

The malnutrition screening tool in geriatric rehabilitation: A comparison of validity when completed by health professionals with and without malnutrition screening training has implications for practice

Marshall, Skye; Young, Adrienne; Isenring, Elizabeth

Published in:
Journal of the Academy of Nutrition and Dietetics

DOI:
[10.1016/j.jand.2017.03.019](https://doi.org/10.1016/j.jand.2017.03.019)

Licence:
CC BY-NC-ND

[Link to output in Bond University research repository.](#)

Recommended citation(APA):
Marshall, S., Young, A., & Isenring, E. (2018). The malnutrition screening tool in geriatric rehabilitation: A comparison of validity when completed by health professionals with and without malnutrition screening training has implications for practice. *Journal of the Academy of Nutrition and Dietetics*, 118(1), 118-124.
<https://doi.org/10.1016/j.jand.2017.03.019>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

For more information, or if you believe that this document breaches copyright, please contact the Bond University research repository coordinator.

1 **The Malnutrition Screening Tool (MST) in geriatric rehabilitation: A comparison of**
2 **validity when completed by health professionals with and without malnutrition screening**
3 **training has implications for practice.**

4 Skye Marshall^{a,b}, Adrienne Young^c, Elizabeth Isenring^d

5 ^a BNutr&Diet(Hons), PhD, Accredited Practising Dietitian (Australian certified), Faculty of
6 Health Sciences and Medicine, Bond University, Robina, Queensland, 4226, Australia.

7 ^b Corresponding author. Bond Institute of Health and Sport, Robina, Queensland, 4226,
8 Australia. Telephone: +61 7 5595 5530, Fax: +61 7 5595 3524, skye_marshall@bond.edu.au

9 ^c BHlthSci (Nutr&Diet) (Hons), PhD, Accredited Practising Dietitian (Australian certified),
10 Nutrition and Dietetics, Royal Brisbane and Women's Hospital, Herston, Queensland, 4029,
11 Australia

12 ^d Professor of Nutrition & Dietetics, PhD, Advanced Accredited Practising Dietitian
13 (Australian certified), Faculty of Health Sciences and Medicine, Bond University, Robina,
14 Queensland, 4226, Australia.

15 **Keywords:** validity, reliability, malnutrition screening tool, protein-energy malnutrition,
16 rehabilitation

17 **Abstract word count: 296**

18 **Manuscript body word count: 2,929**

19

20

21

22

23

24

25

26 **Abstract**

27 **Background:** The validity of the Malnutrition Screening Tool (MST) in geriatric rehabilitation
28 has been evaluated in a research environment; however, not in professional practice.

29 **Objectives:** In older adults admitted to rehabilitation, this study was undertaken to: 1) compare
30 the MST scoring agreement (inter-rater reliability) between health professionals with and
31 without malnutrition risk and screening training, 2) evaluate the concurrent validity of the
32 MST completed by the trained and untrained health professionals compared to the ICD-10-AM
33 using different MST score cut-offs, and 3) determine if patient characteristics were associated
34 with MST scoring accuracy when completed by untrained health professionals.

35 **Design:** Observational, cross-sectional.

36 **Participants/setting:** n=57 older adults, mean 79.1 years (± 7.3 years) were recruited from
37 August 2013 to February 2014 from two rural rehabilitation units in New South Wales,
38 Australia.

39 **Main outcome measurements:** MST, ICD-10-AM classification of malnutrition.

40 **Statistical analysis performed:** Measures of diagnostic accuracy generated from a
41 contingency table, receiver operating characteristic curve and Spearman's correlation.

42 **Results:** The MST scores completed by trained and untrained health professionals showed
43 moderate correlation and fair agreement (r_s : .465, $P=0.001$; kappa=0.297, $P=0.028$). When
44 compared to the ICD-10-AM, the untrained MST administration showed moderate diagnostic
45 accuracy (sensitivity 56.5%, specificity 83.3%) but increasing the MST score to ≥ 3 caused the
46 sensitivity of both the trained and untrained MST administration to decrease (56.5% and 22.9%
47 respectively).

48 **Conclusion:** The application of the MST by untrained health professionals in rehabilitation
49 may not provide sufficient accuracy in identifying patients with malnutrition risk. Using an

50 MST score of ≥ 2 to indicate malnutrition risk is recommended, as increasing the MST cut-off
51 score to ≥ 3 is likely to have insufficient accuracy even when completed by trained health
52 professionals. Research evaluating the impact of providing rehabilitation staff with regular and
53 ongoing training in completing malnutrition screening and referral pathways is warranted.

54

55 **Introduction**

56 In recognition of the high prevalence (45-65%) and poor outcomes of older patients with
57 protein-energy malnutrition (herein referred to as “malnutrition”) in sub-acute rehabilitation
58 units¹⁻³, best-practice guidelines recommend malnutrition screening upon admission⁴⁻⁷. In
59 response, screening for nutritional problems upon admission to a health care facility is
60 mandated by Joint Commission on Accreditation of Healthcare Organizations in the United
61 States of America⁸. The Malnutrition Screening Tool (MST) is a nutrition screening tool
62 commonly used at admission to acute and sub-acute health facilities to evaluate risk of
63 malnutrition and initiate a nutrition care pathway including referral to a dietitian^{4,9}.

64 The MST consists of two questions: “have you/the patient lost weight recently without trying”
65 (scored 0-4), and “have you/the patient been eating poorly because of a decreased appetite
66 (<3/4 of usual intake and, may also be due to chewing and swallowing problems)” (scored 0-
67 1). Thus the MST provides a continuous score of 0-5, where a score of ≥ 2 indicates risk of
68 malnutrition and need for full nutrition assessment via dietetic referral¹⁰. The MST is a low
69 cost and low burden screening tool, where no physical measurements are required, and can be
70 completed by any person, including the patient for self-assessment. The MST was originally
71 developed in acute care patients, and has also shown moderate to strong concurrent validity in
72 oncology outpatients, aged care residents, older hip-fracture acute care inpatients, and most
73 recently in older rehabilitation patients^{9,11-18}. In these diagnostic accuracy studies, the MST was
74 completed for research purposes by health professionals (dietitians, nurses, nutrition assistants
75 and public health researchers) who have received education regarding malnutrition and training
76 in malnutrition screening techniques. Therefore, accuracy of tool completion by health
77 professionals in the practice setting, as well as the inter-rater reliability of the tool, is of interest
78 as poor screening accuracy may have significant negative impacts on patient outcomes as well
79 as costs to the health care facility¹⁸. Of additional interest in the rehabilitation setting, some

80 facilities will now refer to the dietitian upon an MST score of ≥ 3 , where a patient with a score
81 of 2 is placed on a standardized high-protein, high-energy diet code and monitored by nurses¹⁹.
82 There has been no evaluation of using an MST score of ≥ 3 to indicate need for a dietetic
83 referral.

84 Therefore, in older adults admitted to rehabilitation, this study was undertaken to: 1) compare
85 the MST scoring agreement (inter-rater reliability) between health professionals with and
86 without malnutrition risk and screening training, 2) evaluate the concurrent validity of the MST
87 completed by the trained and untrained health professionals compared to the ICD-10-AM using
88 different MST score cut-offs, and 3) determine if patient characteristics were associated with
89 MST scoring accuracy when completed by untrained health professionals.

90 **Materials and methods**

91 An observational cross-sectional study was undertaken from August 2013 to February 2014 in
92 two publicly-funded rural rehabilitation units in New South Wales, Australia. This study was
93 conducted as part of the MARRC (Malnutrition in the Australian Rural Rehabilitation
94 Community) Study, registered at the Australian New Zealand Clinical Trials Registry (trial
95 version 2.0, 9 May 2013; ACTRN12613000518763), and received ethical and governance
96 approval (North Coast NSW Human Research Ethics Committee: LNR063, G108). Written
97 informed consent was obtained from all participants and/or their guardians.

98 *Study sample*

99 The study sample has been described in detail elsewhere¹³. Briefly, 57 community-dwelling
100 older adults (≥ 65 years) were consecutively sampled in two public rehabilitation units in rural
101 New South Wales, Australia²⁰. The sample size reflects the number of eligible and consenting
102 participants in the recruitment period (consent rate 98%). Participants were recruited if they

103 were admitted with the expectation they would return to the community, and had an
104 informal/family caregiver.

105 *Data collection*

106 All data collection including a full nutrition assessment was completed by the primary
107 researcher (an Accredited Practising Dietitian [Australian certified], referred to as the trained
108 health professional) at bedside (median 2 days following admission), except for the MST
109 completed by nursing staff as part of usual care (referred to as the “untrained-MST”).
110 Assessment was informed by medical notes and participant or family caregiver report. The
111 primary researcher obtained weight and height measurements using calibrated scales and a
112 sliding knee-height caliper, which was used to measure the knee height. Knee height was then
113 entered into a population specific formula to estimate the true height²¹. Participant
114 characteristics which were used to determine association with the accuracy of the untrained-
115 MST were age, gender, marital status, highest level of education attained, living alone, reason
116 for admission (acute/chronic condition), source of admission (acute care/community),
117 dentures, being on a pension, English as first language, ethnicity, religion, body mass index
118 (BMI; kg/m²) and BMI weight category (normal BMI for older adults was considered 22kg/m²
119 to 27kg/m², <22kg/m² was considered underweight, and >27kg/m² overweight/obese)²².

120 *Nutrition screening and assessment*

121 In both units, nursing staff completed the MST during a full “admission assessment” which
122 also included items related to demographics, care needs, falls risk, and initial care plans. The
123 nurses received no specific training on completion of the MST as part of the study nor as part
124 of usual care, and were blinded to results of how the trained health professional completed the
125 MST (referred to as the “trained-MST”). Upon the new appointment of nurses in the
126 rehabilitation units, the nurses received a brief introduction to the MST and dietetics referral
127 pathway, by the clinical nurse educator (site A) or nursing colleagues (site B), which used no

128 standardized screening training or malnutrition education program. At time of data collection,
129 the sampled rehabilitation units were still recommended to refer to the dietitian upon an MST
130 score of ≥ 2 .

131 The full nutrition assessment completed by the trained health professional was used to inform
132 the trained-MST and the International Classification for Diseases, 10th revision, Australian
133 Modification (ICD-10-AM) classification of protein-energy malnutrition²³. As there is no gold
134 standard for diagnosing malnutrition, the ICD-10-AM criteria was selected as the reference
135 measure to diagnose “malnutrition” as it is the recognized standard diagnostic criteria for the
136 identification, documentation and coding of protein-energy malnutrition and is used to provide
137 case-mix funding reimbursements in Australia. The ICD-10-AM considers a patient as
138 malnourished if they a) have a BMI $< 18.5 \text{ kg/m}^2$, or b) have unintentional weight loss of $\geq 5\%$
139 with evidence of suboptimal dietary intake as well as evidence of loss of subcutaneous fat
140 and/or muscle²³. For the MST scoring recommended by the original developers of the tool, a
141 score of 0-1 indicated “no malnutrition risk”, and a score of ≥ 2 indicated “malnutrition risk”
142 (referred to as the trained-MST and untrained-MST)⁹. To test the validity of using a higher cut-
143 off (MST ≥ 3), patients were re-classified, with a score of 0-2 indicating “no malnutrition risk”,
144 and ≥ 3 indicating “malnutrition risk” (referred to as the “altered-trained-MST” and “altered-
145 untrained-MST”).

146 *Statistical approach*

147 All statistical analysis was completed using SPSS Statistics 24²⁴. Significance was considered
148 at the $P < 0.05$ level two tailed. Normality of the trained-MST and untrained-MST was tested
149 using the Shapiro-Wilk test, and descriptive statistics were used to summarize the results of the
150 MST (patient characteristics reported previously¹³).

151 To compare the trained-MST and untrained-MST continuous scores, a Spearman's rank-order
152 correlation coefficient was used. A weighted Cohen's kappa coefficient was used to compare
153 the trained-MST and untrained-MST to evaluate how much of the difference between the two
154 tests was due to error variance (true differences between raters) for "no malnutrition risk" or
155 "malnutrition risk".

156 The concurrent validity (comparison of the score of a new measure to that of an established
157 measure) of the trained-MST has been reported previously¹³. To evaluate the concurrent
158 validity of the untrained-MST, altered-untrained-MST and altered-trained-MST, contingency
159 tables were produced and the sensitivity, specificity, positive predictive value (PPV), negative
160 predictive value (NPV) and weighted Cohen's kappa statistic, with 95% confidence intervals
161 (CIs) were reported. The ICD-10-AM classification for protein energy malnutrition in adults
162 was used as the reference standard against which the MST was compared in the contingency
163 table. In line with previous research, we set a minimum value of 80% for sensitivity and 60%
164 for specificity to indicate a good nutrition screening tool^{9,13}. The trained-MST and untrained-
165 MST continuous scores were further assessed against the ICD-10-AM classification of
166 malnutrition using a Receiver Operating Characteristic (ROC) curve. An ROC curve provides
167 an assessment on the discriminative power of a test score, with an ROC area under the curve
168 (AUC) on a scale of 0.0 (no clinical use) to 1.0 (excellent test)²⁵.

169 To determine if participant characteristics were associated with the correct/accurate completion
170 of the MST by untrained health professionals, the untrained-MST was dichotomized as
171 "correct" or "incorrect" if the score indicated "agreement" or "no agreement" with the ICD-
172 10-AM classification of malnutrition respectively. Participant characteristics were also tested
173 for association with missing cases, (no untrained-MST documented). Associations were tested
174 using the chi-square test and independent t-test.

175 **Results**

176 The participants were $\mu 79.1 \pm 7.3$ years of age and 49% female. The majority were admitted by
177 transfer from an acute care hospital (86.0%) for an acute condition (73.7%). At admission, the
178 mean BMI was $25.0 \pm 5.7 \text{ kg/m}^2$, and according to the ICD-10-AM, 45.6% of the participants
179 were malnourished. The untrained health professionals documented the MST for 47 (82.5%)
180 participants. The median untrained-MST was 0 (IQR: 0.0-2.0), indicating that more than half
181 of the participants were documented as having an MST score of 0 by the untrained health
182 professionals, and 17 (36.2%) were documented as at risk of malnutrition (MST score ≥ 2).
183 However, the altered-untrained-MST (MST score ≥ 3) only considered five participants as at
184 risk of malnutrition (8.8%). The trained-MST was completed for all participants with a median
185 score of 2 (interquartile range (IQR): 0.5-3.0), where 54.4% were at risk of malnutrition. This
186 was reduced to 35.1% being considered at risk of malnutrition using the altered-trained-MST.
187 Both the trained-MST and untrained-MST were not normally distributed; however, only the
188 untrained-MST had a statistically significant positive skew (skewness: 0.920, standard error
189 (SE): 0.347, $P < 0.01$). The trained-MST and untrained-MST showed moderate correlation (r_s :
190 0.465, $P = 0.001$) and fair agreement (kappa=0.297, $P = 0.028$, 95%CI: 0.046-0.548). The
191 altered-trained-MST and altered-untrained-MST also showed fair agreement (kappa=0.322,
192 $P = 0.003$, 95%CI: 0.091-0.553).

193 The results of the diagnostic accuracy (concurrent validity) of the untrained-MST, altered-
194 untrained-MST and altered-trained-MST are reported in table 1. The concurrent validity of the
195 trained-MST, although reported previously, is also included in table 1 for the purposes of
196 comparison. Of the ten participants in which untrained health professionals failed to complete
197 and document the MST score, three (30%) were malnourished according to the ICD-10-AM.
198 The trained-MST showed moderate agreement with the ICD-10-AM, where the untrained-
199 MST only showed fair agreement (kappa=0.478, $P < 0.001$ versus kappa=0.401, $P = 0.004$

200 respectively). The agreement with the ICD-10-AM was reduced in both altered MST versions
201 (MST score ≥ 3), but particularly for the altered-untrained-MST ($\kappa=0.221$, $P<0.016$,
202 95%CI: 0.045-0.397). Except for the trained-MST, no tool met the a-priori value of $\geq 80\%$ for
203 sensitivity to identify malnutrition risk (true positive). The altered-trained-MST and altered-
204 untrained-MST both revealed an increase in specificity from the original scoring; however, the
205 sensitivity was lowered, indicating a significant risk of under-recognizing the risk of
206 malnutrition (increased risk of false negatives).

207 When considered as a continuous score, the trained-MST was considered a “very good test”²⁵
208 when compared to the ICD-10-AM (ROC area under the curve (AUC): $0.805 \pm \text{S.E.:}0.058$,
209 $P<0.001$; 95% CI: 0.692 – 0.919). The ROC AUC of the untrained-MST was poor (ROC AUC:
210 $0.681 \pm \text{S.E.:}0.080$, $P<0.033$; 95% CI: 0.524 – 0.838), falling into the ROC AUC category
211 “sufficient test without much value in the clinical setting”²⁵. The coordinates of the curve
212 produced by the ROC test (table 2) suggests that the best MST score to identify risk of
213 malnutrition, when used by a trained health professional, is an MST score of 2 as per the
214 original development of the tool⁹. However, no untrained-MST score had enough sensitivity to
215 meet the a-priori minimum sensitivity of 80%.

216 No participant characteristics were associated with the untrained-MST correctly identifying
217 “malnutrition risk” according to the ICD-10-AM (data not shown, all tests $P>0.05$). In addition,
218 no participant characteristics were associated with the untrained-MST not being documented
219 by untrained health professionals (missing cases) (data not shown, all tests $P>0.05$).

220 **Discussion**

221 The results of this diagnostic accuracy study have important implications for clinical practice.
222 Although the untrained-MST completion rate of 82% may be considered acceptable by some
223 **health services**, it is worth noting that this resulted in three malnourished patients not being

224 identified as at risk of malnutrition. For benchmarking purposes, this study suggests that an
225 MST completion rate of 100% is needed upon patient admission. This finding compliments
226 other research which emphasizes the need for regular re-screening of older rehabilitation
227 patients³⁰.

228 While the untrained-MST showed some clinical value categorizing participants as having
229 malnutrition risk or no malnutrition risk, the continuous score had poor discriminative value,
230 where the ROC AUC was categorized as a 'sufficient test without much value in the clinical
231 setting'²⁵. When applied by health professionals without malnutrition screening training in the
232 practice setting, it appears the MST was better able to identify well-nourished patients than
233 malnourished (higher specificity of 83.3%, lower sensitivity of 57.7%). As reported
234 previously³⁰, 16 of the 30 malnourished patients were referred to the dietitian, which closely
235 aligns with the 17 patients identified as at risk of malnutrition by the untrained-MST in practice
236 (referral rate of 94%). However, this low sensitivity of the untrained-MST carries negative
237 clinical implications as it is important to identify and manage all patients with malnutrition to
238 prevent further downstream health outcomes such as rehospitalization and mortality³. Also
239 considering these serious health outcomes when malnutrition fails to be identified and treated,
240 this study does not support the referral to a dietitian only after a MST score of ≥ 3 as this resulted
241 in a severe decrease in the sensitivity of the MST to identify malnourished patients (sensitivity
242 of 23%, specificity of 98% when conducted by practice nurses).

243 **It should also be acknowledged that other malnutrition screening tools have shown inadequate**
244 **diagnostic accuracy in older patients.** The Mini-Nutritional Assessment-Short Form failed to
245 have sufficient specificity in geriatric rehabilitation **even when applied by a highly trained**
246 **dietitian** (sensitivity 100%, specificity 22.6%)¹³. In an older hip-fracture population, Bell et
247 al.¹⁸ evaluated eight nutrition screening tools and anthropometric measures; however, none had
248 sufficient validity to identify the risk of malnutrition when completed by nutrition assistants

249 with basic training in malnutrition screening. However, it must be acknowledged that this was
250 in a sample where 65% had dementia, delirium or cognitive impairment¹⁸.

251 This study showed a clear difference in screening accuracy when completed by a trained health
252 professional compared with health professionals without malnutrition education or screening
253 training. Although the level of malnutrition education and nutrition screening training is a clear
254 difference between the health professionals in this study, it should be acknowledged, while
255 important, that the level of training may not be the primary or sole reason for the difference in
256 MST screening accuracy. Factors related to the screening tool itself (ease and acceptability of
257 the tool), staff (value of clinical judgment, prioritization of other clinical activities, knowledge
258 and skills) and context (organizational culture, adequate time and resources, communication
259 processes) have been identified as important barriers and facilitators to nutrition screening in
260 the practice setting^{26,27}. These factors are unlikely to present a barrier to screening when
261 completed by a trained health professional as part of a research study (as was the case in this
262 study with the “trained-MST”), which may explain the observed difference between screening
263 results. Although no participant characteristics were associated with the accuracy and
264 documentation of the untrained-MST in this study, patient factors may be an important
265 contributor in other settings, particularly those with increased prevalence of cognitive
266 impairment. With the cost of treating malnutrition with nutrition support estimated to be less
267 than 2.5% of the total expenditure of malnutrition³¹⁻³³, ensuring rehabilitation staff are properly
268 educated, trained and supported to implement malnutrition screening and referral pathways is
269 an important strategy in providing more cost-effective treatment for this patient group.
270 Reflecting this, identifying and treating malnutrition is ranked fifth in the top clinical (including
271 medical and pharmaceutical) guidelines shown to produce savings to healthcare by the National
272 Institute for Health and Care Excellence³⁴.

273 *Limitations and implications for further research*

274 The limitation of this study lies primarily in the small representation of health care facilities
275 and practitioners, which may limit generalizability to other facilities and rehabilitation teams.
276 However, results align with studies conducted in acute settings, and highlight the importance
277 of appropriate training and support of rehabilitation staff in malnutrition screening and referral
278 pathways¹⁸. Although this study found no association between participant characteristics and
279 the accuracy of MST completion by health professionals without malnutrition screening
280 training, this may be because the rehabilitation units did not admit patients with significant
281 cognitive impairment or dementia, and the rural sample was mostly culturally homogenous¹³.
282 Therefore, it may be worth exploring patient characteristics associated with nutrition screening
283 accuracy in larger and more diverse samples internationally.

284 Although further research could be directed towards observing the inter-rater reliability and
285 accuracy of nutrition screening by health professionals in different settings, research directed
286 towards evaluating the cost-benefit and efficacy of interventions which overcome barriers in
287 malnutrition screening accuracy and completion would be of high clinical value.

288 **Conclusion**

289 Although the MST has sufficient accuracy when completed by health professionals with
290 training in nutrition screening, application of the tool by health professionals without
291 malnutrition screening training may not provide sufficient accuracy in identifying patients with
292 malnutrition risk. Additionally, this study demonstrates that increasing the MST cut-off score
293 to ≥ 3 as a strategy to manage high demand may result in a severe under-diagnosis and under-
294 treatment of malnutrition. Future research should be directed towards providing high quality
295 interventional research to train and support rehabilitation staff in accurately implementing
296 malnutrition screening and referral pathways.

References

1. Marshall S, Young A, Bauer J, Isenring E. 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) *J Acad Nutr Diet.* 2016;116(5):785-794.
2. Marshall S. Protein-energy malnutrition in the rehabilitation setting: evidence to improve identification. *Maturitas.* 2016;86:77-85.
3. Marshall S, Bauer J, Isenring E. The consequences of malnutrition following discharge from rehabilitation to the community: a systematic review of current evidence in older adults. *J Hum Nutr Diet.* 2014;27(2):133-141.
4. Hoffman D. *Malnutrition Coding Review CLP Project Summary.* <http://www.aci.health.nsw.gov.au/>: NCAHS;2010.
5. *Nutrition support in adults: oral nutrition support, enteral tube feeding and parenteral nutrition.* London: National Collaborating Centre for Acute Care;2006.
6. Watterson C, Fraser A, Banks M, et al. Evidence based practice guidelines for the nutritional management of malnutrition in patients across the continuum of care. *Nutr Diet.* 2009;66(Suppl 3):S1-S34.
7. Lacey K, Prichett E. Nutrition Care Process and Model: ADA adopts road map to quality care and outcomes management. *J Am Diet Assoc.* 2003;103(8):1061-1072.
8. Joint Commission: Accreditation, Health Care, Certification. 2017; www.jointcommission.org/.
9. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutr.* 1999;15(6):458-464.

10. Ferguson M, Capra S, Bauer J, Banks M. Malnutrition. Is your patient at risk? In. *Nutrition Support Resources: NEMO Nutrition Support Group, Queensland Government, Queensland Health; 1999.*
11. Ferguson M, Bauer J, Gallagher B, Capra S, Christie D, Mason B. Validation of a malnutrition screening tool for patients receiving radiotherapy. *Australas Radiol.* 1999;43(3):325-327.
12. Isenring EA, Banks M, Ferguson M, Bauer JD. Beyond malnutrition screening: Appropriate methods to guide nutrition care for aged care residents. *J Acad Nutr Diet.* 2012;112(3):376-381.
13. Marshall S, Young A, Bauer J, Isenring E. Nutrition screening in geriatric rehabilitation: Criterion (concurrent and predictive) validity of the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment-Short Form (MNA-SF). *J Acad Nutr Diet.* 2016;116(5):795-801.
14. Isenring EA, Bauer JD, Banks M, Gaskill D. The Malnutrition Screening Tool is a useful tool for identifying malnutrition risk in residential aged care. *J Hum Nutr Diet.* 2009;22(6):545-550.
15. Wu ML, Courtney MD, Shortridge-Baggett LM, Finlayson K, Isenring EA. Validity of the malnutrition screening tool for older adults at high risk of hospital readmission. *J Gerontol Nurs.* 2012;38(6):38-45.
16. Isenring E, Cross G, Daniels L, Kellett E, Koczwara B. Validity of the malnutrition screening tool as an effective predictor of nutritional risk in oncology outpatients receiving chemotherapy. *Support Care Cancer.* 2006;14(11):1152-1156.
17. Bell J, Bauer J, Capra S. The malnutrition screening tool versus objective measures to detect malnutrition in hip fracture. *J Hum Nutr Diet.* 2013;26(6):519-526.

18. Bell JJ, Bauer JD, Capra S, Pulle RC. Quick and easy is not without cost: Implications of poorly performing nutrition screening tools in hip fracture. *J Am Geriatr Soc.* 2014;62(2):237-243.
19. Patient Admission Screening Tool for Adults (PASTA). In: NSW Health; 2016.
20. *Rural, regional and remote health: a guide to remoteness classifications. AIHW cat. no. PHE 53.* Canberra: AIHW;2004.
21. *Nutrition screening as easy as mna. A guide to completing the Mini Nutritional Assessment (MNA).* Switzerland Nestle Nutrition Institute.
22. Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes. In. Canberra: National Health and Medical Research Council; 2005.
23. *Australian coding standards for I.C.D.-10-AM.* Sydney: National Centre for Classification in Health;2008.
24. *SPSS Statistics for Windows, version 24* [computer program]. Armon, New York: IBM Corp.; 2016.
25. Šimundić A-M. Measures of diagnostic accuracy: basic definitions. *Med Biol Sci.* 2008;22(4):61-65.
26. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* 1977;33:159-174.
27. Deeks JJ, Higgins JP. Statistical algorithms in Review Manager 5. *Statistical Methods Group of The Cochrane Collaboration.* 2010:1-11.
28. Glas AS, Lijmer JG, Prins MH, Bossel GJ, Bossuyt PM. The diagnostic odds ratio: a single indicator of test performance. *J Clin Epidemiol.* 2003;56(11):1129-1135.
29. Pagano M, Gauvreau K, Pagano M. *Principles of biostatistics.* Vol 2: Duxbury Pacific Grove, CA; 2000.

30. Marshall S, Young A, Bauer J, Isenring E. Malnourished older adults admitted to rehabilitation in rural New South Wales remain malnourished throughout rehabilitation and once discharged back to the community: a prospective cohort study *J Aging Res Clin Pract.* 2015;4(4):197-204.
31. Elia M, Stratton R. Calculating the cost of disease-related malnutrition in the UK in 2007 (public expenditure only) In: *Combating Malnutrition: Recommendations for Action. Report from the advisory group on malnutrition, led by BAPEN.*2009.
32. Stratton RJ, Elia M. Encouraging appropriate, evidence-based use of oral nutritional supplements. *Proc Nutr Soc.* 2010;69(04):477-487.
33. Wilson L. *A review and summary of the impact of malnutrition in older people and the reported costs and benefits of interventions.* www.malnutritiontaskforce.org.uk: Malnutrition Task Force, International Longevity Centre - UK;2013.
34. *Cost saving guidance.* <https://www.nice.org.uk/about/what-we-do/into-practice/cost-saving-guidance>: National Institute for Health and Clinical Excellence (NICE); Accessed 27/04/2015 2016.

Table 1: Measures of diagnostic accuracy (concurrent validity) of the Malnutrition Screening Tool (MST) completed a highly-trained health professional (trained-MST) and health professionals with no malnutrition screening training (untrained-MST) against the ICD-10-AM classification of protein-energy malnutrition using different cut-off points in a cohort of 57 older adults admitted to two rural rehabilitation facilities in rural New South Wales, Australia

	Kappa statistic	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Trained-MST ^a - value - 95% CI ^b	0.478 ^c 0.193-0.677	80.8 62.1-91.5	67.7 50.1-81.4	67.7 48.6-83.3	80.8 60.6-93.4
Altered-trained-MST ^d - value - 95% CI	0.424 ^e 0.191 – 0.657	57.7 57.1 – 58.3	83.9 83.5 – 84.3	75.0 74.4 – 75.6	70.3 69.8 – 70.8
Untrained-MST ^{a,f} - value - 95% CI	0.401 ^g 0.146 – 0.656	56.5 34.5 – 76.8	83.3 62.6 – 95.3	76.5 50.1 – 93.2	66.7 47.2 – 82.7
Altered-untrained-MST ^d - value - 95% CI	0.221 ^g 0.045 – 0.397	22.9 ^h 22.4 – 23.5	98.0 ^h 97.8 – 98.2	91.7 ^h 90.9 – 92.4	57.0 ^h 56.5 – 57.5

^a Trained-MST and untrained-MST apply the usual MST scoring where 0 – 1 indicates “no malnutrition risk”, and a score of 2 – 5 indicates “malnutrition risk”.

^b CI, confidence interval.

^c $P < 0.0001$, “moderate agreement” as per Landis and Koch kappa statistic classification²⁶.

^d Altered-trained MST and altered-untrained-MST apply a different scoring where 0 – 2 indicates “no malnutrition risk”, and a score of 3 – 5 indicates “malnutrition risk”.

^e $P = 0.001$, “moderate agreement” as per Landis and Koch kappa statistic classification²⁶.

^f Data analysed for $n = 47$ as there were 10 missing cases. No participant characteristics were associated with the untrained-MST not being completed (missing cases).

^g $P < 0.05$, “fair agreement” as per Landis and Koch kappa statistic classification²⁶.

^h The false positive value for the altered-untrained-MST compared with the ICD-10-AM criteria was zero. However, due the problems with computation of diagnostic accuracy measures with a zero value, each cell in the contingency table had 0.5 added²⁷⁻²⁹.

Table 2: The Receiver Operating Characteristics (ROC) Coordinates of the Curve for the Malnutrition Screening Tool (MST) scores completed by a highly-trained health professional (trained-MST) and health professionals with no malnutrition screening training (untrained-MST) compared to the ICD-10-AM classification of protein-energy malnutrition in adults.

MST scores (cut-off value to indicate risk of malnutrition) ^a	Trained-MST		Untrained-MST	
	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
-1	100.0	0.0	100.0	0.0
1	96.2	41.9	56.5	66.7
2 ^b	80.8	67.7	56.5	83.3
3 ^c	57.7	83.9	21.7	100.0
4	23.1	96.8	8.7	100.0
5	11.5	96.8	- ^d	- ^d
6	0.0	100.0	0.0	100.0

^a The smallest cutoff value is the minimum observed MST score minus one, and the largest cutoff value is the maximum observed MST score plus one.

^b A cut-off value of 2 indicates the reported sensitivity and specificity of the trained-MST and untrained-MST reported in table 1.

^c A cut-off value of 3 indicates the reported sensitivity and specificity of the altered-trained-MST and altered-untrained-MST reported in table 1.

^d No values provided as the nursing staff did not score any participant as having an MST score of 5.