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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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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)

Background: Accurate identification and management of malnutrition is essential so that 1 2 patient outcomes may be improved and resources used efficaciously. **Objectives:** In malnourished older adults admitted to rehabilitation: 1) report the prevalence, health and aged 3 care use, and mortality of malnourished older adults; 2) determine and compare the criterion 4 (concurrent and predictive) validity of the Scored Patient-Generated Subjective Global 5 6 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. 7 **Design**: Observational, prospective cohort. **Participants/setting**: n=57 older adults ≥ 65 years 8 9 (y), mean age 79.1y (\pm 7.3y) from two rural rehabilitation units in New South Wales, 10 Australia. Measurements/statistical analysis: Scored PG-SGA, MNA and ICD-10-AM 11 classification of malnutrition were compared to establish concurrent validity and report malnutrition prevalence. Length of stay (LOS), discharge location, rehospitalization, 12 13 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 14 varied according to assessment tool (ICD-10-AM: 46%; Scored PG-SGA: 53%; MNA: 28%). 15 Using ICD-10-AM as the reference standard, the Scored PG-SGA ratings (sensitivity 100%, 16 specificity 87%) and score (sensitivity 92%, specificity 84%, ROC AUC 0.910±0.038) 17 18 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-19 SGA score and MNA showed good predictive validity. Malnutrition may increase the risk of 20 longer readmission LOS, admission to an RACF and discharge to hospital or RACF instead 21 of home. Conclusion: Malnutrition prevalence in the geriatric rural rehabilitation population 22 is high and associated with increased health and aged care use. The Scored PG-SGA ratings 23

- 24 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
- 27 Scored PG-SGA and MNA will lend confidence to these findings.

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31 Introduction

The physiological and psychosocial consequences of malnutrition are significant and diverse. 32 In health care facilities, malnutrition increases morbidity, mortality and incidence of 33 complications. Overall this leads to increased treatment costs and length of stay ^{1,2}. Common 34 symptoms of malnutrition, such as confusion, fatigue and weakness, are often attributed to 35 other conditions leading to frequent misdiagnosis and under-recognition of malnutrition³. 36 37 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 38 of malnutrition in rural rehabilitation facilities, as opposed to metropolitan facilities, has not 39 been reported 4 . 40

41 Accurate identification, management and monitoring of malnutrition are essential steps in the 42 nutrition care process so that patient outcomes may be improved and resources used efficaciously⁵. Nutrition assessment is often completed through the application of a nutrition 43 assessment tool. Unlike nutrition screening tools, nutrition assessment tools can be used to 44 make a diagnosis of malnutrition by medical staff or a dietitian ⁶. However, the tool chosen 45 should be validated for the population to which it is applied. In the rehabilitation setting, 46 there are only two nutrition assessment tools which have been evaluated for validity. These 47 include the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment 48 (MNA)⁴. The MNA was designed specifically for an older population, and is perhaps the 49 most widely reported nutrition assessment tool in the literature across health care settings 4,7,8 ; 50 however, both the MNA and SGA lack sensitivity to show changes in nutrition status over a 51 short period of time, such as during hospital and rehabilitation admissions⁹. The Scored 52

53 Patient-Generated Subjective Global Assessment (PG-SGA) was adapted from the SGA and includes seven components for assessment: weight, food intake, nutrition impact symptoms, 54 activities and function, medical condition, metabolic stress and physical examination⁹. The 55 questions regarding short-term weight loss and nutrition impact symptoms increase the 56 Scored PG-SGA's sensitivity to changes in nutrition status over a short period of time ^{9,10}. 57 The Scored PG-SGA provides a global rating of nutrition status for a nutritional diagnosis as 58 well as a continuous numerical score for intervention triage ^{11,12}. Since its development, the 59 Scored PG-SGA has shown to be appropriate for use in oncology, acute medical, renal, 60 stroke, neurology and respiratory patients as well as the residential aged care setting ¹³⁻¹⁸. The 61 Scored PG-SGA has not been evaluated in the rehabilitation setting nor in an older adult 62 population. Therefore, in the older adult rural rehabilitation population, the aims of this study 63 64 were to: 1) report the prevalence, health and aged care use, and mortality of malnourished 65 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-66 SGA score cut-off value associated with malnutrition. 67

68 Materials and methods

69 *Study sample*

Participants consecutively admitted to one of two public rehabilitation units in rural ¹⁹ New 70 South Wales, Australia, were approached to participate if they were: English-speaking 71 inpatients \geq 65 years (y), lived in the community prior to admission and had an informal 72 caregiver. Patients were only included if they were admitted with the expectation they would 73 74 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 75 76 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 77 received ethical and governance approval (North Coast NSW Human Research Ethics 78 79 Committee: LNR 063, G108; School of Human Movement Studies Ethics Committee: 80 HMS13/0731). Written informed consent was obtained from all participants and/or their guardians. 81 Data collection 82 Outcome measurement tools, including all components of the Scored PG-SGA, were 83 completed on behalf of the participant by the primary researcher (Accredited Practising 84 Dietitian) and were informed by interview with the patient, their caregivers, rehabilitation 85

86 staff and consultation of medical notes.

87 *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 PGSGA 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 98 99 Revision Australian Modification (sixth edition, ICD-10-AM) criteria are the recognized standard diagnostic criteria in Australia for the diagnosis, documentation and diagnostic 100 101 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 102 intake and a physical assessment of fat and/or muscle wasting. As these criteria are used in 103 104 Australian hospitals to provide case-mix funding reimbursements, failure to identify and 105 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 106 the ICD-10-AM criteria to ensure that resources are available for treatment. As there is no 107 gold standard for diagnosing malnutrition, the criterion validity (i.e. the concurrent and 108 predictive validity) of a diagnostic tool must be established. In this study, the ICD-10-AM 109 classification was used as the reference standard for malnutrition as it is the agreed upon 110 standard in the Australian health care setting, and has recently been used as the standard 111 against which nutritional screening and assessment tools have been validated ^{21,22}. The 112 Scored PG-SGA components of current weight, height, one or six month weight loss and 113 assessment of fat stores and muscle status were used to inform the ICD-10-AM classification 114 of malnutrition for each participant. Weight (kg) was measured by the primary researcher 115 using Tanita InnerScan Body Composition Monitor scales model: BC-541 (2005, Tanita 116 Corporation, Tokyo, Japan) or rehabilitation wards scales (chair or roll-on scales) for non-117

weight 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.

120 *Health and aged care service use*

A range of variables were chosen to represent rehabilitation outcome, health service use and 121 patient wellbeing. These included discharge location [home/other: hospital, residential aged 122 care facility (RACF), or friend/family] and rehabilitation length of stay (days) upon 123 124 discharge; and rehospitalization incidence (number of acute care and rehabilitation readmissions), rehospitalization length of stay (total days of all subsequent rehabilitation and 125 acute admissions), admission to an RACF (yes/no) and death (yes/no) at 12 weeks post-126 127 discharge. Data were obtained from the health service's electronic admissions database and confirmed by telephone or in-home interviews. 128

129 *Statistical approach*

All statistical analysis was completed using SPSS Version 22.0 2013 [IBM SPSS Statistics 130 131 for Windows. Armonk, NY: IBM Corp.]. Significance was considered at the P < 0.05 level. 132 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 133 nutrition status categories according to each nutrition assessment method. For examination of 134 the criterion validity and to report prevalence, nutrition status was considered as binary 135 variables, and therefore collapsed into 'well-nourished' and 'malnourished' for each tool and 136 the diagnostic criteria. Only patients with existing malnutrition and not risk of malnutrition 137 were considered 'malnourished' in order to evaluate a tools ability to diagnose existing 138 malnutrition. Therefore, 'malnourished' ratings were given for Scored PG-SGA ratings of B 139 and C, MNA score <17 and any participant meeting the ICD-10-AM criteria of E43 (severe 140 malnutrition), E44.0 (moderate malnutrition) or E44.1 (mild malnutrition) (as per table 1). In 141 142 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 "wellnourished".

147 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

150 contingency tables against the ICD-10-AM classification of malnutrition. The Scored PG-

151 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

153 provides an assessment on the discriminative power of a test, where an ROC area under the

154 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

156 test and <0.5 of no use ²⁴.

157 Any longitudinal outcome with results significantly different between the well-nourished and

158 malnourished groups according to the ICD-10-AM criteria was used to evaluate the

159 predictive validity of the Scored PG-SGA and MNA using the Mann-Whitney U test and chi-

160 square test. Participants who did not have any readmissions were excluded from the

161 rehospitalization length of stay analysis.

163 **Results**

164 *Study participants*

165 Over the study recruitment period, 57 consecutive rehabilitation inpatients consented to

166 participate in the study (response rate of 98%). The sample was 49% female, with a mean age

167 of 79.1y $(\pm 7.3y)$, 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,

169 unpublished data).

170 Nutrition status and health-related patient outcomes

Malnutrition prevalence varied according to nutrition assessment method, where the ICD-10-171 AM criteria determined 46% were malnourished, the Scored PG-SGA ratings determined 172 53% were malnourished and the MNA determined 28% were malnourished with a further 173 58% at risk of malnutrition (table 2). The median Scored PG-SGA score was 7.0 (IQR: 3-174 11.5). Rehabilitation length of stay excluded three participants who had emergency 175 admissions to acute care. According to the ICD-10-AM classification of malnutrition, 176 177 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 178 patients also had a higher incidence of admission to an RACF within 12 weeks (P=0.052) 179 and a lower incidence of discharge to home, as more were discharged to hospital, an RACF 180 or to stay with family or friends (P=0.052). Three malnourished participants died following 181 discharge from rehabilitation; there were no deaths in the well-nourished group. 182

183

184 The Scored Patient-Generated Subjective Global Assessment score to indicate malnutrition 185 The sensitivity and specificity for coordinates of the curve (cut-off values) were provided for 186 the average of two test values (Scored PG-SGA scores which are whole numbers), where 7.5 187 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.

195 Concurrent and predictive validity of the Scored Patient-Generated Subjective Global

196 Assessment and Mini Nutritional Assessment tools

Results of the contingency table analysis for Scored PG-SGA ratings, Scored PG-SGA score 197 and MNA against the ICD-10-AM criteria and their predictive validity are presented in table 198 4. The Scored PG-SGA ratings showed strong diagnostic accuracy, with perfect sensitivity, 199 good specificity and 'almost perfect' agreement ²⁵. In addition, the Scored PG-SGA ratings 200 had the strongest association with rehospitalization and admission to an RACF. Using a cut-201 off of 7, the Scored PG-SGA score showed strong sensitivity and specificity, and had 202 substantial agreement; however, the score was not able to predict admission to an RACF. The 203 ROC AUC for the Scored PG-SGA score against ICD-10-AM classification indicated the 204 Scored PG-SGA score has excellent discriminative power to detect malnutrition (figure 1). 205 The MNA showed good predictive validity, however the sensitivity and specificity were 206 207 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 208 test' ²⁴ (figure 2). The ROC analysis of the MNA score against the ICD-10-AM criteria also 209 provided the sensitivity and specificity for coordinates of the curve (data not shown). A value 210 of 19 provided the strongest results with sensitivity (83.3%) and specificity (74.4%), 211 compared with current cut-off of 17 (sensitivity 57.7%, specificity 96.8%) (figure 2). The 212

213 large 95%CIs of the DOR for each of the nutrition assessment tools shows the DOR is not214 adequately powered by the current sample size and is of little value.

215 Discussion

The nutrition assessment results in this sample indicate that older adults admitted to rural 216 rehabilitation facilities have a high prevalence of malnutrition (46% according to the ICD-10-217 AM criteria) which is associated with increased health and aged care utilization. This is the 218 219 first study investigating malnutrition prevalence in a rural rehabilitation population, and results suggest the prevalence is comparable to that reported in metropolitan areas of 220 Australia. Three Australian metropolitan studies reported a prevalence of 6%, 29% and 30% 221 ²⁶⁻²⁸ (using MNA score <17 for "malnourished"), compared to 28% in the current rural 222 sample. A fourth Australian metropolitan study reported a malnutrition prevalence of 49% 223 using the SGA (B and C ratings indicating malnutrition)²⁹, compared to 53% in the current 224 225 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 $33 - 53\%^{32,33}$. 226 227 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 228 populations. No studies were identified reporting the malnutrition prevalence in geriatric 229 230 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 231 only considered six were severely malnourished due to differences in timeframes of weight 232 loss and the severity of muscle wasting required by each assessment method. The MNA does 233 not categorize patients by severity of malnutrition, but reported similar numbers of patients as 234 "malnourished" that the Scored PG-SGA ratings considered "severely malnourished". 235 The Scored PG-SGA score and ratings performed consistently well when compared to the 236

237 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 238 study to evaluate a cut-off value for the Scored PG-SGA score to indicate malnutrition in 239 older patients, as previously the score was derived for an adult medical sample only ¹¹. The 240 Scored PG-SGA has not previously been evaluated for validity in a geriatric population. 241 Previous studies evaluating the Scored PG-SGA ratings have established concurrent validity 242 using clinical outcomes such as BMI, physical function, serum albumin and oxygen 243 244 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 245 246 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 247 the health care system. 248

Although the MNA had a strong specificity and positive predictive value, the sensitivity 249 250 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 251 compared with physician assessment of malnutrition ⁷; however, this was in an acute and 252 community population. Neumann et al. ³⁶ evaluated the MNA in a geriatric rehabilitation 253 population against body composition, and found that the AUC was 0.74, which was lower 254 255 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. 256

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 263 a score of <24 is used to identify all patients at risk and already malnourished, as opposed to 264 accurately identifying existing malnutrition (using a score of <17) for intervention ³⁹⁻⁴¹. 265 Although 'risk of malnutrition' according to the MNA (scored 17 - 23.5) is associated with 266 poor patient outcomes in an older rehabilitation population, including increased risk of 267 institutionalization and rehospitalization and decreased physical function and quality of life 268 26,28 , this study suggests the category of "malnourished" (score of <17) closer reflects the 269 ICD-10-AM for diagnosing malnutrition in geriatric rehabilitation than using a score <24. 270

This study indicates the Scored PG-SGA and MNA have good predictive validity in regards 271 272 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 273 readmission incidence between well-nourished and malnourished groups. There were three 274 275 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 276 mortality, as seen in larger studies ²⁸. Overall, these outcomes suggest that rural older 277 rehabilitation patients are likely to have a high need for medical and aged care services, 278 which may increase health care costs and impact on quality of life. 279

280 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 \geq 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.

299 Limitations

A limitation of using the ICD-10-AM classification of malnutrition as the standard in this population is the BMI cut-off of <18.5kg/m², 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 healthrelated 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.

313 Conclusions

314	The prevalence of malnutrition in the geriatric rural rehabilitation population is high and is
315	associated with increased use of health and aged care. This study suggests the Scored PG-
316	SGA ratings and a cut-off value of \geq 7 have strong concurrent and predictive validity in
317	assessing malnutrition in the geriatric rehabilitation setting. The MNA showed good
318	predictive validity but moderate concurrent validity as the MNA may not identify all
319	malnourished patients as some may be labelled as "at risk of malnutrition". Further
320	examination of the criterion validity of the Scored PG-SGA and MNA will lend confidence to
321	these findings.
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330	The authors declare no conflicts of interest. SM was employed as a dietitian for New South
331	Wales Health which occasionally involves a short-term contract to a rehabilitation ward. SM
332	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 proteinenergy malnutrition in adults ⁴⁵

Classification	Definition
E43: Unspecified severe	In adults, BMI ^a <18.5 kg ^b /m ^{c2} or unintentional loss of weight
protein-energy	$(\geq 10\%)$ with evidence of suboptimal intake resulting in severe
malnutrition	loss of subcutaneous fat and/or severe muscle wasting
E44.0: Moderate	In adults, BMI <18.5 kg/m ² or unintentional loss of weight (5-
protein-energy	9%) with evidence of suboptimal intake resulting in moderate
malnutrition	loss of subcutaneous fat and/or moderate muscle wasting
E44.1: Mild protein-	In adults, BMI <18.5 kg/m ² or unintentional loss of weight (5-
energy malnutrition	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 NewSouth Wales, Australia, as assessed by the ICD-10-AM classification of protein-energymalnutrition, Scored Patient-Generated Subjective Global Assessment (PG-SGA) and MiniNutritional Assessment (MNA) overall and by facility

ICD-10-AM ^a Classification of PEM ^b							
	Well-nourished	E44.1: Mild		E44.0: Moderate		E43: Unspecified	
			PEM	PEM		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		Moderate or suspected		Severely malnourished		
	(rated A)	malnutritio		n (rated B)		(rated C)	
Both sites							
(n=57)	=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		Risk of malnutrition		Malnourished		
	status (scored 24-30)		(scored 17-23.5)		(scored 0-16)		
Both sites							
(n=57)	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	n=27 (87.1%)	n=17 (65.4%)	n=44 (77%) ^f		
- Other ^e	n=4 (12.9%)	n=9 (34.6%)	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	Rehospitalization LOS ^d p-value ^e	Admission to RACF ^f p-value ^g	Discharge location p-value ^g
Scored									
PG-SGA ⁿ									
ratings	0.000	100	07 1	967	100	222 ok	0.005	0.000	0.046
- value	0.860	100	8/.1	80.7	100	323.9	0.005	0.008	0.046
- 95%CI	0.639-	87.1-	71.2-	69.3-	87.1-	16.6-			
	0.860	100	94.9	96.2	100	6313.6			
Scored									
PG-SGA									
score									
- value	0.755^{1}	92.3	83.9	82.8	92.9	62.4	0.03	0.107	0.033
- 95%CI	0.499-	75.9-	67.4-	64.2-	76.5-	11.2-			
	0.869	97.9	92.9	94.1	98.9	352.4			
MNA ^m									
- value	0.562^{n}	57.7	96.8	93.8	73.2	40.9	0.023	0.034	0.019
- 95%CI	0.303-	39.0-	83.8-	69.7-	57.1-	4.8-			
	0.631	74.5	99.4	99.0	85.8	347.3			

^a PPV, positive predictive value

^b NPV, negative predictive value

^c DOR, diagnostic odds ratio

^dLOS, length of stay

^eChi-square test

^fRACF, residential aged care facility

^g Mann-U Whitney test

^h PG-SGA, Patient-Generated Subjective Global Assessment

ⁱ CI, confidence interval

 $^{\rm j}$ 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.

 1P <0.0001, "substantial agreement" as per Landis and Koch kappa statistic classification 25 m MNA, Mini Nutritional Assessment

 $^{\rm n}P$ <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.