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Evaluation of different screening tools for detection of malnutrition in hospitalised patients

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Abstract

Aims and Objectives: To assess the prevalence of malnutrition in hospitalised adult patients, and to evaluate the accuracy of the most commonly used nutritional screening tools for identifying individuals at risk of malnutrition.

Methods: A prospective cross-sectional study was conducted on a total of 248 hospitalised patients in internal medicine wards (mean age: 75.2 years; 39.5% females). Nutritional screening was performed within 48 h of admission using the following tools: Malnutrition Universal Screening Tool (MUST), Nutrition Risk Screening Tool (NRS-2002), Malnutrition Screening Tool (MST), Short Nutritional Assessment Questionnaire (SNAQ), and Mini Nutritional Assessment Short Form (MNA-SF). The criteria of the European Society for Clinical Nutrition and Metabolism (ESPEN) were used as the gold standard for defining malnutrition. Patients were also evaluated using the Subjective Global Assessment (SGA) and the Global Leadership Initiative on Malnutrition (GLIM) criteria. Accuracy was determined by examining sensitivity, specificity, and positive and negative predictive values, and diagnostic agreement was determined by calculation of Cohen's kappa (κ). The study is reported as per the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Results: The ESPEN criteria classified 20.2% of the hospitalised patients as malnourished. Overall, the MUST had the highest sensitivity (80.0%), specificity (74.7%) and positive predictive value (44.4%). For the subgroup of patients aged >65 years, the MNA-SF had high sensitivity (94.4%) but low specificity (39.0%). Based on Cohen's κ, the SGA and GLIM criteria showed low agreement with the ESPEN criteria.

Conclusion: The MUST was the most accurate nutritional screening tool, through the MST is more easily applied in many clinical settings. A comprehensive assessment of malnutrition that considers muscle mass is crucial for the reliable diagnosis of malnutrition.

Implications for the profession and/or patient care: The present findings underscore the importance of accurate assessment of the malnutrition status of hospitalised patients and the need for a reliable screening tool.

No patient or public contribution.

KEYWORDS
diagnostic criteria, ESPEN, malnutrition, malnutrition definition, nutrition screening tools, nutritional status

1 | INTRODUCTION

Malnutrition affects 30%–50% of hospitalised patients, depending on patient age, the criteria used to define malnutrition, and the specific hospital setting (Cass & Charlton, 2022; van Vliet et al., 2020; Zhang et al., 2021; Zugasti Murillo et al., 2021). Furthermore, malnutrition is associated with reduced quality of life, increased morbidity and mortality, prolonged hospital stay, and increased readmission rate, all of which can increase healthcare costs (Allard et al., 2016; Cardenas et al., 2020; Domenech-Briz et al., 2022). Several risk factors contribute to malnutrition in hospitalised patients, including the pathophysiological processes of the primary disease, specific pharmacological interventions that hinder nutrient intake and assimilation, and diagnostic procedures that require fasting (Cass & Charlton, 2022; Seron-Arbeloa et al., 2022; Sorensen et al., 2008).

It is important to evaluate nutritional status of patients at admission to prevent malnutrition and to identify the need for nutritional therapy (Lim et al., 2012; Miguel Montoya et al., 2017; Uhl et al., 2022). Despite clinical guidelines that strongly advocate the use of routine nutritional screening at admission followed by a comprehensive assessment, these recommendations are often not followed in real-world clinical settings (Smith et al., 2018; Yarnoz-Esquiroz et al., 2019). In fact, only 10%–20% of hospitalised patients receive nutritional screening (Cascio & Logomarsino, 2018; Sorensen et al., 2008), even in hospitals with established clinical nutrition departments. One reason for this could be the lack of a screening tool that is efficient, adaptable and easy to implement (Schindler et al., 2010).

Successful management of malnutrition requires an accurate diagnosis of the condition. The two main challenges in diagnosing are defining malnutrition and selecting an appropriate screening tool. No single anthropometric or analytical value can be used to identify malnutrition (Jensen et al., 2013), and this has led to the establishment of diverse criteria for its diagnosis. Moreover, there is some confusion in the literature about the terminology used to describe malnutrition, especially regarding nutritional screening (identifying the risk of malnutrition) and the diagnosis of malnutrition (Charney, 2008).

Many scientific societies have recommended different criteria for the diagnosis of malnutrition (Cederholm et al., 2015; White et al., 2012). For example, the European Society for Clinical Nutrition and Metabolism (ESPEN) defined malnutrition on the basis of the presence of one or more of the following: (*i*) low body mass index (BMI); (*ii*) unintentional body weight loss combined with a decreased BMI; and (*iii*) unintentional body weight loss, decreased BMI, and low fat-free mass index (FFMI) (Cederholm et al., 2015). However, these three criteria do not consider the aetiology of malnutrition. Therefore, an international consensus recently proposed the Global Leadership Initiative on Malnutrition (GLIM), and introduced more comprehensive diagnostic criteria. The GLIM assesses a variety of phenotypic factors (including body weight loss, low BMI, and decreased muscle mass) and etiological factors (including decreased food intake or assimilation due to gastrointestinal disorders and symptoms, inflammation, and/or disease burden). These phenotypic criteria can be used to assess the severity of malnutrition, and the etiological criteria can help to select interventions that help to achieve the desired outcomes (Cederholm et al., 2019; Charney, 2008). Other assessment tools, such as the Subjective Global Assessment (SGA) (Hirsch et al., 1991), rely on similar clinical variables. However, the SGA assesses the risk of malnutrition based on a subjective evaluation by an observer. Nonetheless, the SGA has been widely adopted in different healthcare settings, and is often considered the gold standard for validating nutritional screening tools (Kyle et al., 2006; Seron-Arbeloa et al., 2022).

Numerous nutritional screening tools have been developed, including the Malnutrition Universal Screening Tool (MUST) (Stratton et al., 2004), which is used in community and hospital settings; the Nutritional Risk Screening 2002 (NRS-2002) (Kondrup, Rasmussen, et al., 2003), which is recommended by ESPEN; the Mini Nutritional Assessment Short Form (MNA-SF) (Rubenstein et al., 2001), which was specifically designed for patients aged 65 years and above; the Short Nutritional Assessment Questionnaire (SNAQ) (Kruizenga et al., 2005), which is applicable for many age groups in hospitals, nursing homes, and community settings; and the Malnutrition Screening Tool (MST) (Ferguson

What does this paper contribute to the wider global community?

- The prevalence of malnutrition in internal medicine wards was found to be 20.2%, as per ESPEN criteria.
- The MUST displayed the highest sensitivity, specificity, and positive predictive value. For patients aged over 65 years, MNA-SF showed high sensitivity but lower specificity.
- Our study highlights the importance of considering muscle mass in a comprehensive assessment of malnutrition diagnosis.

et al., 1999), which can be self-administered by patients. However, these tools differ in terms of validity, reliability, generalizability, and the often produce discordant results (Skipper et al., 2020). The various tools developed to date evaluate different characteristics of patients using objective measures, such as recent body weight loss, changes in food intake, and the presence of a physical or mental illness that impacts food intake or absorption. Although a score can be used to classify a patient based on the risk of malnutrition, consensus has yet to be reached about which tool is most appropriate in hospital settings. In addition, some of these screening tools have not been validated against a gold standard (Baltazar-Luna et al., 2017). Therefore, studies are needed to evaluate the accuracy of these different screening tools within a single population (Seron-Arbeloa et al., 2022; van Bokhorst-de van der Schueren et al., 2014).

Consequently, the aim of the present study was to assess the prevalence of malnutrition in a population of hospitalised adult patients, and to evaluate the accuracy of the most commonly used screening tools (MUST, NRS-2002, MST, SNAQ, and MNA-SF) and assessment tools (SGA, and GLIM) for identification of patients at risk of malnutrition, with the ESPEN diagnostic criteria used as the gold standard.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

This prospective cross-sectional study enrolled adult patients (age ≥ 18 years) admitted to the internal medicine wards at Son Espases University Hospital (Mallorca, Spain) between July 2021 and January 2023. For 4 days per week during this period, all newly admitted patients were invited to participate, and those who agreed and provided written informed consent within 48 h of admission were included. Patients were excluded if they were unable to communicate, had eating disorders, had severe burns or were pregnant. The study is reported as per the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Data S1).

The COVID-19 pandemic necessitated interruption of data collection on multiple occasions. On days when data collection was feasible, all patients who met the inclusion and exclusion criteria were examined. To minimise potential bias, a single researcher (RC), an experienced nurse and nutritionist, performed all clinical evaluations and used the same measurement instruments for all patients.

Sociodemographic and medical data and the results of the different questionnaires were collected during a structured interview. These data included diagnosis at admission, health-related habits, and sociodemographic variables (gender, date of birth, nationality, education level, marital status, occupation, and household living conditions).

The Barthel index was used to evaluate functional status and the ability to perform daily life activities (Gonzalez et al., 2018). The risk of pressure ulcers was assessed using the Braden scale (Braden & Bergstrom, 1987), and the risk of falling was determined using the Downton scale (Bueno-García et al., 2017).

2.2 | Sample size

Accepting an alpha risk of 0.05 for a precision of +/− 0.05 units in a two-sided test for an estimated proportion of malnutrition about 30% (Sanchez-Rodriguez et al., 2019), 323 subjects were required.

2.3 | Ethical considerations

All participants were informed about the aim of the study and provided written informed consent prior to participation. The study protocol was approved by the hospital Research Commission and the Ethics Committee of the Balearic Islands (CEI-IB Ref. number IB4500/21). The study was conducted in accordance with the ethical and legal standards required for biomedical research as outlined in the Helsinki Declaration.

2.4 | Anthropometric measurements and biochemical analyses

Body weight was measured to the nearest 0.1 kg using electronic scales (Seca 700 Scale, Seca GMBH, Hamburg) and height was measured to the nearest 0.5 cm using a stadiometer (Seca 220 [CM] Telescopic Height Rod for Column Scales, Seca GMBH). If measurement of height was not possible (e.g. for patients unable to stand), a tape measure was employed and the methods recommended by the British Association for Parenteral and Enteral Nutrition (BAPEN) were applied (Todorovic et al., 2003).

The BMI was calculated as body weight divided by height squared (kg/m^2). For patients with restricted mobility or incapable of standing, mid-upper arm circumference was measured using a calibrated tape measure and the BMI was estimated using the formula: BMI = (arm circumference (cm) x 30)/32. For BMI values ≥28 kg/m^2, an additional two points were added to the final score (Mill-Ferreyra et al., 2018).

Grip strength was evaluated using an electronic hand dynamometer (Camry Digital Handgrip Dynamometer Model EH101, Zhongshan Camry Electronic Co). For these measurements, the patient held the device with the arm unsupported and extended parallel to the body, and then applied the maximum force. This procedure was repeated twice for each hand (with a recovery period between measurements), and the highest value was recorded (Bohannon, 2015; Flood et al., 2014; Guerra et al., 2015; Norman et al., 2011).

Blood levels of albumin, lymphocytes, cholesterol, and C-reactive protein (CRP) were determined using an automated instrument at hospital admission.

2.5 | Body composition analysis

Body composition was assessed using bioelectrical impedance analysis (BIA) with a multi-frequency BIA analyser (QuadScan 4000, Bodystat, Isle of Wight, United Kingdom). For measurements, a patient was positioned supine with the arms and legs separated from the body, and electrodes were placed in a tetrapolar (wrist-ankle) arrangement (Evans et al., 2018; Mulasi et al., 2015). The derived parameters were resistance, reactance, phase angle, body fat, lean body mass, total body water, extracellular water, intracellular water, nutritional index, body fat mass index and muscle mass index.

2.6 | Nutritional screening and diagnosis of malnutrition

Nutritional screening was performed within 48h of admission using the following tools: MUST, NRS-2002, MST, SNAQ and MNA-SF (only for those aged >65 years). The SGA, GLIM and ESPEN were used for the diagnosis of malnutrition. The ESPEN diagnostic criteria for malnutrition were used as the gold standard. Validated Spanish language versions of all tools were employed.

2.6.1 | Malnutrition universal screening tool (MUST)

The MUST is a validated, rapid, and reproducible screening tool developed for all adult patients in different healthcare settings (Poulia et al., 2017; Stratton et al., 2004). It considers BMI, involuntary body weight loss, and the potential for future body weight loss due to acute diseases that could impede food intake for more than 5 days. Each criterion has a score of 0–2 points. BMI was scored as 0 (>20 kg/m^2), 1 (18.5–20 kg/m^2) or 2 (<18.5 kg/m^2); body weight loss was scored as 0 (<5%), 1 (5%–10%), or 2 (>10%); and acute disease and potential impact on food intake during the subsequent 5 days was scored as 0 (absent) or 2 (present). Patients were also classified according to the risk of malnutrition as low (0), medium (1) or high (2).

The ESPEN recommends use of this tool at the community level, and its reliability is comparable to that of the MNA when screening for nutritional risk in geriatric populations (Poulia et al., 2012). This tool can also predict the duration of hospital stay and likelihood of readmission, and can monitor changes in nutritional status over time.

2.6.2 | Nutrition risk screening (NRS-2002)

The NRS-2002 is a nutritional screening tool recommended by the ESPEN guidelines for the nutritional screening of hospitalised patients (Kondrup, Rasmussen, et al., 2003). Although it is regarded as a user-friendly and rapid screening instrument, its reliance on a subjective evaluation of disease severity can affect the score. Moreover, the NRS-2002 was validated for efficacy in identifying patients who benefit from various forms of nutritional support, rather than strictly as a screening tool for malnutrition (Kondrup, Allison, et al., 2003).

The total NRS-2002 score ranges from 0 to 7 points. First, the patient is assessed for the presence of a low BMI (<20.5 kg/m^2), body weight loss during the previous 3 months, reduced food intake during the previous week, and presence of a serious illness. A patient with one or more of these conditions is then subjected to screening. The screening phase assigns a nutritional score (0–3 points), based on body weight loss, BMI, and reduced food intake; and a disease severity score (0–3 points), based on the current clinical condition and chronic diseases with acute complications (e.g. cerebrovascular incident, traumatic brain injury, major abdominal surgery or bone marrow transplant); in addition, patients aged ≥70 years are assigned an additional 1 point. An NRS-2002 score less than three suggests no risk of malnutrition, and a score of three or more indicates risk of malnutrition.

2.6.3 | Malnutrition screening tool (MST)

The MST is a rapid and simple screening tool that assesses recent body weight loss, appetite, and nutritional intake. The maximum score is 7, and a score ≥2 suggests the need for a comprehensive nutritional assessment and/or intervention (Castro-Vega et al., 2018; Ferguson et al., 1999).

2.6.4 | Short nutritional assessment questionnaire (SNAQ)

The SNAQ has three questions: (*i*) Has there been body weight loss of >6 kg during the previous 6 months or >3 kg during the previous 1 month? (*ii*) Has there been a loss of appetite? And (*iii*) was there a requirement for nutritional supplementation during the past 1 month? The response to each question was scored on a 5-point scale ranging from "very bad" to "very good", with a score of 2 indicating moderate malnutrition and a score of 3 or higher indicating severe malnutrition (Kruizenga et al., 2005).

2.6.5 | Mini-nutritional assessment short form (MNA-SF)

The MNA-SF is a short form of the MNA, and is a frequently employed screening instrument that was designed for elderly populations (Rubenstein et al., 2001). This tool has six questions, and the response to question was scored from 0–2 or 0–3. These questions assess body weight loss (during the last 3 months), appetite level, physical mobility, psychological stress, neuro-psychological problems and BMI. Based on the total score, patients are categorised as having "normal nutritional status" (12–14 points), "nutritional risk" (8–11 points) or "malnourishment" (0–7 points) (Rubenstein et al., 2001). In addition, if the total score is ≤11 points, the patient is classified as "at risk for malnutrition", and the full version of the MNA is administered. The MNA-SF is considered a convenient screening tool that is reproducible, straightforward, cost-effective, and rapid (requiring less than 5 min). However, the MNA and MNA-SF have certain limitations, in that patients who cannot provide reliable information about themselves (e.g. those with dementia, stroke, or Alzheimer's disease) or those dependent on a nasogastric tube for nutrition cannot be evaluated (Ockenga et al., 2005).

2.6.6 | Subjective global assessment (SGA)

The SGA is a nutrition assessment tool that provides an overall evaluation of a patient based on history and physical examination results, and uses structured clinical parameters to diagnose malnutrition (Baker et al., 1982; Duerksen et al., 2021). The American Society for Parental and Enteral Nutrition (ASPEN) recommends this tool, and it has been validated in different clinical settings (internal medicine, surgical, and critical care) and in patients with chronic renal failure or cancer and in geriatric patients (Duerksen et al., 2021; Lew et al., 2017). The SGA considers a patient's history (body weight loss, changes in oral/dietary intake, gastrointestinal symptoms, and functional capacity) and includes measurements of physical function and parameters from a physical examination (loss of muscle mass and subcutaneous fat mass, presence of ascites, and appearance of ankle and sacral edema). Patients are then classified into three categories based on their symptoms: SGA-A, well-nourished; SGA-B, moderately malnourished (5%–10% body weight loss, reduced food intake during recent weeks, and loss of subcutaneous tissue); or SGA-C, severely malnourished (>10% body weight loss, severe loss of muscle mass and subcutaneous tissue, or presence of edema) (Reber et al., 2021).

2.6.7 | Global leadership initiative on malnutrition (GLIM)

The GLIM tool, which was developed from a collaboration of prominent clinical nutrition societies (Cederholm et al., 2019; de van der Schueren et al., 2020; Jensen et al., 2019), employs a two-phase process. Initially, a validated screening tool identifies potential nutritional risks. Then, a comprehensive assessment determines the presence and severity of malnutrition and its diagnosis.

The GLIM criteria include three phenotypic and two etiological criteria (Cederholm et al., 2019), and the diagnosis of malnutrition requires the presence of at least one phenotypic criterion and one etiological criterion. The phenotypic criteria are: body weight loss (≥5% involuntary body weight loss during the previous 6 months or ≥10% during the previous 7 or more months), low BMI (<20 kg/m^2 if aged <70 years, or <22 kg/m^2 if aged ≥70 years), and reduced muscle mass (based on validated body composition analysis, such as BIA). The etiological criteria are: reduced food intake or assimilation (ingestion below 50% of nutritional needs for 1–2 weeks, or any reduction for more than 2 weeks, or any chronic gastrointestinal condition that adversely impacts food assimilation or absorption); and inflammation and disease burden from an acute or chronic injury or disease. The severity of malnutrition is then categorised as moderate or severe, based on parameters such as the magnitude of unintentional body weight loss, BMI, and reduced muscle mass.

Because it was difficult to assess a patient's food intake prior to hospital admission, we used a modification of the GLIM criteria, replacing "reduced food intake or assimilation" with "reduced appetite".

2.6.8 | European society for clinical nutrition and metabolism (ESPEN)

The ESPEN defines malnutrition on the basis of the presence of one of the following criteria (Cederholm et al., 2015): (*i*) BMI <18.5 kg/m^2; (*ii*) unintentional body weight loss of >10% of total body weight during an indefinite of time, or >5% during the previous 3 months, combined with an age-related low BMI (< 20 kg/m^2 for those aged <70 years, <22 kg/m^2 for those 70 years or more), or a fat-free mass index (FFMI) below 17 kg/m^2 in men and below 15 kg/m^2 in women. The FFMI was calculated from the BIA results as FFM/height squared (kg/m^2).

2.7 | Statistical analysis

Continuous variables were presented as medians and interquartile ranges (IQRs), because the normality of distributions could not be assumed based on the Kolmogorov–Smirnov test. Categorical variables were determined as absolute numbers and percentages. The Chi-squared test and the Mann–Whitney *U* test were used to compare malnourished and well-nourished hospitalised patients. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for each screening tool were calculated using ESPEN criteria as the gold standard. Cohen's kappa (κ) statistic (range: 0–1) was calculated to evaluate the diagnostic agreement of SGA, GLIM, and ESPEN in identifying malnutrition, with a higher κ indicating better agreement. Effect sizes were calculated to measure the magnitude of the differences (Lenhard & Lenhard, 2016) and are interpreted as small (0.20–0.49), medium (0.50–0.79) and large (>0.80) differences. All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk). All reported *p*-values are based on two-sided tests, and a value <0.05 was considered significant. All estimated values are presented with 95% confidence intervals (95% CIs).

3 | RESULTS

3.1 | Characteristics of the study population

We initially enrolled 338 patients. However, 90 patients (26.6%) were excluded because they or their caregivers either did not know their usual body weight or information on body weight was missing from clinical records, which prevented application of the MUST and ESPEN diagnostic criteria. Finally, a total of 248 patients were included in the analysis (Table 1). The median age was 75.2 years (IQR: 61.8–82.5), there were 150 males and 98 females, and 90.7% of the patients had Spanish nationality.

The scores on the Barthel index demonstrated that most patients (62.5%) could function independently in daily life activities, but 21.8% had severe or total dependence. A total of 59.2% of the patients were engaged in some form of physical activity, and the median BMI of all patients was 25.3 kg/m^2 (IQR: 22.5–29.7).

3.2 | Risk factors for malnutrition

According to the ESPEN criteria, 50 patients had malnutrition (prevalence of malnutrition 20.2%; 95% CI: 15.2%–25.2%). The most prevalent characteristic in these patients was the combination of body weight loss with low muscle mass index, which was present in 42 of these 50 patients (84.0%).

We then compared the malnourished and well-nourished patients (Table 2). The malnourished group had a lower median BMI (20.7 vs. 26.2 kg/m^2, $p < 0.001$), a greater risk of falls (30% vs. 15.7%, $p = 0.020$) according to the Downton scale, a lower median grip

TABLE 1 Characteristics of the study population.*

Characteristic	Total (*n* = 248)	Females (*n* = 98)	Males (*n* = 150)	*p*-value
Age (years)	75.18 (61.83, 82.5)	75.53 (63.43, 84.1)	74.92 (61.75, 82.4)	0.443
Body weight (kg)	69.75 (60.00, 84.0)	63.25 (56.00, 73.0)	74.00 (64.00, 87.0)	<0.001
Height (cm)	166.00 (160.00, 171.0)	158.00 (153.00, 164.0)	170.00 (165.00, 175.0)	<0.001
BMI (kg/m^2)	25.30 (22.50, 29.7)	25.71 (22.32, 30.0)	25.26 (22.72, 29.3)	0.867
Usual body weight (kg)	73.00 (64.00, 84.0)	67.50 (57.50, 75.5)	78.00 (70.00, 87.0)	<0.001
Chewing problems	78 (31.8%)	35 (36.1%)	43 (29.1%)	0.248
Physical activity				
Only walking	103 (41.5%)	38 (38.8%)	65 (43.3%)	0.476
Other physical activity	43 (17.7%)	8 (8.5%)	35 (23.5%)	0.003
Living alone	34 (13.7%)	14 (14.3%)	20 (13.3%)	0.831
Smoker				<0.001
Yes	32 (13.0%)	12 (12.4%)	20 (13.3%)	
Former smoker	101 (40.9%)	17 (17.5%)	84 (56.0%)	
Final education level				0.013
Primary school	45 (26.2%)	19 (30.6%)	26 (23.6%)	
Secondary school	79 (45.9%)	34 (54.8%)	45 (40.9%)	
Higher education	48 (27.9%)	9 (14.5%)	39 (35.4%)	
Barthel index				0.712
Independent	156 (62.9%)	59 (60.2%)	97 (64.7%)	
Mild dependence	16 (6.4%)	7 (7.1%)	9 (6.0%)	
Moderate dependence	22 (8.9%)	8 (8.2%)	14 (9.3%)	
Severe dependence	36 (14.5%)	17 (17.4%)	19 (12.7%)	
Total dependence	18 (7.3%)	7 (7.1%)	11 (7.3%)	
Braden Scale (pressure ulcer)				0.402
No risk	171 (69.0%)	62 (63.3%)	109 (72.7%)	
Low risk	34 (13.7%)	16 (16.3%)	18 (12.0%)	
Moderate risk	26 (10.5%)	11 (11.2%)	15 (10.0%)	
High-risk	17 (6.9%)	9 (9.2%)	8 (5.3%)	
Downton scale (risk of falls)				0.052
At risk	46 (18.5%)	24 (24.5%)	22 (14.7%)	

Abbreviation: BMI, body mass index.

*Data are expressed as median (IQR) or *N* (%).

TABLE 2 Sociodemographic, clinical and bioelectrical impedance parameters in well-nourished and malnourished patients according to ESPEN criteria.*

Characteristic	Well-nourished ($n = 198$)	Malnourished ($n = 50$)	p-value	*Effect size d*
Age (years)	74.5 (61.4, 81.4)	79.9 (62.9, 86.8)	0.015	*0.313*
Male gender	121 (61.1%)	29 (58.0%)	0.688	*0.051*
BMI (kg/m^2)	26.2 (23.8, 30.8)	20.7 (17.6, 22.5)	<0.001	*1.405*
Usual body weight (kg)	77.00 (67.60, 86.0)	65.00 (55.00, 71.0)	<0.001	*1.013*
Chewing problems	136 (69.7%)	31 (62.0%)	0.294	*0.134*
Physical activity	39 (20.1%)	4 (8.2%)	0.050	*0.253*
Living alone	28 (14.1%)	6 (12.0%)	0.694	*0.050*
Smoker			0.447	
Yes	26 (13.2%)	6 (12%)		*−0.163*
Former smoker	84 (42.6%)	17 (34%)		*−0.236*
Educational level			0.256	
Primary	40 (28.4%)	5 (16.1%)		
Secondary	61 (43.3%)	18 (58.1%)		*0.474*
Higher education	40 (28.3%)	8 (25.9%)		*0.259*
Barthel index			0.507	
Independent	128 (64.6%)	28 (56.0%)		
Mild dependence	11 (5.6%)	5 (10.0%)		*0.399*
Moderate dependence	19 (9.6%)	3 (6%)		*−0.184*
Severe dependence	27 (13.6%)	9 (18%)		*0.228*
Total dependence	13 (6.6%)	5 (10%)		*0.307*
Braden scale (pressure ulcer)			0.425	
No risk	141 (71.2%)	30 (60.0%)		
Low risk	24 (12.1%)	10 (20%)		*0.371*
Moderate risk	20 (10.1%)	6 (12%)		*0.189*
High-risk	13 (6.6%)	4 (8%)		*0.203*
Downton scale (risk of falls)	31 (15.7%)	15 (30%)	0.020	*0.194*
Handgrip strength (kg, $n = 238$)	20.0 (13.0–31.0)	16.0 (11.0–21.0)	0.003	*0.397*
Blood test parameters				
Albumin (g/dL)	33.9 (30.6, 37.2)	31.8 (28.6, 37.1)	0.233	*0.486*
Total Lymphocytes (cells/mm^2)	1.32 (0.85, 1.9)	1.24 (0.81, 1.9)	0.517	*0.187*
Total Cholesterol (mg/dL)	133.0 (108.0, 161.0)	128.0 (93.0, 156.0)	0.246	*0.602*
CRP (mg/L)	5.28 (1.28, 12.2)	3.80 (0.42, 9.6)	0.247	*0.410*
Bioelectrical impedance				
Resistance	514.0 (458.0, 586.0)	640.5 (592.0, 715.0)	<0.001	*1.104*
Reactance	43.5 (34.2, 55.3)	47.9 (39.0, 59.8)	0.048	*0.253*
Phase angle	4.8 (3.8, 5.6)	4.3 (3.4, 5.2)	0.062	*0.238*
Body fat (kg)	24.5 (19.3, 32.6)	19.4 (15.5, 22.6)	<0.001	*0.639*
Body fat (%)	33.3 (27.7, 41.1)	35.1 (29.1, 43.8)	0.394	*0.108*
Lean body mass (kg)	50.2 (41.3, 59.6)	35.3 (29.2, 41.4)	<0.001	*1.039*
Lean body mass (%)	65.6 (58.9, 72.3)	64.8 (56.2, 70.9)	0.394	*0.108*
Dry lean body weight (kg)	10.1 (6.5, 13.9)	3.9 (1.1, 7.0)	<0.001	*1.018*
Total body water (TBW, L)	38.9 (34.2, 45.7)	31.8 (27.8, 35.8)	<0.001	*0.905*
Total body water (TBW, %)	52.7 (46.9, 57.1)	57.9 (53.9, 64.5)	<0.001	*0.637*
Extracellular water (ECW, L)	17.6 (15.3, 19.5)	14.3 (13.0, 15.4)	<0.001	*1.078*

(Continues)

TABLE 2 (Continued)

Characteristic	Well-nourished ($n=198$)	Malnourished ($n=50$)	*p*-value	*Effect size d*
Extracellular water (ECW, %)	23.3 (21.3, 25.2)	25.6 (24.7, 28.0)	<0.001	*0.797*
Intracellular water (ICW, L)	21.8(18.5, 25.1)	17.5 (13.7, 19.4)	<0.001	*0.926*
Intracellular water (ICW, %)	28.5 (25.9, 31.3)	31.2 (27.0, 33.0)	0.004	*0.368*
Cellular body mass (kg)	31.2 (26.5, 35.8)	25.1(19.5, 27.7)	<0.001	*0.928*
FMI (kg/m^2)	9.0 (6.7, 11.9)	7.3 (5.8, 8.9)	<0.001	*0.494*
FFMI (kg/m^2)	17.9 (15.8, 20.0)	13.7 (11.4, 15.0)	<0.001	*1.412*

Abbreviations: BMI, body mass index; CRP, C-reactive protein; FFMI, fat-free mass index; FMI, fat mass index.
*Data are expressed as median (IQR) or *N* (%).

strength (16 kg vs. 20 kg, $p=0.003$), and a lower level of physical activity other than walking (8.2% vs. 20.1%, $p=0.05$). Furthermore, all but two body composition variables (phase angle and body fat percentage) that were measured by BIA differed significantly between the two groups (all $p<0.05$). However, the two groups showed no significant differences in all four blood markers (albumin, total lymphocytes, total cholesterol and CRP) and no differences in education level, dependency index, or risk of pressure ulcer (all $p>0.05$).

3.3 | Diagnostic validity of nutrition screening tools

Next, we assessed the diagnostic validity of the different tools, using the ESPEN criteria as the gold standard (Table 3). Among the four tools that applied to all patients, the MUST had the highest sensitivity (80.0%; 95% CI: 68.9–91.9%), specificity (74.7%; 95% CI: 68.7–80.8%), and PPV (44.4%; 95% CI: 34.2–54.7%). The NRS-2002, MST, and SNAQ had similar sensitivity (70.0%–78.0%) and specificity (65.2%–68.2%). The MNA-SF, which applied only to patients older than 65 years ($n=172$), had high sensitivity (94.4%; 95% CI: 97.0%–100%) but low specificity (39.0%; 95% CI: 30.8–47.2%).

3.4 | Diagnosis of malnutrition using SGA and GLIM vs. ESPEN

The prevalence of malnutrition using the SGA was 33.9% (95% CI: 28.0%–39.8%) and the prevalence using the GLIM criteria was 50.0% (95% CI: 43.8%–56.2%) (Table 4). Based on Cohen's κ, the SGA showed better agreement with the ESPEN criteria ($\kappa=0.421$) than did the GLIM criteria ($\kappa=0.368$). Within the GLIM criteria, the phenotype of low muscle mass index (phenotype 3) had the highest agreement with the ESPEN criteria ($\kappa=0.773$).

4 | DISCUSSION

The present study of hospitalised patients indicated that one in five of these patients were malnourished according to the ESPEN criteria. In addition, our examination of the different tools used to assess the risk of malnutrition demonstrated that the MUST had the highest sensitivity (80.0%), specificity (74.7%), and PPV (44.4%). Conversely, the SGA criteria ($\kappa=0.421$) and the GLIM criteria ($\kappa=0.368$) showed low agreement with the ESPEN criteria in this population.

The present results are consistent with those of several previous studies of hospitalised patients that reported prevalence rates of malnutrition using the ESPEN criteria (de Araujo et al., 2022; Sanchez-Rodriguez et al., 2019), including one study that examined patients aged 70 years or older (Sanchez-Rodriguez et al., 2019) and another study that examined patients with chronic obstructive pulmonary disease (de Araujo et al., 2022). However, the GLIM criteria indicated a higher prevalence of malnutrition (50.2%) than the ESPEN criteria (20.7%) in our population. This result is also consistent with the findings of previous studies (Clark et al., 2020; Yin et al., 2021). Although the GLIM is a tool based on an international consensus for the identification of malnourished patients, it probably requires additional refinements to better detect patients who have the greatest risk of malnutrition and its complications, so that more appropriate and targeted interventions can be administered.

According to our results, the MUST was the most suitable screening tool, similar to previous findings (Calleja Fernández et al., 2015; Poulia et al., 2012), although many of those previous studies used the SGA as the gold standard. Some other studies found that the NRS-2002 was a better tool than the SGA (Kyle et al., 2006) or the GLIM criteria (Zhou et al., 2022). However, for patients older than 65 years, we found that the MNA-SF had the highest sensitivity (94%). Previous studies of elderly patients also showed that the MNA-SF was superior to the MUST (Castro-Vega et al., 2018). The MUST is a rapid screening tool that is applicable to all types of hospitalised patients, although it requires information about a patient's usual body weight and also requires certain calculations. Thus, we were not able to calculate the MUST for about 27% of our population because patients or their caregivers were unable to provide reliable information about usual body weight. Given that nutritional screening is pivotal for assessing malnutrition, it is crucial to incorporate a reliable and easy-to-use tool upon hospital admission (Poulia et al., 2012). Other malnutrition screening tools, such as the MST, showed slightly lower accuracy but do not require knowledge of a patient's usual body weight (Skipper et al., 2020). Furthermore, the MST is easy to administer and can be completed by the patient.

TABLE 3 Diagnostic parameters of five nutritional screening tools relative to the ESPEN criteria as the gold standard ($n = 248$).

	MUST	NRS-2002	MST	SNAQ	MNA-SF*
Sensitivity (95% CI)	80.0% (68.9, 91.1)	70.0% (57.3, 82.7)	78.0% (66.5, 89.5)	74.0% (61.8, 86.2)	94% (87.0, 100.0)
Specificity (95% CI)	74.7% (68.7, 80.8)	65.2% (58.5, 71.8)	67.2% (60.6, 73.7)	68.2% (61.7, 74.7)	39.0% (30.8, 47.2)
PPV (95% CI)	44.4% (34.2, 54.7)	33.7% (24.6, 42.7)	37.5% (28.2, 46.8)	37.0% (27.5, 46.5)	29.1% (20.8, 37.3)
NPV (95% CI)	93.7% (89.9, 97.5)	89.6% (84.6, 94.6)	92.4% (88.0, 96.7)	91.2% (86.7, 95.8)	96.4% (91.4, 100.0)

Abbreviations: ESPEN, European Society for Clinical Nutrition and Metabolism; ESPEN, European Society for Clinical Nutrition and Metabolism; MNA-SF, Mini Nutritional Assessment Short Form; MST, Malnutrition Screening Tool; MUST, Malnutrition Universal Screening; NPV, Negative Predictive Value; NRS-2002, Nutrition Risk Screening; PPV, Positive Predictive Value; SNAQ, Short Nutritional Assessment Questionnaire.

*Only for patients older than 65 years ($n = 172$).

TABLE 4 Agreement of the SGA and GLIM criteria with the ESPEN criteria (gold standard) for diagnosis of malnutrition.

		GLIM criteria					
	SGA	Total	Phenotype 1 low BMI	Phenotype 2 weight loss	Phenotype 3 reduced muscle mass	Aetiology 1 appetite	Aetiology 2 inflammation
Cohen's κ	0.421	0.368	0.636	0.426	0.773	0.080	−0.070
95% CI	0.302, 0.540	0.274, 0.461	0.510, 0.763	0.319, 0.533	0.682, 0.863	−0.002, 0.162	−0.130, 0.010

Abbreviations: ESPEN, European Society for Clinical Nutrition and Metabolism; GLIM, Global Leadership Initiative on Malnutrition; SGA, Subjective Global Assessment.

A limitation of most screening tools is that they only detect recent risk of malnutrition because they are mostly based on a very low body weight or recent loss of body weight. Thus, a patient with sarcopenia may have a normal body weight but low muscle mass, and could therefore be incorrectly classified as well-nourished (Hu et al., 2017).

Body composition can be used as a tool for the diagnosis of malnutrition, and parameters obtained using BIA can effectively identify malnourished patients. In our study population, the most reliable diagnostic criteria according to the ESPEN were body weight loss and low muscle mass index (Sanchez-Rodriguez et al., 2019). Therefore, evaluation of muscle mass and fat mass by BIA can assist in the accurate diagnosis of malnutrition (Kyle et al., 2006). The loss of muscle mass in the elderly, indicative of sarcopenia, leads to decreased autonomy and increased mortality in these individuals. An individualised nutritional approach is crucial for the clinical management of these patients (Bosy-Westphal et al., 2006).

Handgrip strength is a quick, cost-effective, and straightforward measurement (Guerra et al., 2015; Norman et al., 2011). This measurement was reliable in distinguishing well-nourished and malnourished patients in our sample and is widely used in clinical settings as a primary diagnostic criterion for sarcopenia (Cruz-Jentoft et al., 2019). However, 4% of our patients were unable to perform the handgrip strength test due to cognitive impairment and/or musculoskeletal conditions, demonstrating that this test is not universally applicable (Byrnes et al., 2018). The reduction in muscle strength, as indicated by low handgrip strength, may indicate an increased risk of falls. Our malnourished patients had a higher risk of falls (as assessed by the Downton scale), in agreement with other studies that reported associations of malnutrition with an increased risk of falls (Xu et al., 2022). Thus, early identification of malnutrition and prompt implementation of appropriate interventions could help to prevent falls and improve patient outcomes. Falls and malnutrition are also significantly associated with prolonged hospital stay, and adversely affect patient quality of life and increase healthcare expenditures (Cass & Charlton, 2022; Cotter et al., 2006; Seron-Arbeloa et al., 2022).

Several studies have highlighted the lack of associations between blood biomarkers (such as albumin, total proteins, cholesterol, total lymphocytes) and malnutrition, suggesting these biomarkers are not reliable indicators of nutritional status (Sanchez-Rodriguez et al., 2019; Seron-Arbeloa et al., 2022; Zhang et al., 2017). Our findings are consistent with these previous studies. We also found that the BIA phase angle (which represents the relationship between tissue resistance and reactance) was not associated with nutritional status, consistent with a previous report (Scheunemann et al., 2011). However, another study found a relationship between phase angle and malnutrition, suggesting this parameter has potential as a tool for identifying malnourished patients in certain settings (Di Vincenzo et al., 2021). In fact, a considerable body of research has validated the clinical prognostic value of phase angle and its use as an indicator of nutritional status (Bosy-Westphal et al., 2006; Di Vincenzo et al., 2021; Mulasi et al., 2015). Phase angle varies depending on cell integrity (reflecting cell membrane permeability) and cell size (reflecting cellular hydration). Consequently, it may be superior to other biochemical and anthropometric indicators in terms of accuracy and relevance (Bosy-Westphal et al., 2006). However, our finding of no association between phase angle and nutritional status suggests the need to further examine the use of this parameter for assessment of the nutritional status of hospitalised patients.

5 | STRENGTHS AND LIMITATIONS

One of the main limitations of our study was the exclusion of 90 patients (26.6% of the original sample) because they did not know their usual body weight, which prevented application of the MUST and ESPEN diagnostic criteria. A drawback with the ESPEN criteria and the MUST screening tool is the significant emphasis on body weight, which can be affected by various factors, such as the presence of edema or ascites. Moreover, BMI can be misleading because it does not separately consider muscle mass and fat mass. Thus, a patient will show the same change in BMI regardless of whether he or she loses muscle mass or fat, but the health implications of losing muscle mass differ from those of losing fat. (Cederholm et al., 2015). Body weight loss in obese patients might cause healthcare professionals to overlook other indicators of malnutrition if this weight loss is considered beneficial (Almeida Dos Santos et al., 2016; Saunders & Smith, 2010). Another limitation in our study was the inability to include patients with dementia who were unaccompanied and did not consent to participate. Thus, we were unable to assess the prevalence of malnutrition in this subgroup. Moreover, we compared GLIM and SGA with the ESPEN criteria. Because it was difficult to assess a patient's food intake prior to hospital admission, we used a modification of the GLIM criteria. Finally, we evaluated screening tools in patients receiving treatment in the setting of an internal medicine department in a single hospital. Thus, generalising these results to other groups should be performed with caution.

The main strength of our study is the rigorous evaluation of the accuracy of the most widely used nutritional screening tools based on the objective gold standard: the ESPEN criteria. Furthermore, we also measured the FFMI in all patients. A previous study recommended detection of malnutrition using the combination of FFMI and body weight loss (Rojer et al., 2016). Although a low BMI and FFMI could be used interchangeably, it is preferable to use them as complementary measurements, as indicated by our results. Previous studies on this topic have primarily compared different screening tools with subjective criteria, such as the SGA (Calleja Fernández et al., 2015; Poulia et al., 2012) or another screening tool.

6 | CONCLUSION

Malnutrition is a modifiable condition that has a high prevalence in hospitalised patients. Despite the development of various tools for screening and assessment, malnutrition remains under-detected and under-treated. Our results suggest that the MUST is the most accurate nutritional screening tool. However, tools such as the MST could be more feasible for routine clinical use in hospitals. Most current screening tools do not consider body composition determined by BIA measurements, and yet low muscle mass is a common condition in malnourished patients. Therefore, we suggest a comprehensive approach that includes nutritional screening and body composition analysis for the more accurate diagnosis and effective management of malnutrition in hospitalised patients.

AUTHOR CONTRIBUTIONS

RC conceived the study, contributed to the sample collection and data acquisition, and drafted the manuscript. AMP contributed to the statistical analyses and data interpretation. AY and MBV wrote the study protocol, and contributed to the writing of the manuscript and statistical data interpretation. LC contributed to the data collection and data interpretation. All authors read and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflicts of interest with respect to the authorship and publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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