr*. 2005;38:322-7.
55. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. *Clin Nutr*. 2015;34:335-40.

Table 1 Characteristic of study participants

Variable	All subjects（n=425）
Age (year)	81.2±5.9 (70-98)
Gender	
Male	68.9% (293)
Female	31.1% (132)
Height (m)	1.6±0.1 (1.4-1.8)
Weight (kg)	62.9±11.5 (28.4-92.0)
Body mass index (kg/m^2)	23.2±3.7 (11.1-34.1)
Length of hospital stay (day)	21.9±13.8 (4-133)
Primary cause of admission to hospital	
Cardiac disease	160 (37.6%)
Pulmonary infection	84 (19.8%)
Hypertension	76 (17.9%)
Cerebrovascular disease	45 (10.6%)
Digestive disease	25 (5.9%)
Malignancy	19 (4.5%)
Others	16 (3.8%)
Comorbidities	
Hypertension	210 (49.4%)
Diabetes mellitus	101 (23.8%)
Cardiac disease (including atrial fibrillation)	94 (22.1%)
Cerebrovascular disease	30 (7.1%)

Values are mean ± standard deviation (with ranges in brackets) or % (numbers), respectively.

Table 2 Nutritional status (%, n) of 425 patients classified by NRS2002, MNA, BMI and serum parameters

	Under-nourished	Well-nourished
NRS2002	40.9% (174)	59.1% (251)
MNA	58.6% (249)	41.4% (176)
BMI	23.7% (93)	76.3% (300)
ALB	28.7% (122)	71.3% (303)
PAB	47.3% (70)	52.7% (78)
Hb (male)	41.7% (121)	58.3% (169)
Hb (female)	25.6% (33)	74.4% (96)
TLC	35.9% (149)	64.1% (266)

ALB = albumin, BMI = Body mass index, Hb = hemoglobin, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count. Under-nourished (malnourished + at risk of malnutrition).

Table 3 Cross-classification

MNA	NRS2002		Total
	Under-nourished	Well-nourished	
Under-nourished	159	90	249
Well-nourished	15	161	176
Total	174	251	425
Kappa	0.521		
P	<0.001		

Number of patients classified into two categories according to MNA and NRS2002, respectively. MNA = Mini-Nutritional assessment, NRS2002 = Nutritional risk score 2002. Under-nourished: malnutrition + at risk of malnutrition.

Table 4 Pearson correlation coefficients of MNA and NRS2002 scores with BMI, serum parameters and LOS

	MNA		NRS2002	
	r	***p***	***r***	***p***
Age	-0.239	＜0.001	0.238	＜0.001
BMI	0.578	＜0.001	-0.347	＜0.001
Hb	0.387	＜0.001	-0.321	＜0.001
TLC	-0.002	0.966	0.011	0.819
ALB	0.501	＜0.001	-0.383	＜0.001
PAB	0.481	＜0.001	-0.332	＜0.001
LOS	-0.109	0.048	0.178	0.001
NRS2002	-0.640	＜0.001	—	—

ALB = albumin, BMI = body mass index, Hb = hemoglobin, LOS = length of hospital stay, MNA = Mini-Nutritional Assessment, NRS2002 = Nutritional Risk Screening 2002, PAB = prealbumin, TLC = total lymphocyte count.

Table 5 The simple linear regression analysis of LOS

	B	SE	β	t	*P*	95%CI	R^2	F
MNA	-0.261	0.131	-0.109	-1.987	<0.05	-0.519,-0.003	0.012	3.949
NRS2002	1.891	0.575	0.178	3.291	<0.01	0.761,3.022	0.032	10.834

LOS = length of hospital stay, CI = confidence interval, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002.

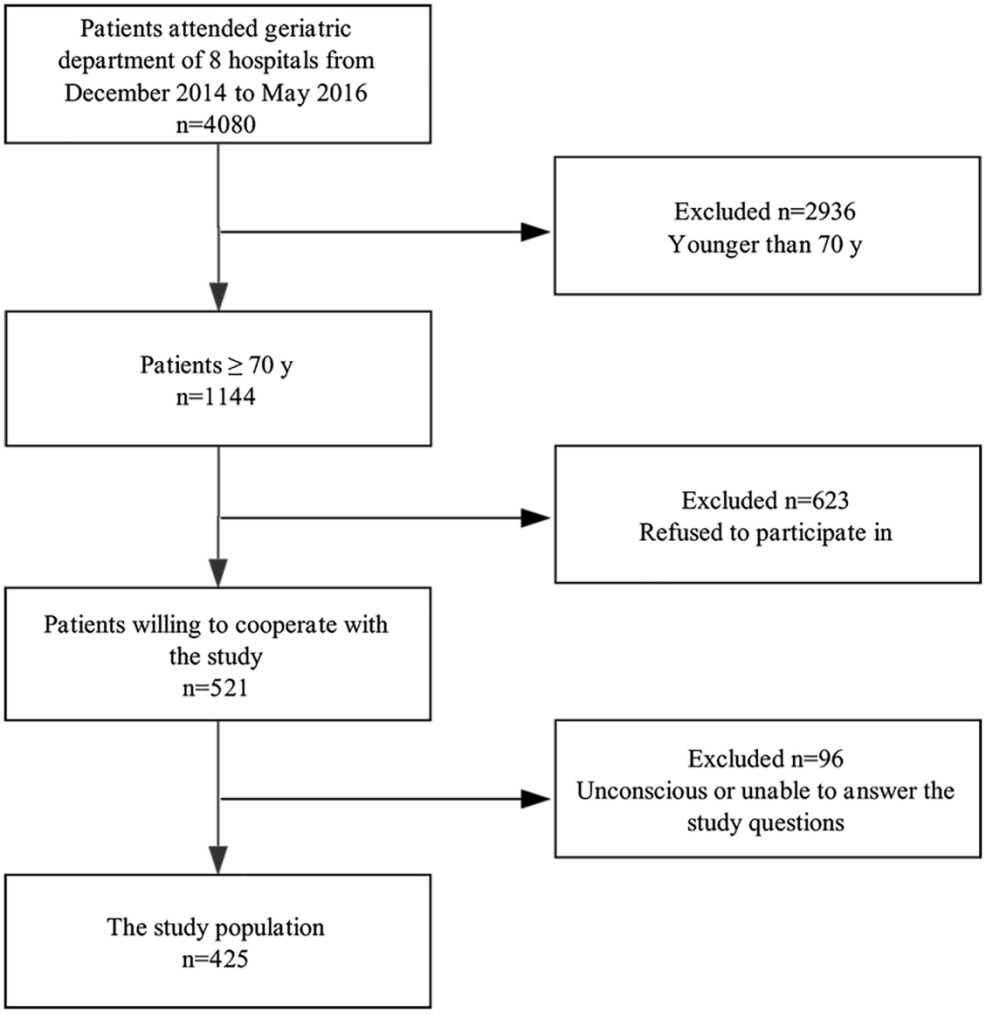

Figure 1 Flow diagram of participant inclusion and exclusion.

167x172mm (300 x 300 DPI)

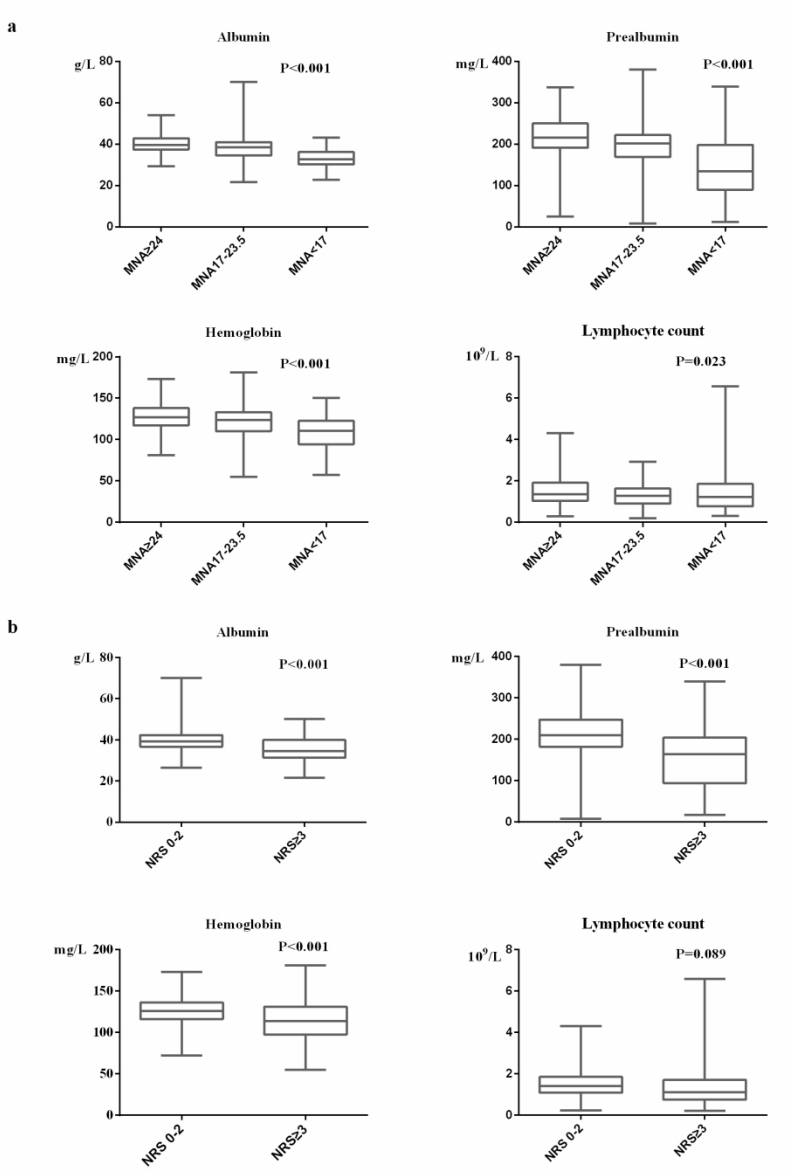

Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

175x262mm (300 x 300 DPI)

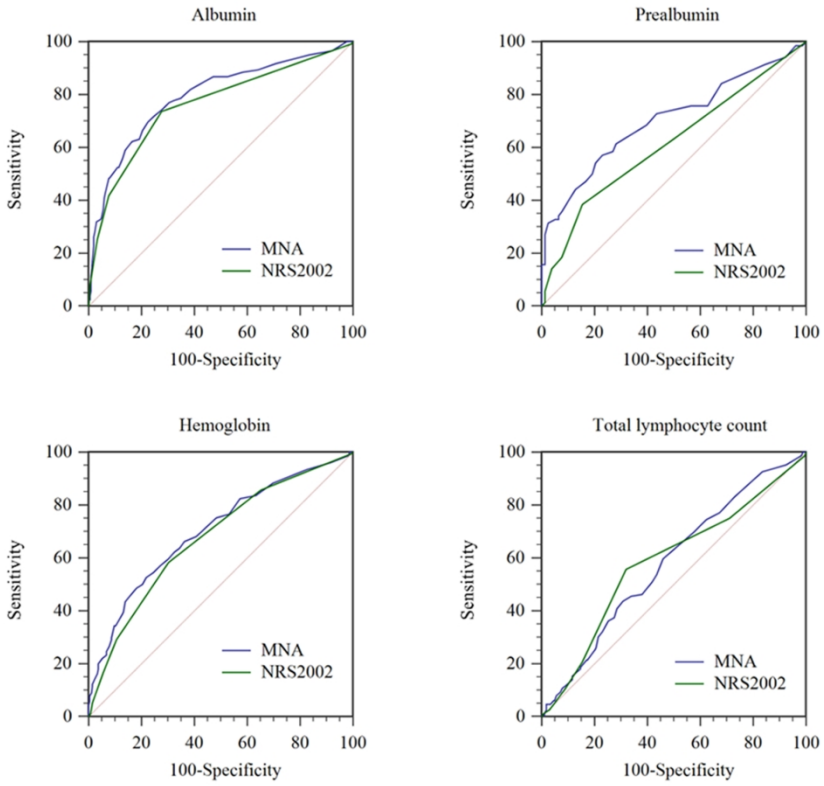

Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

170x139mm (300 x 300 DPI)

Additional Table 1 Nutritional parameters of study participants classified by MNA and NRS2002

	ALB (g/L)	PAB (mg/L)	Hb (g/L)	TLC (10^9/L)
MNA				
<17	33.3±4.8 (22.8-43.2)	140.8±81.7 (12-339)	109.0±20.8 (57-150.2)	1.5±1.2 (0.3-6.6)
17-23.5	37.9±5.6 (21.6-70)	192.3±61.8 (8-380)	120.2±22.0 (55-181)	1.3±0.6 (0.2-2.9)
≥24	39.8±3.8 (29.3-54)	216.7±54.4 (25-337)	127.6±15.3 (81-173)	1.5±0.7 (0.3-4.3)
NRS2002				
≥3	35.1±5.6 (21.6-50.2)	148.5±79.3 (17-339)	113.3±23.6 (55-181)	1.4±1.0 (0.2-6.6)
0-2	39.4±4.5 (26.4-70)	210.2±56.1 (8-380)	125.8±16.2 (72-173)	1.5±0.6 (0.2-4.3)

ALB = albumin, PAB = prealbumin, Hb = hemoglobin, TLC = total lymphocyte count, MNA = Mini-Nutritional Assessment, NRS2002=Nutritional Risk Screening 2002. Values are mean ± standard deviation (with ranges in brackets)

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.