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Validity of Nutritional Screening Tools for Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis

Abstract

Objectives: The aim of this systematic review was to summarize the validity of nutritional screening tools to detect the risk of malnutrition in community-dwelling older adults.

Design: A systematic review and meta-analysis. The protocol for this systematic review was registered in the PROSPERO database (CRD42017072703).

Setting and participants: A literature search was performed in PubMed, EMBASE, CINAHL and Cochrane using the combined terms “malnutrition”, “aged”, “community-dwelling” and “screening”. The timeframe of the literature interrogated was from 1 January 2001 to 18 May 2018. Older community-dwellers were defined as: individuals with a mean/median age of >65 years who were community-dwellers or attended hospital outpatient clinics and day hospitals. All nutritional screening tools which were validated in community-dwelling older adults against a reference standard to detect the risk of malnutrition, or with malnutrition, were included.

Measures: Meta-analyses were performed on the diagnostic accuracy of identified nutritional screening tools validated against the Mini Nutritional Assessment-Long Form (MNA-LF). The symmetric hierarchical summary receiver operating characteristic models were used to estimate test performance.

Results: Out of 7,713 articles, 35 articles were included in the systematic review, and 9 articles were included in the meta-analysis. Seventeen nutritional screening tools and

10 reference standards were identified. The meta-analyses showed an average sensitivities and specificities of 0.95 (95% CI 0.75 – 0.99) and 0.95 (95% CI: 0.85 – 0.99) for the Mini Nutritional Assessment-Short Form ((MNA-SF), cutoff point ≤11), 0.85 (95% CI: 0.80 – 0.89) and 0.87 (95% CI: 0.86 – 0.89) for the MNA-SF-V1 (MNA-SF using body mass index, cutoff point ≤11), 0.85 (95% CI: 0.77 – 0.89) and 0.84 (95% CI: 0.79 – 0.87) for the MNA-SF-V2 (MNA-SF using calf circumference instead of body mass, cutoff point ≤11), respectively, using MNA-LF as the reference standard.

Conclusions and Implications: The MNA-SF, MNA-SF-V1 and MNA-SF-V2 showed good sensitivity and specificity to detect community-dwelling older adults at risk of malnutrition validated against the MNA-LF. Clinicians should consider the use of the cutoff point ≤11 on the MNA-SF, MNA-SF-V1 and MNA-SF-V2 to identify community-dwelling older adults at risk of malnutrition.

Introduction

The proportion of individuals over the age of 65 years worldwide is projected to rise to 22% by 2050.[1, 2] Ageing may induce malnutrition due to multiple factors such as loss of appetite, oral impairment,[3] taste and smell, drug interactions and social isolation.[4] Malnutrition is associated with a range of negative health outcomes,[5, 6] such as low quality of life, frailty,[6] loss of autonomy, morbidity, higher frequency of hospital admissions and mortality.[7-10] In community-dwelling older adults, the prevalence of malnutrition is reported to range between 2 to 42%.[6, 11] The wide variation in the prevalence of malnutrition may be due to the various nutritional screening tools, and the many reference standards used to validate these nutritional screening tools.[12-14]

The absence of a gold standard to define the risk of malnutrition and actual malnutrition, has led to different approaches in validating nutritional screening tools. A recent review on the validity of nutritional screening tools used in older adults in the community, residential care, rehabilitation and hospitals, identified a total of 34 nutritional screening tools and 17 different reference standards.[15] The most widely used and acceptable reference standards were the Mini Nutritional Assessment – Long Form (MNA-LF) and the clinical assessment given by a nutrition-trained professional.[15] To our knowledge, no meta-analysis has been performed on the diagnostic accuracy of nutritional screening tools used to identify community-dwelling older adults at risk of malnutrition.

This study was conducted as part of the Physical Activity and Nutrition Influences In ageing (PANINI) network research[14] and aimed to perform a systematic review of all available nutritional screening tools validated against reference standards in

community-dwelling older adults. We reported on the validity of the cutoff points used on the nutritional screening tools to identify those at risk of malnutrition, and with malnutrition. Secondly, we performed a meta-analysis on the diagnostic accuracy of identified nutritional screening tools validated against the Mini-nutritional Assessment – Long Form or a health professional's rating of nutritional status.

Methods

The protocol for this systematic review was registered at PROSPERO International prospective register of systematic reviews (Registration number: CRD42017072703). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to guide the reporting of this review.[16]

Search Strategy

A systematic search was performed by a librarian and the articles identified were obtained through electronic searches of the following databases: PubMed, EMBASE, CINAHL (via Ebsco) and Cochrane. The timeframe interrogated for the search was from 01/01/2001 to 18/05/2018. The search strategy combined the terms "malnutrition", "aged", "community-dwelling" and "screening" and synonyms. Language was not restricted in the search strategy; publications that were not in English were later excluded. The reference lists of the identified articles were further searched for relevant publications. The search strategy syntax can be found in *Appendix 1*.

Selection Process

The relevant titles and abstracts, then the full-texts were independently screened for eligibility by two authors (JI and MB) using the Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. When conflicts/discrepancy arose between the two authors then a third author (SY) made the final judgment of the articles.

Inclusion criteria and exclusion criteria

For the purpose of this systematic review, we included all nutritional screening tools validated against a reference standard. If a nutritional screening tool had multiple versions, such as the Mini-Nutritional Assessment Short-Form (MNA-SF) or Seniors in the community: risk evaluation for eating nutrition (SCREEN) then each version of the tool was assessed independently. Our rational for not grouping similar tools together was because, despite their similarity, these tools differ importantly in their measurements, questions and scoring methods. Therewith they might have different construct validities. As there is no gold standard for the assessment of malnutrition, the MNA-LF, a detailed nutritional assessment by a dietitian or physician and Subjective Global Assessment (SGA), were considered as identifiers of patients with the risk of malnutrition. The European Society of Parenteral and Enteral Nutrition (ESPEN) recommend the use of MNA-LF, SGA, Patient Generated Subject Global Assessment (PG-SGA) to facilitate the assessment of malnutrition.[18] A detailed nutritional assessment should include medical, social, psychological and nutrition history, as well as energy and fluid requirements.[18]

The criteria for selecting articles included: validation studies of nutritional screening tools developed to identify the risk of malnutrition, or malnutrition, with description of psychometric properties (sensitivity, specificity and criterion validity). Community-dwelling older adults were defined as: individuals living at home with a mean/median age of >65 years who attended hospital outpatient clinics, day hospitals, community centres or participated in a population study.

The articles were excluded if the population being screened for malnutrition consisted of less than 50% community-dwelling older adults. Additionally, articles were excluded if the screening tool included laboratory values, such as Prognostic Nutritional Index, Controlling Nutritional Status (CONUT), Maastricht Index. Conference abstracts, systematic reviews and letters to editors were also excluded.

Data Extraction

The data was independently extracted by two authors (JI, MB) for each eligible article. The extracted variables included: author, year of publication, country origin of the research population, study population, number of included individuals, recruitment strategy, percentage of male, age of individuals, nutritional screening tool and its version, the reference standard and the prevalence of community-dwelling older adults at risk of malnutrition and those with malnutrition as determined by the reference standard. If the articles included a mixed population (e.g. hospitalized and community-dwelling older adults) and data was available on both populations then only data pertaining to the community-dwelling older adults was extracted.

As part of the systematic review, to evaluate the diagnostic accuracy of the nutritional screening tools, the following data were extracted from the eligible articles: cutoff points used to identify individuals at risk of malnutrition or with malnutrition, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), area under the curve (AUC), correlation coefficient and kappa. Validity of a screening tool was defined as good if: sensitivity ≥ 80%, specificity ≥ 80%, AUC ≥ 0.8, correlation coefficient ≥ 0.75 and/or kappa ≥ 0.6; fair if: sensitivity ≥ 50% but <80%, specificity ≥50% but <80%, AUC 0.6 – 0.8, correlation coefficient 0.40 – 0.75, kappa 0.40 – 0.6; poor if: sensitivity <50%, specificity <50%, AUC <0.6, correlation coefficient <0.40, kappa <0.40.[19]

Methodological quality of extracted papers

To assess the methodological quality of the included studies, the Quality Assessment of Diagnostic Accuracy Studies – version 2 (QUADAS-2) was used.[20] The signaling questions used to assess the quality of the studies are in *Appendix 2*.

Statistical analysis for the Meta-analysis

Revman 5.3 was used to calculate true positives (TP), false positives (FP), true negatives (TN), false negatives (FN) and PPV and NPV from the values of sensitivity, specificity and prevalence reported in the articles. [21] Symmetric hierarchical summary receiver operative characteristic (HSROC) models were used to jointly estimate sensitivity and specificity, positive and negative likelihood ratio, and diagnostic odd ratio (DOR) using STATA statistical software, version 14.1 (StataCorp). We were unable to pool estimates when the number of studies was less than 4.[22] Instead, forest plots were

used to display sensitivity and specificity for all nutritional screening tools validated against the MNA-LF, a health professional's rating of nutritional status or SGA.

Results

Study Selection

The search yielded 12,103 citations, including 4,394 duplicates; an additional four articles were identified from checking the reference list of relevant articles and review articles. After title, abstract and full text screening, 7,678 articles were excluded, resulting in 35 articles which were included in this systematic review and 9 articles were included in the meta-analysis. The article selection flow is shown in Figure 1.

Study Characteristics

The study characteristics are presented in Table 1. The median sample size was 283 individuals (Interquartile range (IQR) 199 to 754, range 45 – 22,007), the mean age was 74 years (SD ± 3.5, range 67 – 86 years), and including a median of 39 percent males (IQR 35 to 47%, range 19 – 59%). The median prevalence of malnutrition as determined by the reference standard was 5% (IQR 2 to 15%), and the median prevalence of individuals at risk of malnutrition was 32% (IQR 23 to 44%). Seventeen malnutrition screening tools were identified: Mini-Nutritional Assessment Short-Form (MNA-SF),[23-29] MNA-SF-V1 (MNA-SF using BMI)[30-39] and MNA-SF-V2 (MNA-SF using calf circumference instead of BMI),[31, 32, 34, 35, 37, 39-41] Self-MNA,[42] MNA-LF,[12, 29, 43-46] Malnutrition Risk Screening Tool (MRST),[27] South African Tool,[47] DETERMINE Checklist,[24] SGA,[12, 46] Nutritional Risk Screening Tool,[48] Seniors in the community: risk

evaluation for eating nutrition (SCREEN) version I[49] and II,[50, 51] Japanese adaptation of SCREEN II,[48] Malnutrition Universal Screening Tool (MUST),[25, 34, 46, 52] Short Nutritional Assessment Questionnaire (SNAQ),[53, 54] Body Mass Index (BMI),[25, 38] Nutritional form for the elderly (NUFE)[55, 56] and Malnutrition Screening Tool.[57]

Quality Assessment

Figure 2 shows the methodological quality assessment of the studies. The majority of the articles did not specify if the researchers interpreted the nutritional screening tools without knowledge of the results of the reference standard and vice versa. Therefore, the risk of bias for the interpretation of the index test and the reference standard was often unclear (70% and 67%, respectively). Ten reference standards were identified. The reference standard varied widely between studies: MNA-LF,[23, 24, 26, 28, 30-37, 39, 41-44] dietitian's or physician's rating,[25, 29, 49-51] SGA,[38, 57] Anthropometry – BMI,[27, 45] Calf Circumference and Mid Upper Arm Circumference,[27] self-reported unintentional weight loss and BMI,[52] MNA-SF [42, 48, 55, 56], MNA-SF-V1,[34, 40] Geriatric Nutrition Risk Index (GNRI)[48] and CONUT.[54] Ten out of thirty-four articles used a reference standard other than the MNA-LF, a health professional's rating of nutritional status or SGA.

Diagnostic Performance of Nutritional Screening Tools in Community-dwelling Older Adults based on the Systematic Review

Figure 3 displays the sensitivity and specificity of all nutritional screening tools validated against the MNA-LF, SGA or a health professional's rating of nutritional status. The most frequently tested nutritional screening tools compared to the MNA-LF or health professional were the MNA-SF, MNA-SF-V1, MNA-SF-V2 and SCREEN II. On the

MNA-SF, MNA-SF-V1 and MNA-SF V2, the cutoff point ≤11 was used to identify individuals at risk of malnutrition, whereas the cutoff point ≤7 was used to identify those with malnutrition on the MNA-SF-V1 and MNA-SF-V2. On the MNA-SF, the sensitivity of the cutoff point ≤11 ranged from 74% to 100% and the specificity ranged from 89% to 100%. On the MNA-SF-V1, the sensitivity of the cutoff point ≤11 ranged from 73% to 93% and specificity ranged from 85% to 93%, whereas the sensitivity of cutoff point ≤7 ranged from 76% to 100%, and specificity ranged from 94% to 87%. On the MNA-SF-V2, the cutoff point ≤11 ranged from 73% to 90% and specificity ranged from 77% to 86%, whereas the cutoff point ≤7 ranged from 81% to 88% and specificity from 90% to 97%. SCREEN II was validated against a dietitian's rating of nutritional status in 2 articles, the cutoff points <54 was used to identify older adults at risk of malnutrition. Both of these studies showed good sensitivity (84% and 88%) and fair specificity (62% and 71%). The Self MNA, MNA-CC-MAC, MNA-P, the South African tool, DETERMINE, SCREEN, Abbreviated SCREEN II, MUST, BMI and MST were compared to either the MNA-LF, health professionals' rating or SGA in only one study.

Table 2 lists the sensitivity, specificity, PPV, NPV, AUC, correlation coefficient and kappa of each nutritional screenings tools and their cutoff points compared to a reference standard. In community-dwelling older adults, the MUST was validated against self-reported weight loss and measured BMI,[52] MNA-LF[34] and a dietitian's rating of nutritional risk. [25] The reported sensitivity of the MUST to identify individuals at risk of malnutrition varied greatly between these studies (64% vs 100%); however specificity was high in both studies (96% and 98%). The nutritional tool SNAQ was validated against both self-reported unintentional weight loss and measured BMI,[52] and CONUT.

[54] The sensitivity and specificity of the SNAQ varied widely between these studies (31% vs 92%) and (98% vs 63%), respectively. The NUFE tool was validated against another nutritional screening tool, that is, MNA-SF, and the NUFE was reported to have fair sensitivity, specificity and AUC compared to the MNA-SF.[55, 56] The use of BMI and SGA was used interchangeably as a nutritional screening tool[25, 38] and a reference standard.[27, 45] Sheard *et al.*[38] validated BMI against SGA whereas Kozakova *et al.*[46] validated SGA against BMI. In community-dwelling older adults, the following nutritional screening tools were validated in only one study: SCREEN,[49] self-MNA,[42] DETERMINE,[24] South African Tool,[47] MRST-C and MRST-H[27] and MST.[57]

Meta-analysis of the diagnostic accuracy of the MNA-SF, MNA-SF-V1 and MNA-SF-V2 to identify risk of malnutrition in community-dwelling older adults

All articles identified used the cutoff point ≤11 to identify community-dwelling older adults at risk of malnutrition on the MNA-SF, MNA-SF-V1 and MNA-SF-V2. These nutritional screening tools were all validated against the MNA-LF and the TP, FN, TN, FP, sensitivity and specificity of each study is displayed in forest plots in Figure 3. The pooled sensitivity, specificity, DOR, positive likelihood ratio, negative likelihood ratio of the cutoff point ≤11 on the MNA-SF, MNA-SF-V1 and MNA-SF-V2 are shown in Supplementary Table A1. The MNA-SF had a sensitivity of 0.95 (95%CI 0.75 – 0.99) and specificity was 0.95 (95% CI 0.85 – 0.99). The summary estimates for sensitivity on MNA-SF-V1 was 0.85 (95%CI 0.80 – 0.89) and specificity was 0.87 (95%CI 0.85 – 0.89). The pooled sensitivity of the MNA-SF-V2 was 0.85 (95%CI 0.77 – 0.89) and specificity was 0.84 (95%CI 0.79 – 0.87). The hierarchical summary receiver operating

characteristic curves for the MNA-SF, MNA-SF-V1 and MNA-SF-V2 at the cutoff point of ≤11 is shown in Supplementary Figure A1.

Discussion

The nutritional screening tools which displayed good sensitivity and at least fair specificity were the MNA-SF, MNA-SF-V1 and MNA-SF-V2 and SCREEN II. The meta-analyses showed high sensitivity and specificity for MNA-SF, MNA-SF-V1 and MNA-SF-V2 screening tools validated against the MNA-LF identifying community-dwelling older adults at risk of malnutrition.

The MNA-SF was developed in 2001 and consists of six questions and a score of ≤11 points classifies individuals as at risk of malnutrition. The meta-analysis showed that the MNA-SF had good sensitivity and specificity for the cutoff point of ≤11; however the 95% confidence interval was wide. In 2009, the MNA-SF was revised by Kaiser *et al.*[58] which led to a three-category system: “malnourished - ≤7”; “at risk of malnutrition 8 – 11”; “normal nutritional status 12 -14”. Kaiser *et al.*[58] suggested two versions of the revised MNA-SF, that is, MNA-SF-V1 which includes BMI or MNA-SF-V2 in which calf-circumference is used when BMI cannot be calculated.[58] Our meta-analysis demonstrated that the cutoff point ≤11 on both the MNA-SF-V1 and MNA-SF-V2 had a good sensitivity, specificity and a narrow 95% confidence interval. There was an insufficient number of studies that reported the sensitivity and specificity of the cutoff of ≤7 points on the MNA-SF-V1 and MNA-SF-V2 to identify malnutrition in community-dwelling older adults. Overall, our findings suggest that the MNA-SF-V1 and MNA-SF-

V2, a simple, quick and effective screening tool, can identify community-dwelling older adults at risk of malnutrition.

In a recent review, SCREEN II was suggested as the most appropriate tool in community-dwelling older adults,[15] however, it should be noted that this tool was only validated in two studies including small populations.[50, 51] The cutoff of <54 points was previously recommended to detect the risk of malnutrition and our results show that this cutoff point has good sensitivity but only fair specificity in community-dwelling older adults. The fair specificity would suggest that this screening tool would identify many false positive tests when identifying individuals at risk of malnutrition. To improve on the sensitivity and specificity, lower cutoff points were suggested such as cutoff of <50 points [50] and cutoff of <49 points.[51] Although, the cutoff of <49 points on SCREEN II showed good sensitivity and specificity when identifying older adults with malnutrition, this cutoff points was only validated in a small sample size (n = 45). Therefore, larger studies are needed to further validate the use of this cutoff point in community-dwelling older adults.

When choosing a nutritional screening tool to identify individuals at risk of malnutrition, it is important to ensure that the nutritional screening tool accurately identifies individuals at risk of, or with, malnutrition. However, one of the major limitations is that there is no "gold standard" for the diagnostic criteria for malnutrition. Indeed, we identified ten different reference standards in this review alone. When assessing the quality of the studies, we reasoned that the MNA-LF, dietitian/physician's rating of nutritional status or SGA would be most likely to correctly identify patients at risk of malnutrition, or with malnutrition. However, it should be noted that in recent years societies such as The

European Society of Clinical Nutrition and Metabolism (ESPEN)[59] and more recently the Global Leadership Initiative on Malnutrition (GLIM) proposed consensus schemes for diagnosing malnutrition.[59, 60] To our knowledge there are a growing number of studies evaluating the ESPEN definition of malnutrition[5, 13] and no studies that have validated any nutritional screening tools against the GLIM definition of malnutrition in community-dwelling older adults.

Risk of Bias

It was often unclear whether the nutritional screening tools were interpreted without knowledge of the results of the reference standard and vice versa. The lack of blinding may have inflated the diagnostic accuracy of the nutritional screening tool. It is recommended for future studies to be more transparent in their methodology and provide details on whether assessors were blinded to the index test results and vice versa. To reduce the risk of bias, investigators should follow the guidelines described by the Standards for Reporting of Diagnostic Accuracy Studies.[61] Additionally, a high risk of bias was considered if a single measurement such as BMI was the reference standard and if a nutritional screening tool was considered as the reference standard (e.g. MNA-SF). Interestingly, the MNA-SF, MNA-LF and SGA were interchangeably used as either the index test (screening tool) or the reference standard (assessment tool).

Strengths and Limitations

The strengths of this systematic review is that we identified: i) all nutritional screening tools validated against a reference standard, ii) the cutoff points that were validated to identify community-dwelling older adults at risk of malnutrition, or with, malnutrition, and

iii) summarized the results in a meta-analysis. To our knowledge, this is the first meta-analysis on the diagnostic accuracy of nutritional screening tools used to identify community-dwelling older adults at risk of malnutrition, and those with malnutrition. However, a limitation of our study is that our search strategy started after 2001; therefore any validity studies prior to that time were excluded. Furthermore, it was out of the scope of this review to describe reliability, repeatability and predictive validity of the nutritional screening tools.

Conclusions and Implications

This systematic review further highlights that there is a need for a universal gold standard for the diagnostic criteria of malnutrition. The results from this meta-analysis show evidence for the use of the cutoff of ≤11 points on the MNA-SF or MNA-SF-V1 or MNA-SF-V2 to detect community-dwelling older adults at risk of malnutrition. Although, it should be noted, that we were unable to analyze the other cutoff points on these nutritional screening tools. Overall, our results suggest that, in the community setting if scales and stadiometers are available, and thus BMI can be calculated, then the MNA-SF-V1 should be used. Otherwise, if a scale is not available then calf circumference should be obtained, and the MNA-SF-V2 should be used to identify community-dwelling older adults at risk of malnutrition, or with malnutrition. Further research is needed in community-dwelling older adults on the validity of the other available nutritional screening tools such as SCREEN II and NUFE.

Conflict of Interest: No conflicts to declare.

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Figure Captions:

Figure 1. PRISMA flowchart of the article selection procedure for the systematic review

Figure 2. Methodological quality assessment of included studies using QUADAS-2

Figure 3. Forest plots of all nutritional screening tools validated against the MNA-LF, a health professional's rating of nutritional status and the SGA. Abbreviations: MNA-LF: Mini nutritional Assessment - Long form, SGA: Subjective global assessment.

Supplementary Figure A1. Pooled sensitivity, specificity and HSROC curve for screening for the risk of malnutrition using the cutoff point ≤11 on the MNA-SF (A), MNA-SF-V1 (B) and MNA-SF-V2 (C) compared to the MNA-LF. Abbreviations: HSROC: Hierarchical Summary Receiver-Operating Characteristic, MNA-SF: Mini nutritional assessment - Short form (left panel, number of articles = 4, number of participants = 23,331), MNA-SF-V1: Mini nutritional assessment - Short form Version 1 using body mass index (middle panel, number of articles = 6, number of participants = 4,037), MNA-SF-V2: Mini nutritional assessment - Short form Version 2 using calf-circumference instead of body mass index (right panel, number of articles = 4, number of participants.