Risk of Malnutrition Assessment in Hospitalized Adults: A Scoping Review of Existing Instruments

Abstract:

Aims and objectives: The aim of this study was to find tools for screening the risk of malnutrition in adult hospitalized patients, evaluate their key characteristics including selected psychometric properties, and propose the most appropriate tools for nursing practice.

Background: A large number of existing tools for nutritional screening make it difficult to be aware of all the possibilities and especially to select the optimal tool.

Design: The research methodology was designed as secondary research using a scoping review search to map and compare existing tools for assessing the risk of malnutrition in hospitalized adults.

Methods: The analysis focused on the selected psychometric properties of the instruments (sensitivity, specificity, positive and negative predictive value) and key characteristics relevant to the selection of an appropriate instrument. This study follows the PRISMA-ScR Checklist.

Results: The review included 27 publications containing 17 tools. The best sensitivity (57-100%) and specificity (76-96%) were achieved by the Malnutrition Universal Screening Tool (MUST) and the Nutritional Risk Screening 2002 (NRS 2002). Minimal Eating Observation and Nutrition Form-Version II (MEONF-II) has solid sensitivity (up to 73%), specificity (88%) and high positive predictive values, 81-82%.

Conclusions: The MUST, NRS 2002 and MEONF-II showed satisfactory psychometric properties. MEONF-II and MUST are able to assess risk without weighing the patient. The Hand Grip Strength (HGS) assessment can be recommended to detect reductions in muscle strength.

Relevance to clinical practice: We recommend the MUST, NRS 2002 and MEONF-II tools for use in clinical practice, as they have the best psychometric properties and are user-friendly. The HGS, which proved to be related to the length of hospital stay (LOS) and used as an indicator of protein-energy malnutrition in obese patients, may be a useful complementary tool. For nursing practice, we recommend selecting a tool with respect to the specifics of a particular workplace.

Keywords: Malnutrition; Nutrition Assessment; Screening; Risk Assessment; Sensitivity and Specificity; Predictive Value of Tests; Length of Stay; Hospitals; Inpatients;

What does this paper contribute to the wider global clinical community?:

- Overview of existing malnutrition risk assessment tools with their psychometric properties and basic characteristics.
- Recommendation of tools, which sufficiently fulfil selected criteria, based on the findings.
- Presented data allow nurses to select a tool with respect to the specifics of particular departments via an evidence-based method.

Introduction

Malnutrition in the form of inadequate nutrient supply or total nutrient volume is a constant problem in adult hospitalized patients. In developed countries, malnutrition is usually considered to be a minor problem compared with excessive energy and nutrient intake (Kruizenga et al., 2005). However, especially in seriously ill and frail hospitalized patients, this may be incorrect. Adequate nutritional care is a prerequisite for the provision of high-quality nursing and medical care. It is associated with improved clinical outcomes, reduced incidence of complications, reduced mortality, reduced length of hospital stay (LOS) and subsequent readmissions, and reduced hospital costs (Freijer et al., 2013; Muscaritoli et al., 2017; Ruiz et al., 2019). A reduced LOS results in cost savings of up to 20% (Smith et al., 2016). According to the National Institution for Health and Clinical Excellence (NICE), implementation and adherence to malnutrition guidelines may lead even to 75% cost savings (Khalatbari-Soltani & Marques-Vidal, 2015). Conversely, the presence of malnutrition in a patient increases hospitalization costs by more than 20% (Guerra et al., 2016). The prevalence of the risk of malnutrition in adult hospitalized patients varies widely depending on the spectrum of hospitalized patients and the methodology of its assessment. According to recent publications, it ranges from 25% to 79% (Taipa-Mendes et al., 2021; van Vliet et al., 2020). However, malnutrition is preventable with early detection and rapid initiation of interventions (Volkert et al., 2019).

Despite these important facts, nutritional care often remains inadequate even in developed countries, thus negatively affecting the overall health of patients. Adequate care requires early detection of people at risk of malnutrition, which often develops during acute illness just before or during hospitalization. The use of a quality validated screening tool for malnutrition risk is essential for early identification of these individuals (Blanař et al., 2020; Eglseer et al., 2017). Regular use of the screening tools at a hospital or institution admission and periodical screening is rising nowadays. However, despite the strong support of health professionals, there are some barriers and uncertainties in its implementation in nursing practice. A notable part of the barriers would be overcome from the bottom-up in medical institutions, especially regarding the acceptance and attitudes towards screening tools for malnutrition. The acceptability of a screening tool by the nurses depends on wider conditions. The tool should be easy for usage and completion. Nurses need to see a positive effect, resulting from the screening tool use (clinical outcomes). Also, nurses demand enough time and resources to screen patients, the particular wards should have necessary anthropometry equipment, ideally on an institutional level there should be nursing support provided by an institutional nutrition team (Green et al., 2014; Taipa-Mendes et al., 2021). The appropriate instrument can improve clinical outcomes, reduce the incidence of complications, reduced mortality, reduce the length of hospital stay and subsequent readmissions, and reduce hospital costs.

From the above-mentioned wider conditions and research studies three areas of criteria for the ideal malnutrition risk assessment tool could be derived. At first, the tools should have high validity, which was usually assessed when tools were developed or translated (Gibson et al., 2012; Stratton et al., 2004; Tran et al., 2018; Vallén et al., 2017). The second criterion area would cover satisfactory psychometric properties which are directly connected with patients' health status, diagnostic accuracy and further prediction (sensitivity, specificity, positive and negative predictive value). Finally, the third criterion area focuses on the variables which affect the acceptance of the tool by the nurses. Out of these, the most important ones are ease of completion, user-friendliness for the staff, simplicity and short execution time (ideally within

5 minutes). The ideal instrument should not involve complex calculations or laboratory tests, which are invasive and economically demanding (Neelemaat et al., 2011; Reber et al., 2019; Westergren et al., 2011). Without consideration of these criteria (key characteristics), it would not be possible to select the "best fit" screening tool for the general population of adult hospitalized patients.

Healthcare professionals in clinical practice often cannot invest enough time to find and review all available tools for the risk of malnutrition screening and read a large number of articles related to the topic, which keeps rising every few weeks. Therefore, it is desirable to summarize up to date scientific knowledge in the form of a scoping review, which allows us to review not only quantifiable psychometric properties of instruments but, also, to identify key characteristics and factors, which are related to every screening tool for the assessment of risk of malnutrition. The scoping review design allows us to map all available evidence regarding this topic. Moreover, this approach enables us to identify if there are any additional knowledge gaps (Munn et al., 2018).

An extensive systematic review of screening tools for assessment of malnutrition risk both in hospitals and in a nursing home setting was published (van Bokhorst-de van der Schueren et al. 2014a; van Bokhorst-de van der Schueren et al. 2014b). Nevertheless, since then, new research has been published comparing the sensitivity and specificity of available tools, the relationship of these tools to clinical outcomes or LOS. Furthermore, new validated screening tools were published (Alston et al., 2022; Efthymiou et al., 2021; Guerra et al., 2016; Poulia et al., 2017; Roller et al., 2016; Ruiz et al., 2019; Smith et al., 2016; Skipper et al., 2020; VanDerBosch et al., 2019). Thus, this research aims to update the available information regarding malnutrition risk screening tools, review the key characteristics about them and present a basis that allows nurses to choose the most appropriate tool for their particular workplace.

Aim

The aim of this study was to find tools for screening the risk of malnutrition in adult hospitalized patients, evaluate their key characteristics including selected psychometric properties, and propose the most appropriate tools for nursing practice.

Methods

Design

To achieve the aims, a scoping review approach was used in line with the Joanna Briggs Institute (JBI) and Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews (PRISMA-ScR) methodology (Peters et al., 2020; Tricco et al., 2018). Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist is included (Supplementary File 1). The first step of the research was to formulate a research review question in PCC format (P= Population; C= Concept; C= Context):
"What tools are appropriate to detect malnutrition risk in hospitalized adult patients?" The requirements that a suitable tool for assessing malnutrition risk in hospitalized adults should meet were formulated, based on the authors' discussion and literature research.
The two sub-questions developed to achieve aim were:

1. What tools achieve the best psychometric properties for use as a screening tool for risk of malnutrition in clinical practice for adult hospitalized patients?
2. What tools have useful key characteristics which are relevant to the selection of an appropriate malnutrition risk screening instrument?

Eligibility criteria

To map relevant peer-reviewed publications, exclusion and inclusion criteria were established (Table 1). Eligible studies were published in Czech or English prior to 22nd January 2022. Only studies focusing on adult patients were included. Studies had to include screening tools for malnutrition risk assessment that were not limited in their applicability to specific patient groups (specific disease, culture, famine-affected countries). Because of its unsuitability for screening use, the assessment tool could not include laboratory tests as an inseparable component (Neelemaat et al., 2011; Reber et al., 2019).

Search strategy

The CINAHL (via EBSCO), PubMed, and Medvik databases were used to search for publications. To provide a sufficient amount of material, also literature not indexed in large international databases was examined (via Google Scholar), articles found by manual searches were used, and resources of already found articles were researched. A three-step search strategy was used as recommended by JBI. The first step was excluding ineligible sources based on publication title, and the second step was excluding sources based on their abstracts and keywords. The third step was to evaluate the articles according to the full text (Peters et al., 2020). These three steps were carried out in accordance to the exclusion criteria. The search procedure was set up in a student's final thesis (Chrástecká, 2020). Protocol of this review has not been registered.

The keywords for searching Czech and English publications differed. In addition to linguistic differences, these words were modified for subsequent use of Medical Subject Headings (MeSH terms). Boolean search operators were used to sufficiently capture publications matching the review question. When synonyms needed to be included, an "OR" condition linked the terms. To avoid the occurrence of unwanted studies, the "NOT" condition was used. In the refinement process, an "AND" condition was also used to specify the search studies and indicate the common occurrence of the search terms. The pilot testing of the search strategy was performed in July 2019. It has shown the need to change specify and change some key words. Worksheets were created to record the data retrieved from each keyword-based database, which tracked the entire process (Table 2). Search in PubMed database is available to see in supplementary file 2 (Supplementary file 2 examples of the search strategy in PubMed).

An example of searching in PubMed database in the English language:

Search: ((((("general population"[Title/Abstract] OR "inpatient*"[Title/Abstract]) NOT "nursing home"[Title/Abstract]) NOT "child*"[Title/Abstract]) NOT "paediatric*"[Title/Abstract]) NOT "elderly"[Title/Abstract]) AND ("malnutrition"[MeSH Terms] OR "malnutrition"[All Fields] OR "malnutrition s"[All Fields] OR "malnutritional"[All Fields] OR "malnutritions"[All Fields] OR ("nutrition s"[All Fields] OR "nutritional status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "nutritional status"[All Fields] OR "nutrition"[All Fields] OR "nutritional sciences"[MeSH Terms] OR ("nutritional"[All Fields] AND "sciences"[All Fields]) OR "nutritional sciences"[All Fields] OR "nutritional"[All Fields] OR "nutritionals"[All Fields] OR "nutritions"[All Fields] OR "nutritive"[All Fields]) OR ("malnutrition"[MeSH Terms] OR "malnutrition"[All Fields] OR "undernutrition"[All Fields] OR "undernutritional"[All Fields]) OR "nutritional status"[All Fields] OR "nutritional risk"[All Fields]) AND ((("valid"[All Fields] OR "validate"[All Fields] OR "validated"[All Fields] OR "validates"[All Fields] OR "validating"[All Fields] OR "validation"[All Fields] OR "validational"[All Fields] OR "validations"[All Fields] OR "validator"[All Fields] OR "validators"[All Fields] OR "validities"[All Fields] OR "validity"[All Fields] OR "clinical outcome"[All Fields]) AND "assessment instrument"[All Fields]) OR "screening tool"[All Fields]) AND ("hasabstract"[All Fields] AND 1990/01/01:2022/01/22[Date - Publication] AND "english"[Language]) AND (("malnutrition"[Title/Abstract] OR "nutrition"[Title/Abstract] OR "undernutrition"[Title/Abstract] OR "nutritional status"[Title/Abstract] OR "nutritional risk"[Title/Abstract]) AND ("hasabstract"[All Fields] AND 1990/01/01:2022/01/22[Date - Publication] AND "english"[Language])) AND (((("validity"[Title/Abstract] OR "clinical outcome"[Title/Abstract]) AND "assessment instrument"[Title/Abstract]) OR "screening tool"[Title/Abstract]) AND ("hasabstract"[All Fields] AND 1990/01/01:2022/01/22[Date - Publication] AND "english"[Language]))

An example of searching in PubMed database in Czech language:

Search: ((((((pacient*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) OR (hospit*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) NOT (děti[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) NOT (pedia*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) NOT (senio*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) AND ((((Podvýživ*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) OR (Nutri*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (Výživa[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (Malnutri*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) AND (((((((Valid*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) OR (Použit*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (výsled*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (význam*[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (screening[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (hodnocení[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter])))) OR (nástroje[Title/Abstract] AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) AND ((1900/1/1:2022/1/22[pdat]) AND (czech[Filter]))) Filters: Czech, from 1900/1/1 - 2022/1/22

Study selection inc. PRISMA flow diagram

The total number of found studies via CINAHL, Medvik and PubMed was 237. Outside the search algorithm, 124 studies were manually added. After removing duplicates, 325 studies remained and were subsequently excluded or classified by their titles/abstracts. Out of these, 53 studies remained for a full-text review. During assessing the full-text study eligibility we discovered five studies whose inclusion would be questionable due to the Exclusion Criterion 2 (EC 2). These studies contain the Mini Nutritional Assessment (MNA) tool, which is designed only for assessing the nutritional status of the elderly. Nevertheless, the MNA was found in the studies every time alongside the other screening tools which were not intended for the elderly only. Moreover, the MNA was historically used often for the comparison of tools and for calculating the sensitivity and specificity. Thus, considering the reasons mentioned above, we decided to keep articles with MNA in the final set of studies. After the full-text review, 27 studies formed the final set. This process is illustrated using a flow diagram that depicts the entire publication selection process and was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Peters et al., 2020; Tricco et al., 2018). See figure 1.

Evaluation of articles

The selection of publications was made by two independent assessors (MC) and (VB). In case of disagreement, a third assessor (JP) made the decision. The quality of the articles was not assessed in the scoping review due to the lack of a methodology for their evaluation.

Data extraction and analysis

Data were recorded using Microsoft Excel in a table for inclusion/exclusion of the studies. The table included the title of the study, its authors, the year of publication, its focus and tools that were examined. If the inclusion criteria were not met, the study was excluded. Another table recorded the selected psychometric properties of the tools found (sensitivity, specificity, positive predictive value, negative predictive value), including the tool with which it was compared. Other researched information included the user-friendliness of the tool and their pros and cons identified from the studies. The data were summarized in tables indicating the retrieved psychometric properties of each tool. The results section describes each tool and the main information relevant to nursing practice.

Results

All the 27 studies contained information on malnutrition risk assessment tools. The algorithm illustrating the selection of studies for inclusion is summarised in PRISMA Flow Chart Diagram (Figure 1). Of the total, four publications were in the form of a review study, 22 used a quantitative approach and one was designed as a mixed-method study. The study sample consisted of 50 patients in the smallest study and 564 063 patients in the largest. The researched studies included a total of 17 different malnutrition risk assessment tools (or their modifications). The studies are summarized according to the publication date in Table 3. All tools in Table 4 were compared to a "gold standard", which was most often a previously published tool (e.g., Subjective Global Assessment-SGA, Mini Nutritional Assessment-MNA) or predefined criteria based on diagnostic criteria for malnutrition risk. In addition to the above-mentioned psychometric properties or information on ease of fill-out, data on the correlation of screening tools with the LOS were found in the included publications. The study of Guerra et al. (2016) even assessed Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening 2002 (NRS-2002) and Patient Generated Subjective Global Assessment (PG-SGA) as predictors of hospitalization cost.

Properties of screening tools

The psychometric properties, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of each instrument are summarized in Table 4. There was a notable difference between the values of psychometric properties for the same instruments across studies in some cases (Table 4). Further findings and comments on each instrument are presented below.

The sample of studies contained a total of 17 malnutrition risk screening tools, including the modifications. Only 12 publications contained data on the psychometric properties of these tools. The remaining studies were used to evaluate the key characteristics as suitability, user-friendliness, an association of the tools with the LOS, or to add additional information. Van Bokhorst-de van der Schueren et al. (2014a, 2014b) comprised a total of 32 instruments. However, their study searched and encompassed studies in six languages (van Bokhorst-de van der Schueren et al., 2014a; van Bokhorst-de van der Schueren et al., 2014b).

Graz Malnutrition Screening (GMS) is one of the youngest screening tools. It was published by an Austrian multidisciplinary team. It targets diverse patients in all departments of large healthcare institutions. The tool includes 3 assessment items screened by a nurse (weight loss within the last 3 months, BMI and decrease of food intake within the last month) and one item related to the International Classification of Diseases (ICD) medical diagnosis filled in by a physician. The psychometric properties of the GMS are very good. Sensitivity and specificity are 94% and 77%, respectively, when compared with the NRS 2002, with PPV and NPV of 76% and 95%, respectively (Roller et al., 2016). The GMS achieved also a very good Cohen's kappa coefficient for the inter-rater reliability (0.82), which represents an almost ideal agreement between the evaluators. Eglseer et al. (2018) mentioned a short-term positive impact of using this tool for the nutritional interventions provided to patients, which raised from 13.4% to 22.0%, but decreased after a few months.

Hand Grip Strength (HGS) uses muscle strength assessment to screen for malnutrition risk. It, therefore, uses a different approach to the other tools mentioned, which focus on anamnestic and simple anthropometric data. An advantage of HGS might be that changes in muscle strength occur earlier than the structural changes associated with protein malnutrition. It is therefore possible to initiate appropriate nursing interventions earlier and prevent malnutrition early. The Global Leadership Initiative on Malnutrition (GLIM) recommend considering reduced muscle mass as one of the important criterion for the malnutrition diagnosis (Cederholm et al., 2019). When compared to SGA, HGS achieves a sensitivity of greater than 74% but a specificity of only around 51% (Guerra et al., 2014). Normative age- and sex-disaggregated data have been published for the Hand Grip Strength, but this test has several limitations in patients with neurological disease, post-trauma, joint disease, or a history of unilateral strain at work (Massy-Westropp et al., 2011).

Malnutrition Screening Tool (MST) was first published by Ferguson et al. (1999). The tool was developed for a quick malnutrition screening. It contains two questions which were originally derived from 21 assessed items. Ferguson et al. (1999) state its sensitivity and specificity both at 93% when compared with SGA, which would represent a suitable tool for screening for malnutrition. Frew et al. (2010) support using this tool preferably for patients who can communicate. However, in studies in subsequent years, its sensitivity when compared with SGA ranged only from 41.8% to 74.4% (Table 4). The tool did not achieve better values when compared with diagnostic criteria (Nursal et al., 2005; Tran et al., 2018). However, it performed well when compared with Body Mass Index (BMI), with particularly high positive and negative predictive values (Neelemaat et al., 2011). Raja et al. (2004) reported sensitivity (69.1%) and specificity (91.8%) of MST compared against SGA for the Asian population in Singapore. Tran et al. (2018) verified the applicability of MST with BMI modification for the Asian population. In the combination with the BMI cut-off value <18.5 kg/m^2, MST achieves a sensitivity of 66.8% and specificity of 82.0%.

VanDerBosch et al. (2019) discuss whether MST scores 2 versus >2 were independently predictive of health outcomes. They proved that there are no statistically significant differences in LOS between the patients with MST 2 and MST >2, and there was no significant difference in unplanned 30-d readmission rates in the same groups. On the contrary, Ruiz et al. (2019) described the association between positive MST and increased hospital LOS, readmissions and mortality, as well as a more than 30% increase of the average cost associated with hospitalization.

The Malnutrition Universal Screening Tool (MUST) was originally introduced by the British Association for Parenteral and Enteral Nutrition (BAPEN) for community care. To assess the patient's condition, it requires 3 parameters including weight loss, interruption of food intake for more than 5 days, presence of acute illness, with the calculation of BMI. If the weight cannot be measured, the BMI could be estimated from a mid-upper arm circumference (Kohutová, 2018). Stratton et al. (2004) recommend MUST as a valid, simple and quick tool, and Skipper et al. (2020) consider MUST to have high validity and moderate reliability. It took the researcher to administer the MUST tool usually less than two minutes (Raslan et al. 2010). According to Neelemaat et al. (2011), the Malnutrition Universal Screening Tool (MUST) has satisfactory sensitivity and specificity values of 96% and 80%, respectively, when compared with BMI. However, Vallén et al. (2017) report a sensitivity of only 57% (compared to the MNA), which is 20% lower than the study by Gibson et al. (2012) which used a comparison with the SGA. Despite the lower sensitivity, Vallén et al. (2017) report that, given the high specificity and predictive values, the accuracy of the tool is 78%. Tran et al. (2018) report a MUST reliability of 78.4%. Anthony (2008) points out the tool's ability to predict LOS, readmissions and mortality. Guerra et al. (2016) described the predictive ability of MUST in relation to the cost of hospitalization. Also, MUST tool could be useful for the prediction of the LOS. Kruizenga et al. (2016) compared LOS of patients with positive MUST (≥2) and negative MUST (0–1). Patients with positive MUST had LOS 9.5 (SD 11.0) days and with negative MUST 6.3 (SD 7.8) days.

The Minimal Eating Observation and Nutrition Form-Version II (MEONF-II) is a tool first published in 2011 and its format is aimed specifically at the assessment of adult hospitalized patients by a nurse. It includes a total of 6 assessment items, unintentional weight loss, BMI, difficulty eating or swallowing, decreased appetite, and an item on the presence of a clinical sign of malnutrition (e.g., decreased subcutaneous fat, decreased muscle mass or muscle strength). Risk assessment is in three categories - mild, moderate or high risk of malnutrition (Smith et al., 2016).

Apart from Westergren et al. (2011), a small number of studies focuses on user-friendliness for the staff, which is mentioned in MEONF-II. According to this publication, the MEONF-II is a simple tool, with satisfactory sensitivity and specificity (up to 73% and 88%, respectively) when compared with MNA. This tool has one of the highest positive predictive values, 81-82%. Westergren et al. (2011) also describe a version of the MEONF-II-CC that is suitable when it is not possible to obtain data on patient weight and height. A substitute for height and weight measurements is the measurement and assessment of calf circumference. The psychometric properties were almost identical when compared with the basic version of this instrument (Table 4).

The Mini Nutritional Assessment (MNA) was published in 1990 as a geriatric scale to assess the risk of malnutrition in patients over 65 years of age. This nutritional screening tool should be used preferably for older adults as the authors of the instrument intended. It is designed in two parts. A screening part (MNA-SF) comprises 6 items. The larger examining part (full MNA) consisting of 18 items is completed in patients with a positive screening. The abbreviated MNA-SF is recommended for use in the non-risk population for screening purposes. The administration of the MNA-SF can take 4 to 5 minutes (Raslan et al., 2010). Conversely, the full unabbreviated version of the MNA is appropriate for the elderly and can take up to 15 minutes to complete (Anthony, 2008). Full MNA has a high sensitivity of up to 96% and specificity of up to 98%, with a high positive predictive value of 97%. However, the six-item version of the MNA-SF has a sensitivity of 35% only (Table 4) when compared with the SGA (Tran et al., 2018). Neelemaat et al. (2011) do not recommend the stand-alone MNA-SF for use in elderly hospitalized patients due to its low specificity. These data are mainly supported by older studies summarized in the literature review published by Guigoz (2006).

The Nutritional Risk Screening 2002 (NRS 2002) is one of the tools recommended by the European Society for Clinical Nutrition and Metabolism (ESPEN) alongside MUST, especially for adult hospitalized patients (Neelemaat et al., 2011). The advantage of this tool is the ability to predict impending malnutrition (Kozáková et al., 2011). The NRS 2002 consists of 4 assessment items (Kondrup et al., 2003) and it is one of the fast tools. The administration can take 2 to 3 minutes (Raslan et al., 2010). It achieves a higher sensitivity when compared with BMI and weight loss (92%), with a specificity of 85%. Similarly, it achieves a higher sensitivity when compared with SGA combined with BMI (Tran et al., 2018), but the sensitivity decreases (61%) when compared with ESPEN diagnostic criteria (Poulia et al., 2017). It reaches the lowest sensitivity (37%) when compared with MNA (Westergren et al., 2011) See Table 4. Tran et al. (2018) recommend the NRS 2002 as the most appropriate screening tool for use in the Vietnamese population, based on sensitivity and specificity. The NRS 2002 and its components have proven a prognostic value for long-term mortality, especially in polymorbid patients with NRS ≥5 points. In an open-label randomised trial with 1874 patients and 5-year follow-up, Efthymiou et al. (2021) described that the Hazard ratio based on the positive NRS is the highest for “All-cause mortality within 1 year” 1.34 (1.21–1.48) $p \leq 0.001$ and decreases in the following years.

The Subjective Global Assessment (SGA) is one of the oldest validated tools used for malnutrition risk assessment (Detsky et al., 1987). It is a frequently used tool, and other tools are compared against it in the retrieved studies. Comparison and evaluation of the psychometric properties of SGA against other tools or diagnostic criteria are missing. In its original version, the tool contained 6 domains with additional assessment items. Over time, individual items have been modified and added. A disadvantage may be that weight loss is calculated as a percentage in this tool, which leads to a longer time of completion, and thus places greater demands on staff. One of the multiple uses of the SGA is a version adapted for self-completion by patients, the PG-SGA (Patient Generated Subjective Global Assessment) (Guerra et al., 2015; Guerra et al., 2016). In a recent study, Alston et al. (2022) explored the extrapolation of the standard PG-SGA to electronic medical records (EMR). The PG-SGA+EMR searched predefined symptoms in the EMR to calculate PG-SGA. The ideal cut-off value was verified at the ≥4 points of PG-SGA+EMR (same as the standard PG-SGA) for high sensitivity 86.5% but lower specificity 38.5% compared to standard PG-SGA. The preferable cut-off for clinical use might be between 4 and ≥ 7 points with sensitivity between 86.5% - 67.6% and specificity 38.5% - 76.9%. A limitation described by Alston et al. (2022) lies in the fact that medical diagnosis and other input data might not be in a standardised format in EMR.

The Short Nutritional Assessment Questionnaire (SNAQ) was developed by a team of Dutch dietitians in response to the need for screening the risk of malnutrition in hospitalized adults. The authors intended to develop a tool that does not require any calculations and can be completed within 5 minutes. This can significantly speed up screening and ensure that it is actually implemented in practice (Kruizenga et al., 2005). This instrument is designed as a 4-item instrument. The sensitivity of the SNAQ is 75% and specificity 84% when compared with BMI and weight loss (Neelemaat et al., 2011). When compared with a comprehensive 26-item nutrition questionnaire, sensitivity was 79-86% and specificity was 83-89% (Kruizenga et al., 2005). Regarding the LOS, the Dutch Association of Dietitians and the Dutch Malnutrition Steering Group performed a large population study in 13 Dutch hospitals where 564,063 patients were included. The LOS of the undernourished patients (according to SNAQ) had a mean of LOS 9.5 (SD 10.7) days, whereas not-undernourished patients had a mean of LOS 6.2 (SD 7.2) days (Kruizenga et al., 2016).

Discussion

To evaluate the suitability of the instruments for use in nursing practice, criteria related to their psychometric properties were selected, in particular sensitivity and specificity. The ideal instrument should not involve laboratory tests, complex calculations, be invasive, economically demanding and time-consuming (Kruizenga et al., 2005; Neelemaat et al., 2011; Reber et al., 2019; Westergren et al., 2011). It should also be user-friendly for the staff (Westergren et al., 2011).

Van Bokhorst-de van der Schueren et al. (2014a) report a lack of information on LOS in relation to the instruments. Since their study, Kruizenga et al. (2016) evaluate SNAQ and MUST as predictors of LOS based on data obtained from 564,063 patients. The ability to predict the LOS using MUST, PG-SGA, NRS 2002 and HGS is also confirmed by (Guerra et al., 2015).

Tools that, given the specific patient mix, might be most appropriate for screening for malnutrition risk on admission to a health facility and then for periodic re-screening during hospitalization include MUST, NRS 2002, and MEONF-II.

The MUST has achieved high sensitivity and specificity in several studies on larger cohorts when compared with different tools or criteria (Gibson et al., 2012; Neelemaat et al., 2011; Poulia et al., 2017). It has predictive power for length and cost of hospital stay (Anthony, 2008; Guerra et al., 2016). Its other advantages are its simplicity to complete, requiring 3 items only, a clear algorithm, a recommended procedure based on the results, and the possibility of using alternative measurement methods if weight and height cannot be obtained. Unlike some other tools, MUST also works with information on the amount of weight the patient has lost in the last 3-6 months, which can positively contribute to the assessment of the severity of the condition. However, in practice, the patient sometimes does not know how much weight they have lost. The disadvantage of this tool may be the late detection of protein-energy malnutrition associated with muscle wasting in obese patients. The MUST tool may identify malnutrition in these patients later, only when muscle loss is within several kilograms, as suggested by the focus of its items. Kruizenga et al. (2016) proved in a large population study that MUST (as well as SNAQ) is a significant determinant of LOS.

Promising diagnostic support for malnutrition for the future would be the MUST-Plus, which is not exactly a classic malnutrition risk screening tool, but a random forest classifier, which analyses the nutritional status and predicts its development using machine learning. MUST-Plus analysing the data from electronic health records. The system analysing anthropometrics similarly as MUST score, but also a wider range of blood tests including haemoglobin, serum albumin, serum creatinine, blood urea nitrogen, and serum alanine-aminotransferase (Timsina et al., 2020), which is the reason why this tool was not incorporated into our results. Its role in the malnutrition screening might not lie in the wide inpatient population screening due to higher costs of a blood sample analysis. On the other hand, MUST-Plus could have the highest potential for the people who are already diagnosed with malnutrition or in the high-risk population of patients.

The NRS 2002 tool also has relatively good sensitivity and specificity. An exception is reported by Westergren et al., 2011, who found the sensitivity was 37% only when comparing the NRS 2002 with the MNA, but these results were published based on an analysis of 87 patients only. Moreover, the full MNA tool itself has a high sensitivity (Abd Aziz et al., 2019; Guigoz, 2006; Fernández et al., 2015). In a sample of 693 patients, a sensitivity of 74.6% and a specificity of 80.6% were found when compared to SGA and BMI (Tran et al., 2018). However, the positive predictive value and negative predictive value for NRS 2002 performed worse overall than MUST (Table 4). Unlike MUST, it does not account for the amount of weight loss.

The MEONF-II achieved satisfactory psychometric parameters despite being compared with the MNA, which is characterized by high sensitivity and specificity. The undisputed advantages of the MEONF-II include its high positive predictive value. Given the aim of its creation, as a tool that is designed for nurses, and is user-friendly, its use is simple and quick. The median time required to conduct assessments by the MEONF-II are 5 minutes (Westergren et al., 2011). For the actual use of the tool by staff in nursing practice, user-friendliness and time efficiency are crucial. Jeznach-Steinhagen et al. (2016) highlighted the need to educate staff on the importance of keeping records of nutritional status assessments as well as the rules for processing them. The MEONF-II contains a manual that serves this purpose. Another component of the MEONF-II is a set of recommended interventions that can be chosen based on the outcome of the nutritional status assessment by this tool Westergren et al. (2011). When it is not possible to determine BMI using weight and height calculations, an alternative option of measurement of calf circumference can be used. This tool also takes into account clinical signs that may help to detect malnutrition despite the patient not having substantial weight loss. One way to effectively incorporate objective quantitative measurements into the assessment of malnutrition risk is to assess Hand-Grip Strength (HGS), which can be measured with a dynamometer. Although the clinical value of the MEONF-II as a predictor of LOS has not yet been confirmed, this tool can be complemented by the HGS, which has this ability (Guerra et al. 2015). Its complementation and subsequent use would also allow earlier detection of protein malnutrition in obese patients.

The psychometric properties of the sensitivity and specificity of the HGS tool were not high, but the accuracy reported by Sharma et al. (2017) was 87%. The use of the HGS is simple, quick and inexpensive. It appears to be ideal for overall screening, but because it assesses one parameter only and its other many limitations, it is not suitable as a sole identifier of malnutrition or risk of malnutrition (Massy-Westropp et al., 2011). The HGS can be used as a complement to any validated malnutrition assessment tool, but MEONF-II allows for this possibility and assigns a specific risk score to the

HGS result. The above fact indicates that the combination of the MEONF-II and HGS tools that may be one of the best options for clinical use. However, this assumption needs to be verified by a sufficiently large quantitative study.

Similarly, to MEONF-II, the GMS achieved satisfactory psychometric performance. However, it requires obtaining a record of the diagnosis from a physician according to the ICD, which can be limitation for its use as screening tool in clinical practice.

A challenge in assessing the best psychometric properties of individual instruments after malnutrition screening is that they are almost all compared with other pre-existing instruments. Thus, for example, both the sensitivity and specificity of a particular tool are quite significantly influenced by which tool it is compared with. A large number of instruments have been compared with SGA and MNA, with SGA being one of the oldest (Detsky et al., 1987). A weakness of the current procedures may be that the SGA tool itself has been very limitedly compared against, for example, diagnostic criteria for malnutrition or evaluated in the context of LOS. The MNA tool, on the other hand, has very high sensitivity and specificity in its Full MNA version, 96% and 98%, respectively (Guigoz, 2006). This inherently affects the psychometric properties of the instruments that are compared to the MNA. Thus, the question is whether these two instruments should be used as the "gold standard" in the development and evaluation of other instruments. A more reasonable would be to compare the screening tools with internationally accepted criteria for malnutrition, for example the Global Leadership Initiative on Malnutrition (GLIM) criteria for the diagnosis of malnutrition. The GLIM criteria include the Phenotypic Criteria (weight loss in time, BMI, reduced muscle mass) and the Etiologic Criteria (Reduced food intake or assimilation and Inflammation) (Cederholm et al., 2019). The alternative option would be to compare the quality and appropriateness of the use of screening tools for malnutrition risk with clinical outcomes, the LOS, mortality or with cost-effectiveness.

A new research gap was identified during the research. Our second research sub-question was focused on the key characteristics which are relevant to the selection of an appropriate malnutrition risk screening instrument. An important variable is also the time needed to complete the tool. We discovered that the time for completing the tool was measured in very few studies only. In the rest of the studies, the time for completion was just estimated by the investigators, nurses and dieticians or even was not mentioned at all. For example, Raslan et al. (2010) estimate the time of the researcher to administer the MNA-SF to 4-5 min., 2-3 min. to administer the NRS 2002 and less than 2 min. to administer the MUST. However, they stated that they did not systematically measure the time during the data collection. Therefore, we recommend for future research to conduct new research focused not just on comparison of the tools regarding psychometric properties, but also to compare and measure accurately the time required for completion of the instruments including every component (measure weight, height, HGS or calf circumference).

Limitations

A scoping review design might have its strengths and limitations. In this research, scoping review design let us map all the available evidence regarding the malnutrition screening which was not fully defined at the start point. It was a benefit because the researchers often used a different approach when reporting their results regarding the topic in their studies.

On the other hand, different reporting of data in the articles limited our outcomes. For example, the study population is not precisely described in several articles (imprecise or vague information about the setting, age, health status) which rises the risk of bias. Some of the mentioned effects in the description of Properties of screening tools were assessed and extracted from a few studies and the level of evidence is low.

The limitation of this design could be also seen in a broader, less defined search, which is typical for scoping reviews. Another limitation might be information missing in the search, which has been minimized through a literature search in the biggest nursing databases and through extensive manual search in the references of studies, which were already found, and using key words in the Google Scholar. Psychometric evaluation can be also different due to the influence of population culture, economic conditions, race or ethnicity.

Conclusion

By selecting and using a valid malnutrition risk assessment tool on a daily basis, patients who are already malnourished or at risk of developing malnutrition can be identified. Early identification and targeted interventions against malnutrition can reduce the cost of hospitalization, LOS, and mortality. On the other hand, it can improve clinical outcomes, thereby providing adequate care. In conclusion of the first sub-question focused on psychometric properties, the MUST, NRS 2002 and MEONF-II tools have the best psychometric properties and user-friendliness. The HGS can be used as a complementary tool, preferably in combination with the MEONF-II. The conclusion of the second sub-question focused on key characteristics is wider. There are many screening tools that have suitable features. Based on the findings, we recommend selecting a tool with respect to the specifics of a particular workplace. For nursing practice, besides psychometric properties, the user-friendliness of the tool, and the time required to fill out are particularly important. These parameters may influence the quality and thoroughness of completing the documentation of nutritional status and thus the identification of patients with nutritional risk. New tools have emerged using the machine-learning component and reading data from the patient's electronic documentation in the last two years (PG-SGA+EMR and MUST-Plus). This development may herald an evolution in malnutrition risk screening using artificial intelligence, which will save nurses time and allow them to use more extensive tools without the negative impact of the time required to complete them.

Relevance to clinical practice

A non-negotiable minimum is to "at least" screen every patient admitted to a healthcare facility for malnutrition risk with any validated tool, which has been previously published (van Bokhorst-de van der Schueren et al., 2014b). However, assessing only on the basis of weight, clinical judgement or BMI is wholly inadequate (Eglseer et al., 2017). Based on the results of our research, we can recommend 3 tools, MUST, NRS 2002 and MEONF-II. A good complement to the standard malnutrition risk assessment tool may be the HGS, which is a predictor of LOS and an indicator of malnutrition even in obese patients who might have protein-energy malnutrition. Each of these tools has advantages and disadvantages. The choice depends on the requirements of the specific facility.

- The MUST is the fastest tool with high sensitivity and specificity. It can also be used very well in outpatient care. Alternatively, arm circumference can be assessed instead of weight.
- A second instrument that can be recommended is the NRS 2002, which achieved similar psychometric parameters to the MUST. NRS 2002 could have a higher clinical potential in polymorbid patients, as it shows a value for long-term mortality in this group of patients.
- A third option is the MEONF-II instrument, of which the aforementioned HGS may be a part. The combination of these instruments is particularly suitable for hospitalized adults and can also be used for patients who cannot be measured or weighed. In addition, it can be used advantageously in patients who are obese but may be at risk for hidden protein-energy malnutrition.

Conflict of Interests

The authors report no conflicts of interest.

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Authorship

MC and VB were responsible for the conception and design of the study. MC, VB, JP performed article assessment, data analysis and interpretation. MC and VB wrote the paper. MC, VB, JP revised the paper. All authors read and approved the final version of the paper.

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Table 1: Exclusion and inclusion criteria

Criterion number	Criterion	Exclusion Criteria (EC)
1	Population	Respondent sample with a too specific disease, culture, or place of life (e.g. famine-affected areas).
2	Population	Publications containing tools that can only be used for children, the elderly, or people with specific conditions.
3	Population	Respondents younger than 18 years.
4	Population	Too specific research environment (long-term care, etc.).
5	Context	Tools or publications published only in languages other than English and Czech.
6	Context	Tools requiring laboratory testing.
7	Methodology	Insufficiently described methodology (e.g. undescribed spectrum of patients).
8	Methodology	Fewer than 25 respondents in the studies with a quantitative design.
9	Publication	Publications published after 22nd January 2022
10	Publication	Publications not published in peer-reviewed journals.
11	Topic	The content of the publication is not relevant to the research question.

Table 2: Example of searching in PubMed database in English language with Filters: English, Title/abstract, 1990/01/01-2022/01/22

Number	PCC	Keywords	Number of results
1	**Population**	“General population “	108419
2		Inpatient*	126233
3		“Nursing home”	22202
4		Child*	1308950
5		Paediatric*	71334
6		Elderly	236988
7		**1 OR 2 NOT 3 NOT 4 NOT 5 NOT 6**	**199993**
8	**Concept**	Malnutrition	40208
9		Nutrition	172546
10		Undernutrition	8653
11		“Nutritional status”	32721
12		“Nutritional risk”	2634
13		**8 OR 9 OR 10 OR 11 OR 12**	**223626**
14	**Context**	Validity	184457
15		“Clinical outcome”	80579
16		“Assessment instrument”	2955
17		“Screening tool”	19975
18		**14 OR 15 AND 16 OR 17**	**20739**
19		**7 AND 13 AND 18**	**99**

Table 3: Overview of publications included in the study sorted by year (n=27).

Author(s)	Year	Country	Tools†	Focus of the study	Research file
Alston et al.	2022	Australia	PG-SGA,PG-SGA+EMR	Applying tool to electronic medical records	50 patients
Efthymiou et al.	2021	Switzerland	NRS 2002	Predictor of long-term mortality and morbidity	1874 patients
Skipper et al.	2020	USA	MST, SGA, PG-SGA, BMI+ BCC,MNA,MUST,MNA-SF, SNAQ,NRS-2002,	Overview of tools	Review study
VanDerBosch et al.	2019	USA, Australia	MST	Focus on health economic outcomes	1269 patients
Eglseer et al.	2018	Austria	GMS	Examine the effect of the use of a tool	Mix method study 1171 patients 11 Interviewees
Kohutová	2018	Czech Republic	MNA, SGA, MUST,	Overview of tools	Review study
Ruiz et al.	2018	Columbia, USA	MST	Overview of tools	800 patients
Tran et al.	2018	Australia, Vietnam	BMI, MST, Mod-MST, MUST, NRS-2002, MNA-SF	Comparison of tools	693 patients
Poulia et al.	2017	Greece, Poland	MUST, NRS-2002	Comparison of tools	1,146 patients
Guerra et al.	2016	Portugal	MUST, NRS-2002, PG-SGA	Tools as predictors of hospitalization prices	637 patients
Kruizenga et al.	2016	Netherlands	MUST, SNAQ	Focus on LOS	564,063 patients
Roller et al.	2016	Austria	GMS	Creating a tool	404 patients
Smith et al.	2016	Sweden, Great Britain	MEONF-II	Translation of a tool	266 patients
Guerra et al.	2015	Portugal	HGS, MUST, NRS-2002, PG-SGA	Comparison of tools in LOS prediction	371 patients
Guerra et al.	2014	Portugal	HGS	Values of a tool	712 patients
Gibson, et al.	2012	Australia	Mod-MST, MUST	Comparison of tools	262 patients
Kozáková et al.	2011	Czech Republic	MNA, MNA-SF, MUST, NRS-2002, SGA	Overview of tools	Review study
Neelemaat et al.	2011	Netherlands	MST, MUST, NRS-2002, SNAQ	Comparison of tools	275 patients
Vallén et al.	2011	Sweden	MEONF-II, MEONF II-CC, MUST	Comparison of tools	100 patients
Westergren et al.	2011	Sweden	MEONF-II, NRS-2002	Utilization of tools	87 patients
Frew et al.	2010	Australia	MST, MUST,	Exploring the limits of selected instruments	3,033 patients
Raslan et al.	2010	Brazil	MNA-SF, MUST, NRS-2002	Comparison of tools in prediction of outcomes	705 patients
Anthony	2008	Switzerland	MNA, MST, MUST, NRS-2002, SNAQ, SGA	Overview of tools	Review study

Nursal et al.	2005	Turkey	MST	Comparison of tools	2,211 patients
Raja et al.	2004	Singapore	MST, SGA	Comparison of tools	658 patients
Stratton et al.	2004	Great Britain	MNA, MST, MUST	Comparison of tools	416 patients
Ferguson et al.	1999	Australia	MST, SGA	Creating a tool	408 patients

† *BMI-Body Mass Index; BMI + BCC- Body Mass Index + Body Composition Change; EMR- Electronic Medical Records; GMS-The Graz Malnutrition Screening; HGS-Hand-Grip Strength; MEONF-II-Minimal Eating Observation and Nutrition Form – version II; MEONF-II-CC-Minimal Eating Observation and Nutrition Form – version II - calf circumference; MNA-Mini Nutritional Assessment-MNA-SF-Mini Nutritional Assessment – Short Form; Mod-MST-Modified Malnutrition Screening Tool; MST-Malnutrition Screening Tool; MUST-Malnutrition Universal Screening Tool; NPV-Negative Predictive Value; NRS-2002-Nutritional Risk Screening 2002; PG-SGA-Patient Generated Subjective Global Assessment; PPV-Positive Predictive Value; SGA-Subjective Global Assessment; SNAQ- Short Nutritional Assessment Questionnaire;*

Table 4: Psychometric properties of the included screening instruments sorted by the tool.

Tool	Tool Comparison	Author, year	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
BMI- Body Mass Index	SGA- Subjective Global Assessment	Tran et al., 2018	39.6%	100.0%	39.4%	100.0%
GMS- The Graz Malnutrition Screening	NRS 2002- Nutritional Risk Screening 2002	Roller et al., 2016	94.0%	77.0%	76.0%	95.0%
HGS-Hand Grip Strength	SGA- Subjective Global Assessment	Guerra et al., 2014	>74.0%	>51.0%	____	____
MEONF-II- Minimal Eating Observation And Nutrition Form – Version II	MNA- Mini Nutritional Assessment	Vallén et al., 2011	73.0%	88.0%	81.0%	82.0%
MEONF-II- Minimal Eating Observation And Nutrition Form – Version II	MNA- Mini Nutritional Assessment	Westergren et al., 2011	61.0%	79.0%	82.0%	57.0%
MEONF-II-CC- Minimal Eating Observation And Nutrition Form – Version II- Calf Circumference	MNA- Mini Nutritional Assessment	Vallén et al., 2011	68.0%	90.0%	82.0%	80.0%
MNA-SF-Mini Nutritional Assessment-short form	SGA- Subjective Global Assessment	Tran et al., 2018	35.0%	95.3%	77.3%	75.1%
MST- Malnutrition Screening Tool	SGA- Subjective Global Assessment	Ferguson et al., 1999	93.0%	93.0%	98.4%	72.7%
MST- Malnutrition Screening Tool	SGA- Subjective Global Assessment + BMI- Body Mass Index	Tran et al., 2018	41.8%	82.0%	55.0%	72.2%
MST- Malnutrition Screening Tool	SGA- Subjective Global Assessment	Nursal et al., 2005	74.4%	76.2%	27.9%	87.2%
MST- Malnutrition Screening Tool	Combination Criteria	Nursal et al., 2005	42.0%	73.1%	22.5%	87.2%
MST- Malnutrition Screening Tool	BMI- Body Mass Index, loss of weight	Neelemaat et al., 2011	78.0%	96.0%	89.0%	91.0%

MST- Malnutrition Screening Tool	SGA- Subjective Global Assessment	Raja et al., 2004	69.1%	91.8%	____	____
MST- Malnutrition Screening Tool + BMI- Body Mass Index	SGA- Subjective Global Assessment + BMI- Body Mass Index	Tran et al., 2018	66.8%	82.0%	65.2%	82.1%
MUST- Malnutrition Universal Screening Tool	SGA- Subjective Global Assessment	Gibson et al., 2012	77.0%	80.0%	79.0%	94.7%
MUST- Malnutrition Universal Screening Tool	Diagnostic criteria ESPEN†	Poulia et al., 2017	100.0%	96.0%	75.9%	100.0%
MUST- Malnutrition Universal Screening Tool	SGA- Subjective Global Assessment + BMI- Body Mass Index	Tran et al., 2018	63.4%	85.2%	70.0%	80.8%
MUST- Malnutrition Universal Screening Tool	BMI- Body Mass Index, loss of weight	Neelemaat et al., 2011	96.0%	80.0%	69.0%	98.0%
MUST- Malnutrition Universal Screening Tool	MNA- Mini Nutritional Assessment	Vallén et al., 2011	57.0%	93.0%	86.0%	75.0%
NRS 2002- Nutritional Risk Screening 2002	BMI- Body Mass Index, loss of weight	Neelemaat et al., 2011	92.0%	85.0%	72.0%	96.0%
NRS 2002- Nutritional Risk Screening 2002	MNA- Mini Nutritional Assessment	Westergren et al., 2011	37.0%	82.0%	76.0%	47.0%
NRS 2002- Nutritional Risk Screening 2002	Diagnostic criteria ESPEN†	Poulia et al., 2017	61.0%	76.3%	24.8%	93.9%
NRS 2002- Nutritional Risk Screening 2002	SGA- Subjective Global Assessment + BMI- Body Mass Index	Tran et al., 2018	74.6%	80.6%	64.9%	84.4%
PG-SGA + EMR- Patient Generated Subjective Global Assessment + Electronic Medical Records	PG-SGA- Patient Generated Subjective Global Assessment	Alston et al., 2022	67.6%	76.8%	____	____
SNAQ- Short Nutritional Assessment Questionnaire	BMI- Body Mass Index, loss of weight	Neelemaat et al., 2011	75.0%	84.0%	66.0%	90.0%

†*ESPEN- European Society for Clinical Nutrition and Metabolism*