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

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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

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3 **Comparison of two malnutrition risk screening tools with nutritional**  
4 **biochemical parameters in Chinese geriatric inpatients: a multicenter,**  
5 **cross-sectional study**  
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10 Jian-Ping Miao<sup>1</sup>, Xiao-Qing Quan<sup>1</sup>, Cun-Tai Zhang<sup>1</sup>, Hong Zhu<sup>2</sup>, Mei Ye<sup>3</sup>,  
11 Li-Ya Shen<sup>4</sup>, Qiu-Hui Guo<sup>4</sup>, Gang-Yan Zhu<sup>5</sup>, Qi-Jian Mei<sup>6</sup>, Yan-Xia Wu<sup>7</sup>,  
12 Shu-Guo Li<sup>8</sup>, Hong-Lian Zhou<sup>1</sup>  
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20 **Running title: Malnutrition risk screening in Chinese geriatric inpatients**  
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22

- 23 1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong  
24 University of Science and Technology, Hubei, China  
25  
26 2. Department of Geriatrics, the Central Hospital of Wuhan University, Hubei, China  
27  
28 3. Department of Geriatrics, Zhongnan Hospital of Wuhan University, Hubei, China  
29  
30 4. Department of Geriatrics, Wuhan No. 6 Hospital, Hubei, China  
31  
32 5. Department of Geriatrics, Hubei General Hospital, Hubei, China  
33  
34 6. Department of Geriatrics, General Hospital of the Yangtze River Shipping, Hubei,  
35 China  
36  
37 7. Department of Geriatrics, Wuhan No 1 Hospital, Hubei, China  
38  
39 8. Department of Geriatrics, First Clinical Medical College, Three Gorges University  
40 & Yichang Central People's Hospital, Hubei, China  
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47 JPM and XQQ contributed equally.  
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54 Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com  
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## 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  $\geq 70$  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  $81.16 \pm 5.89$  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 ( $\kappa = 0.521$ ,  $P < 0.001$ ) 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 ( $P < 0.05$ ).

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3 **Conclusions:** The results show a relatively high prevalence of malnutrition risk in our  
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6 sample cohort. We found NRS2002 and MNA both were suitable to screen  
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8 malnutrition risk among Chinese geriatric inpatients.  
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### 10 11 12 13 14 15 16 17 **Strengths and limitations of this study**

- 18  
19 ▶ This study assessed the risk of malnutrition among Chinese elderly inpatients with  
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21 two different tools (NRS2002 and MNA).  
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- 23  
24 ▶ The study provides useful information to assess the risk of malnutrition among  
25  
26 Chinese elderly inpatients.  
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- 28  
29 ▶ Because of the lack of a gold standard for malnutrition diagnosing, we could only  
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31 compare two assessment scores with BMI and biochemical parameters.  
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- 33  
34 ▶ The small sample size of women may limit the power of data analysis.  
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45 **Keywords:** Malnutrition risk, NRS2002, MNA, Elderly  
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## INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.<sup>1</sup> It is highly associated with many adverse outcomes including frailty,<sup>2</sup> muscle wasting,<sup>3</sup> weakened immune system,<sup>4</sup> longer hospitalization,<sup>5</sup> increased morbidity<sup>6</sup> and mortality.<sup>7,8</sup> These outcomes contribute to large increases in medical expenditures.<sup>9</sup> Early identification and treatment of malnutrition can lead to better quality of life<sup>10</sup> and improved outcomes<sup>11</sup> 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.<sup>12</sup> 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,<sup>13</sup> 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).<sup>14</sup> It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.<sup>15,16</sup> However, NRS2002 use excludes patients who cannot be weighed or have problems of communication and the tool isn't specifically

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3 developed for elderly inpatients.  
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6 The Mini-Nutritional Assessment (MNA) is established for the nutritional  
7 screening and assessment in the geriatrics settings.<sup>1</sup> The ESPEN recommends the use  
8 of this tool for elderly populations.<sup>17</sup> It has been shown to predict outcomes,  
9 functional status, mortality, number of hospital visits and the related healthcare costs.<sup>7,</sup>  
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17-21 In contrast to the NRS2002, the MNA is more time consuming.<sup>22</sup> 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.<sup>23-25</sup> Hemoglobin and total lymphocyte count were also proposed as useful indicators of nutritional status.<sup>24, 26</sup> 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 Jiangnan 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



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3 mass index (BMI) was then calculated as weight/height squared ( $\text{kg}/\text{m}^2$ ).  
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6 Blood samples were also obtained within 24 hours after admission. Nutritional  
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8 biochemical parameters: serum hemoglobin (Hb), total lymphocyte count (TLC),  
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10 albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical  
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12 chemistry laboratory. Malnutrition was determined when the value of Hb was  $<120$   
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14  $\text{g}/\text{L}$  for males and  $<110$   $\text{g}/\text{L}$  for females. The cutoff value of ALB was 35  $\text{g}/\text{L}$  (normal  
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16 range 35-55  $\text{g}/\text{L}$ ), PAB was 200 $\text{mg}/\text{L}$  (normal range 200-400  $\text{mg}/\text{L}$ ), TLC was  
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18  $1.1 \times 10^9/\text{L}$  (normal range  $1.1$ - $3.2 \times 10^9/\text{L}$ ) for both genders for malnutrition.<sup>27</sup> Moreover,  
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20 based on previous research, the cutoff value of BMI was set at 20.5  $\text{kg}/\text{m}^2$  for  
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22 malnutrition.<sup>26</sup>  
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### 32 **Nutritional risk screening 2002 (NRS2002)**

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35 The NRS2002 consists of the following parameters: the severity of acute illness,  
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37 BMI, patient appetite, accidental weight loss and patient age.<sup>15</sup> The total score ranges  
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39 from 0 to 7.<sup>16</sup> For investigational purposes, patients were categorized into two groups:  
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41 a total score  $\geq 3$  indicates under-nourished (at nutritional risk/malnourished), 0-2  
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43 indicates normal nutrition status.<sup>14, 28</sup> A nutritional care plan was initiated for patients  
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45 with a score  $\geq 3$ .<sup>28</sup>  
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### 52 **Mini-Nutritional Assessment (MNA)**

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55 The MNA consists of four parts: anthropometric assessment (0-8 points), general  
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3 assessment (0-9 points), dietetic habits evaluation (0-9 points) and self-assessment of  
4 the nutrition and health status (0-4 points).<sup>29</sup> A score below 17 indicates malnutrition,  
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8 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.<sup>1</sup>  
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### 10 11 12 13 **Statistical analysis**

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15 The statistical analyses were conducted using SPSS 19.0. Data were presented as  
16 mean  $\pm$  standard deviation and ranges in blanket. The chi-square test or student's *t*-test  
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18 was used according to the data type. One-way analysis of variance was applied for  
19  
20 multigroup comparisons. Correlation analysis was qualified by the spearman  
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22 correlation test. Agreement between the two screening tools was achieved by the  
23  
24 kappa ( $\kappa$ ) statistic. The results were interpreted as follows: <0, no agreement; 0-0.19,  
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26 poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate agreement;  
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28 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.<sup>26</sup> The level  
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30 of significance was set at  $P < 0.05$ .  
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## 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  $81.16 \pm 5.89$  years (range, 70-98) and 31.1% were females. The average body mass index was  $23.22 \pm 3.73$  kg/m<sup>2</sup> (range, 11.09-34.14). The average length of hospitalization was  $21.86 \pm 13.75$  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 coincidentally 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 ( $\kappa=0.521$ ,  $P<0.001$ ).

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  $33.34\pm 4.81$  g/L (range, 22.8-43.2), an average prealbumin of  $140.82\pm 81.72$  mg/L (range, 12-339) and an average hemoglobin of  $109.04\pm 20.82$  mg/L (range, 57-150.2), an average lymphocyte count of  $1.53\pm 1.21$   $10^9$ /L (range, 0.31-6.58). In the risk of malnutrition group with an MNA score of 17-23.5 ( $n=150$ ),

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3 average serum albumin was  $37.87 \pm 5.61$  g/L (range, 21.6-70), average prealbumin  
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6  $192.25 \pm 61.78$  mg/L (range, 8-380) and average hemoglobin  $120.16 \pm 22.01$  mg/L  
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8 (range, 55-181), an average lymphocyte count of  $1.29 \pm 0.56 \times 10^9$ /L (range, 0.20-2.92).  
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11 The group with  $MNA \geq 24$  (n=180) had an average serum albumin concentration of  
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13  $39.84 \pm 3.83$  g/L (range, 29.3-54), an average prealbumin of  $216.74 \pm 54.42$  mg/L (range,  
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15 25-337) and an average hemoglobin of  $127.59 \pm 15.32$  mg/L (range, 81-173), an  
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17 average lymphocyte count of  $1.51 \pm 0.69 \times 10^9$ /L (range, 0.28-4.30; figure 1a).  
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21 Similarly, ALB, PAB and Hb gradually declined with increasing risk of  
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23 malnutrition according to NRS2002 results ( $P < 0.001$ , figure 1b). In under-nourished  
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25 patients (NRS2002: 3-7, n=174), average serum albumin was  $35.13 \pm 5.58$  g/L (range,  
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27 21.6-50.2), average prealbumin  $148.51 \pm 79.25$  mg/L (range, 17-339) and average  
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29 hemoglobin  $113.27 \pm 23.64$  mg/L (range, 55-181). In the normal nutritional state group  
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31 (NRS2002: 0-2, n=251), the results were: albumin  $39.36 \pm 4.47$  g/L (range, 26.4-70),  
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33 prealbumin  $210.19 \pm 56.08$  mg/L (range, 8-380) and hemoglobin  $125.80 \pm 16.16$  mg/L  
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35 (range, 72-173). In contrast, no difference in lymphocyte count was found in both  
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37 groups ( $P = 0.089$ , figure 1b).  
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43 Table 4 showed the Pearson correlation coefficients of MNA and NRS2002  
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45 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated  
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47 negatively with malnutrition scores of NRS2002, while correlated positively with the  
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49 MNA scores ( $P < 0.001$ ). There was an inverse correlation between age and the two  
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51 tools ( $P < 0.001$ ). Besides, a significant association between both tools and LOS was  
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53 demonstrated ( $P < 0.05$ ). No correlation was found between TLC and the two tools.  
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## 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.<sup>30</sup> In several of studies, low serum ALB correlated with longer hospitalization, medical complications, and increased mortality.<sup>30-32</sup> Nevertheless, its value is limited by the long half-life (14-20 days), inflammation, the impairment of hepatic or renal, and possibly aging itself.<sup>24</sup> 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*<sup>33</sup> 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

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

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

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

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26 Our study revealed that NRS2002 and MNA, in moderate agreement with each  
27 other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless,  
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3 the MNA identified more patients with or at risk of malnutrition than did the  
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5 NRS2002. The lower percentage of malnutrition classified by NRS2002 may be  
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7 explained in several ways. First, the NRS2002 mainly consider the influence of acute  
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9 diseases to nutritional status, while the MNA take chronic long-term condition into  
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11 account, such as psychological factors and the BMI. Psychological factors may play a  
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13 large role in the nutritional status of elderly inpatients. In addition, we categorized  
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15 undernutrition as NRS2002  $\geq 3$ , while patients with a score of 1-2 indicates low risk of  
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17 malnutrition.<sup>46</sup> This may have underestimated the percentage of malnutrition.  
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19 Moreover, our study subjects were internal medical patients, of which the proportion  
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21 of overweight and obesity was high. The NRS2002 take BMI  $< 18.5 \text{ kg/m}^2$  as one of  
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23 the criteria, which leads to a lower proportion of malnutrition with NRS2002 than that  
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25 of MNA. Our results are in agreement with findings from Raslan *et al*,<sup>5</sup> but differ  
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27 from the study conducted by Drescher *et al*.<sup>46</sup> The latter study was conducted in  
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29 elderly patients with acute disease, which may explain the difference.

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32 Norman *et al* suggested that there is a close relationship between the degree of  
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34 malnutrition and LOS.<sup>47</sup> In the present study, we found a positive relationship between  
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36 NRS2002 scores and LOS. Our findings corroborated those of the study by Bauer *et*  
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38 *al*,<sup>48</sup> which showed longer hospital stay was associated with malnutrition assessed by  
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40 the MNA. We conclude, therefore, that in Chinese geriatric inpatients, the NRS2002  
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42 and MNA might reflect malnutrition or the studied biochemical parameters, as well as  
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44 predicting the length of hospitalization, however, the MNA was available for  
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46 identifying most of the patients with or at risk of malnutrition.  
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## 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.<sup>49</sup> 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.

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9  
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14  
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17 study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ  
18  
19 took part in the discussion and modification of the design and the questionnaire. XQQ,  
20  
21 HZ, MY, LYS, QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of  
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23 data. JPM and XQQ contributed to the drafting of the manuscript. JPM participated in  
24  
25 data gathering, analysis and interpretation. HLZ and CTZ were involved in the critical  
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27 revision. All authors have seen and agreed to the submission of the final manuscript.  
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54 Huazhong University of Science and Technology (TJ-C20141112).  
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7 **Provenance and peer review** Not commissioned; externally peer reviewed.  
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13 **Data sharing statement** No additional data are available.  
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#### 42 **Figure legend**

43 **Figure 1** MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin,  
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45 hemoglobin and blood lymphocytes count respectively.  
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**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 <sup>2</sup> )	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 <sup>9</sup> /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

	<b>Under-nourished</b>	<b>Well-nourished</b>
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		
<i>P</i>	<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	
	<i>rs</i>	<i>p</i>	<i>rs</i>	<i>p</i>
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.

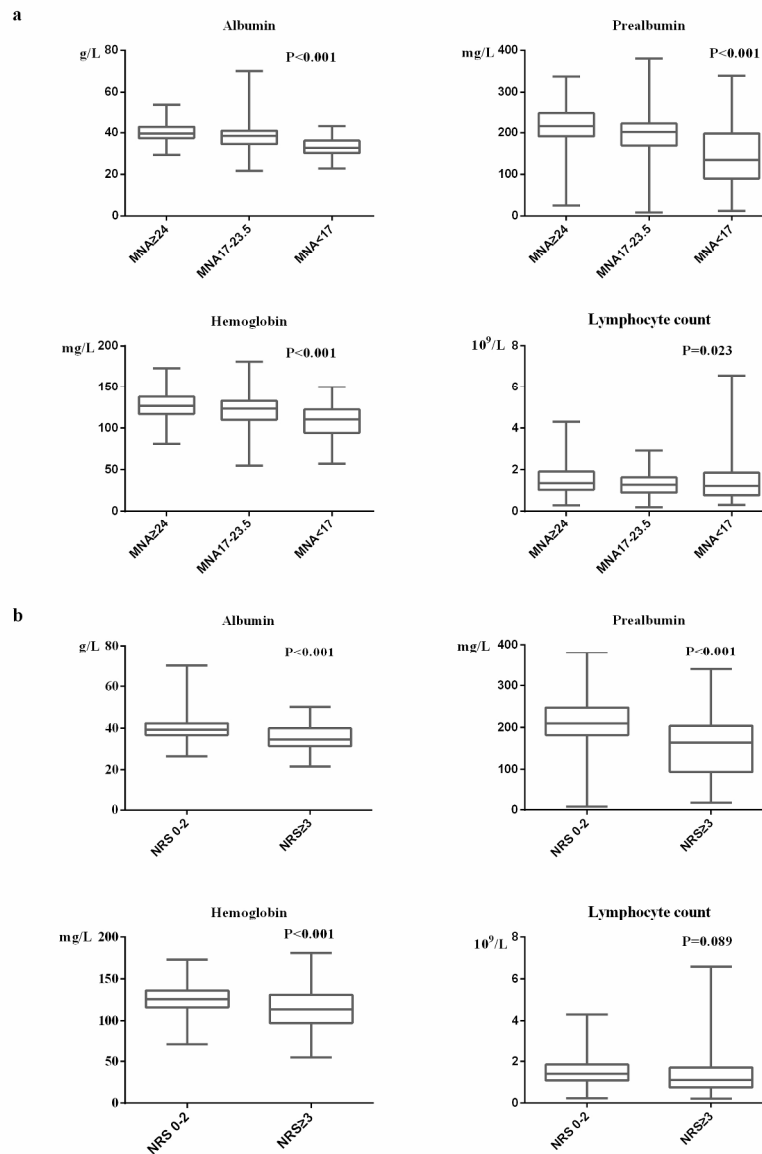


Figure 1 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

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# 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

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Complete List of Authors:	<p>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</p> <p>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</p> <p>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</p> <p>Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics</p> <p>Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics</p> <p>Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics</p> <p>Mei, Qi-Jian; General Hospital of the Yangtze River Shipping</p> <p>Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics</p> <p>Li, Shu-Guo; First Clinical Medical College, Three Gorges University &amp; Yichang Central People's Hospital, Department of Geriatrics</p> <p>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</p>
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Manuscripts

For peer review only

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3 **Comparison of two malnutrition risk screening tools with nutritional**  
4 **biochemical parameters, BMI and length of stay in Chinese geriatric inpatients:**  
5 **a multicenter, cross-sectional study**  
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10 Jian-Ping Miao<sup>1,2,3</sup>, Xiao-Qing Quan<sup>1,2,3</sup>, Cun-Tai Zhang<sup>1,2,3</sup>, Hong Zhu<sup>4</sup>, Mei Ye<sup>5</sup>,  
11 Li-Ya Shen<sup>6</sup>, Qiu-Hui Guo<sup>6</sup>, Gang-Yan Zhu<sup>7</sup>, Qi-Jian Mei<sup>8</sup>, Yan-Xia Wu<sup>9</sup>,  
12 Shu-Guo Li<sup>10</sup>, Hong-Lian Zhou<sup>1,2,3\*</sup>  
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20 **Running title: Malnutrition screening in Chinese geriatric patients**  
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- 23 1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong  
24 University of Science and Technology;  
25  
26 2. Clinical Research Center for Geriatric Prevention and Treatment and Health  
27 Medicine in Hubei Province  
28  
29 3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ  
30 Dysfunction in Wuhan  
31  
32 4. Department of Geriatrics, the Central Hospital of Wuhan University;  
33  
34 5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;  
35  
36 6. Department of Geriatrics, Wuhan No. 6 Hospital;  
37  
38 7. Department of Geriatrics, Hubei General Hospital;  
39  
40 8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;  
41  
42 9. Department of Geriatrics, Wuhan No 1 Hospital;  
43  
44 10. Department of Geriatrics, First Clinical Medical College, Three Gorges University  
45 & Yichang Central People's Hospital.  
46  
47  
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50 JPM and XQQ contributed equally.  
51  
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53

54 Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com  
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## 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  $\geq 70$  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  $81.2 \pm 5.9$  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 ( $\kappa = 0.521$ ,  $P < 0.001$ ) 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 ( $P < 0.05$ ).

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3 **Conclusions:** The results show a relatively high prevalence of malnutrition risk in our  
4 sample cohort. We found NRS2002 and MNA both were suitable to screen  
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6 malnutrition risk among Chinese geriatric inpatients.  
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### 10 11 12 13 14 15 16 17 18 **Strengths and limitations of this study**

- 19  
20 ▶ This study assessed the risk of malnutrition among Chinese elderly inpatients with  
21 two different tools (NRS2002 and MNA).  
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24 ▶ The study provides useful information to assess the risk of malnutrition among  
25 Chinese elderly inpatients.  
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28 ▶ The consensus statement with diagnostic criteria for malnutrition was proposed in  
29 2015 after our study initiated, thus it was not utilized in our study.  
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33 ▶ The small sample size of women may limit the generalizability of the results.  
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36 ▶ Regarding the cross-classification of MNA, more patients will be categorized as at  
37 risk since the two groups malnourished and at risk are combined.  
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47 **Keywords:** malnutrition risk; NRS2002; MNA; older patients  
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## INTRODUCTION

Malnutrition is a common condition affecting almost 13-78% of the elderly population.<sup>1</sup> It is highly associated with many adverse outcomes including frailty,<sup>2</sup> muscle wasting<sup>3</sup>, weakened immune system<sup>4</sup>, longer hospitalization,<sup>5</sup> increased morbidity<sup>6</sup> and mortality.<sup>7,8</sup> These outcomes contribute to large increases in medical expenditures.<sup>9</sup> Early identification and treatment of malnutrition can lead to better quality of life<sup>10</sup> and improved outcomes<sup>11</sup> 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.<sup>12</sup> 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,<sup>13</sup> 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).<sup>14</sup> It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.<sup>15,16</sup> However, NRS2002 use excludes patients who cannot be weighed or have problems of communication and the tool isn't specifically

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3 developed for older patients.  
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6 The Mini-Nutritional Assessment (MNA) is established for the nutritional  
7 screening and assessment in the geriatrics settings.<sup>1, 17</sup> The ESPEN recommends the  
8 use of this tool for elderly populations.<sup>18</sup> The MNA was validated against a clinical  
9 evaluations of two geriatrics, including biochemical parameters (nutritional  
10 parameters, C-reactive protein, cholesterol, vitamins), anthropometry (BMI, brachial  
11 circumference, calf circumference, skinfold width of the triceps and subscapular  
12 muscles), dietary components and functional assessment outcomes.<sup>19</sup> It has been  
13 shown to predict outcomes, functional status, mortality, number of hospital visits and  
14 the related healthcare costs.<sup>18, 20-23</sup> In contrast to the NRS2002, the MNA is more time  
15 consuming.<sup>24</sup> Hence, two short forms of the MNA has been developed and validated,  
16 the most recently the revised MNA-SF by Kaiser *et al*<sup>25</sup>, which is nowadays the  
17 recommended version of the MNA for clinical use. This instrument only incorporates  
18 6 of the original 18 items and takes approximately 5 minutes to perform.  
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39 A number of studies suggested serum proteins are associated with malnutrition,  
40 but the nature of this association is controversial.<sup>26-28</sup> Hemoglobin and total  
41 lymphocyte count were also proposed as useful indicators of nutritional status.<sup>27, 29</sup>  
42  
43 The aim of our study was to assess the risk of malnutrition among Chinese older  
44 participants with two different tools (NRS2002 and MNA), to compare them in terms  
45 of nutritional biochemical parameters and length of hospital stay (LOS), and to  
46 determine the most appropriate tool for these patients. We hypothesized that both  
47 tools were suitable for the study population.  
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## 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 Jiangnan 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.<sup>15</sup> The total score ranges from 0 to 7.<sup>16</sup> For investigational purposes, patients were categorized into two groups: a total score  $\geq 3$  indicates under-nourished (at nutritional risk/malnourished), 0-2 indicates normal nutrition status.<sup>14,30</sup> A nutritional care plan was initiated for patients with a score  $\geq 3$ .<sup>31</sup>

### **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).<sup>32</sup> A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.<sup>33</sup> A nutritional care plan was initiated for patients with a score  $< 17$ .<sup>31</sup>

### **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

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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  $\pm 0.5$  cm). The actual body mass was measured with a calibrated scale (corrected to  $\pm 0.2$  kg). The body mass index (BMI) was then calculated as weight/height squared ( $\text{kg}/\text{m}^2$ ).

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  $1.1 \times 10^9/\text{L}$  (normal range  $1.1-3.2 \times 10^9/\text{L}$ ) for both genders for malnutrition.<sup>34</sup> Moreover, based on previous research, the cutoff value of BMI was set at  $20.5 \text{ kg}/\text{m}^2$  for malnutrition according to the epidemiological study in China.<sup>35</sup>

### **Patient and public involvement**

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

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3 After obtaining informed consent, the two trained researchers in each hospital were  
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5 responsible for investigating the subjects, and the results of measurements would be  
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7 disseminated to participants immediately after the investigation.  
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### 10 11 12 13 **Statistical analysis** 14

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16 The statistical analyses were conducted using SPSS 19.0. Data were presented as  
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18 mean  $\pm$  standard deviation and ranges in blanket. The chi-square test or student's *t*-test  
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20 was used according to the data type. One-way analysis of variance was applied for  
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22 multigroup comparisons. Correlation analysis was qualified by the Pearson correlation  
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24 test. The simple linear regression analysis was used to estimate the relationship  
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26 between both instruments (MNA/NRS2002) and LOS. Agreement between the two  
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28 screening tools was achieved by the kappa ( $\kappa$ ) statistic. The results were interpreted as  
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30 follows:  $<0$ , no agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement;  
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32 0.40-0.59, moderate agreement; 0.60-0.79, substantial agreement; and 0.80-1.00,  
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34 almost perfect agreement.<sup>29</sup> The level of significance was set at  $P < 0.05$ .  
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## 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  $81.2 \pm 5.9$  years (range, 70-98) and 31.1% were females. The average body mass index was  $23.2 \pm 3.7$  kg/m<sup>2</sup> (range, 11.1-34.1). The average length of hospitalization was  $21.9 \pm 13.7$  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

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

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8 Although both instruments were closely related to each other ( $P<0.001$ ), they  
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10 showed substantial differences. Table 3 shows the cross-classification of MNA and  
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12 NRS2002 regarding two nutritional categories. The MNA classified more patients as  
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14 under-nourished than the NRS2002 (249 vs 174, respectively). Of the 249 patients  
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16 classified as under-nourished by the MNA, the NRS2002 coincidentally categorized  
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18 159 as malnourished, and 90 as well-nourished. The NRS2002, on the other hand,  
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20 classified 174 patients as under-nourished. Within this group of participants, the MNA  
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22 classified 159 patients as under-nourished and 15 as well-nourished. What's more, a  
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24 participant considered by the MNA to be well-nourished can be classified as  
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26 under-nourished using the NRS2002. The individual categorization of nutritional  
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28 status showed moderate agreement between MNA and NRS2002 ( $\kappa=0.521$ ,  $P<0.001$ ).

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

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3 correlation between the MNA scores and LOS ( $P<0.05$ ), so was the NRS2002 scores  
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6 ( $P<0.01$ ).  
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## 10 11 12 13 14 15 16 17 **DISCUSSION**

18 Based on the current study, the nutritional health of older inpatients were  
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20 assessed using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. We found the overall  
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22 prevalence of malnutrition risk for the enrolled older patients ranged from 23.7% to  
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24 58.6%. The highest prevalence of malnutrition risk was detected by MNA and the  
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26 lowest by BMI. These results illustrated the differences in nutritional risk detected by  
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28 different screening tools.  
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32 Biochemical markers have many advantages in assessing the nutritional status,  
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34 such as fast application, low cost. They can also be incorporated into the routine of  
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36 clinical application. Albumin, the most abundant plasmatic protein, is commonly used  
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38 in the assessment of malnutrition.<sup>36</sup> In several of studies, low serum ALB correlated  
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40 with longer hospitalization, medical complications, and increased mortality.<sup>36-38</sup>  
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42 Nevertheless, its value is limited by the long half-life (14-20 days), inflammation, the  
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44 impairment of hepatic or renal, and possibly aging itself.<sup>27</sup> In the present study,  
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46 prevalence of malnutrition detected by ALB is lower than MNA and NRS2002, which  
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48 suggest that ALB was not suitable for assessing malnutrition in our patients. The  
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50 reason may be its long half-life to make it insensitive to malnutrition. In contrast, a  
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3 study by Covinsky *et al*<sup>39</sup> showed ALB is highly sensitive but low specific in the  
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5 diagnosis of malnutrition in the hospitalized older adults.  
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8 Prealbumin has been regarded as a more sensitive marker than albumin for acute  
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10 nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in  
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12 nutritional screening and mortality prediction are controversial.<sup>40-43</sup> In our study,  
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14 prealbumin levels showed a great decline with deteriorating nutrition status assessed  
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16 by both NRS2002 and MNA. The correlation between serum prealbumin and MNA  
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18 consistent with one study<sup>44</sup>, but in contrast with another report.<sup>42</sup> This latter study had  
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20 a small sample size (23 older patients), which may explain the discrepancies. Similar  
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22 to serum albumin, the usage of prealbumin in predicting malnutrition is limited due to  
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24 systemic inflammatory diseases.<sup>41, 45</sup>  
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30 Hemoglobin has been shown to decrease with progressive malnutrition.<sup>46, 47</sup> This  
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32 relationship, consistent with a recent analysis performed in Northern China<sup>29</sup>, is found  
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34 in our study. Total lymphocyte count was assumed to be suitable in screening test for  
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36 assessing malnutrition and being an indicator of a poor prognosis.<sup>27</sup> In agreement with  
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38 Lei *et al*<sup>48</sup>, we found a significant correlation between TLC and MNA. However, no  
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40 correlation was found between NRS2002 and TLC, coincidence with a previous  
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42 study.<sup>29</sup>  
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47 The prevalence of malnutrition diagnosed by BMI was far below that detected by  
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49 MNA. Consistent with findings from another study<sup>49</sup>, this study suggest malnutrition  
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51 is also under diagnosed when using BMI as the sole criteria. The reason is most likely  
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53 related to water-sodium retention in patients, leading to an overestimation of their true  
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3 weight.<sup>50</sup> In spite of this, low BMI was significantly associated with mortality.<sup>51</sup>  
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6 Our study revealed that NRS2002 and MNA, in moderate agreement with each  
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8 other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless,  
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10 the MNA identified more patients with or at risk of malnutrition than did the  
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12 NRS2002. The lower percentage of malnutrition classified by NRS2002 may be  
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14 explained in several ways. First, the NRS2002 mainly consider the influence of acute  
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16 diseases to nutritional status, while the MNA take chronic long-term condition into  
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18 account, such as psychological factors and the BMI. Psychological factors may play a  
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20 large role in the nutritional status of older inpatients. In addition, we categorized  
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22 undernutrition as  $NRS2002 \geq 3$ , while patients with a score of 1-2 indicates low risk of  
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24 malnutrition.<sup>52</sup> This may have underestimated the percentage of malnutrition.  
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26 Moreover, our study subjects were internal medical patients, of which the proportion  
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28 of overweight and obesity was high. The NRS2002 take  $BMI < 18.5 \text{ kg/m}^2$  as one of  
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30 the criteria, which leads to a lower proportion of malnutrition with NRS2002 than that  
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32 of MNA. Our results are in agreement with findings from Raslan *et al*,<sup>5</sup> but differ  
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34 from the study conducted by Drescher *et al*.<sup>52</sup> The latter study was conducted in older  
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36 patients with acute disease, which may explain the difference.  
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45 Norman *et al* suggested that there is a close relationship between the degree of  
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47 malnutrition and LOS.<sup>53</sup> In the present study, we found the linear relation between  
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49 both instruments (MNA and NRS2002) and LOS. Our findings corroborated those of  
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51 the study by Bauer *et al*,<sup>54</sup> which showed longer hospital stay was associated with  
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53 malnutrition assessed by the MNA. We conclude, therefore, that in Chinese geriatric  
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3 inpatients, the NRS2002 and MNA might reflect malnutrition or the studied  
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5 biochemical parameters, as well as predicting the length of hospitalization, however,  
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7 the MNA was available for identifying most of the patients with or at risk of  
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9 malnutrition.  
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### 18 **Limitations**

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

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42 In summary, the results of the present study show a high prevalence of  
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44 malnutrition risk in Chinese geriatric hospitalized patients. Although the nutritional  
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46 risk varied depending on the method used, both NRS2002 and MNA correlated with  
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48 each other and with age, BMI and laboratory parameters. Besides, both tools were  
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50 found to be a good predictor of the length of hospitalization. Therefore, this study  
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52 suggests NRS2002 and MNA both were suitable to screen malnutrition risk among  
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3 Chinese geriatric inpatients. We recommend one of them to be used in admission.  
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12 ethics committee and the individual researchers, clinicians and nurses for their  
13 participation in the data collection.  
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21  
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23 study. JPM and XQQ contributed to the study conception and design. HLZ and CTZ,  
24 took part in the discussion and modification of the study design. HZ, MY, LYS, QHG,  
25 GYZ, QJM, YXW, and SGL contributed to the study conception. XQQ, HZ, MY, LYS,  
26 QHG, GYZ, QJM, YXW and SGL were involved in the acquisition of data. JPM and  
27 XQQ contributed to the drafting of the manuscript. HLZ and CTZ were involved in  
28 the critical revision. All the authors were involved in the analysis and interpretation of  
29 the data and gave their final approval.  
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7 **Ethics approval** Ethics Review Board of Tongji Hospital, Tongji Medical College,  
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10 Huazhong University of Science and Technology (TJ-C20141112).

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22 **Data sharing statement** No additional data are available.

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3 **Figure legend**

4 **Figure 1** Flow diagram of participant inclusion and exclusion.

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7 **Figure 2** MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin,  
8 hemoglobin and blood lymphocytes count respectively.  
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For peer review only



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**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 <sup>2</sup> )	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

	<b>Under-nourished</b>	<b>Well-nourished</b>
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		
<i>P</i>	<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	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
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	$\beta$	t	P	95%CI	R <sup>2</sup>	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.

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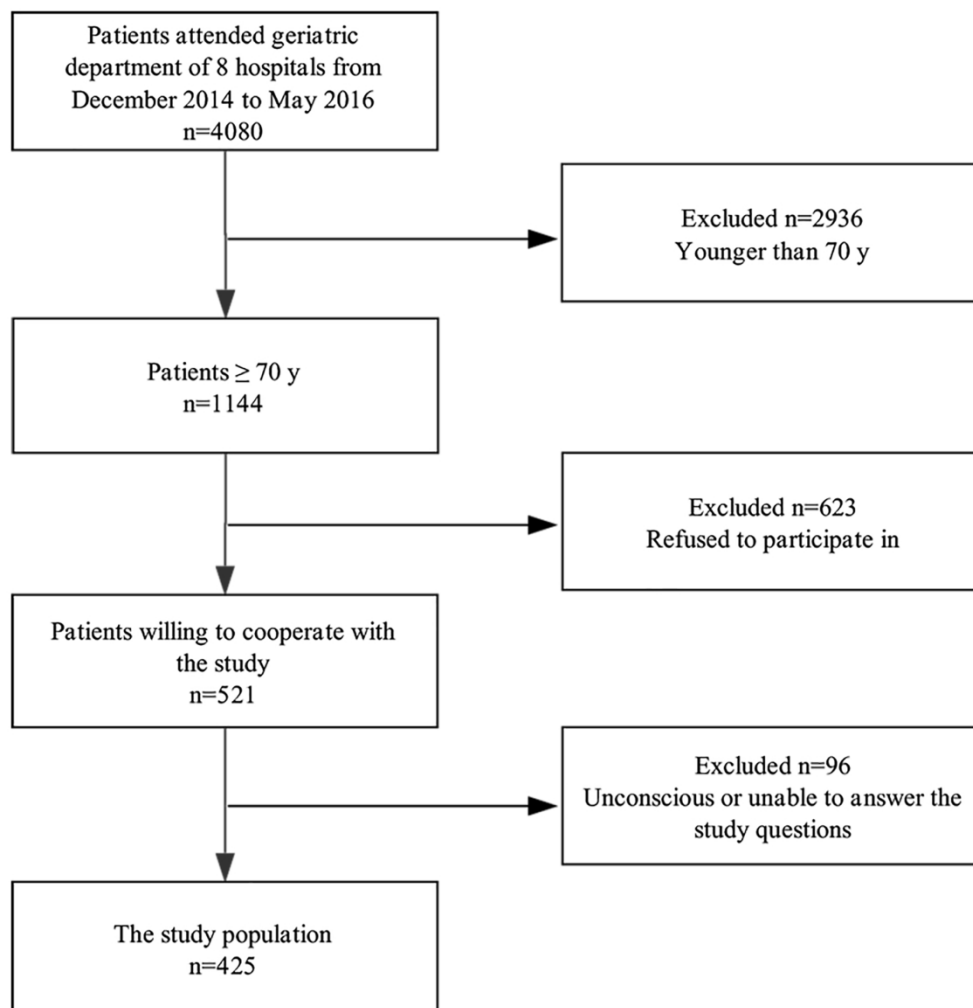


Figure 1 Flow diagram of participant inclusion and exclusion.

167x172mm (300 x 300 DPI)

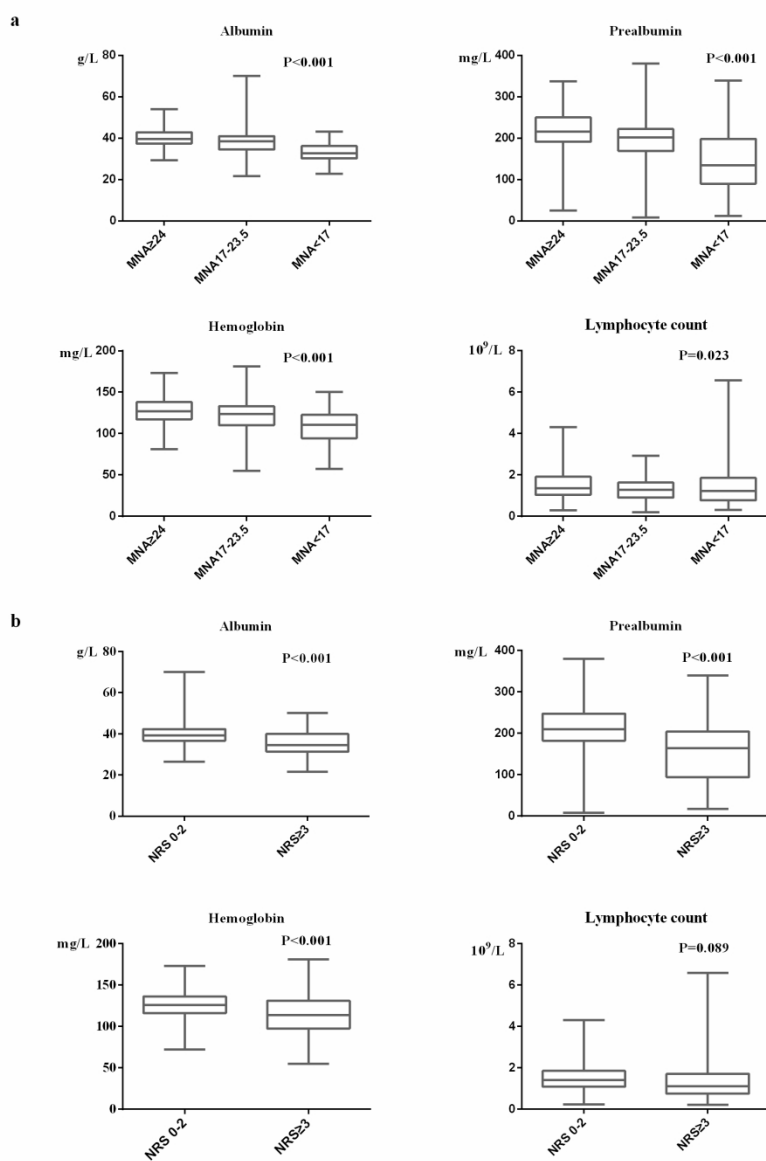


Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

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

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Complete List of Authors:	<p>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</p> <p>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</p> <p>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</p> <p>Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics</p> <p>Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics</p> <p>Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics</p> <p>Mei, Qi-Jian; General Hospital of the Yangtze River Shipping</p> <p>Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics</p> <p>Li, Shu-Guo; First Clinical Medical College, Three Gorges University &amp; Yichang Central People's Hospital, Department of Geriatrics</p> <p>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</p>
<b>Primary Subject Heading</b>:	Nutrition and metabolism
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	malnutrition risk, NRS2002, MNA, older patients

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3 **Comparison of two malnutrition risk screening tools with nutritional**  
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10 Jian-Ping Miao<sup>1,2,3</sup>, Xiao-Qing Quan<sup>1,2,3</sup>, Cun-Tai Zhang<sup>1,2,3</sup>, Hong Zhu<sup>4</sup>, Mei Ye<sup>5</sup>,  
11 Li-Ya Shen<sup>6</sup>, Qiu-Hui Guo<sup>6</sup>, Gang-Yan Zhu<sup>7</sup>, Qi-Jian Mei<sup>8</sup>, Yan-Xia Wu<sup>9</sup>,  
12 Shu-Guo Li<sup>10</sup>, Hong-Lian Zhou<sup>1,2,3\*</sup>  
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20 **Running title: Malnutrition screening in Chinese geriatric patients**  
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- 23 1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong  
24 University of Science and Technology;  
25  
26 2. Clinical Research Center for Geriatric Prevention and Treatment and Health  
27 Medicine in Hubei Province  
28  
29 3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ  
30 Dysfunction in Wuhan  
31  
32 4. Department of Geriatrics, the Central Hospital of Wuhan University;  
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34 5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;  
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36 6. Department of Geriatrics, Wuhan No. 6 Hospital;  
37  
38 7. Department of Geriatrics, Hubei General Hospital;  
39  
40 8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;  
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42 9. Department of Geriatrics, Wuhan No 1 Hospital;  
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44 10. Department of Geriatrics, First Clinical Medical College, Three Gorges University  
45 & Yichang Central People's Hospital.  
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50 JPM and XQQ contributed equally.  
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54 Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com  
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**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  $\geq 70$  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  $81.2 \pm 5.9$  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 ( $\kappa = 0.521$ ,  $P < 0.001$ ) 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.<sup>1</sup> It is highly associated with numerous adverse outcomes including frailty,<sup>2</sup> muscle wasting<sup>3</sup>, weakened immune system<sup>4</sup>, longer hospitalization,<sup>5</sup> increased morbidity<sup>6</sup> and mortality.<sup>7,8</sup> These outcomes contribute to large increases in medical expenditures.<sup>9</sup> Early identification and treatment of malnutrition can lead to better quality of life<sup>10</sup> and improved outcomes<sup>11</sup> 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.<sup>12</sup> 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,<sup>13</sup> 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).<sup>14</sup> It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.<sup>15, 16</sup> However, the use of NRS2002 excludes patients who cannot be weighed or have problems of communication and the tool is

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3 not specifically developed for older patients.  
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6 The Mini-Nutritional Assessment (MNA) is established for the nutritional  
7 screening and assessment in the geriatrics settings.<sup>1, 17</sup> The ESPEN recommends using  
8 this tool for elderly populations.<sup>18</sup> The MNA was validated against a clinical  
9 evaluations of two geriatrics, including biochemical parameters (nutritional  
10 parameters, C-reactive protein, cholesterol, vitamins), anthropometry (BMI, brachial  
11 circumference, calf circumference, skinfold width of the triceps and subscapular  
12 muscles), dietary components and functional assessment outcomes.<sup>19</sup> It has been  
13 shown to predict outcomes, functional status, mortality, number of hospital visits and  
14 the related healthcare costs.<sup>18, 20-23</sup> In comparison with the NRS2002, the MNA is  
15 more time consuming.<sup>24</sup> Hence, two short forms of the MNA have been developed  
16 and validated, the most recently the revised MNA-SF by Kaiser *et al*<sup>25</sup>, which is  
17 currently the recommended version of the MNA for clinical use. This instrument only  
18 incorporates 6 of the original 18 items and takes approximately 5 minutes to perform.  
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39 Although a number of studies suggested that serum proteins are associated with  
40 malnutrition, the nature of this association is controversial.<sup>26-28</sup> In addition,  
41 hemoglobin and total lymphocyte count were also proposed as useful indicators of  
42 nutritional status.<sup>27, 29</sup> The aim of our study was to assess the risk of malnutrition  
43 among Chinese older participants with two different tools (NRS2002 and MNA), to  
44 compare them in terms of nutritional biochemical parameters and length of hospital  
45 stay (LOS), and determine the most appropriate tool for these patients. We  
46 hypothesized that both tools were suitable for the study population.  
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## 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 Jiangnan 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.<sup>15</sup> The total score ranges from 0 to 7.<sup>16</sup> For investigational purposes, patients were categorized into two groups: a total score  $\geq 3$  indicates under-nourished (at nutritional risk/malnourished) and 0-2 indicates normal nutrition status.<sup>14,30</sup> A nutritional care plan was initiated for patients with a score  $\geq 3$ .<sup>31</sup>

### **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).<sup>32</sup> A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.<sup>33</sup> In addition, a nutritional care plan was initiated for patients with a score  $< 17$ .<sup>31</sup>

### **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

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3 both MNA and NRS2002 by two trained researchers on the first day of admission or  
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6 early morning of the next day.  
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9 Comorbidities and length of hospitalization were obtained from medical records.  
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11 Patients were diagnosed by their bedside clinician and superior clinicians. Two trained  
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13 researchers of each hospital verified the diagnoses and acquired data. Both body  
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15 height and weight were measured at 6-8 am within 24 hours after admission. Patients  
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17 were asked to be fasting, only wearing ward clothes and taking off shoes before  
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19 measurement. Besides, height was measured with a calibrated scale (corrected to  $\pm 0.5$   
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21 cm). The actual body mass was measured with a calibrated scale (corrected to  $\pm 0.2$   
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23 kg). Then, the body mass index (BMI) was calculated as weight/height squared  
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32 Blood samples were also obtained within 24 hours after admission. Nutritional  
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34 biochemical parameters including serum hemoglobin (Hb), total lymphocyte count  
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36 (TLC), albumin (ALB) and prealbumin (PAB) were examined in the hospital's  
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38 clinical chemistry laboratory. Malnutrition was determined when the value of Hb was  
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40  $<120$  g/L for males and  $<110$  g/L for females. The cutoff value of ALB was 35 g/L  
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42 (normal range 35-55 g/L), PAB was 200mg/L (normal range 200-400 mg/L) and TLC  
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44 was  $1.1 \times 10^9$ /L (normal range  $1.1-3.2 \times 10^9$ /L) for both genders for malnutrition.<sup>34</sup>  
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48 Moreover, based on previous research<sup>35</sup>, the cutoff value of BMI was set at 20.5  
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## 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  $\pm$  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 ( $\kappa$ ) 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.<sup>29</sup> 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  $81.2 \pm 5.9$  years (range, 70-98) and 31.1% were females. The average body mass index was  $23.2 \pm 3.7$  kg/m<sup>2</sup> (range, 11.1-34.1). The average length of hospitalization was  $21.9 \pm 13.8$  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



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3 showed substantial differences. Table 3 showed the cross-classification of MNA and  
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6 NRS2002 regarding two nutritional categories. The MNA classified more patients as  
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8 under-nourished than the NRS2002 (249 vs 174, respectively). Among the 249  
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10 patients classified as under-nourished by the MNA, the NRS2002 coincidentally  
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12 categorized 159 as malnourished, and 90 as well-nourished. The NRS2002, on the  
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14 other hand, classified 174 patients as under-nourished. Within this group of  
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16 participants, the MNA classified 159 patients as under-nourished and 15 as  
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18 well-nourished. What's more, a participant considered by the MNA to be  
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20 well-nourished can be classified as under-nourished using the NRS2002. The  
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22 individual categorization of nutritional status presented moderate agreement between  
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24 MNA and NRS2002 ( $\kappa=0.521$ ,  $P<0.001$ ).  
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30 Data of Hb, TLC, ALB and PAB concentrations are listed in Table 2 and  
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32 additional Table 1. There existed significant decrease of ALB, PAB, Hb and TLC in  
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34 the three groups of MNA scores ( $P<0.001$  and  $P=0.023$ , Figure 2a). Specifically, the  
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36 group with the lowest MNA score  $<17$  ( $n=99$ ), indicating a poor nutritional state, had  
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38 an average serum albumin of  $33.3\pm 4.8$  g/L (range, 22.8-43.2), an average prealbumin  
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40 of  $140.8\pm 81.7$  mg/L (range, 12-339) and an average hemoglobin of  $109.0\pm 20.8$  g/L  
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42 (range, 57-150.2) as well as an average lymphocyte count of  $1.5\pm 1.2$   $10^9$ /L (range,  
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44 0.3-6.6). In the risk of malnutrition group with an MNA score of 17-23.5 ( $n=150$ ),  
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46 average serum albumin was  $37.9\pm 5.6$  g/L (range, 21.6-70), average prealbumin  
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48  $192.3\pm 61.8$  mg/L (range, 8-380), average hemoglobin  $120.2\pm 22.0$  g/L (range, 55-181)  
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50 and an average lymphocyte count of  $1.3\pm 0.56$   $10^9$ /L (range, 0.2-2.9). The group with  
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3 MNA $\geq$ 24 (n=180) had an average serum albumin concentration of 39.8 $\pm$ 3.8 g/L  
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5 (range, 29.3-54), an average prealbumin of 216.7 $\pm$ 54.4 mg/L (range, 25-337), an  
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7 average hemoglobin of 127.6 $\pm$ 15.3 g/L (range, 81-173) and an average lymphocyte  
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9 count of 1.5 $\pm$ 0.7 10<sup>9</sup>/L (range, 0.3-4.3; Figure 2a, additional Table 1).  
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13 Similarly, ALB, PAB and Hb gradually declined with increasing risk of  
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15 malnutrition according to NRS2002 results ( $P$ <0.001, figure 2b). In under-nourished  
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17 patients (NRS2002: 3-7, n=174), average serum albumin was 35.1 $\pm$ 5.6 g/L (range,  
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19 21.6-50.2), average prealbumin 148.5 $\pm$ 79.3 mg/L (range, 17-339) and average  
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21 hemoglobin 113.3 $\pm$ 23.6 g/L (range, 55-181). In the normal nutritional state group  
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23 (NRS2002: 0-2, n=251), the results were as follows: albumin 39.4 $\pm$ 4.5 g/L (range,  
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25 26.4-70), prealbumin 210.2 $\pm$ 56.1 mg/L (range, 8-380) and hemoglobin 125.8 $\pm$ 16.2  
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27 g/L (range, 72-173). By contrast, no difference in lymphocyte count was found in both  
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29 groups ( $P$ =0.089, Figure 2b, additional Table 1).  
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35 Table 4 showed the Pearson correlation coefficients of MNA and NRS2002  
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37 scores with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated  
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39 negatively with malnutrition scores of NRS2002, while showed positive correlation  
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41 with the MNA scores ( $P$ <0.001). There existed an inverse correlation between age and  
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43 the two tools ( $P$ <0.001). Besides, a significant association between both tools and  
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45 LOS was demonstrated ( $P$ <0.05). No correlation was found between TLC and the two  
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47 tools.  
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52 Table 5 showed the simple linear regression of LOS. There was a linear  
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54 correlation between the MNA scores and LOS ( $P$ <0.05) and so was the NRS2002  
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4 scores ( $P<0.01$ ).

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6 Figure 3 showed the ROC curve analysis of the sensitivities and specificities of  
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8 MNA and NRS2002 for predicting nutritional risk. The comparison between MNA  
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10 and NRS2002 in those patients revealed the area under ROC curve (AUC) values for  
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12 MNA (0.794, ALB; 0.704, PAB; 0.702, Hb; 0.581, TLC) and NRS2002 (0.761, ALB;  
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14 0.616, PAB; 0.677, Hb; 0.586, TLC). Besides, the comparison between the AUC  
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16 showed that NRS2002 was not different from MNA for predicting nutritional risk  
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18 ( $P=0.191$ , ALB;  $P=0.063$ , PAB;  $P=0.299$ , Hb;  $P=0.866$ , TLC).  
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## 28 **DISCUSSION**

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30 Based on the current study, the nutritional health of older inpatients was assessed  
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32 using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. The results showed that the  
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34 overall prevalence of malnutrition risk for the enrolled older patients ranged from  
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36 23.7% to 58.6%. The highest prevalence of malnutrition risk was detected by MNA  
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38 and the lowest by BMI. These results illustrated the differences in nutritional risk  
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40 detected by different screening tools.  
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45 Biochemical markers possess many advantages in assessing the nutritional status,  
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47 such as fast application and low cost. In addition, they can also be incorporated into  
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49 the routine of clinical application. As the most abundant plasmatic protein, albumin is  
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51 commonly used in the assessment of malnutrition.<sup>36</sup> In several of studies, low serum  
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53 ALB correlated with longer hospitalization, medical complications, and increased  
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3 mortality.<sup>36-38</sup> Nevertheless, its value is still limited by the long half-life (14-20 days),  
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5 inflammation, the impairment of hepatic or renal, and possibly aging itself.<sup>27</sup> Due to  
6  
7 the reasons above, the prevalence of malnutrition detected by ALB is lower than  
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9 MNA and NRS2002 in our study. Comparatively, a study by Covinsky *et al*<sup>39</sup> showed  
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11 ALB is highly sensitive yet low specific in the diagnosis of malnutrition in the  
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13 hospitalized older adults.  
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18 Prealbumin has been regarded as a more sensitive marker than albumin for acute  
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20 nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in  
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22 nutritional screening and mortality prediction remain controversial.<sup>40-43</sup> In our study,  
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24 prealbumin levels showed a great decline with deteriorating nutrition status assessed  
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26 by both NRS2002 and MNA. The correlation between serum prealbumin and MNA is  
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28 consistent with one study<sup>44</sup>, yet is in contrast with another report.<sup>42</sup> This latter study  
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30 had a small sample size (23 older patients), which may account for the discrepancies.  
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32 Similar to serum albumin, the usage of prealbumin in predicting malnutrition is  
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34 limited due to systemic inflammatory diseases.<sup>41, 45</sup>  
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40 Hemoglobin has been demonstrated to decrease with progressive malnutrition.<sup>46,</sup>  
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42 <sup>47</sup> This relationship, consistent with a recent analysis performed in Northern China<sup>29</sup>,  
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44 is found in the proposed study. Total lymphocyte count was assumed to be suitable in  
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46 screening test for assessing malnutrition and being an indicator of a poor prognosis.<sup>27</sup>  
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48 In agreement with Lei *et al*<sup>48</sup>, we also found a significant correlation between TLC  
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50 and MNA. However, no correlation was found between NRS2002 and TLC, which  
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52 was consistent with a previous study.<sup>29</sup>  
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4 The prevalence of malnutrition diagnosed by BMI was far below that detected by  
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6 MNA. Consistent with findings from another study<sup>49</sup>, this study suggested that  
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8 malnutrition was also under diagnosed when using BMI as the sole criteria. The  
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10 reason is most possibly related to water-sodium retention in patients, leading to an  
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12 overestimation of their true weight.<sup>50</sup> In spite of this, low BMI was significantly  
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14 associated with mortality.<sup>51</sup>  
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18 Our study revealed that NRS2002 and MNA, in moderate agreement with each  
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20 other, were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless,  
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22 the MNA identified more patients with or at risk of malnutrition than the NRS2002  
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24 did. The lower percentage of malnutrition classified by NRS2002 may be explained in  
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26 several ways. First, the NRS2002 mainly consider the influence of acute diseases on  
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28 nutritional status, while the MNA take chronic long-term condition into consideration,  
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30 such as psychological factors and the BMI. Psychological factors may play a large  
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32 role in the nutritional status of older inpatients. In addition, we categorized  
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34 undernutrition as  $NRS2002 \geq 3$ , while patients with a score of 1-2 indicates low risk of  
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36 malnutrition.<sup>52</sup> This may have underestimated the percentage of malnutrition.  
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38 Moreover, our study subjects were internal medical patients, among which the  
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40 proportion of overweight and obesity was high. The NRS2002 takes  $BMI < 18.5$   
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42  $kg/m^2$  as one of the criteria, leading to a lower proportion of malnutrition with  
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44 NRS2002 than that of MNA. Our results agree with findings from Raslan *et al*,<sup>5</sup> yet  
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46 differ from the study conducted by Drescher *et al*.<sup>52</sup> The latter study was conducted in  
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48 older patients with acute disease, which may explain the difference.  
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4 Norman *et al* suggested that there exists a close relationship between the degree  
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6 of malnutrition and LOS.<sup>53</sup> In the present study, we found the linear relation between  
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8 both instruments (MNA and NRS2002) and LOS. Our findings corroborated those of  
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10 the study conducted by Bauer *et al*,<sup>54</sup> showing longer hospital stay was associated  
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12 with malnutrition assessed by the MNA. Comparison of the MNA and NRS 2002 and  
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14 their ability to predict nutritional risk according to different standards showed that  
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16 MNA and NRS 2002 were the both suitable screening tools, in terms of the ROC  
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18 curve area. Therefore, we conclude, that in Chinese geriatric inpatients, the NRS2002  
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20 and MNA might reflect malnutrition or the studied biochemical parameters, as well as  
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22 predict the length of hospitalization. However, the MNA was available for identifying  
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24 most of the patients with or at risk of malnutrition.  
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### 35 **Limitations**

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

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2  
3 XQQ made contributions to the drafting of the manuscript. HLZ and CTZ were  
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6 involved in the critical revision. All the authors were involved in the analysis and  
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8 interpretation of the data and gave their final approval.  
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23 **Competing interests** None declared.  
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30 **Ethics approval** Ethics Review Board of Tongji Hospital, Tongji Medical College,  
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33 Huazhong University of Science and Technology (TJ-C20141112).  
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38 **Provenance and peer review** Not commissioned; externally peer reviewed.  
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45 **Data sharing statement** No additional data are available.  
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For peer review only

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3 **Figure legend**  
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5 **Figure 1** Flow diagram of participant inclusion and exclusion.  
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9 **Figure 2** MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin,  
10 hemoglobin and blood lymphocytes count respectively.  
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14 **Figure 3** Receiver operating characteristics of sensitivity and specificity of predicted  
15 probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.  
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**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 <sup>2</sup> )	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

	<b>Under-nourished</b>	<b>Well-nourished</b>
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		
<i>P</i>	<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	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
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	$\beta$	t	P	95%CI	R <sup>2</sup>	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.

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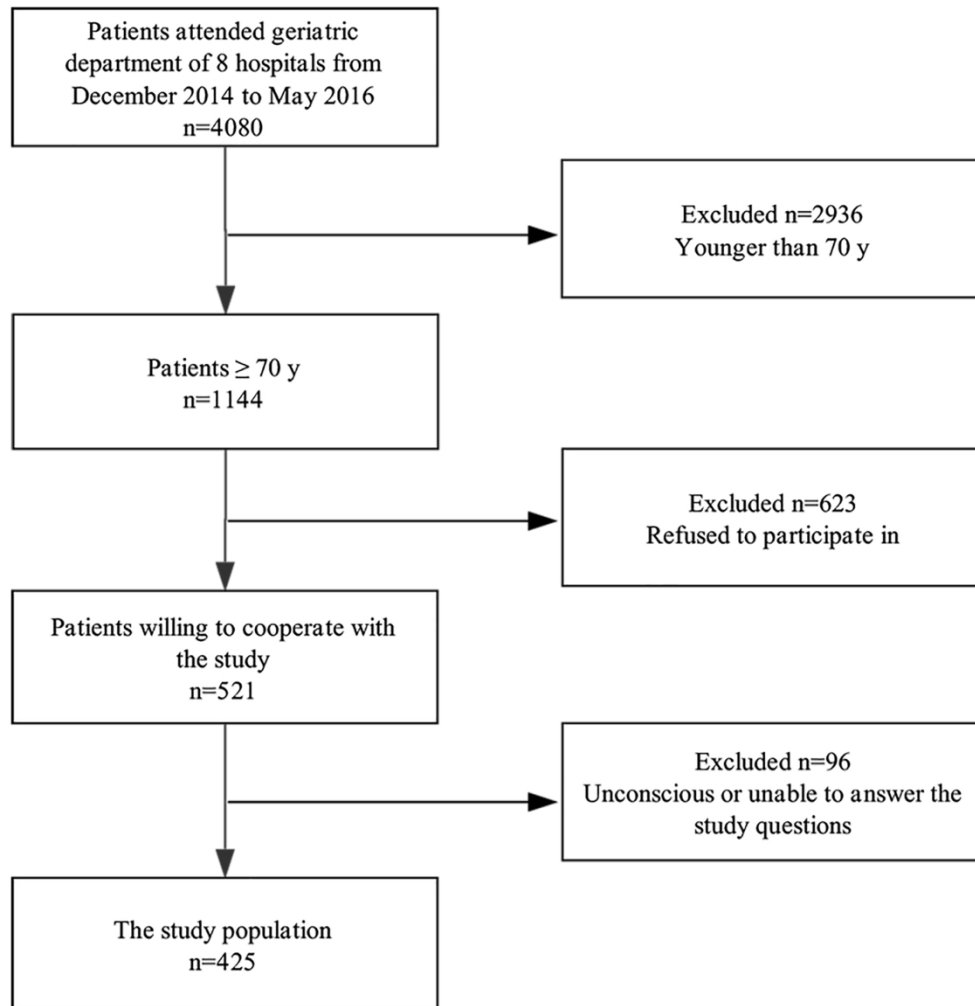


Figure 1 Flow diagram of participant inclusion and exclusion.

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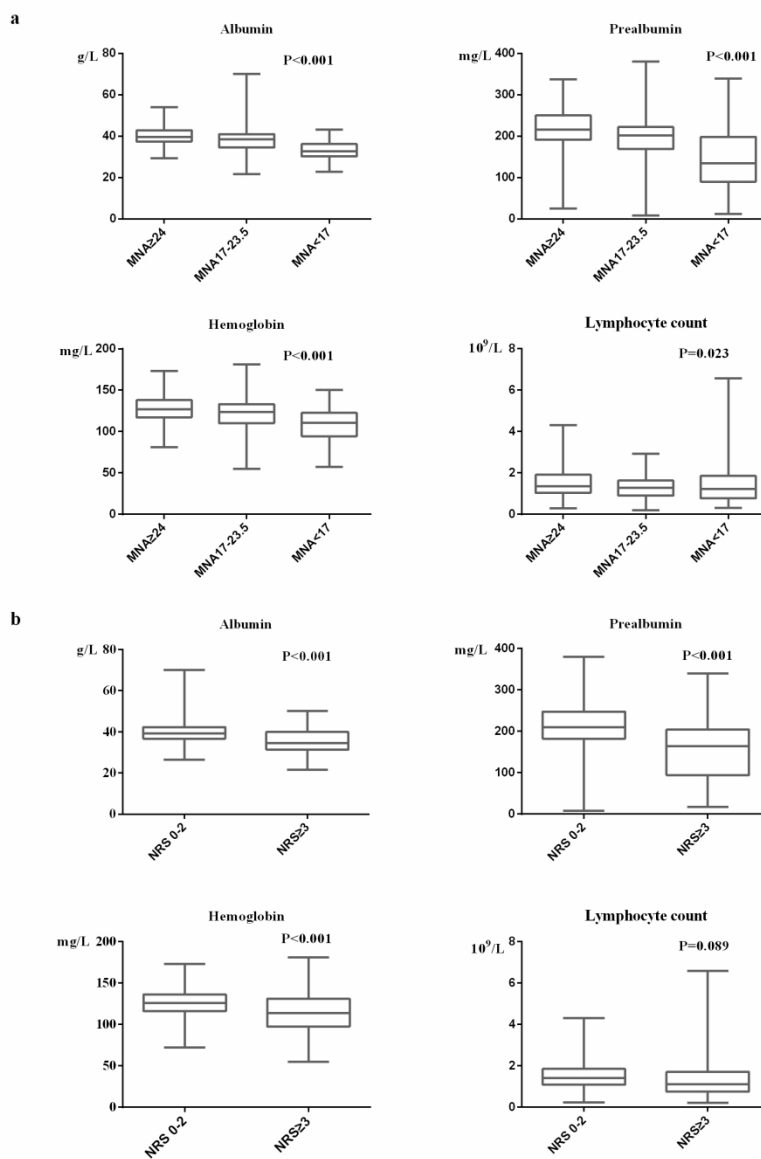


Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

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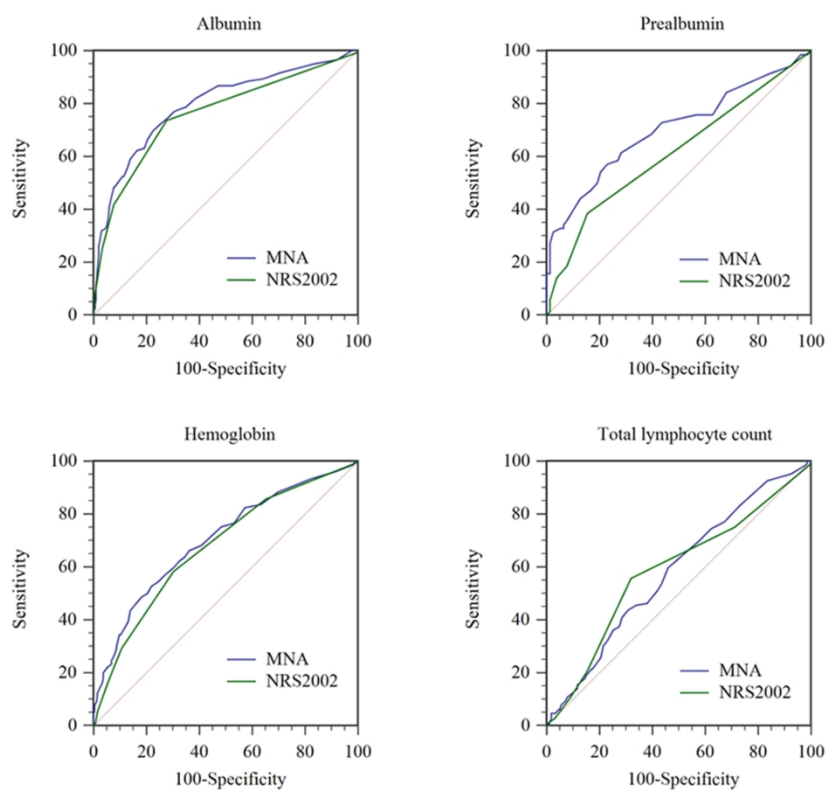


Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

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 ( $10^9/L$ )
<b>MNA</b>				
<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)
<b>NRS2002</b>				
≥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
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		<i>Case-control study</i> —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	
		<i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	NA
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
		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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	NA
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	9



Section/Topic	Item No	Recommendation	Reported on Page No
<b>Results</b>			
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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	NA
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	NA
		<i>Cross-sectional study</i> —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
<b>Discussion</b>			
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
<b>Other Information</b>			
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](http://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

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Complete List of Authors:	<p>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</p> <p>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</p> <p>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</p> <p>Zhu, Hong; the Central Hospital of Wuhan University, Department of Geriatrics</p> <p>Ye, Mei; Zhongnan Hospital of Wuhan University, Department of Geriatrics</p> <p>Shen, Li-Ya; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Guo, Qiu-Hui; Wuhan No. 6 Hospital, Department of Geriatrics</p> <p>Zhu, Gang-Yan; Hubei General Hospital, Department of Geriatrics</p> <p>Mei, Qi-Jian; General Hospital of the Yangtze River Shipping</p> <p>Wu, Yan-Xia; Wuhan No 1 Hospital, Department of Geriatrics</p> <p>Li, Shu-Guo; First Clinical Medical College, Three Gorges University &amp; Yichang Central People's Hospital, Department of Geriatrics</p> <p>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</p>
<b>Primary Subject Heading</b>:	Nutrition and metabolism
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	malnutrition risk, NRS2002, MNA, older patients

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4 **Comparison of two malnutrition risk screening tools with nutritional biochemical**  
5 **parameters, BMI and length of stay in Chinese geriatric inpatients: a multicenter,**  
6 **cross-sectional study**  
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11 Jian-Ping Miao<sup>1,2,3</sup>, Xiao-Qing Quan<sup>1,2,3</sup>, Cun-Tai Zhang<sup>1,2,3</sup>, Hong Zhu<sup>4</sup>, Mei Ye<sup>5</sup>, Li-  
12 Ya Shen<sup>6</sup>, Qiu-Hui Guo<sup>6</sup>, Gang-Yan Zhu<sup>7</sup>, Qi-Jian Mei<sup>8</sup>, Yan-Xia Wu<sup>9</sup>,  
13 Shu-Guo Li<sup>10</sup>, Hong-Lian Zhou<sup>1,2,3\*</sup>  
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21 **Running title: Malnutrition screening in Chinese geriatric patients**  
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- 25 1. Department of Geriatrics, Tongji Hospital, Tongji Medical College, Huazhong  
26 University of Science and Technology;  
27  
28 2. Clinical Research Center for Geriatric Prevention and Treatment and Health Medicine  
29 in Hubei Province  
30  
31 3. Clinical Research Center for Treatment and Rehabilitation of Elderly Multi-Organ  
32 Dysfunction in Wuhan  
33  
34 4. Department of Geriatrics, the Central Hospital of Wuhan University;  
35  
36 5. Department of Geriatrics, Zhongnan Hospital of Wuhan University;  
37  
38 6. Department of Geriatrics, Wuhan No. 6 Hospital;  
39  
40 7. Department of Geriatrics, Hubei General Hospital;  
41  
42 8. Department of Geriatrics, General Hospital of the Yangtze River Shipping;  
43  
44 9. Department of Geriatrics, Wuhan No 1 Hospital;  
45  
46 10. Department of Geriatrics, First Clinical Medical College, Three Gorges University &  
47 Yichang Central People's Hospital.  
48  
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51

52  
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54 JPM and XQQ contributed equally.  
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Correspondence to Dr Hong-Lian Zhou; zhouhonglian63@163.com

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## 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  $\geq 70$  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  $81.2 \pm 5.9$  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 ( $\kappa = 0.521$ ,  $P < 0.001$ ) 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.<sup>1</sup> It is highly associated with numerous adverse outcomes including frailty,<sup>2</sup> muscle wasting<sup>3</sup>, weakened immune system<sup>4</sup>, longer hospitalization,<sup>5</sup> increased morbidity<sup>6</sup> and mortality.<sup>7, 8</sup> These outcomes contribute to large increases in medical expenditures.<sup>9</sup> Early identification and treatment of malnutrition can lead to better quality of life<sup>10</sup> and improved outcomes<sup>11</sup> 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.<sup>12</sup> 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,<sup>13</sup> 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).<sup>14</sup> It can quickly determine whether a patient needs nutritional support, especially for patients with acute complications.<sup>15, 16</sup> 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.



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4 The Mini-Nutritional Assessment (MNA) is established for the nutritional screening  
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6 and assessment in the geriatrics settings.<sup>1, 17</sup> The ESPEN recommends using this tool for  
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8 elderly populations.<sup>18</sup> The MNA was validated against a clinical evaluations of two  
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10 geriatrics, including biochemical parameters (nutritional parameters, C-reactive protein,  
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12 cholesterol, vitamins), anthropometry (BMI, brachial circumference, calf circumference,  
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14 skinfold width of the triceps and subscapular muscles), dietary components and functional  
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16 assessment outcomes.<sup>19</sup> It has been shown to predict outcomes, functional status, mortality,  
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18 number of hospital visits and the related healthcare costs.<sup>18, 20-23</sup> In comparison with the  
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20 NRS2002, the MNA is more time consuming.<sup>24</sup> Hence, two short forms of the MNA have  
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22 been developed and validated, the most recently the revised MNA-SF by Kaiser *et al*<sup>25</sup>,  
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24 which is currently the recommended version of the MNA for clinical use. This instrument  
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26 only incorporates 6 of the original 18 items and takes approximately 5 minutes to perform.  
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36 Although a number of studies suggested that serum proteins are associated with  
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38 malnutrition, the nature of this association is controversial.<sup>26-28</sup> In addition, hemoglobin  
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40 and total lymphocyte count were also proposed as useful indicators of nutritional status.<sup>27</sup>  
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44 <sup>29</sup> The aim of our study was to assess the risk of malnutrition among Chinese older  
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46 participants with two different tools (NRS2002 and MNA), to compare them in terms of  
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48 nutritional biochemical parameters and length of hospital stay (LOS), and determine the  
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50 most appropriate tool for these patients. We hypothesized that both tools were suitable for  
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52 the study population.  
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## 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 Jiangnan 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.<sup>15</sup> The total score ranges from 0 to 7.<sup>16</sup> For investigational purposes, patients were categorized into two groups: a total score  $\geq 3$  indicates under-nourished (at nutritional risk/malnourished) and 0-2 indicates normal nutrition status.<sup>14, 30</sup> A nutritional care plan was initiated for patients with a score  $\geq 3$ .<sup>31</sup>

## 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).<sup>32</sup> A score below 17 indicates malnutrition, 17-23.5 indicates malnutrition risk and 24-30 indicates well-nourished.<sup>33</sup> In addition, a nutritional care plan was initiated for patients with a score  $< 17$ .<sup>31</sup>

## 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

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4 next day.  
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7 Comorbidities and length of hospitalization were obtained from medical records.  
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9 Patients were diagnosed by their bedside clinician and superior clinicians. Two trained  
10 researchers of each hospital verified the diagnoses and acquired data. Both body height and  
11  
12 researchers of each hospital verified the diagnoses and acquired data. Both body height and  
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14 weight were measured at 6-8 am within 24 hours after admission. Patients were asked to  
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16 be fasting, only wearing ward clothes and taking off shoes before measurement. Besides,  
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18 height was measured with a calibrated scale (corrected to  $\pm 0.5$  cm). The actual body mass  
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20 was measured with a calibrated scale (corrected to  $\pm 0.2$  kg). Then, the body mass index  
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22 (BMI) was calculated as weight/height squared ( $\text{kg}/\text{m}^2$ ).  
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28 Blood samples were also obtained within 24 hours after admission. Nutritional  
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30 biochemical parameters including serum hemoglobin (Hb), total lymphocyte count (TLC),  
31  
32 albumin (ALB) and prealbumin (PAB) were examined in the hospital's clinical chemistry  
33  
34 laboratory. Malnutrition was determined when the value of Hb was  $< 120$  g/L for males and  
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36  $< 110$  g/L for females. The cutoff value of ALB was 35 g/L (normal range 35-55 g/L), PAB  
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38 was 200mg/L (normal range 200-400 mg/L) and TLC was  $1.1 \times 10^9/\text{L}$  (normal range 1.1-  
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40  $3.2 \times 10^9/\text{L}$ ) for both genders for malnutrition.<sup>34</sup> Moreover, based on previous research<sup>35</sup>,  
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42 the cutoff value of BMI was set at  $20.5 \text{ kg}/\text{m}^2$  for malnutrition.  
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### 53 **Patient and public involvement**

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56 Patients did not participate in the design and conception of the proposed study. No  
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4 patients were asked to advice on interpretation or writing up of results. Besides, the results  
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6 of measurements would be disseminated to participants immediately after the investigation.  
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### 10 11 12 **Statistical analysis**

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14 The statistical analyses were conducted using SPSS 19.0. Data were presented as  
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16 mean  $\pm$  standard deviation and ranges in blanket. The chi-square test or student's *t*-test was  
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18 used according to the data type. One-way analysis of variance was applied for multigroup  
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20 comparisons and correlation analysis was qualified by the Pearson correlation test. The  
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22 simple linear regression analysis was used to estimate the relationship between both  
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24 instruments (MNA/NRS2002) and LOS. Agreement between the two screening tools was  
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26 achieved by the kappa ( $\kappa$ ) statistic. The results were interpreted as follows:  $<0$ , no  
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28 agreement; 0-0.19, poor concordance; 0.20-0.39, fair agreement; 0.40-0.59, moderate  
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30 agreement; 0.60-0.79, substantial agreement; and 0.80-1.00, almost perfect agreement.<sup>29</sup> In  
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32 addition, the receiver operating characteristic (ROC) curve was applied to compare MNA  
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34 and NRS2002 separately with nutritional parameters using Medcalc 18.6. The level of  
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36 significance was set at  $P < 0.05$ .  
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## 52 53 **RESULTS**

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

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4 eight hospitals in Hubei Province met the eligibility criteria and completed a nutrition  
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6 assessment within 24 hours of admission (Figure 1). The average age was  $81.2\pm 5.9$  years  
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8 (range, 70-98) and 31.1% were females. The average body mass index was  $23.2\pm 3.7$  kg/m<sup>2</sup>  
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10 (range, 11.1-34.1). The average length of hospitalization was  $21.9\pm 13.8$  days (range, 4-  
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12 133). The most frequent cause of hospitalization was cardiac disease, followed by  
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14 pulmonary infection, hypertension, cerebrovascular diseases, digestive disease and  
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16 malignancies. However, the most frequent comorbidities were hypertension, diabetes  
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18 mellitus, cardiac disease and cerebrovascular disease. Characteristics of study participants  
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20 are shown in Table 1.  
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28 According to the NRS2002, approximately 174 patients (40.9%) were under-  
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30 nourished and 251 patients (59.1%) were at normal nutritional status. The MNA  
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32 demonstrated that 99 patients (23.3%) were malnourished, 150 patients (35.3%) were at  
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34 risk of malnutrition and 176 patients (41.4%) had a normal nutritional status.  
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38 Table 2 showed the risk of undernutrition, varying from 23.7% to 58.6%, according  
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40 to the different methods employed in the current work. The risk of under-nourished  
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42 participants classified by NRS2002, MNA, BMI, ALB, PAB, TLC were 40.9%, 58.6%,  
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44 23.7%, 28.7%, 47.3%, 35.9%, respectively. The risk of malnutrition was higher in men  
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46 than that in women according to hemoglobin (41.7% vs 25.6%, respectively).  
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51 Although both instruments were closely related to each other ( $P<0.001$ ), they showed  
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53 substantial differences. Table 3 showed the cross-classification of MNA and NRS2002  
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4 regarding two nutritional categories. The MNA classified more patients as under-nourished  
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6 than the NRS2002 (249 vs 174, respectively). Among the 249 patients classified as under-  
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8 nourished by the MNA, the NRS2002 coincidentally categorized 159 as malnourished, and  
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10 90 as well-nourished. The NRS2002, on the other hand, classified 174 patients as under-  
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12 nourished. Within this group of participants, the MNA classified 159 patients as under-  
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14 nourished and 15 as well-nourished. What's more, a participant considered by the MNA to  
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16 be well-nourished can be classified as under-nourished using the NRS2002. The individual  
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18 categorization of nutritional status presented moderate agreement between MNA and  
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20 NRS2002 ( $\kappa=0.521$ ,  $P<0.001$ ).  
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27 Data of Hb, TLC, ALB and PAB concentrations are listed in Table 2 and additional  
28  
29 Table 1. There existed significant decrease of ALB, PAB, Hb and TLC in the three groups  
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31 of MNA scores ( $P<0.001$  and  $P=0.023$ , Figure 2a). Specifically, the group with the lowest  
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33 MNA score  $<17$  ( $n=99$ ), indicating a poor nutritional state, had an average serum albumin  
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35 of  $33.3\pm 4.8$  g/L (range, 22.8-43.2), an average prealbumin of  $140.8\pm 81.7$  mg/L (range, 12-  
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37 339) and an average hemoglobin of  $109.0\pm 20.8$  g/L (range, 57-150.2) as well as an average  
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39 lymphocyte count of  $1.5\pm 1.2$   $10^9$ /L (range, 0.3-6.6). In the risk of malnutrition group with  
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41 an MNA score of 17-23.5 ( $n=150$ ), average serum albumin was  $37.9\pm 5.6$  g/L (range, 21.6-  
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43 70), average prealbumin  $192.3\pm 61.8$  mg/L (range, 8-380), average hemoglobin  $120.2\pm 22.0$   
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45 g/L (range, 55-181) and an average lymphocyte count of  $1.3\pm 0.56$   $10^9$ /L (range, 0.2-2.9).  
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47 The group with  $MNA\geq 24$  ( $n=180$ ) had an average serum albumin concentration of  
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49  $39.8\pm 3.8$  g/L (range, 29.3-54), an average prealbumin of  $216.7\pm 54.4$  mg/L (range, 25-337),  
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4 an average hemoglobin of  $127.6 \pm 15.3$  g/L (range, 81-173) and an average lymphocyte  
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6 count of  $1.5 \pm 0.7 \times 10^9$ /L (range, 0.3-4.3; Figure 2a, additional Table 1).  
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9 Similarly, ALB, PAB and Hb gradually declined with increasing risk of malnutrition  
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11 according to NRS2002 results ( $P < 0.001$ , figure 2b). In under-nourished patients (NRS2002:  
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13 3-7, n=174), average serum albumin was  $35.1 \pm 5.6$  g/L (range, 21.6-50.2), average  
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15 prealbumin  $148.5 \pm 79.3$  mg/L (range, 17-339) and average hemoglobin  $113.3 \pm 23.6$  g/L  
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17 (range, 55-181). In the normal nutritional state group (NRS2002: 0-2, n=251), the results  
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19 were as follows: albumin  $39.4 \pm 4.5$  g/L (range, 26.4-70), prealbumin  $210.2 \pm 56.1$  mg/L  
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21 (range, 8-380) and hemoglobin  $125.8 \pm 16.2$  g/L (range, 72-173). By contrast, no difference  
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23 in lymphocyte count was found in both groups ( $P = 0.089$ , Figure 2b, additional Table 1).  
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30 Table 4 showed the Pearson correlation coefficients of MNA and NRS2002 scores  
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32 with BMI, serum parameters and LOS. BMI, Hb, ALB and PAB correlated negatively with  
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34 malnutrition scores of NRS2002, while showed positive correlation with the MNA scores  
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36 ( $P < 0.001$ ). There existed an inverse correlation between age and the two tools ( $P < 0.001$ ).  
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38 Besides, a significant association between both tools and LOS was demonstrated ( $P < 0.05$ ).  
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42 No correlation was found between TLC and the two tools.  
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45 Table 5 showed the simple linear regression of LOS. There was a linear correlation  
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47 between the MNA scores and LOS ( $P < 0.05$ ) and so was the NRS2002 scores ( $P < 0.01$ ).  
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50 Figure 3 showed the ROC curve analysis of the sensitivities and specificities of MNA  
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52 and NRS2002 for predicting nutritional risk. The comparison between MNA and NRS2002  
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54 in those patients revealed the area under ROC curve (AUC) values for MNA (0.794, ALB;  
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4 0.704, PAB; 0.702, Hb; 0.581, TLC) and NRS2002 (0.761, ALB; 0.616, PAB; 0.677, Hb;  
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6 0.586, TLC). Besides, the comparison between the AUC showed that NRS2002 was not  
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8 different from MNA for predicting nutritional risk ( $P=0.191$ , ALB;  $P=0.063$ , PAB;  
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10  $P=0.299$ , Hb;  $P=0.866$ , TLC).  
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## 20 **DISCUSSION**

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22 Based on the current study, the nutritional health of older inpatients was assessed  
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24 using NRS2002, MNA, BMI, Hb, TLC, ALB and PAB. The results showed that the overall  
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26 prevalence of malnutrition risk for the enrolled older patients ranged from 23.7% to 58.6%.  
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28 The highest prevalence of malnutrition risk was detected by MNA and the lowest by BMI.  
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30 These results illustrated the differences in nutritional risk detected by different screening  
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32 tools.  
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38 Biochemical markers possess many advantages in assessing the nutritional status,  
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40 such as fast application and low cost. In addition, they can also be incorporated into the  
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42 routine of clinical application. As the most abundant plasmatic protein, albumin is  
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44 commonly used in the assessment of malnutrition.<sup>36</sup> In several of studies, low serum ALB  
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46 correlated with longer hospitalization, medical complications, and increased mortality.<sup>36-38</sup>  
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48 Nevertheless, its value is still limited by the long half-life (14-20 days), inflammation, the  
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50 impairment of hepatic or renal, and possibly aging itself.<sup>27</sup> Due to the reasons above, the  
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52 prevalence of malnutrition detected by ALB is lower than MNA and NRS2002 in our study.  
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4 Comparatively, a study by Covinsky *et al*<sup>39</sup> showed ALB is highly sensitive yet low  
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6 specific in the diagnosis of malnutrition in the hospitalized older adults.  
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9 Prealbumin has been regarded as a more sensitive marker than albumin for acute  
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11 nutritional changes, as it has a shorter half-life (2-3 days). However, its functions in  
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13 nutritional screening and mortality prediction remain controversial.<sup>40-43</sup> In our study,  
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15 prealbumin levels showed a great decline with deteriorating nutrition status assessed by  
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17 both NRS2002 and MNA. The correlation between serum prealbumin and MNA is  
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19 consistent with one study<sup>44</sup>, yet is in contrast with another report.<sup>42</sup> This latter study had a  
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21 small sample size (23 older patients), which may account for the discrepancies. Similar to  
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23 serum albumin, the usage of prealbumin in predicting malnutrition is limited due to  
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25 systemic inflammatory diseases.<sup>41, 45</sup>  
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32 Hemoglobin has been demonstrated to decrease with progressive malnutrition.<sup>46, 47</sup>  
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34 This relationship, consistent with a recent analysis performed in Northern China<sup>29</sup>, is found  
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36 in the proposed study. Total lymphocyte count was assumed to be suitable in screening test  
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38 for assessing malnutrition and being an indicator of a poor prognosis.<sup>27</sup> In agreement with  
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40 Lei *et al*<sup>48</sup>, we also found a significant correlation between TLC and MNA. However, no  
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42 correlation was found between NRS2002 and TLC, which was consistent with a previous  
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44 study.<sup>29</sup>  
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50 The prevalence of malnutrition diagnosed by BMI was far below that detected by  
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52 MNA. Consistent with findings from another study<sup>49</sup>, this study suggested that malnutrition  
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54 was also under diagnosed when using BMI as the sole criteria. The reason is most possibly  
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4 related to water-sodium retention in patients, leading to an overestimation of their true  
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6 weight.<sup>50</sup> In spite of this, low BMI was significantly associated with mortality.<sup>51</sup>  
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9 Our study revealed that NRS2002 and MNA, in moderate agreement with each other,  
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11 were consistently associated with age, BMI, Hb, ALB and PAB. Nevertheless, the MNA  
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13 identified more patients with or at risk of malnutrition than the NRS2002 did. The lower  
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15 percentage of malnutrition classified by NRS2002 may be explained in several ways. First,  
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17 the NRS2002 mainly consider the influence of acute diseases on nutritional status, while  
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19 the MNA take chronic long-term condition into consideration, such as psychological  
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21 factors and the BMI. Psychological factors may play a large role in the nutritional status of  
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23 older inpatients. In addition, we categorized undernutrition as  $NRS2002 \geq 3$ , while patients  
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25 with a score of 1-2 indicates low risk of malnutrition.<sup>52</sup> This may have underestimated the  
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27 percentage of malnutrition. Moreover, our study subjects were internal medical patients,  
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29 among which the proportion of overweight and obesity was high. The NRS2002 takes BMI  
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31  $< 18.5 \text{ kg/m}^2$  as one of the criteria, leading to a lower proportion of malnutrition with  
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33 NRS2002 than that of MNA. Our results agree with findings from Raslan *et al*,<sup>5</sup> yet differ  
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35 from the study conducted by Drescher *et al*.<sup>52</sup> The latter study was conducted in older  
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37 patients with acute disease, which may explain the difference.  
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48 Norman *et al* suggested that there exists a close relationship between the degree of  
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50 malnutrition and LOS.<sup>53</sup> In the present study, we found the linear relation between both  
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52 instruments (MNA and NRS2002) and LOS. Our findings corroborated those of the study  
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54 conducted by Bauer *et al*,<sup>54</sup> showing longer hospital stay was associated with malnutrition  
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4 assessed by the MNA. Comparison of the MNA and NRS2002 and their ability to predict  
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6 nutritional risk according to different standards showed that MNA and NRS2002 were the  
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8 both suitable screening tools, in terms of the ROC curve area. Therefore, we conclude, that  
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10 in Chinese geriatric inpatients, the NRS2002 and MNA might reflect malnutrition or the  
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12 studied biochemical parameters, as well as predict the length of hospitalization. However,  
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14 the MNA was available for identifying most of the patients with or at risk of malnutrition.  
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### 24 **Limitations**

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

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53 To conclude, the results of the present study show a high prevalence of malnutrition  
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55 risk in Chinese geriatric hospitalized patients. Although the nutritional risk varied  
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4 depending on the applied method, both NRS2002 and MNA correlated with each other and  
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6 with age, BMI and laboratory parameters. Besides, both tools were proved to be a good  
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8 predictor of the length of hospitalization. Moreover, the NRS2002 was not different from  
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10 MNA for predicting nutritional risk according to the AUC. Therefore, this study suggested  
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12 NRS2002 and MNA both were suitable to screen malnutrition risk among Chinese geriatric  
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14 inpatients. We recommend using one of them in admission.  
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26  
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28  
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36  
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39 JPM and XQQ contributed to the study conception and design. HLZ and CTZ, took part in  
40  
41 the discussion and modification of the study design. HZ, MY, LYS, QHG, GYZ, QJM,  
42  
43 YXW, and SGL contributed to the study conception. XQQ, HZ, MY, LYS, QHG, GYZ,  
44  
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46  
47 contributions to the drafting of the manuscript. HLZ and CTZ were involved in the critical  
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49 revision. All the authors were involved in the analysis and interpretation of the data and  
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51 gave their final approval.  
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24  
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31 **Provenance and peer review** Not commissioned; externally peer reviewed.  
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39 **Data sharing statement** No additional data are available.  
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6 **Figure 1** Flow diagram of participant inclusion and exclusion.  
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10 **Figure 2** MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin  
11 and blood lymphocytes count respectively.  
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16 **Figure 3** Receiver operating characteristics of sensitivity and specificity of predicted  
17 probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.  
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**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 <sup>2</sup> )	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

	<b>Under-nourished</b>	<b>Well-nourished</b>
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		
<i>P</i>	<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	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
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	$\beta$	t	P	95%CI	R <sup>2</sup>	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.

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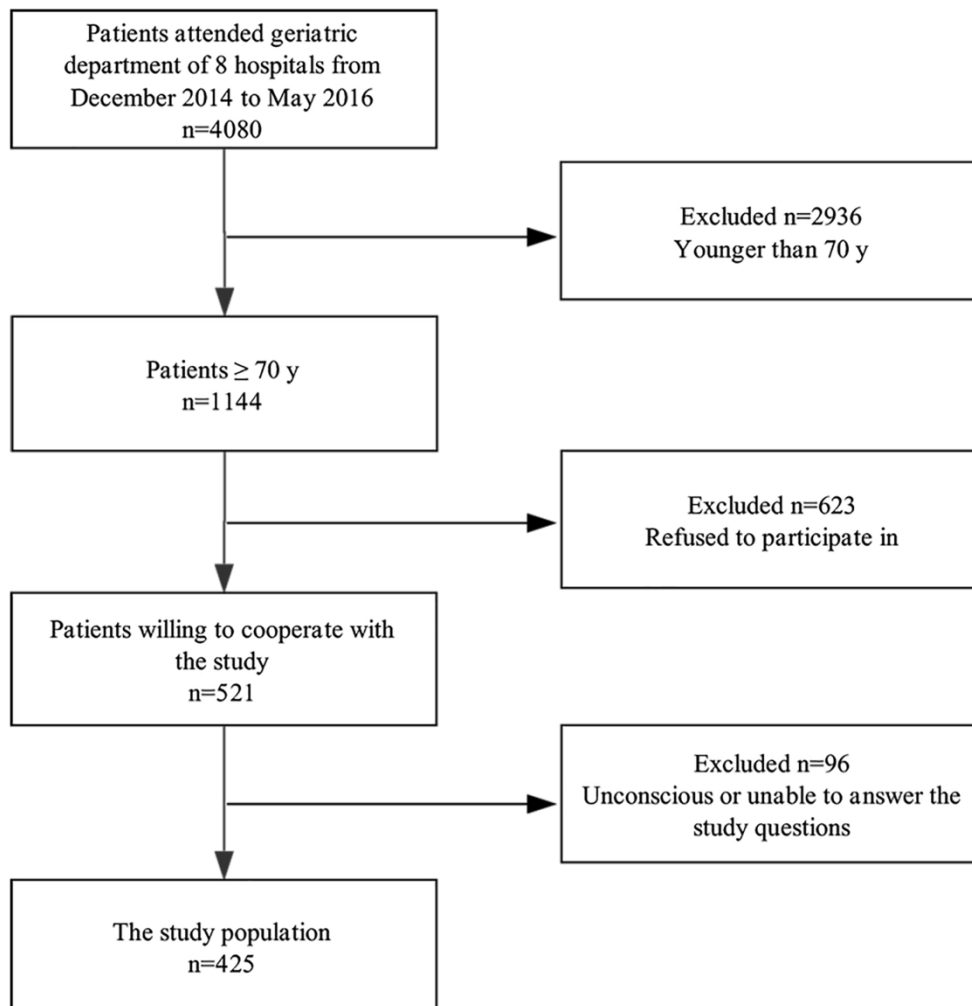


Figure 1 Flow diagram of participant inclusion and exclusion.

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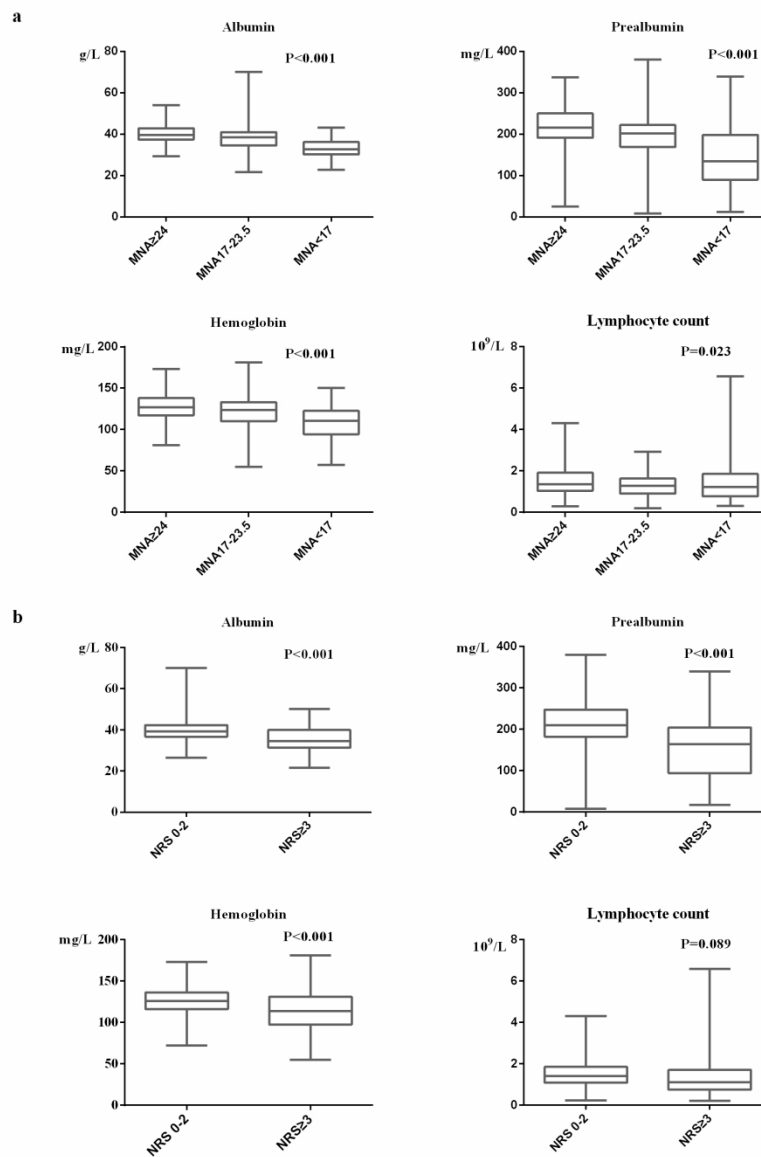


Figure 2 MNA (a) and NRS2002 (b) referring to serum albumin, prealbumin, hemoglobin and blood lymphocytes count respectively.

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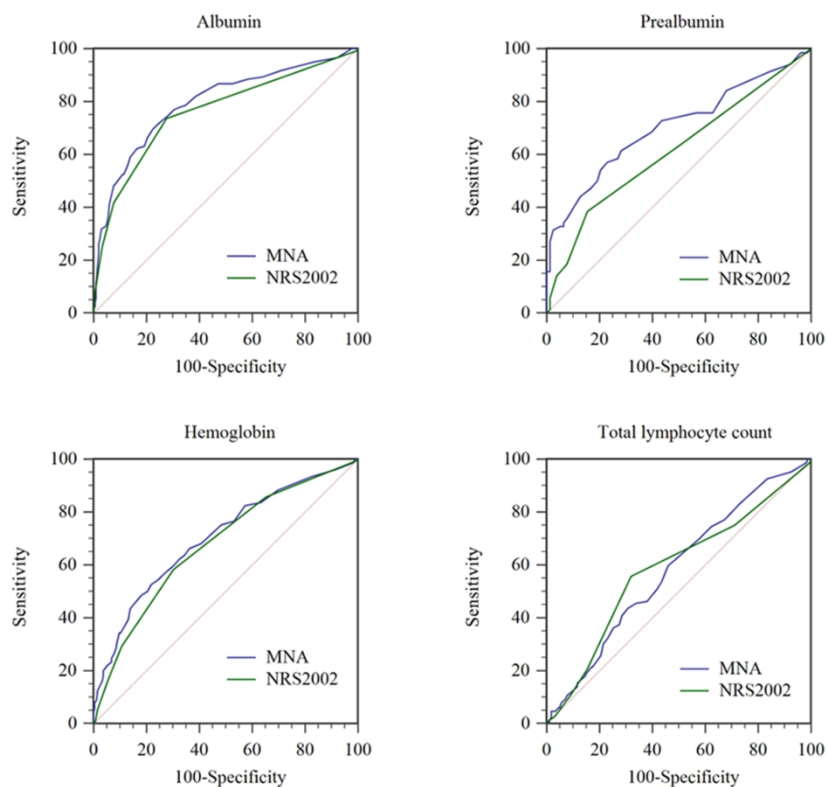


Figure 3 Receiver operating characteristics of sensitivity and specificity of predicted probabilities for nutritional risk incorporating the MNA score or the NRS2002 score.

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 ( $10^9/L$ )
<b>MNA</b>				
<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)
<b>NRS2002</b>				
≥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
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		<i>Case-control study</i> —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	
		<i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	NA
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
		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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	NA
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
<b>Results</b>			
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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	NA
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	NA
		<i>Cross-sectional study</i> —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
<b>Discussion</b>			
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
<b>Other Information</b>			
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](http://www.strobe-statement.org).