

# Identifying nutritional risk in critical illness

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## Abstract

**Purpose of review** While several tools are available to quantify nutritional risk in clinical practice, most of these consider all critically ill patients to be at equally high risk despite clear evidence that ICU patients express a range of responses to nutritional therapy.

**Recent findings** Recent studies indicate that patients at high nutritional risk benefit the most from aggressive nutritional intervention compared to those with lower risk. This association is most pronounced in patients with a body mass index (BMI) below 25 or greater than 35, with less benefit observed in patients with a BMI between 25 and 35. Additionally, critically ill ICU patients with a high NUTRIC score are more likely to benefit from therapeutic nutritional interventions than those with low NUTRIC scores.

**Summary** Several scoring tools have been developed and validated to assess nutritional risk in critically ill patients, and this review will describe the historical, current, and future direction of risk assessment in ICU nutritional therapy.

**Keywords** Critical illness · Intensive care · Nutrition risk · Screening · Malnutrition · NRS-2002 · NUTRIC · Adult

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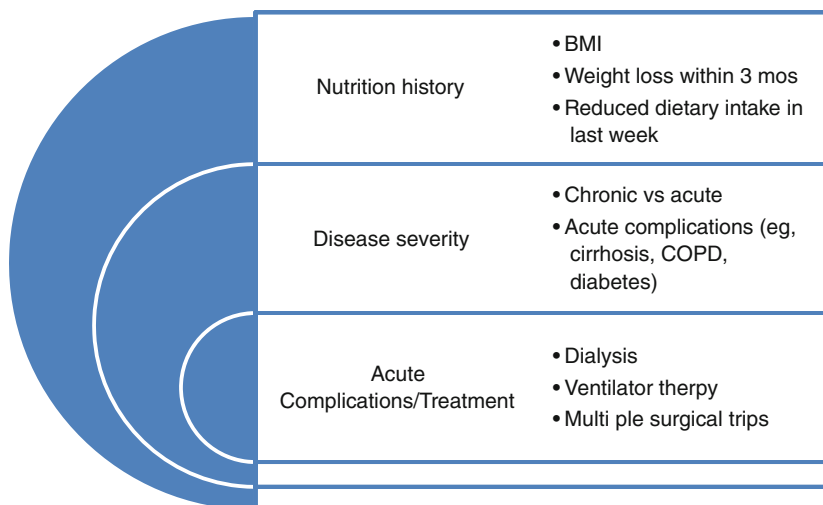
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## Introduction

Malnourished patients demonstrate worse clinical outcomes than their well-nourished counterparts [1–3]. Although nutrition screening is the first step in nutrition care, there is no consensus on the best tool to identify these patients, especially in the intensive care unit (ICU). Simple to more complex tools dating back to 1995 have been developed, validated, and applied to patients in the outpatient and inpatient settings [4]. Traditional nutrition risk screening tools generally incorporate variables such as body mass index, weight loss, and oral intake. Due to the nature of critical illness, patients/families are often unable to provide accurate intake and/or weight histories. Additionally, nutrition risk in the ICU becomes more complex as it is affected by not only the patient's medical and nutritional history, but also their disease severity, and the impact of any life-sustaining therapies provided (Fig. 1).

In the past 5 years, clinicians and researchers have begun to emphasize that not all ICU patients are the same and that nutritionally at-risk patients should be provided more aggressive nutrition therapy to yield a positive outcome [5••]. Acknowledging that BMI is also likely an important determinant in outcome, a recent analysis by Heyland et al. demonstrated that an increase of 1000 cal per day was associated with an overall reduction in mortality (odds ratio for 60-day mortality 0.76, 95% confidence intervals (CI), 0.61–0.95,  $p=0.014$ ) [6]. Surprisingly, the improved mortality effect from increased calories was specifically seen in patients whose body mass index (BMI) was below 25 or above 35. For patients with BMIs between 25 and 35, no benefit was seen. Coupled with idea that critical illness itself affects nutrition risk by means of starvation and inflammation, the concept that ICU patients respond differently to nutrition therapy led to the development of several tools to assess the nutritional risk of individual ICU patients.

**Fig. 1** Nutrition assessment in the critically ill



**Disease severity and its impact on nutrition status**

For many years, the approach to identifying and diagnosing adult malnutrition varied widely. While the term “malnutrition” can be applied to any nutritional imbalance, adult undernutrition has more recently been described along a continuum of inadequate intake and increased nutrient requirements which often result in weight loss and body composition changes. A malnutrition assessment includes obtaining intake and weight history and completing a nutrition-focused physical examination to evaluate for the presence and severity of muscle wasting, subcutaneous fat loss, and fluid accumulation [7•]. The prevalence of malnutrition in hospitalized patients has been estimated at 30–60%, with up to 69% of patients experiencing a decline in their nutritional status during hospitalization [8]. Healthcare providers must pay close attention to the nutrition risk of their patients to prevent the downstream complications that can result from inadequate nutrient intake in the hospital setting such as increased morbidity and mortality related to iatrogenic malnutrition (including pressure ulcer development, surgical site infection, and falls), longer lengths of hospital stay, increased readmission rates, and increased hospital costs.

**Nutrition risk screening**

The purpose of nutrition risk screening is to predict the probability of a better or worse outcome due to nutritional factors and whether nutritional treatment is likely to influence this [9••]. Since 2008, the Joint Commission has mandated nutrition screening within 24 h of admission to an acute care center. Nutrition risk screening for hospitalized patients is supported by national practice guidelines as well [4]. In response, many nutrition screening tools have been developed for the hospitalized patient, including the Mini Nutritional Assessment, the

Mini Nutritional Assessment-Short Form, the Malnutrition Universal Screening Tool, the Short Nutritional Assessment Questionnaire, the Malnutrition Screening Tool, and the Canadian Nutrition Screening Tool [10–14]. The majority of these tools are designed to identify patients with unintentional weight loss, decreased appetite and/or food intake, and a BMI outside of defined limits (Table 1).

Use of these tools pose a challenge to clinicians in the ICU, as many critically ill patients are not able to provide these details

**Table 1** Nutrition risk screening tools

	Parameters				
	Weight loss	Decreased appetite and/or intake	BMI	Others	
Mini Nutritional Assessment	x	x	x	Mobility, psychological stress or acute illness, neuropsychological problems	
Mini Nutritional Assessment-Short Form	x	x	x	Mobility, psychological stress or acute illness, neuropsychological problems	
Malnutrition Universal Screening Tool	x	x	x	Acute illness	
Short Nutritional Assessment Questionnaire	x	x		Supplemental drinks, enteral nutrition	
Malnutrition Screening Tool	x	x			
Canadian Nutrition Screening Tool	x	x			

and weight history is often confounded by rapid weight gain secondary to intravenous fluid administration. Further, the nutritional status of even well-nourished patients can deteriorate rapidly in the setting of critical illness. More importantly, the tools listed above have not been validated in the ICU setting. Due to the catabolic impact of inflammation generated by critical illness, the most recent guidelines suggest use of a nutritional screening tool that captures disease severity [15] (Table 1). To date, this includes only the NRS 2002 and the NUTRIC score(s).

## Nutrition risk screening tools

The goals of nutritional risk scoring system development are to create a tool that is generalizable to a heterogeneous population of patients and one that is responsive to appropriate nutritional intervention. These goals have been approached by several assessment scores over the past 15 years.

### Nutritional risk screening (NRS-2002)

One of the oldest scoring systems of this type is the nutritional risk screening (NRS-2002) developed by Kondrup in concert with an ad hoc ESPEN working group [16]. The NRS-2002 score is based on disease severity, age, and degree of malnutrition and is designed to detect the presence and risk of malnutrition in a hospital setting. A pre-screen consisting of four questions (Table 2) is initially undertaken for all categories of disease severity. A “yes” to any question on the initial screen mandates performance of a second screening to evaluate nutritional status, weight loss or BMI, food intake, and general condition (Table 3). Nutritional status impairment and severity of disease are represented as a score between 0 (absent) and 3 (severe). If the sum of the scores is greater than or equal to 3, the patient is considered to be nutritionally at-risk and institution of a nutrition plan is recommended.

NRS-2002 was validated by application to a retrospective analysis of 128 randomized controlled trials of nutritional support. Each of four authors independently decided whether the patients in each study were undernourished, what their disease severity was, and whether the effect on clinical outcome should

be considered “positive” or “no effect.” The majority of these studies were in hospitalized patients, but outpatient studies were also included. Nearly 16% of studies did not provide concise information about nutritional status (height, weight, BMI, recent weight loss) or nutritional intake of the control groups. In these cases, the authors used their clinical experience with that group of patients to draw a conclusion. Although the content validity of NRS-2002 has subsequently been supported in the literature and its practicability has been established by application to 99% of 750 newly admitted patients [17], its generalizability is limited with regards to the ICU population. Using the NRS-2002 scoring tool, any “intensive care patient” is automatically given a score of 3, suggesting that all ICU patients are the same in terms of nutritional risk.

### Nutrition risk in the critically ill (NUTRIC) score

In 2011, Heyland et al. developed a new scoring system to address the differences in ICU populations as well as their differential response to nutritional therapy [5•]. Unlike other assessment tools, the nutrition risk in the critically ill (NUTRIC) score is specifically designed for the ICU setting. Discussion of nutritional risk in the ICU is significantly different from outpatient or even other inpatient settings.

The originators of NUTRIC began by creating a conceptual model describing the effects of acute and chronic malnutrition and inflammation on nutrition status at ICU admission and the impact of these conditions on patient outcomes. The six variables in the NUTRIC score (age, APACHE II score, SOFA score, number of comorbidities, IL-6, and days from hospital admission to ICU admission) were included because each was significantly associated with mortality (Table 4). Each variable was assigned a point value, with high scores (6–10) being associated with worse clinical outcomes (e.g., mortality, ventilation) and low scores (0–5) indicating a low malnutrition risk (Table 5). Similar to the previous work of Jensen et al, Heyland and colleagues addressed the link between starvation, inflammation, and outcome. Apart from BMI, the variables comprising the score have a statistically significant relationship with 28-day mortality and ventilator-free days. The authors acknowledge that BMI may still be an important determinant in outcome, but very few patients with low BMI (<20) were included in their study.

The authors of the NUTRIC score had to demonstrate that this tool successfully predicted the risk of developing adverse events in a diverse group of ICU patients and that the association between the NUTRIC score and outcome was modifiable by nutritional intervention. In their initial validation study, the association between adequate nutritional therapy and mortality was assessed in 211 patients who started mechanical ventilation within 48 h after ICU admission, remained in the ICU for 3 days or longer, and had recorded caloric intake. The final version of the NUTRIC score was strongly associated with observed days on mechanical ventilation ( $p < 0.0001$ ) and was predictive of 28-day

**Table 2** NRS-2002 pre-screen

Initial screening		
Is BMI <20.5?	Yes	No
Has the patient lost weight within the last 3 months?	Yes	No
Has the patient had a reduced dietary intake in the last week?	Yes	No
Is the patient severely ill?	Yes	No

If the answer is “Yes” to any question, the final screen (below) is performed

If the answer is “No” to all questions, it is recommended to re-screen at weekly intervals

**Table 3** NRS-2002 final screen

Impaired nutritional status			Severity of disease		
Absent	Normal nutritional status	Score 0	Absent	Normal nutritional requirements	Score 0
Mild	Weight loss >5% in 3 months or food intake <50–75% of normal requirement in preceding week	Score 1	Mild	Hip fracture, chronic patients, especially with acute complications (e.g., COPD, chronic dialysis, diabetes, oncology)	Score 1
Moderate	Weight loss >5% in 2 months or BMI 18.5–20.5 + impaired general condition or food intake 25–60% of normal requirement in preceding week	Score 2	Moderate	Major abdominal surgery, stroke, severe pneumonia, hematologic malignancy	Score 2
Severe	Weight loss >5% in 1 month (>15% in 3 months) or BMI > 18.5 + impaired general condition or food intake 0–25% of normal requirement in preceding week	Score 3	Severe	Head injury, bone marrow transplant, intensive care patients	Score 3
Score			Score		
Total score from both sections					

mortality (c-index = 0.783). But more importantly, the authors also found that patients with a high NUTRIC score benefit the most from aggressive nutrition therapy, whereas patients with a low score may not benefit from such aggressive attempts at feeding. The ability to predict which patients will benefit from early aggressive calorie and protein provision, and which patients will not be harmed by trophic feeding (or iatrogenic underfeeding) in the first week of ICU admission, is a quality that separates the NUTRIC scoring tool from any other.

In 2015, Coltman et al [18] compared the use of an institution-specific nutrition screening method, the Subjective Global Assessment, and the NUTRIC score in identifying nutritionally at-risk patients. The authors found that patients identified using the NUTRIC score had the longest hospital and ICU length of stay.

**Modified NUTRIC (mNUTRIC) score**

Although most of the variables used to calculate the NUTRIC score are easily obtained, IL-6 level is not routinely determined for most patients. Rahman et al. performed a post hoc analysis of a randomized controlled trial of ICU patients with multi-organ failure [19••]. The authors collected all of the NUTRIC variables with the exception of IL-6 levels and calculated the score using the point system developed by Heyland. The new scoring system with IL-6 excluded gives a high score (5–9) and low score (0–4) (Table 5). The authors observed the same relationship between provision of nutritional support and 28-day survival in patients with a high mNUTRIC score and no relationship between nutrition intake and survival as the score decreased (test for interaction  $p=0.029$ ). In addition, higher mNUTRIC scores were significantly associated with higher 6-month mortality ( $p<0.0001$ ). The authors therefore concluded that the mNUTRIC risk

assessment tool was valid and IL-6 data contributes very little to the overall predictive value of the NUTRIC score.

Heyland and colleagues also calculated the mNUTRIC score for all patients in an observational study of 3390 patients from 201 ICUs from around the world [20]. A total of 1929 (57%) had a mNUTRIC score  $\geq 5$ . There were no clinically significant differences in nutrition outcomes (i.e., type of nutrition, mean energy intake, mean protein intake) compared with mNUTRIC scores  $<5$ . However, significant differences

**Table 4** NUTRIC score variables

Variable	Range	Points
Age	<50	0
	50–74	1
	$\geq 75$	2
APACHE II	<15	0
	15–19	1
	20–28	2
	$\geq 28$	3
SOFA	<6	0
	6–9	1
	$\geq 10$	2
Number of comorbidities	0–1	0
	$\geq 2$	1
Days from hospital to ICU admission	0–<1	0
	$\geq 1$	1
IL-6 <sup>a</sup>	0–399	0
	$\geq 400$	1

<sup>a</sup> If IL-6 is not available, exclude this data point and follow the mNUTRIC scoring system

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**Table 5** NUTRIC and mNUTRIC scoring system

Category	NUTRIC <sup>a</sup>	mNUTRIC <sup>b</sup>	Explanation
High score	6–10	5–9	<ul style="list-style-type: none"> <li>• Associated with worse clinical outcomes (i.e., mortality, ventilation)</li> <li>• Patients will likely benefit from early aggressive calorie and protein provision</li> </ul>
Low score	0–5	0–4	<ul style="list-style-type: none"> <li>• Low malnutrition risk</li> <li>• Patients will likely not be harmed by trophic feeding (or iatrogenic underfeeding) in the first week of ICU</li> </ul>

<sup>a</sup> NUTRIC is used if IL-6 is available

<sup>b</sup> mNUTRIC is used if IL-6 is not available

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in outcomes were again seen between patients with low and high mNUTRIC scores; patients with high mNUTRIC scores had higher 60-day mortality (34 vs 18%,  $p < 0.001$ ). The size of this data set and representation from ICUs around the world further enhances the generalizability of this scoring tool.

Building on the initial validation study in a mainly Caucasian population in Canada, Mukhopadhyay and colleagues performed a subgroup analysis of 273 patients who received mechanical ventilation for at least 48 h [21]. The authors found that the mNUTRIC score was an independent predictor of 28-day mortality and was associated with length of hospital and ICU length of stay in the adult Asian population. Regarding impact of nutrition, among patients with a high mNUTRIC score (5–9), higher nutritional adequacy was associated with a lower predicted 28-day mortality. This was not observed in patients with a low mNUTRIC score (0–4). The authors therefore concluded that the mNUTRIC scoring tool is valid in a mixed adult Asian ICU population.

A second cultural validation of the mNUTRIC score was done by Mendes and colleagues in a multicenter prospective cohort study of 1143 Portuguese ICU patients [22]. Again, a high mNUTRIC score ( $\geq 5$ ) was associated with longer lengths of stay ( $p < 0.001$ ), less mechanical ventilation-free days ( $p = 0.002$ ), and higher 28-day mortality ( $p < 0.001$ ). These findings were consistent with the associations described in the initial validation study despite differences in the demographic characteristics of this group versus the original validation group. Compared with the original group, participants in this Portuguese cohort were older, had higher proportions of low APACHE II scores, higher SOFA scores, and a lower proportion of participants had two or more comorbidities [22]. The authors concluded that the mNUTRIC scoring tool demonstrated translation reliability and good correlation with main clinical outcomes in a heterogeneous Portuguese ICU population.

## Conclusions

The original NRS-2002 scoring system was revolutionary in its conceptual design, incorporating acute and chronic

starvation with inflammation. While generalizable to the in-patient setting, NRS-2002 did not recognize the diversity of ICU patients, considering all critically ill patients to be at high risk. The evidence indicates that for critically ill patients with BMIs less than 25 or greater than 35, an inverse linear relationship exists between increased calorie and protein intake and odds of mortality. The conclusion was that response to nutritional therapy varies among ICU populations. The newer scoring systems (NUTRIC and mNUTRIC) were formulated with the hypothesis that ICU patients are a heterogeneous population in terms of nutritional risk.

Hospitals using a single nutrition risk screening tool for all patients regardless of the severity of illness are likely missing an opportunity to provide appropriate and timely nutrition support to patients who would experience the greatest benefit. Similarly, clinicians may be missing an opportunity to improve patient outcomes if nutrition interventions are not tailored to nutrition risk. This may be the case in many hospitals. In a study of 3390 patients from 201 ICUs from around the world, Heyland et al. observed no difference in nutrition intake when comparing high mNUTRIC score patients to low mNUTRIC score patients, and those with high mNUTRIC scores actually waited longer to be fed [20]. Moreover, utilization of enhanced feeding protocols designed to maximize delivery of nutrition was low overall and the use of motility agents, small bowel feeding, volume-based feeding, and supplemental parenteral nutrition was not different in the different risk stratum in this observational study [20]. The same study revealed that among patients deemed nutritionally high risk using the mNUTRIC score, 80% failed to receive the recommended 80% of estimated energy and protein needs. That is, clinicians are not treating high-risk patients any differently than low-risk patients in current practice despite evidence that high-risk critically ill ICU patients are more likely to benefit from therapeutic nutritional interventions than those at low risk.

The available scoring systems acknowledge the differences among ICU patients and the fact that nutritional therapy impacts ICU patients differently based on their risk. Further, a positive effect of nutritional support on clinical outcome was observed in RCTs that included patients meeting nutritional risk criteria and not observed in RCTs enrolling patients not

considered to be nutritionally at-risk [9]. While the NUTRIC and mNUTRIC scores are limited in their ability to identify malnutrition, they do provide valid, rigorously tested tools to help categorize ICU patients and guide appropriate therapy. As such, these tools should be used preferentially over tools, including the NRS-2002, that have not been validated for use in the ICU.

### Compliance with ethical standards

**Conflict of interest** Michelle Kozeniecki and Panna Codner declare no conflict of interest. Darren Heyland reports grants and personal fees from Nestle, grants and personal fees from Abbott, outside the submitted work.

**Human and animal rights and informed consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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