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Published in:
Journal of the Academy of Nutrition and Dietetics

DOI:
10.1016/j.jand.2015.06.013

Malnutrition in geriatric rehabilitation: prevalence, patient outcomes and criterion validity of the Scored Patient-Generated Subjective Global Assessment (PG-SGA) and the Mini Nutritional Assessment (MNA)

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Keywords: nutrition assessment, malnutrition, rehabilitation, rural, aged

Abstract: 300 words

Text: 3517

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Background: Accurate identification and management of malnutrition is essential so that patient outcomes may be improved and resources used efficaciously. **Objectives:** In malnourished older adults admitted to rehabilitation: 1) report the prevalence, health and aged care use, and mortality of malnourished older adults; 2) determine and compare the criterion (concurrent and predictive) validity of the Scored Patient-Generated Subjective Global Assessment (PG-SGA) and the Mini Nutritional Assessment (MNA) in diagnosing malnutrition; 3) identify the Scored PG-SGA score cut-off value associated with malnutrition. **Design**: Observational, prospective cohort. **Participants/setting:** n=57 older adults ≥65 years (y), mean age 79.1y (±7.3y) from two rural rehabilitation units in New South Wales, Australia. **Measurements/statistical analysis:** Scored PG-SGA, MNA and ICD-10-AM classification of malnutrition were compared to establish concurrent validity and report malnutrition prevalence. Length of stay (LOS), discharge location, rehospitalization, admission to a residential aged care facility (RACF) and mortality were measured to report health-related outcomes and to establish predictive validity. **Results:** Malnutrition prevalence varied according to assessment tool (ICD-10-AM: 46%; Scored PG-SGA: 53%; MNA: 28%). Using ICD-10-AM as the reference standard, the Scored PG-SGA ratings (sensitivity 100%, specificity 87%) and score (sensitivity 92%, specificity 84%, ROC AUC 0.910±0.038) showed strong concurrent validity and the MNA had moderate concurrent validity (sensitivity 58%, specificity 97%, ROC AUC 0.854±0.052). The Scored PG-SGA rating, Scored PG-SGA score and MNA showed good predictive validity. Malnutrition may increase the risk of longer readmission LOS, admission to an RACF and discharge to hospital or RACF instead of home. **Conclusion:** Malnutrition prevalence in the geriatric rural rehabilitation population is high and associated with increased health and aged care use. The Scored PG-SGA ratings

and score are suitable for nutrition assessment in geriatric rehabilitation. The MNA may be suitable for nutrition assessment in geriatric rehabilitation but care should be taken to ensure all malnourished patients are identified. Further examination of the criterion validity of the Scored PG-SGA and MNA will lend confidence to these findings.

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Introduction

The physiological and psychosocial consequences of malnutrition are significant and diverse. In health care facilities, malnutrition increases morbidity, mortality and incidence of complications. Overall this leads to increased treatment costs and length of stay [1,2]. Common symptoms of malnutrition, such as confusion, fatigue and weakness, are often attributed to other conditions leading to frequent misdiagnosis and under-recognition of malnutrition [3]. There is strong evidence showing malnutrition is under-recognized and under-diagnosed in the rehabilitation setting despite a high prevalence (30 – 50%) [4]. In addition, the prevalence of malnutrition in rural rehabilitation facilities, as opposed to metropolitan facilities, has not been reported [4].

Accurate identification, management and monitoring of malnutrition are essential steps in the nutrition care process so that patient outcomes may be improved and resources used efficaciously [5]. Nutrition assessment is often completed through the application of a nutrition assessment tool. Unlike nutrition screening tools, nutrition assessment tools can be used to make a diagnosis of malnutrition by medical staff or a dietitian [6]. However, the tool chosen should be validated for the population to which it is applied. In the rehabilitation setting, there are only two nutrition assessment tools which have been evaluated for validity. These include the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment (MNA) [4]. The MNA was designed specifically for an older population, and is perhaps the most widely reported nutrition assessment tool in the literature across health care settings [4,7,8]; however, both the MNA and SGA lack sensitivity to show changes in nutrition status over a short period of time, such as during hospital and rehabilitation admissions [9]. The Scored

Patient-Generated Subjective Global Assessment (PG-SGA) was adapted from the SGA and includes seven components for assessment: weight, food intake, nutrition impact symptoms, activities and function, medical condition, metabolic stress and physical examination [9]. The questions regarding short-term weight loss and nutrition impact symptoms increase the Scored PG-SGA's sensitivity to changes in nutrition status over a short period of time [9,10]. The Scored PG-SGA provides a global rating of nutrition status for a nutritional diagnosis as well as a continuous numerical score for intervention triage [11,12]. Since its development, the Scored PG-SGA has shown to be appropriate for use in oncology, acute medical, renal, stroke, neurology and respiratory patients as well as the residential aged care setting [13-18]. The Scored PG-SGA has not been evaluated in the rehabilitation setting nor in an older adult population. Therefore, in the older adult rural rehabilitation population, the aims of this study were to: 1) report the prevalence, health and aged care use, and mortality of malnourished older adults; 2) determine and compare the criterion (concurrent and predictive) validity of the Scored PG-SGA and the MNA in diagnosing malnutrition; 3) identify the Scored PG-SGA score cut-off value associated with malnutrition.

Materials and methods

Study sample

Participants consecutively admitted to one of two public rehabilitation units in rural [19] New South Wales, Australia, were approached to participate if they were: English-speaking inpatients ≥65years (y), lived in the community prior to admission and had an informal caregiver. Patients were only included if they were admitted with the expectation they would return to their own homes upon discharge. This study was conducted between August 2013 and February 2014 as part of the MARRC (Malnutrition in the Australian Rural Rehabilitation Community) Study (Trial version 2.0, 9 May 2013) which has been registered at the Australian New Zealand Clinical Trials Registry (ACTRN12613000518763) and has received ethical and governance approval (North Coast NSW Human Research Ethics Committee: LNR 063, G108; School of Human Movement Studies Ethics Committee: HMS13/0731). Written informed consent was obtained from all participants and/or their guardians.

<u>Data collection</u>

Outcome measurement tools, including all components of the Scored PG-SGA, were completed on behalf of the participant by the primary researcher (Accredited Practising Dietitian) and were informed by interview with the patient, their caregivers, rehabilitation staff and consultation of medical notes.

Nutrition assessment

Nutrition assessment using both the Scored PG-SGA and MNA was conducted by the primary researcher within a median of two days following admission. A higher Scored PG-SGA score indicates an increased risk for malnutrition [9]. The Scored PG-SGA also provides global ratings of well-nourished (rated A), moderately or suspected of being malnourished (rated B) or severely malnourished (rated C) which are analogous to the SGA ratings [11]. For this study, an increase or decrease of ≥0.5kg within two weeks was considered a change in weight, any nutrition impact symptoms present within the previous two weeks were included, and functional impairment was considered only where it was related to nutrition status. The MNA is scored 0 to 30 where a score of <17 indicates ‘malnourished’, 17 – 23.5 indicates ‘at risk of malnutrition’ and 24 – 30 indicates ‘normal nutrition status’ [8].

The *International Statistical Classification of Diseases and Health Related Problems 10th Revision Australian Modification* (sixth edition, ICD-10-AM) criteria are the recognized standard diagnostic criteria in Australia for the diagnosis, documentation and diagnostic related group coding of protein-energy malnutrition (or “malnutrition”) (table 1). The ICD-10-AM classification is determined using body mass index (BMI), weight history, dietary intake and a physical assessment of fat and/or muscle wasting. As these criteria are used in Australian hospitals to provide case-mix funding reimbursements, failure to identify and document malnutrition in the health care setting can have significant detrimental impacts upon funding [20]. Therefore, the nutrition assessment method used must be in agreement with the ICD-10-AM criteria to ensure that resources are available for treatment. As there is no gold standard for diagnosing malnutrition, the criterion validity (i.e. the concurrent and predictive validity) of a diagnostic tool must be established. In this study, the ICD-10-AM classification was used as the reference standard for malnutrition as it is the agreed upon standard in the Australian health care setting, and has recently been used as the standard against which nutritional screening and assessment tools have been validated [21,22]. The Scored PG-SGA components of current weight, height, one or six month weight loss and assessment of fat stores and muscle status were used to inform the ICD-10-AM classification of malnutrition for each participant. Weight (kg) was measured by the primary researcher using Tanita InnerScan Body Composition Monitor scales model: BC-541 (2005, Tanita Corporation, Tokyo, Japan) or rehabilitation wards scales (chair or roll-on scales) for nonweight bearing participants. All three scales were within 0.1kg calibration. Weights recorded for amputees were adjusted [23]. Estimated height was calculated using knee height [23].

Health and aged care service use

A range of variables were chosen to represent rehabilitation outcome, health service use and patient wellbeing. These included discharge location [home/other: hospital, residential aged care facility (RACF), or friend/family] and rehabilitation length of stay (days) upon discharge; and rehospitalization incidence (number of acute care and rehabilitation readmissions), rehospitalization length of stay (total days of all subsequent rehabilitation and acute admissions), admission to an RACF (yes/no) and death (yes/no) at 12 weeks post-discharge. Data were obtained from the health service's electronic admissions database and confirmed by telephone or in-home interviews.

Statistical approach

All statistical analysis was completed using SPSS Version 22.0 2013 [IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.]. Significance was considered at the $P<0.05$ level. Descriptive statistics were used to characterize the sample population and prevalence of malnutrition. Chi-squared goodness of fit tests were used to test for a significant difference in nutrition status categories according to each nutrition assessment method. For examination of the criterion validity and to report prevalence, nutrition status was considered as binary variables, and therefore collapsed into 'well-nourished' and 'malnourished' for each tool and the diagnostic criteria. Only patients with existing malnutrition and not risk of malnutrition were considered 'malnourished' in order to evaluate a tools ability to diagnose existing malnutrition. Therefore, 'malnourished' ratings were given for Scored PG-SGA ratings of B and C, MNA score <17 and any participant meeting the ICD-10-AM criteria of E43 (severe malnutrition), E44.0 (moderate malnutrition) or E44.1 (mild malnutrition) (as per table 1). In addition, a cut-off value to identify malnourished geriatric patients for the Scored PG-SGA score was determined using a receiver operating characteristics (ROC) curve using the Scored PG-SGA ratings as the standard. Sensitivity and specificity were considered equally important in determining the cut-off value. All other ratings/scores were classified as "well-nourished".

To determine the concurrent validity of the Scored PG-SGA and MNA, the sensitivity, specificity, positive predictive value, negative predictive value, diagnostic odds ratio (DOR) [24], weighted kappa statistic [25] and their 95% confidence intervals (CI) were determined using contingency tables against the ICD-10-AM classification of malnutrition. The Scored PG-SGA and MNA scores were further assessed as continuous variables for concurrent validity against the ICD-10-AM classification of malnutrition using a ROC curve. An ROC curve provides an assessment on the discriminative power of a test, where an ROC area under the curve (AUC) of 0.9 – 1.0 is considered an excellent test, 0.8 – 0.9 a very good test, 0.7 – 0.8 a good test, 0.6 – 0.7 a sufficient test without much value in the clinical setting, 0.5 – 0.6 a bad test and <0.5 of no use [24].

Any longitudinal outcome with results significantly different between the well-nourished and malnourished groups according to the ICD-10-AM criteria was used to evaluate the predictive validity of the Scored PG-SGA and MNA using the Mann-Whitney U test and chi-square test. Participants who did not have any readmissions were excluded from the rehospitalization length of stay analysis.

Results

Study participants

Over the study recruitment period, 57 consecutive rehabilitation inpatients consented to participate in the study (response rate of 98%). The sample was 49% female, with a mean age of 79.1y (±7.3y), however there was a significant difference in age between sites (77.5y versus 81.4y). The study sample is further described elsewhere (Marshall et al., 2015, unpublished data).

Nutrition status and health-related patient outcomes

Malnutrition prevalence varied according to nutrition assessment method, where the ICD-10-AM criteria determined 46% were malnourished, the Scored PG-SGA ratings determined 53% were malnourished and the MNA determined 28% were malnourished with a further 58% at risk of malnutrition (table 2). The median Scored PG-SGA score was 7.0 (IQR: 3-11.5). Rehabilitation length of stay excluded three participants who had emergency admissions to acute care. According to the ICD-10-AM classification of malnutrition, malnourished participants had a significantly longer cumulative length of stay for all rehabilitation and acute readmissions within 12 weeks (P=0.032) (table 3). Malnourished patients also had a higher incidence of admission to an RACF within 12 weeks (P=0.052) and a lower incidence of discharge to home, as more were discharged to hospital, an RACF or to stay with family or friends (P=0.052). Three malnourished participants died following discharge from rehabilitation; there were no deaths in the well-nourished group.

The Scored Patient-Generated Subjective Global Assessment score to indicate malnutrition

The sensitivity and specificity for coordinates of the curve (cut-off values) were provided for the average of two test values (Scored PG-SGA scores which are whole numbers), where 7.5 had the strongest overall sensitivity (90%) and specificity (96.3%). A value of 6.5 had a sensitivity of 90% and specificity of 92.6% and a value of 8.5 had sensitivity of 80% and specificity of 100%. A cut-off of 6 (represented by coordinate 6.5) was considered not to have a strong enough specificity, and a cut-off of 8 (represented by coordinate 8.5) was considered to have too low a sensitivity, compared with a cut-off value of 7 (represented by coordinate 7.5). Therefore a cut-off value of 7 was considered the most appropriate score to indicate the need for critical intervention in older adult medical patients and was used to classify patients as 'malnourished' for the Scored PG-SGA-score.

Concurrent and predictive validity of the Scored Patient-Generated Subjective Global Assessment and Mini Nutritional Assessment tools

Results of the contingency table analysis for Scored PG-SGA ratings, Scored PG-SGA score and MNA against the ICD-10-AM criteria and their predictive validity are presented in table 4. The Scored PG-SGA ratings showed strong diagnostic accuracy, with perfect sensitivity, good specificity and 'almost perfect' agreement [25]. In addition, the Scored PG-SGA ratings had the strongest association with rehospitalization and admission to an RACF. Using a cut-off of 7, the Scored PG-SGA score showed strong sensitivity and specificity, and had substantial agreement; however, the score was not able to predict admission to an RACF. The ROC AUC for the Scored PG-SGA score against ICD-10-AM classification indicated the Scored PG-SGA score has excellent discriminative power to detect malnutrition (figure 1). The MNA showed good predictive validity, however the sensitivity and specificity were moderate, and it had the lowest agreement (kappa 0.562, 95%CI: 0.303-0.631 indicating 'moderate agreement' [25]). The MNA score's ROC AUC was considered to be a 'very good test' [24] (figure 2). The ROC analysis of the MNA score against the ICD-10-AM criteria also provided the sensitivity and specificity for coordinates of the curve (data not shown). A value of 19 provided the strongest results with sensitivity (83.3%) and specificity (74.4%), compared with current cut-off of 17 (sensitivity 57.7%, specificity 96.8%) (figure 2). The large 95%CIs of the DOR for each of the nutrition assessment tools shows the DOR is not adequately powered by the current sample size and is of little value.

Discussion

The nutrition assessment results in this sample indicate that older adults admitted to rural rehabilitation facilities have a high prevalence of malnutrition (46% according to the ICD-10-AM criteria) which is associated with increased health and aged care utilization. This is the first study investigating malnutrition prevalence in a rural rehabilitation population, and results suggest the prevalence is comparable to that reported in metropolitan areas of Australia. Three Australian metropolitan studies reported a prevalence of 6%, 29% and 30% [26-28] (using MNA score <17 for "malnourished"), compared to 28% in the current rural sample. A fourth Australian metropolitan study reported a malnutrition prevalence of 49% using the SGA (B and C ratings indicating malnutrition) [29], compared to 53% in the current sample indicated by the analogous Scored PG-SGA ratings. According to the MNA, Asia has a lower prevalence at 14 – 17%[30,31], and Europe a higher prevalence at 33 – 53%[32,33]. According to the SGA, Europe has a slightly lower prevalence of malnutrition (32 – 46%) [34,35]. All international prevalence's were reported in a metropolitan geriatric rehabilitation populations. No studies were identified reporting the malnutrition prevalence in geriatric rehabilitation in North America, South America or Africa. The Scored PG-SGA ratings considered 15 participants to be severely malnourished (rating C), however the ICD-10-AM only considered six were severely malnourished due to differences in timeframes of weight loss and the severity of muscle wasting required by each assessment method. The MNA does not categorize patients by severity of malnutrition, but reported similar numbers of patients as "malnourished" that the Scored PG-SGA ratings considered "severely malnourished".

The Scored PG-SGA score and ratings performed consistently well when compared to the ICD-10-AM classification of protein-energy malnutrition. This is the first study evaluating the diagnostic validity of the Scored PG-SGA in the rehabilitation setting. It is also the first study to evaluate a cut-off value for the Scored PG-SGA score to indicate malnutrition in older patients, as previously the score was derived for an adult medical sample only [11]. The Scored PG-SGA has not previously been evaluated for validity in a geriatric population. Previous studies evaluating the Scored PG-SGA ratings have established concurrent validity using clinical outcomes such as BMI, physical function, serum albumin and oxygen saturation as the benchmark, and the predictive validity using length of stay and rate of complications [15-17]. The comparison of the Scored PG-SGA to comprehensive criteria such as the ICD-10-AM classification of protein-energy malnutrition lends strength to the current study, showing the tool will accurately reflect diagnostic and funding criteria used throughout the health care system.

Although the MNA had a strong specificity and positive predictive value, the sensitivity could be considered poor for a diagnostic assessment tool. A previous validation study found significantly higher sensitivity (96%) of the MNA than that reported in this study when compared with physician assessment of malnutrition [7]; however, this was in an acute and community population. Neumann *et al*. [36] evaluated the MNA in a geriatric rehabilitation population against body composition, and found that the AUC was 0.74, which was lower than the current study (AUC=0.85) and the ideal cut-off value was 22.3, a much higher value than the 19 found in this study.

The MNA sensitivity could be improved by using the cut-off value of <24 to indicate malnutrition as reported in previous studies [26,27,36-38] ; however a score of 17 – 24 indicates patients at 'risk of malnutrition' and would lead to the MNA overestimating malnutrition prevalence (86% in this study). Inappropriate diagnosis is clinically significant due to the time and resource restraints of health care facilities to provide nutrition support, therefore the purpose of the nutrition assessment tool should be considered. It has been previously suggested that the MNA may be more suited to an environment focused on prevention, where a score of <24 is used to identify all patients at risk and already malnourished, as opposed to accurately identifying existing malnutrition (using a score of <17) for intervention [39-41]. Although 'risk of malnutrition' according to the MNA (scored 17 – 23.5) is associated with poor patient outcomes in an older rehabilitation population, including increased risk of institutionalization and rehospitalization and decreased physical function and quality of life [26,28], this study suggests the category of "malnourished" (score of <17) closer reflects the ICD-10-AM for diagnosing malnutrition in geriatric rehabilitation than using a score <24.

This study indicates the Scored PG-SGA and MNA have good predictive validity in regards to discharge location, rehospitalization and admission to an RACF within 12 weeks following discharge from rehabilitation. This sample had no difference in rehabilitation length of stay or readmission incidence between well-nourished and malnourished groups. There were three deaths in the malnourished group compared to none in the well-nourished group. It is likely the sample size was not powerful enough to detect a significant difference in this trend in mortality, as seen in larger studies [28]. Overall, these outcomes suggest that rural older rehabilitation patients are likely to have a high need for medical and aged care services, which may increase health care costs and impact on quality of life.

Implications for future research and clinical application

The high prevalence of malnutrition in the rural geriatric rehabilitation population is a major challenge for patients, informal caregivers and health care providers. Although the prevalence of malnutrition in rural communities is similar to that in metropolitan areas, there is decreased availability of health and aged care services [2,42]. It is therefore critical that these patients are accurately identified and engaged with nutrition support both during rehabilitation and post-discharge. This study suggests that the Scored PG-SGA ratings or a score of ≥7 can be used to accurately identify malnourished older adults in rehabilitation, and can be used to triage patients. Future research regarding the validity of the Scored PG-SGA should repeat an evaluation of the criterion validity in a larger and diverse geriatric sample and should include an evaluation of inter-rater reliability in rehabilitation. This would strengthen the results of the current study and lend more confidence to selecting the appropriate cut-off value to indicate malnutrition and triage of older inpatients in general. A direct comparison of the Scored PG-SGA and the MNA would also be of interest.

Regarding the MNA, results suggest that practitioners need to be careful to identify all malnourished older adults in rehabilitation if using the standard MNA criteria (score of <17) as "malnourished" patients may be labelled as "at risk of malnutrition". Future research should evaluate if the scoring criteria for the MNA categories should be adjusted to include a higher cut-off value to indicate patients who are "malnourished" in geriatric rehabilitation.

Limitations

A limitation of using the ICD-10-AM classification of malnutrition as the standard in this population is the BMI cut-off of $<18.5 kg/m^2$, which is likely to be too low for an older population [43,44]. This may have caused a decrease in the sensitivity of the nutrition assessment tools when compared to the ICD-10-AM classifications. While the Scored PG-SGA has shown to be useful in a variety of settings, its use is somewhat limited by the need for health care providers to receive training in its correct application to ensure inter-rater reliability due to a more complicated scoring and rating system compared to the MNA.

Although the sample size in this study was relatively small, it is unlikely to be affected by non-response bias and was powerful enough to detect differences in longitudinal health-related outcomes. The potential bias introduced by having a single researcher completing the assessments was minimized in this study using objective standardized scoring systems and having a second researcher check scores and ratings in a sub-sample of patients.

Conclusions

The prevalence of malnutrition in the geriatric rural rehabilitation population is high and is associated with increased use of health and aged care. This study suggests the Scored PG-SGA ratings and a cut-off value of ≥7 have strong concurrent and predictive validity in assessing malnutrition in the geriatric rehabilitation setting. The MNA showed good predictive validity but moderate concurrent validity as the MNA may not identify all malnourished patients as some may be labelled as “at risk of malnutrition”. Further examination of the criterion validity of the Scored PG-SGA and MNA will lend confidence to these findings.

Acknowledgements

The authors gratefully acknowledge the assistance of E. Rathbone, Bond University, for contributing to the statistical approach and interpretation of data.

Funding disclosure

This study received no specific funding. SM is supported by an Australian Postgraduate Award throughout the duration of her PhD candidature.

Conflict of interest disclosure

The authors declare no conflicts of interest. SM was employed as a dietitian for New South Wales Health which occasionally involves a short-term contract to a rehabilitation ward. SM was not working at the rehabilitation wards at the time of data collection.

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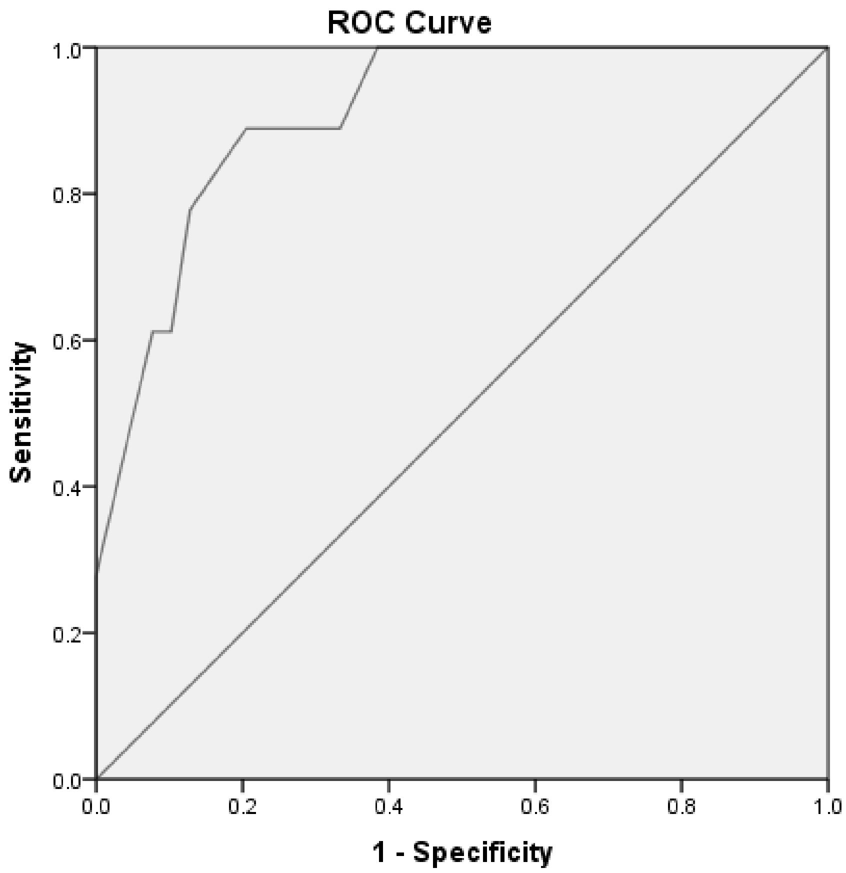

Figure 1: Receiver operating characteristics (ROC) curve plot of the true positive (sensitivity) rate against the false positive (1-specificity) rate at various cut-off values of the Scored Patient-Generated Subjective Global Assessment score compared with ICD-10-AM classification of malnutrition. The area under the curve (AUC) of 0.910±0.038 (*P*<0.0001; 95% CI: 0.836 – 0.983) with a nonparametric assumption indicates an 'excellent test' [24].

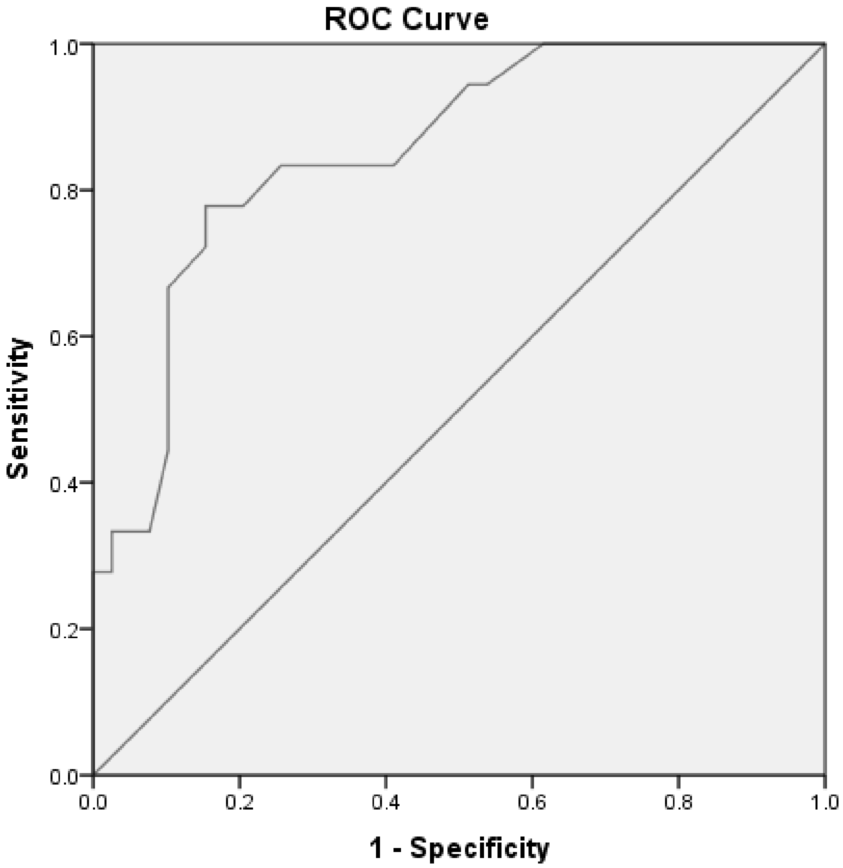

Figure 2: Receiver operating characteristics (ROC) curve plot of the true positive (sensitivity) rate against the false positive (1-specificity) rate at various cut-off values of the Mini Nutritional Assessment score compared with ICD-10-AM classification of malnutrition. The area under the curve (AUC) of 0.854±0.052 (P<0.0001; 95% CI: 0.752 – 0.956) with a nonparametric assumption indicates a 'very good test' [24].

Table 1: The International Statistical Classification of Diseases and Health Related Problems 10th Revision Australian Modification (sixth edition, ICD-10-AM) classifications for protein-energy malnutrition in adults [45]

Classification	Definition
E43: Unspecified severe protein-energy malnutrition	In adults, BMI[a] <18.5 kg[b]/m[c]2 or unintentional loss of weight (≥10%) with evidence of suboptimal intake resulting in severe loss of subcutaneous fat and/or severe muscle wasting
E44.0: Moderate protein-energy malnutrition	In adults, BMI <18.5 kg/m^2 or unintentional loss of weight (5-9%) with evidence of suboptimal intake resulting in moderate loss of subcutaneous fat and/or moderate muscle wasting
E44.1: Mild protein-energy malnutrition	In adults, BMI <18.5 kg/m^2 or unintentional loss of weight (5-9%) with evidence of suboptimal intake resulting in mild loss of subcutaneous fat and/or mild muscle wasting

[a] BMI, body mass index
[b] kg, kilogram
[c] m, meters

Table 2: Nutrition status of 57 older adults admitted to rehabilitation units in rural New South Wales, Australia, as assessed by the ICD-10-AM classification of protein-energy malnutrition, Scored Patient-Generated Subjective Global Assessment (PG-SGA) and Mini Nutritional Assessment (MNA) overall and by facility

ICD-10-AM[a] Classification of PEM[b]				
	Well-nourished	E44.1: Mild PEM	E44.0: Moderate PEM	E43: Unspecified severe PEM
Both sites (n=57)	n=31 (54.4%)	n=4 (7.0%)	n=16 (28.1%)	n=6 (10.5%)***
Site A (n=33)	n=19 (57.6%)	n=2 (6.1%)	n=6 (18.2%)	n=5 (15.2%)***
Site B (n=24)	n=12 (50.0%)	n=3 (12.5%)	n=8 (33.3%)	n=1 (4.2%)[c]

Scored PG-SGA[d]			
	Well-nourished (rated A)	Moderate or suspected malnutrition (rated B)	Severely malnourished (rated C)
Both sites (n=57)	n=27 (47.4%)	n=15 (26.3%)	n=15 (26.3%)
Site A (n=33)	n=19 (57.6%)	n=8 (24.2%)	n=6 (18.2%)
Site B (n=24)	n=8 (33.3%)	n=7 (29.2%)	n=9 (37.5%)

MNA[e]			
	Normal nutrition status (scored 24-30)	Risk of malnutrition (scored 17-23.5)	Malnourished (scored 0-16)
Both sites (n=57)	n=8 (14.0%)	n=33 (57.9%)	n=16 (28.1%)
Site A (n=33)	n=6 (18.2%)	n=22 (66.7%)	n=5 (15.2%)*
Site B (n=24)	n=2 (8.3%)	n=11 (45.8%)	n=11(45.8%)*

* Significant difference between rehabilitation centers (*P*<0.05)

*** Significant difference across nutrition status categories (*P*<0.001)

[a] ICD-10-AM, International Statistical Classification of Diseases and Health Related Problems 10th Revision Australian Modification

[b] PEM, protein energy malnutrition

[c] Significant difference across nutrition status categories (*P*=0.002)

[d] PG-SGA, Patient-Generated Subjective Global Assessment

[e] MNA, Mini Nutritional Assessment

Table 3: Health and aged care use of a sample of 57 older adults admitted to rehabilitation units in rural New South Wales, Australia, by nutrition status and in total according to the ICD-10-AM classification of protein energy malnutrition

Variable	**Well-nourished (n=31)**	**Malnourished (n=26)**	**Total participants (n=57)**
Rehabilitation LOS[a] (days), median (IQR[b])	23.0 (16.0-37.5)	22.0 (13.75-32.75)	23.0 (14.0-33.5)
Rehospitalization LOS (days), median (IQR)[c]	4.0 (1.0-14.75)	10.0 (7.0-36.0)	8.0 (2.0-28.0)[d]
Rehospitalization incidence - Median (IQR)[c]	2.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)
- Counts (%)	n=12 (38.7%)	n=11 (38.5%)	n=23 (40.4%)
Discharge location, counts (%) - Home - Other[e]	 n=27 (87.1%) n=4 (12.9%)	 n=17 (65.4%) n=9 (34.6%)	 n=44 (77%)[f] n=13 (23%)
Admitted to RACF[g], counts (%)	n=4 (12.9%)	n=7 (26.9%)	n=11 (19.3%)
Mortality, counts (%)	n=0	n=3 (11.5%)	n=3 (5.3%)[f]

[a] LOS, length of stay

[b] IQR, interquartile range

[c] Participants with no rehospitalization excluded from analysis

[d] Significant difference between nutrition status (*P*=0.032)

[e] Community-dwelling participants discharged to hospital, a residential aged care facility or to stay with family/friends

[f] Approaching significant difference between nutrition status (*P*=0.052)

[g] RACF, residential aged care facility

Table 4: Measures of diagnostic accuracy of the malnutrition assessment tools against the ICD-10-AM classification of protein-energy malnutrition in a sample of 57 older adult rural rehabilitation inpatients

	Kappa statistic	Sensitivity (%)	Specificity (%)	PPV[a] (%)	NPV[b] (%)	DOR[c]	Rehospitalization LOS[d] p-value[e]	Admission to RACF[f] p-value[g]	Discharge location p-value[g]
Scored PG-SGA[h] ratings - value - 95%CI[i]	0.860[j] 0.639-0.860	100 87.1-100	87.1 71.2-94.9	86.7 69.3-96.2	100 87.1-100	323.9[k] 16.6-6313.6	0.005	0.008	0.046
Scored PG-SGA score - value - 95%CI	0.755[l] 0.499-0.869	92.3 75.9-97.9	83.9 67.4-92.9	82.8 64.2-94.1	92.9 76.5-98.9	62.4 11.2-352.4	0.03	0.107	0.033
MNA[m] - value - 95%CI	0.562[n] 0.303-0.631	57.7 39.0-74.5	96.8 83.8-99.4	93.8 69.7-99.0	73.2 57.1-85.8	40.9 4.8-347.3	0.023	0.034	0.019

[a] PPV, positive predictive value

[b] NPV, negative predictive value

[c] DOR, diagnostic odds ratio

[d] LOS, length of stay

[e] Chi-square test

[f] RACF, residential aged care facility

[g] Mann-U Whitney test

[h] PG-SGA, Patient-Generated Subjective Global Assessment

[i] CI, confidence interval

[j] *P* <0.0001, "almost perfect agreement" as per Landis and Koch kappa statistic classification [25]

[k] The false negative values for the PG-SGA-rating compared with the ICD-10-AM criteria were zero. However, due to the problems with computation of odds ratios with a zero value, each cell in the contingency table had 0.5 added [46-48].

[l] *P* <0.0001, "substantial agreement" as per Landis and Koch kappa statistic classification [25]

[m] MNA, Mini Nutritional Assessment

[n] *P* <0.0001, "moderate agreement" as per Landis and Koch kappa statistic classification [25]

Practice implications

What is the current knowledge on this topic?

The prevalence and health-related outcomes of older adults in rural rehabilitation units is unknown. Regarding nutrition assessment tools, there is a need for evidence of the criterion validity of the Scored PG-SGA and MNA.

How does this research add to knowledge on this topic?

In geriatric rehabilitation, this is the first study to: report rural malnutrition prevalence & health-related outcomes, assess the criterion validity of Scored PG-SGA, evaluate a cut-off value for the Scored PG-SGA, and evaluate the MNA compared to a multidimensional benchmark.

How might this knowledge impact current dietetics practice?

Outcomes may be used for health care policy development and review of resource allocation. Use of the scored PG-SGA in the geriatric rehabilitation setting is supported, and use of the MNA may be suitable for well-resourced facilities.