*British Journal of Nutrition* (2023), 130, 1357–1365 doi:10.1017/S0007114523000363


# Prognostic value of different cut-off points of the NRS-2002 tool to identify nutritional risk in critically ill patients: a longitudinal study

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*(Submitted 7 November 2022 – Final revision received 9 January 2023 – Accepted 1 February 2023 – First published online 17 February 2023)*

## Abstract

The American Society of Parenteral and Enteral Nutrition recommends nutritional risk (NR) screening in critically ill patients with Nutritional Risk Screening – 2002 (NRS-2002) ≥ 3 as NR and ≥ 5 as high NR. The present study evaluated the predictive validity of different NRS-2002 cut-off points in intensive care unit (ICU). A prospective cohort study was conducted with adult patients who were screened using the NRS-2002. Hospital and ICU length of stay (LOS), hospital and ICU mortality, and ICU readmission were evaluated as outcomes. Logistic and Cox regression analyses were performed to evaluate the prognostic value of NRS-2002, and a receiver operating characteristic curve was constructed to determine the best cut-off point for NRS-2002. 374 patients (61·9 ± 14·3 years, 51·1 % males) were included in the study. Of these, 13·1 % were classified as without NR, 48·9 % and 38·0 % were classified as NR and high NR, respectively. An NRS-2002 score of ≥ 5 was associated with prolonged hospital LOS. The best cut-off point for NRS-2002 was a score ≥ 4, which was associated with prolonged hospital LOS (OR = 2·13; 95 % CI: 1·39, 3·28), ICU readmission (OR = 2·44; 95 % CI: 1·14, 5·22), ICU (HR = 2·91; 95 % CI: 1·47, 5·78) and hospital mortality (HR = 2·01; 95 % CI: 1·24, 3·25), but not with ICU prolonged LOS (P = 0·688). NRS-2002 ≥ 4 presented the most satisfactory predictive validity and should be considered in the ICU setting. Future studies should confirm the cut-off point and its validity in predicting nutrition therapy interaction with outcomes.

**Key words:** **Nutritional risk: Intensive care: Cut-off point: Mortality: Prognostic**

Critical illness is a complex and multifactorial condition characterised by intense catabolic stress, and a systemic inflammatory response is associated with worse outcomes such as increased infectious morbidity, multiple organ failure, longer hospital length of stay (LOS) and mortality[1,2]. These patients have an exacerbated release of pro-inflammatory mediators and counter-regulatory hormones that trigger intense muscle wasting, with consequent functionality and contractility reduction, leading to muscle mass loss and subcutaneous fat loss[3]. Although some patients may not present a nutritional status commitment at hospital or intensive care unit (ICU) admission, the persistent inflammatory response associated with critical illness contributes to malnutrition development[4].

Malnutrition prevalence in critically ill patients varies from 37·8 to 78·1 % and is associated with longer ICU LOS and higher death rates[5]. This highlights the relevance of performing nutritional risk (NR) screening at ICU admission[6,7]. In general hospitalised patients, NR screening aims to identify patients at risk of malnutrition who could benefit from a detailed nutritional assessment and early nutritional intervention[8]; screening should occur within the first 24–48 h after hospital admission[1,6]. However, in the ICU setting, there is no consensus on the NR definition and when screening should occur, although 55·9 % (minimum 16·0 % to maximum 99·5 %) of critically ill patients are at NR according to a systematic review of thirty-six studies conducted by our research group[9].

**Abbreviations:** APACHE II, Acute Physiology and Chronic Health Evaluation II; ASPEN, American Society of Parenteral and Enteral Nutrition; ICU, intensive care unit; LOS, length of stay; MV, mechanical ventilation; NR, nutritional risk; NTS-2002, Nutritional Risk Screening – 2002; ROC, receiver operating characteristic; SOFA, Sepsis-Related Organ Failure Assessment.

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The European Society for Clinical Nutrition and Metabolism (ESPEN) recommends that all patients whose ICU LOS exceeds 48 h should be considered at NR, since the weight and muscle mass loss related to the intense catabolic stress of critical illness is unavoidable[7]. On the other hand, the American Society of Parenteral and Enteral Nutrition (ASPEN)[1] and the Brazilian Society of Parenteral and Enteral Nutrition (BRASPEN/SBNPE)[6] recommend that NR screening should be performed and suggest the use of Nutritional Risk Screening – 2002 (NRS-2002)[10] or the Nutrition Risk in Critically Ill (NUTRIC) score[11].

Despite consolidated evidence of the prognostic value of a high NUTRIC score in critically ill patients, its variables do not directly reflect nutritional parameters, including the Acute Physiology and Chronic Health Evaluation II (APACHE II)[12] and Sepsis-Related Organ Failure Assessment (SOFA)[13], age, number of co-morbidities, and total days of hospitalisation before the ICU[11]. ASPEN suggested a new approach for NR classification by NRS-2002 that considers scores ≥ 3 as NR and scores ≥ 5 as high NR[1]. To the best of our knowledge, only three studies[14–16] have evaluated the association between high NR defined by NRS-2002 ≥ 5 and worse clinical outcomes in critically ill patients; this cut-off point was based on expert opinion, and a cut-off point ≥ 3 was established for non-critically ill patients. Therefore, considering the scarce evidence related to the prognostic value of NRS-2002 in ICU settings and the lack of studies testing the best cut-off point for predicting meaningful clinical outcomes (such as ICU readmission, ICU and hospital LOS, and ICU and hospital mortality), further studies are necessary in this field.

## Materials & methods

### Study design

A cohort study was conducted in five ICU at a hospital complex in Porto Alegre (Brazil) to evaluate the validity of different NR screening tools and tools for malnutrition diagnosis, including as a specific objective the aim of the current study. The protocol was approved by the Ethical Committee of the Hospital (number 4·735·356) and conducted according to the 466/12 Resolution of the National Ethics Committee (https://conselho.saude.gov.br/resolucoes/2012/Reso466.pdf) and the principles of the Helsinki Declaration. All patients or their family members provided written informed consent before data collection. When this was not possible, the patient's family provided oral consent before nutritional anamnesis by telephone.

### Inclusion and exclusion criteria

Patients aged ≥ 18 years, of both sexes, that could answer a simplified nutritional anamnesis or whose family members could answer it were included in the study. Patients whose ICU LOS prediction was less than 24 h, pregnant and lactating women (up to 9 months postpartum), those without gasometry in the first 24 h, and those exhibiting anasarca (with the impossibility of performing a physical examination) and with medical contraindication of mobilisation (making not possible to perform anthropometric measures) were excluded. The last exclusion criterion is related to another aim defined by our research group, to be answered through the data collected from these patients. If the NRS-2002 could not be completed, the patient was excluded from this study.

### Data collection

Data collection was performed prospectively between November 2019 and March 2020, and between April 2021 and May 2022, with a suspension period due to the COVID-19 pandemic, since ICU access was limited to professionals in the field. Three trained registered dietitians and three nutrition undergraduate students collected clinical, sociodemographic and nutritional data within 24 h of ICU admission.

Clinical and sociodemographic data were collected from electronic records or nursing sign sheets, and included age, sex, vital signs, hospital and ICU admission dates, reason for ICU admission, morbid history, number of co-morbidities, and number of hospitalisation days before ICU admission. Medications in use at ICU admission, need for mechanical ventilation (MV) and haemodialysis, and the first 24 h of clinical laboratory results were also collected. From these data, the disease severity rating score (Acute Physiology And Chronic Health Evaluation [APACHE II][12] and Sequential Organ Failure Assessment [SOFA][13]) were calculated. We also collected the electronic records of patients who underwent surgical procedures before ICU admission and if they had a cancer diagnosis.

BMI was calculated from the weight and height data provided by the patient or their family members during the patient's visit or telephone contact. It was provided by the patients' family members when the patient was sedated or on MV, or if there was an electronic record of mental confusion by the nursing staff. Simplified nutritional anamnesis performed with the patient or their family members comprised an assessment of food consumption 2 weeks before hospitalisation in terms of quantity and weight loss. To evaluate the alteration in food intake, the percentage of current consumption compared with the usual consumption was rated on a 0–100 % scale, considering the number of days since this modification. Patients or their family members were questioned about their usual and current weight. When weight loss was identified, we asked them about the period in which it occurred and whether it was intentional or not. Therefore, we calculated the percentage of unintentional weight loss and considered it and the period for the NR classification by NRS-2002.

NR was evaluated using the NRS-2002 tool performed in the first 24 h after ICU admission. Nutritional status impairment and disease severity (associated with increased nutritional requirements) were evaluated, with the cut-off points of absent (0), mild (1), moderate (2) or severe (3) being used for each item. If the patient was aged ≥ 70 years, 1 point was added to the final score[10]. The sum of nutritional status impairment items, disease severity and age was classified as follows: without NR (< 3 points), with NR (3–4 points) and high NR (≥ 5 points)[1].

Patients were followed up until hospital discharge to collect outcomes of interest in the medical record: ICU LOS, hospital LOS, ICU mortality and hospital mortality, and ICU readmission during the hospital stay.

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### Statistical analysis

Sample size calculation was based on the Maciel *et al.*[14] study, considering ICU (11·6 % and 33 %) and hospital (28·9 % and 44·7 %) percentage of deaths among patients with NR and high NR according to NRS-2002, a power of 80 %, a significance level of 5 % and an additional 20 % for multivariate analysis adjustments. Based on ICU and hospital deaths, the estimated sample sizes were 163 and 372 patients, respectively. The largest sample size was considered in this study. The sample size was calculated using the OpenEpi calculator (http://www.openepi.com/Menu/OE_Menu.htm).

Descriptive statistics were calculated for sample characterisation: mean and standard deviation for parametric quantitative variables, median and interquartile range for non-parametric quantitative variables, and absolute and relative frequencies for categorical variables. The normality of the variables was evaluated using the Kolmogorov–Smirnov test.

Patients without NR were compared with those with NR and those with high NR in terms of clinical and sociodemographic variables and outcomes of interest using ANOVA, Kruskal–Wallis test or $\chi^2$ test. Tukey's test and Bonferroni correction were performed for *post hoc* analysis. Finally, a significant difference between groups was defined as $P < 0{\cdot}20$ considering the number of groups for comparisons.

The predictive validity of the different cut-off points of the NRS-2002 and its score as a continuous variable were assessed. We tested the following cut-off points of the NRS-2002: ≥ 3 *v.* < 3 and ≥ 5 *v.* < 5. When tested considering the punctuation of the NRS-2002 score, it ranged from 0 to 7 points. Logistic regression was adopted when LOS in the ICU, hospital LOS (categorised by the median of the sample as < median or ≥ median) and ICU readmission were included as dependent variables in the models. Cox regression analysis was performed to evaluate the association between NR according to the different NRS-2002 cut-off points and mortality. All analyses were adjusted for potential confounders (variables with $P < 0{\cdot}20$ in the bivariate analysis and those with recognised clinical relevance) as dependent variables.

We also constructed a receiver operating characteristic (ROC) curve and calculated the sensitivity and specificity of the NRS-2002 to evaluate its predictive value considering all outcomes listed above (one ROC curve was constructed for each outcome). The greatest balance between sensitivity and specificity was defined as the best cut-off point when the ROC AUC was statistically significant. Patients with and without NR according to the new cut-off defined were compared through Student's t test, Mann–Whitney and $\chi^2$ tests. Logistic and Cox regression analyses were also performed to evaluate the independent association of this cut-off point and clinical outcomes after adjustment for confounders.

Data analyses were performed using SPSS 20.0, and statistical significance was set at $P$ values < 0·05.

## Results

### General characteristics of the sample

Data from 374 critically ill patients were collected during the study. Almost one-third (*n* 102, 27·3 %) of patients were admitted to a lung disease-specialised ICU, 26·2 % (*n* 98) to a general ICU and 23·0 % (*n* 86) to an oncological ICU. The mean age of the patients was 61·9 ± 14·3 years, and most of them were males (*n* 191, 51·1 %). The main reasons for admission to the ICU were cancer complications (*n* 116, 31·0 %), pulmonary disorders (*n* 113, 30·2 %) and gastrointestinal disorders (*n* 52, 13·9 %). The median length of hospital stay before ICU admission was 2·0 (0·0–8·0). Most patients had cancer (*n* 191, 51·1 %), underwent surgical procedures during their hospital stay (*n* 243, 65·1 %), required MV upon ICU admission (*n* 198, 53·1 %) and were prescribed vasoactive drugs (*n* 228, 61·0 %). Indeed, 23·4 % of our sample had sepsis at ICU admission, and 8·2 % required haemodialysis at ICU admission.

The median of the SOFA and APACHE II scores were equal to 6·0 (3·0–10·0) and 17·0 (11·0–23·0), respectively. The mean of body weight, height, and BMI was equal to 71·7 ± 17·1 kg, 1·66 ± 0·09 m and 25·8 ± 5·2 kg/m$^2$, respectively. According to dietary prescriptions, 53·8 % (*n* 109) of patients were on an exclusively oral diet, 35·1 % (*n* 130) on an exclusively enteral diet and 3·5 % (*n* 13) on a parenteral diet; four patients were on fasting, and the remaining had a prescription of more than one feeding route.

The median number of days spent in the ICU was 5 (3–9) d. The median hospital LOS was 19 (11–33) d, and 29·1 % (*n* 109) and 19·0 % (*n* 65) of the patients died during the hospital and ICU stays, respectively. Indeed, 10·8 % (*n* 40) of patients had ICU readmissions.

### Nutritional risk according to the Nutritional Risk Screening – 2002

The NRS-2002 was applied from anamnesis performed with the patient (52·4 %) and or with their families (46·2 %). Eleven patients (2·9 %) had anamnesis data collected from electronic records. In our sample, 13·1 % of the patients were classified as without NR (NRS-2002 score < 3), 48·9 % as with NR (NRS-2002 score 3–4) and 38 % as having a high NR (NRS-2002 score ≥ 5). So, 86·9 % presented NR, considering that NRS-2002 ≥ 3.

Figure 1 illustrates the frequencies of scores for the NRS-2002 components. Related to the nutritional status impairment component, most patients presented normal nutritional status (*n* 165; 43·9 %). Otherwise, related to the disease severity component, most patients received the score 3 (*n* 287; 73·6 %). In 27·9 % of the sample, one point was added to the final score due to age ≥ 70 years. The NRS-2002 median score was 4 (3–5) points.

### Comparison of characteristics and clinical outcomes between patients grouped according to Nutritional Risk Screening – 2002 cut-off points proposed by American Society of Parenteral and Enteral Nutrition

Table 1 shows a comparison between patients grouped according to the NRS-2002 NR categories proposed by the ASPEN. No significant differences were observed between the groups regarding sex, frequency of cancer diagnosis and ICU readmission. Patients at high NR (NRS-2002 ≥ 5) were older and had a lower BMI than those classified as NRS-2002 < 3. The APACHE II and SOFA scores were significantly different between the three groups. Patients with an NRS-2002 score ≥ 5 had longer ICU and

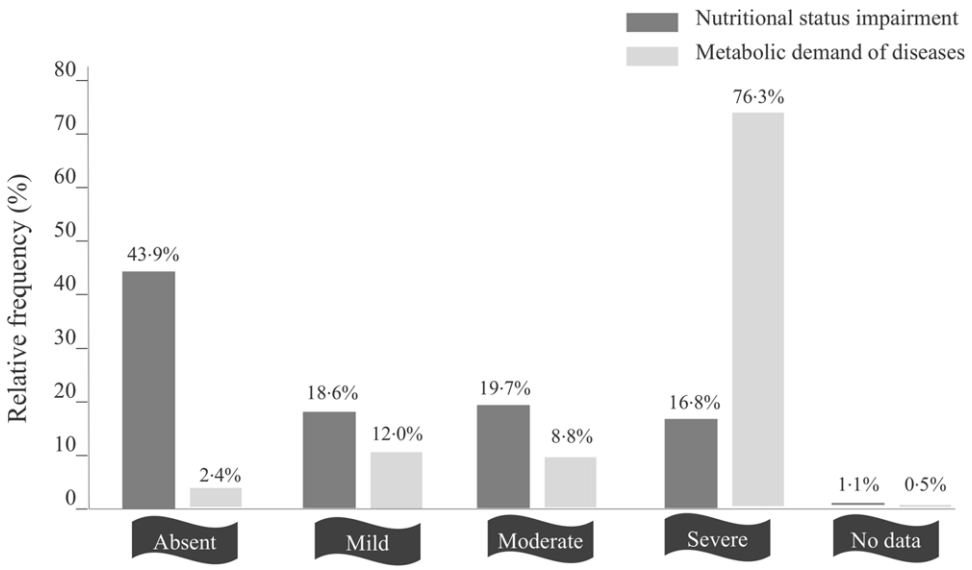


**Fig. 1.** Relative frequency of componentes for Nutritional Risk Screening According to NRS-2002.

**Table 1.** Characteristics and outcomes in critically ill patients according to the different cut-off points of Nutritional Risk Screening (NRS-2002)

| | NRS-2002 < 3 (*n* 49) | | NRS-2002 3–4 (*n* 183) | | NRS-2002 ≥ 5 (*n* 142) | | |
|---|---|---|---|---|---|---|---|
| Variables | *n* | % | *n* | % | *n* | % | *P* |
| Sex, male | 26 | 13·6 | 95 | 49·7 | 70 | 36·6 | 0·845* |
| | Mean | SD | Mean | SD | Mean | SD | |
| Age (years) | 57·84 | 12·00[a] | 60·63 | 13·40[a] | 65·11 | 15·47[b] | 0·002† |
| Current weight (kg) | 78·34 | 17·78[a] | 73·20 | 14·88[a] | 66·97 | 18·48[b] | < 0·001† |
| BMI (kg/m$^2$) | 27·68 | 4·87[a] | 26·25 | 4·55[a] | 24·38 | 5·91[b] | < 0·001† |
| APACHE II | 7·10 | 2·46[a] | 18·24 | 8·09[b] | 21·08 | 7·74[c] | < 0·001† |
| SOFA | 2·57 | 2·10[a] | 6·98 | 4·08[b] | 7·49 | 3·88[c] | < 0·001† |
| | *n* | % | *n* | % | *n* | % | |
| Surgical procedure | 42 | 17·3[a] | 124 | 51·0[a,b] | 77 | 31·7[c] | 0·001* |
| Cancer diagnosis | 31 | 16·2 | 86 | 45·0 | 74 | 38·7 | 0·123* |
| Sepsis | 46 | 16·1[a] | 146 | 51·2[b] | 93 | 32·6[c] | < 0·001* |
| Transplant | 0 | 0·0[a] | 35 | 81·4[b] | 8 | 18·6[a] | < 0·001* |
| MV at admission | 46 | 26·3[a] | 74 | 42·3[b] | 55 | 31·4[b] | < 0·001* |
| HD at admission | 48 | 14·2 | 167 | 49·4 | 123 | 36·4 | 0·022* |
| Hospital LOS, days | | | | | | | |
| Median | 12·0 | | 20·0 | | 20·5 | | 0·001‡ |
| P25–P75 | 6·0–23·0[a] | | 11·0–35·0[b] | | 11·75–34·0[b] | | |
| ICU LOS, days | | | | | | | |
| Median | 3·0 | | 5·0 | | 6·0 | | < 0·001‡ |
| P25–P75 | 2·0–5·0[a] | | 3·0–11·0[b] | | 3·0–9·0[b] | | |
| ICU readmission | 3 | 7·5 | 17 | 42·5 | 20 | 50·0 | 0·202* |
| ICU death | 1 | 1·5[a] | 24 | 36·9[b] | 40 | 61·5[c] | < 0·001* |
| Hospital death | 3 | 2·8[a] | 47 | 43·1[b] | 83 | 31·3[c] | < 0·001* |

APACHE II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sepsis-Related Organ Failure Assessment; MV, mechanical ventilation; HD, haemodialysis; MVd, duration of mechanical ventilation; ICU, intensive care unit; LOS, length of stay.
Data are presented as absolute (relative) frequencies, mean ± standard deviation, or median (P25–P75).
* $\chi^2$ with Bonferroni correction ($P < 0{\cdot}20$ were considered significant, since three pairs of comparisons were performed and are represented by different superscript letters).
† Anova one-way.
‡ Kruskal–Wallis with Tukey's *post hoc* test (Different superscript letters indicate $P < 0{\cdot}05$ while equal superscript letters indicate a non-significant difference between groups).

hospital LOS than those without NR, while no significant difference was found between patients with risk and those with high risk. The incidence of ICU and hospital deaths was also higher in patients with high NR than in those with and without NR.

Considering the differences observed between the groups, we adjusted the multivariate analyses for MV at ICU admission, haemodialysis at ICU admission and SOFA score. Age, APACHE, cancer diagnosis, surgical procedure and transplant status were

not included as covariates because all these variables were already considered in the NRS-2002 to avoid multicolinearity.

### *Predictive validity of the Nutritional Risk Screening – 2002 cut-off points proposed by American Society of Parenteral and Enteral Nutrition*

Multivariate analysis was performed to evaluate the predictive validity of the cut-off points of the NRS-2002 proposed by ASPEN on the clinical outcomes of interest. When adjusted for potential confounders, only the high NR category increased the chance of prolonged hospital LOS by 2·67 times, as presented in Table 2.

### *Predictive validity of Nutritional Risk Screening – 2002 as a categorical or continuous variable*

Considering the results presented in Table 2, which could be due to insufficient power to demonstrate the predictive validity of three categories for NR classification by NRS-2002, another multivariate analysis was conducted considering the NRS-2002 as bicategorical or as a continuous variable. We categorised NR by NRS-2002 as follows: NRS-2002 < 3 (without NR) *v.* NRS-2002 ≥ 3 (with NR), and NRS-2002 < 5 (without NR + with NR) *v.* NRS ≥ 5 (high NR).

According to the logistic and Cox regression results presented in Table 3 (crude and adjusted models), an NRS-2002 ≥ 5 score was an independent predictor of ICU mortality in comparison with an NRS-2002 score < 5. The categorical variable that grouped patients with NR and high NR (NRS-2002 ≥ 3) was only a predictor of hospital LOS ≥ 19 d in the multivariate analysis when compared with patients without NR. On the other hand, an increase of 1 point in the NRS-2002 score increased the chance of prolonged hospital LOS by 1·23 times and the risk of ICU and hospital death by 1·24 and 1·42 times, respectively.

### *Definition of a new cut-off point for Nutritional Risk Screening – 2002*

Considering that the continuous NRS-2002 was a predictor of a greater number of outcomes, we sought to assess the NRS-2002 accuracy and the need to define a new cut-off point for the tool in the context of critical illness. According to the values of accuracy, sensibility, and specificity, and considering a minimum sensitivity of 50 %, the NRS-2002 ≥ 4 cut-off point showed satisfactory performance in identifying prolonged hospital LOS, prolonged ICU LOS, hospital mortality and ICU mortality. For ICU readmission, a cut–off point was not defined because the area under the ROC curve was not significant (Table 4 and online Supplementary Fig. 1). According to this cut-off point, 57·9 % (*n* 216) of our sample was classified as NR.

Since the AUC ROC gives us the results of an unadjusted analysis of predictive validity, based on the aforementioned results, we conducted a multivariate analysis to assess if NRS-2002 ≥ 4 in comparison with NRS-2002 < 4 would be a predictor of a greater number of outcomes when compared with the already established cut-off points.

A comparison of patients with NR (NRS-2002 ≥ 4) and those without NR (NRS-2002 < 4) is presented in Supplementary Table 1. Weight, BMI, age, SOFA, APACHE II, sepsis, MV at ICU admission, transplant status and surgical procedure frequency were different between the groups, while the frequency of males, cancer diagnosis, haemodialysis and vasoactive drug prescription at ICU admission did not differ between the groups. All clinical outcomes differed between the groups and were more frequent in patients with an NRS-2002 ≥ 4. Therefore, we adopted the SOFA score and MV as confounders at admission in the multivariate analysis. In both the univariate and adjusted analyses, NRS-2002 ≥ 4 demonstrated a significant association with all outcomes, except for prolonged ICU LOS (Table 5).

Supplementary Fig. 2 illustrates a summary of the association between NRS-2002 and clinical outcomes, considering its different cut-off points through the calculated OR/HR and its 95 % CI.

## Discussion

The present study aimed to evaluate the predictive validity of the NRS-2002 cut-off points to identify NR in critically ill adult patients. When we compared patients with NR and high NR to those without NR, considering the cut-off points proposed by ASPEN, an NRS-2002 score ≥ 5 was an independent predictor only for hospital LOS ≥ 19 d. For each increase of 1 point in the NRS-2002 score, we demonstrated an increased chance of prolonged LOS of 1·23 times and an increased risk of ICU and hospital mortality of 1·24 and 1·42 times, respectively. Finally, when we explored the best cut-off point of the NRS-2002, we identified that a score ≥ 4 was independently associated with prolonged hospital LOS, ICU readmission, ICU and hospital death.

The frequency of patients with NR evaluated by NRS-2002 ≥ 3 was 86·9 %, and 38 % were classified as having a high NR (NRS-2002 ≥ 5). This tool has been applied in other studies, in which the prevalence of NR ranged from 39·4 % to 99·5 %[9], and a frequency of NRS-2002 score ≥ 5 in critically ill patients ranged between 20·9 % and 62 %[14–18]. This wide range can be explained by the heterogeneity of patients studied in relation to age and disease severity scores, the manner in which nutritional data were collected (from records *v.* informed or measured data), and with whom the anamnesis was taken. Shpata *et al.* showed that elderly patients had a 1·07-fold increase in the likelihood of NR, and an APACHE II score ≥ 15 was identified as a predictor of this condition in critically ill patients (OR = 3·06, 95 % CI: 1·85, 5·04)[19]. Zhao *et al.* considered all critically ill patients with COVID-19 to have a score of 3 in the component disease severity instead of evaluating the APACHE II score, and 73·6 % of patients scored 3 in the NRS-2002 component[16].

High NR was an independent predictor of prolonged hospital stay (≥ 19 d), but it was not associated with other unfavourable clinical outcomes in our sample compared with the other two categories. Indeed, NR (NRS-2002 ≥ 3 and < 5) was not an independent predictor of clinical outcomes when the three NR categories were considered in the analyses. We did not identify studies that performed a similar analysis to explore the association between NRS-2002 categories and hospital LOS. Regarding ICU LOS, Marchetti *et al.*[15] demonstrated that patients with a high NR spent more days in the ICU than those with NR, as in our results. However, in multivariate analyses, we did not find

**Table 2.** Predictive validity of Nutritional Risk Screening (NRS-2002): multivariate analyses on the association between different cut-off points and clinical outcomes

| Dependent variable | | Crude model | | | Adjusted model* | |
|---|---|---|---|---|---|---|
| Hospital LOS ≥ 19 d | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 < 3 | | Reference | | | Reference | |
| NRS-2002 3–4 | 2·38 | 1·21, 4·68 | 0·012† | 1·96 | 0·95, 4·05 | 0·071† |
| NRS-2002 ≥ 5 | 3·38 | 1·68, 6·81 | 0·001† | 2·67 | 1·25, 5·71 | 0·011† |
| ICU LOS ≥ 5 d | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 < 3 | | Reference | | | Reference | |
| NRS-2002 3–4 | 3·109 | 1·54, 6·26 | 0·002† | 1·506 | 0·69, 3·28 | 0·302† |
| NRS-2002 ≥ 5 | 4·014 | 1·95, 8·27 | < 0·001† | 1·65 | 0·73, 3·72 | 0·227† |
| ICU readmission | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 < 3 | | Reference | | | Reference | |
| NRS-2002 3–4 | 1·56 | 0·44, 5·58 | 0·490† | 1·68 | 0·44, 6·37 | 0·448† |
| NRS-2002 ≥ 5 | 2·59 | 0·73, 9·13 | 0·140† | 2·95 | 0·77, 11·24 | 0·114† |
| ICU death | HR | 95 % CI | *P* | HR | 95 % CI | *P* |
| NRS-2002 < 3 | | Reference | | | Reference | |
| NRS-2002 3–4 | 1·87 | 0·25, 14·05 | 0·542‡ | 1·74 | 0·22, 13·90 | 0·601‡ |
| NRS-2002 ≥ 5 | 4·33 | 0·59, 31·89 | 0·150‡ | 3·75 | 0·48, 29·01 | 0·206‡ |
| Hospital death | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 < 3 | | Reference | | | Reference | |
| NRS-2002 3–4 | 2·43 | 0·76, 7·84 | 0·136‡ | 1·62 | 0·49, 5·42 | 0·430‡ |
| NRS-2002 ≥ 5 | 3·37 | 1·05, 10·80 | 0·041‡ | 2·13 | 0·64, 7·06 | 0·215‡ |

LOS, length of stay; ICU, intensive care unit; HR, hazard ratio; MV, mechanical ventilation; HD, haemodialysis; SOFA, Sepsis-Related Organ Failure Assessment.
Multivariate analysis adjusted for sepsis, MV at admission, HD at admission and SOFA.
* For all logistic regression analyses, Hosmer and Lemeshow test presented a *P*-value > 0·05.
† Logistic regression.
‡ Cox regression.

**Table 3.** Predictive validity of Nutritional Risk Screening (NRS-2002) as a categorical or continuous variable: multivariate analyses

| Dependent variable | | Crude model | | | Adjusted model* | |
|---|---|---|---|---|---|---|
| Hospital LOS ≥ 19 d | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 ≥ 3 (risk and high risk) | 2·78 | 1·45, 5·32 | 0·002† | 2·21 | 1·09, 4·48 | 0·028† |
| NRS-2002 ≥ 5 (high risk) | 1·69 | 1·10, 2·60 | 0·016† | 1·52 | 0·97, 2·37 | 0·065† |
| Continuous NRS-2002 | 1·27 | 1·11, 1·46 | 0·001† | 1·23 | 1·06, 1·42 | 0·006† |
| ICU LOS ≥ 5 d | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 ≥ 3 (risk and high risk) | 3·49 | 1·78, 6·84 | < 0·001† | 1·56 | 0·735, 3·33 | 0·246† |
| NRS-2002 ≥ 5 (high risk) | 1·61 | 1·05, 2·48 | 0·029† | 1·17 | 0·73, 1·89 | 0·520† |
| Continuous NRS-2002 | 1·23 | 1·07, 1·40 | 0·003† | 1·06 | 0·91, 1·24 | 0·426† |
| ICU readmission | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| NRS-2002 ≥ 3 (risk and high risk) | 1·98 | 0·59, 6·70 | 0·271† | 2·14 | 0·59, 7·78 | 0·246† |
| NRS-2002 ≥ 5 (high risk) | 1·79 | 0·93, 3·47 | 0·083† | 1·90 | 0·66, 3·76 | 0·064† |
| Continuous NRS-2002 | 1·17 | 0·95, 1·45 | 0·141† | 1·19 | 0·95, 1·49 | 0·120† |
| ICU death | HR | 95 % CI | *P* | HR | 95 % CI | *P* |
| NRS-2002 ≥ 3 (risk and high risk) | 2·88 | 0·40, 21·15 | 0·294‡ | 2·72 | 0·35, 20·91 | 0·336‡ |
| NRS-2002 ≥ 5 (high risk) | 2·44 | 1·45, 4·10 | 0·001‡ | 2·23 | 1·30, 3·83 | 0·004‡ |
| Continuous NRS-2002 | 1·27 | 1·10, 1·47 | 0·001‡ | 1·24 | 1·06, 1·44 | 0·006‡ |
| Hospital death | HR | 95 % CI | *P* | HR | 95 % CI | *P* |
| NRS-2002 ≥ 3 (risk and high risk) | 2·84 | 0·90, 8·96 | 0·076‡ | 1·87 | 0·57, 6·10 | 0·301‡ |
| NRS-2002 ≥ 5 (high risk) | 1·51 | 1·02, 2·23 | 0·040‡ | 1·36 | 0·92, 2·03 | 0·125‡ |
| Continuous NRS-2002 | 1·48 | 1·22, 1·81 | < 0·001‡ | 1·42 | 1·16, 1·74 | 0·001‡ |

LOS, length of stay; ICU, intensive care unit; HR, hazard ratio; MV, mechanical ventilation; HD, haemodialysis; SOFA, Sepsis-Related Organ Failure Assessment.
Multivariate analyses adjusted for sepsis, MV at admission, HD at admission and SOFA.
* For all logistic regression analyses, Hosmer and Lemeshow test presented a *P*-value > 0·05.
† Logistic regression.
‡ Cox regression.

**Table 4.** Definition of a Nutritional Risk Screening (NRS-2002) cut-off point for predicting clinical outcomes

| Clinical outcomes | AUC ROC | 95 % CI | *P* | Sensibility, % | Specificity, % | Cut-off point |
|---|---|---|---|---|---|---|
| Hospital LOS ≥ 19 d | 0·553 | 0·535, 0·652 | 0·002 | 67·2 | 47·8 | 4·0 |
| ICU LOS ≥ 5 d | 0·574 | 0·516, 0·632 | 0·014 | 61·7 | 53·7 | 4·0 |
| ICU readmission | 0·578 | 0·494, 0·662 | 0·107 | – | – | – |
| ICU mortality | 0·694 | 0·630, 0·759 | < 0·001 | 84·4 | 46·8 | 4·0 |
| Hospital mortality | 0·672 | 0·615, 0·728 | < 0·001 | 79·6 | 49·1 | 4·0 |

LOS, length of stay; ICU, intensive care unit; ROC, receiver operating characteristics.

**Table 5.** Predictive validity of Nutritional Risk Screening (NRS-2002) cut-off point ≥ 4 for clinical outcomes: multivariate analyses

| Dependent variable | Crude model | | | Adjusted model* | | |
|---|---|---|---|---|---|---|
| | OR | 95 % CI | *P* | OR | 95 % CI | *P* |
| Hospital LOS ≥ 19 d | 2·35 | 1·54, 3·60 | < 0·001† | 2·13 | 1·39, 3·28 | 0·001† |
| ICU LOS ≥ 5 d | 1·420 | 0·94, 2·15 | 0·099† | 1·10 | 0·70, 1·73 | 0·688† |
| ICU readmission | 2·40 | 1·34, 5·07 | 0·022† | 2·44 | 1·14, 5·22 | 0·022† |
| ICU death | 2·85 | 1·44, 5·63 | 0·003‡ | 2·91 | 1·47, 5·78 | 0·002‡ |
| Hospital death | 1·98 | 1·22, 3·20 | 0·006‡ | 2·01 | 1·24, 3·25 | 0·004‡ |

LOS, length of stay; ICU, intensive care unit; HR, hazard ratio; MV, mechanical ventilation; SOFA, Sepsis-Related Organ Failure Assessment.
Multivariate analyses adjusted for sepsis, MV at admission and SOFA.
* For all logistic regression analyses, Hosmer and Lemeshow test presented a *P*-value > 0·05.
† Logistic regression.
‡ Cox regression.

a significant association, while Marchetti *et al.* did not perform this. A prospective cohort study[14] showed that patients classified as having high NR had a 2·10-fold increase in ICU death compared with patients with NR (NRS-2002 ≥ 3). However, the authors excluded the group of patients without NR from the analyses (*n* 1). Patients with an NRS-2002 score ≥ 5 presented a higher incidence of infection, which could contribute to a higher risk of mortality, and it was not included as a potential confounder in the regression analyses[14]. They did not find a significant association between high NR and hospital mortality in multivariate analyses. A Turkish study[20] demonstrated a significant correlation between hospital mortality and the NRS-2002 score ($r = 0{\cdot}166$, $P < 0{\cdot}05$). However, the correlation test performed is questionable since it is a statistical test indicated for evaluating the association between two quantitative variables that are not applicable for mortality. We did not find any studies evaluating the association between NR categories and ICU readmission, precluding comparisons with our results. Furthermore, the studies discussed above compared patients with NR to patients with high NR, since they identified a reduced number of patients without NR and did not include them in the analyses. This precludes a direct comparison with our study. It is important to highlight that in our sample, only 13 % of patients were classified as without NR, and the incidence of outcomes was low in the three categories of NR. It can reduce the analysis power to identify the real prognostic value of NR and high NR, and these analyses need to be considered exploratory.

We also assessed the NRS-2002 as a categorical and continuous variable. NRS-2002 ≥ 3 compared with NRS-2002 < 3 was significantly associated with hospital LOS ≥ 19 d, while NRS-2002 ≥ 5 compared with NRS-2002 < 5 increased the risk of ICU mortality by 2·23 times. In contrast, the NR analysed as a continuous variable was a predictor of prolonged hospital LOS, ICU mortality and hospital mortality. Zhao *et al.*[16] demonstrated a higher risk of hospital mortality in patients with COVID-19 when NRS-2002 was considered a continuous variable; however, it was not associated with hospital LOS. It is necessary to highlight that the outcome was also considered a continuous variable, and the median LOS was higher than that in the current study (32 d *v.* 19 d). Another study conducted in a post-operative care unit reported a non-significant correlation between NRS-2002 and hospital LOS ($r = 0{\cdot}118$, $P > 0{\cdot}05$); however, a multivariate analysis was not conducted[20]. A Brazilian prospective cohort[15] classified patients with scores < 5 or ≥ 5 using the NRS-2002 tool and reported that a higher score was associated with hospital mortality; however, ICU mortality was not evaluated. Indeed, the authors did not consider potential confounders such as the requirement for MV and infection. The in-hospital mortality risk was 2-fold higher in patients classified as having high NR in the NRS-2002 (score ≥ 5) in another study involving 311 critically ill patients[18]; however, ICU mortality was not evaluated. NRS-2002 ≥ 3 was associated with ICU-LOS ≥ 9 d (OR 5·33; 95 % CI: 2·82, 10·09) and 28-d mortality (OR 1·75; 95 % CI: 1·42, 2·16) in a study involving 440 Iranian critically ill patients, with 83·9 % at NR[21]. The median ICU stay was almost 2-fold higher than that in our study, and the incidence of death was 30·8 %, while in our sample, it was 18·8 %.

To the best of our knowledge, the definition of the cut-off point proposed by the ASPEN, which classifies patients with high NR, is an expert-based recommendation. Kondrup *et al.*[10] developed an NRS-2002 tool to detect NR in hospitalised patients based on the concept that nutrition therapy should be initiated in patients with nutritional status impairment and/or severe illness[22]. It was derived from a systematic review of randomised clinical trials by analysing the nutritional features of patients from trials in which nutrition support was effective in improving clinical outcomes in comparison with trials in which it was not effective. Therefore, they defined a cut-off point ≥ 3 as a NR for non-critically ill patients[10]. To our knowledge, no study has defined an NRS-2002 cut-off point for critically ill patients. Therefore, we constructed an ROC curve and identified a cut-off point ≥ 4, which showed satisfactory prognostic value to identify higher odds for prolonged hospital LOS and ICU readmission, as well as a higher risk of ICU and hospital death.

Despite having satisfactory predictive validity, the NRS-2002 tool depends on a nutritional anamnesis so that it can be performed. In the current study, we were able to apply the NRS-2002 to the majority of patients, but in 46·2 % of patients, the anamnesis needed to be done with the patients' families. However, in ICU, in which most patients require MV and contact with family members or caregivers is not possible, the feasibility of the tool is limited. Few studies address with whom the anamnesis was taken and, even in those studies, information regarding the frequency in which data were measured, collected from medical records, or collected from patients is not covered in detail by the authors[14–17]. It is necessary to highlight the impact of the difference between weight and height data collected from measurements, estimations or information in clinical practice.

Chumlea's equation for weight estimation[23], for example, showed a mean standard error of 4·5 kg for men and 3·8 kg for women. Likewise, a study conducted with 16 573 patients selected from the Third National Health and Nutrition Examination Survey (NHANES III)[24] demonstrated that men tended to overestimate, and women underestimated their body weight. In our study, we used the weight and height provided by patients or family members/caregivers for all patients. Considering that we used informed data of weight and height to calculate BMI and weight loss percentage, the potential bias of measurement was systematic, and we adopted a pragmatic approach for data collection.

Our study had some limitations. The nutritional status impairment component of the NRS-2002 tool was originally subdivided into the percentage of recent weight loss, change in food intake, and/or reduced BMI, and the scores were stratified into mild, moderate, or severe. We did not evaluate the association between each of these factors and the clinical outcomes of interest, considering only the impairment of nutritional status as a whole and the severity of the disease. Furthermore, since we included only 130 patients on an enteral diet and for those on an oral diet we had no prospective control over food acceptance, we could not assess the interaction between outcomes and nutrition therapy, which is also relevant, based on the concept of NR. We did not evaluate the concurrent validity of different cut-off points of NRS-2002 because the agreement between NRS-2002 and NUTRIC is poor (kappa coefficient < 0·350), as demonstrated by Coruja *et al.*[25]. In addition, a previous analysis conducted by our research group demonstrated that NRS-2002 ≥ 3 or NRS-2002 ≥ 5 is inaccurate in identifying NR using NUTRIC as a reference (data not published yet). On the other hand, our study has some strength. This is the first study to propose a specific cut-off point for the NRS-2002 tool in critically ill adults based on its predictive validity, involving a heterogeneous sample of critically ill patients, and achieved the sample size estimated. For future research, the interaction between NR and nutritional therapy should be assessed, and the predictive validity of NRS-2002 ≥ 4 should be confirmed in ICU settings.

### *Conclusion*

A cut-off point of 4 for NRS-2002 was a predictor of prolonged hospital LOS, ICU readmission, and ICU and hospital mortality in critically ill patients, whereas NRS-2002 ≥ 3 was independently associated only with prolonged hospital LOS, while NRS-2002 ≥ 5 was independently associated only with ICU mortality.

## Acknowledgements

The authors thank the Santa Casa de Misericórdia de Porto Alegre Hospital Complex and members of the Evidence-based Clinical Nutrition Research Group for their support in conducting this study. Flávia Moraes Silva has received a productivity scholarship from the Brazilian National Council for Scientific and Technological Development. Danielle Silla Jobim Milanez, Elisa Loch Razzera and Julia Lima received scholarships as Master's Students from the Coordination for the Improvement of Higher Education Personnel.

This research received funding from Fundação de Amparo à Pesquisa do Rio Grande do Sul (FAPERGS, 19/2551–0001789–8).

F. M. S. contributed to the conceptualization, methodology, forma analysis, project administration, supervision, and writing - review & editing of this manuscript. B.B.S. contributed to the conceptualization, investigation, data curation, forma analysis, writing - original draft, and writing - review & editing of this manuscript. D. S. J. M., E. L. R., A. C. and J. L. contributed to the investigation, data curation, and writing - review & editing of this manuscript. A. C. contributed to the conceptualization, project administration, writing - review & editing of this manuscript.

There are no conflicts of interest.

## Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S0007114523000363

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