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1 **Nutrition screening in geriatric rehabilitation: Criterion (concurrent and predictive) validity**  
2 **of the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment-Short Form**  
3 **(MNA-SF)**

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19  
20 **Keywords:** nutrition screening, malnutrition, rehabilitation, rural, aged

21

22 **Abstract**

23 **Background:** Nutrition screening is required for early identification and treatment of patients at  
24 risk of malnutrition so that clinical outcomes may be improved and health care costs reduced.

25 **Objectives:** To determine the criterion (concurrent and predictive) validity of the Malnutrition  
26 Screening Tool (MST) and Mini Nutritional Assessment-Short Form (MNA-SF) in older adults  
27 admitted to inpatient rehabilitation facilities. **Design:** Observational, prospective cohort.

28 **Participants/setting:** n=57 older adults  $\geq 65$  years, median age 79.1y ( $\pm 7.3$ y) from two rural  
29 rehabilitation units in New South Wales, Australia. **Main outcome measurements:** MST, MNA-  
30 SF, ICD-10-AM classification of malnutrition, rehospitalization, length of stay, admission to a  
31 residential aged care facility and discharge location. **Statistical analysis performed:** Measures of  
32 diagnostic accuracy with 95% confidence intervals generated from a contingency table, Mann-  
33 Whitney U test and chi-squared test. **Results:** When compared to the ICD-10-AM criteria, the MST  
34 showed stronger diagnostic accuracy (sensitivity 80.8%, specificity 67.7%) than the MNA-SF  
35 (sensitivity 100%, specificity 22.6%). Neither the MST nor the MNA-SF were able to predict  
36 rehospitalization, institutionalization or discharge location. **Conclusion:** The MST showed good  
37 concurrent validity and can be considered an appropriate nutrition screening tool in geriatric  
38 rehabilitation. The MNA-SF may overestimate the risk of malnutrition in this population. The  
39 predictive validity could not be established for either screening tool.

40 **Nutrition screening in geriatric rehabilitation: Criterion (concurrent and predictive) validity**  
41 **of the Malnutrition Screening Tool (MST) and the Mini Nutritional Assessment-Short Form**  
42 **(MNA-SF)**

43 **Introduction**

44 Nutrition screening is required for early identification and treatment of patients at risk of protein-  
45 energy malnutrition (termed “malnutrition” throughout) and should occur routinely in all health care  
46 settings <sup>1</sup>. Nutrition screening tools are used to identify risk of malnutrition <sup>2</sup>. They should be quick  
47 and simple to implement and able to be used by any trained person or the patient themselves. Once  
48 risk is identified, a diagnosis of malnutrition should be made by a qualified health professional,  
49 such as a Registered Dietitian Nutritionist, following a more comprehensive assessment of nutrition  
50 status <sup>3</sup>. It is critical that nutrition screening tools are validated for the population to which they are  
51 applied so that patient outcomes may be improved and resources are used efficaciously <sup>3</sup>.

52 Rehabilitation facilities are sub-acute health care facilities where patients are admitted when they  
53 require medical and multi-disciplinary treatment with the purpose of increasing independence <sup>1</sup>.

54 Rehabilitation patients typically have a chronic illness, such as chronic obstructive pulmonary  
55 disease or Parkinson’s disease, or are recovering from an acute illness, such as a stroke or hip-  
56 fracture. Due to the nature of rehabilitation facilities, the majority of patients are older adults.

57 Malnutrition in older adults admitted to rehabilitation is associated with adverse clinical outcomes  
58 and mortality during admission <sup>4</sup>; and poorer quality of life and increased levels of physical  
59 dysfunction, hospitalization, institutionalization and mortality once discharged to the community <sup>5,6</sup>.

60 Older adults are often transferred to rehabilitation from acute care facilities where they may have  
61 developed malnutrition as a result of their illness or imposed treatments. Therefore early and  
62 accurate identification of nutrition risk when admitted to rehabilitation facilities is important for  
63 attaining a successful rehabilitation outcome and decreasing the economic burden of malnutrition in  
64 the older adult community.

65 Skipper *et al.* <sup>7</sup> have recently reviewed the nutrition screening tools that have been developed for  
66 identifying risk of malnutrition in a variety of settings, including the Malnutrition Screening Tool  
67 (MST) <sup>8</sup>. The review concluded that the MST was the only nutrition screening tool of the 11  
68 identified which was supported by studies espousing its validity and reliability. The MST has been  
69 widely adopted by health care facilities due to low cost of implementation and low participation  
70 burden <sup>8</sup>. Since its development in acute care patients, the MST has also been shown to be valid in  
71 oncology outpatients and more recently in residential aged care facilities (RACF) <sup>8-10</sup>. In the  
72 rehabilitation setting, there are only two screening tools which have been evaluated for validity.  
73 These include the Mini Nutrition Assessment-Short Form (MNA-SF) <sup>11</sup> and the Rapid Screen <sup>12</sup>.  
74 The MNA-SF showed substantial agreement with the full MNA (kappa 0.626, 95% CI 0.507-0.744)  
75 <sup>13</sup> and the Rapid Screen reported moderate sensitivity (78.6%) and excellent specificity (97.3%) <sup>12</sup>  
76 compared with a standardized nutrition assessment in geriatric rehabilitation. However, the MNA-  
77 SF has not been evaluated for its sensitivity or specificity nor has it been evaluated using a  
78 benchmark unrelated to the MNA. The MST has not been evaluated in geriatric rehabilitation  
79 despite being frequently used by practitioners. Therefore, the aim of this study was to determine the  
80 criterion (concurrent and predictive) validity of the MST and MNA-SF in older adults admitted to  
81 inpatient rehabilitation facilities.

## 82 **Materials and methods**

### 83 *Study sample*

84 Participants were older adults admitted to one of two public rehabilitation units in the same local  
85 health district in rural New South Wales, Australia <sup>14</sup>. Study centers were chosen by convenience  
86 sampling based on location, and participants consecutively sampled. Participants were English-  
87 speaking inpatients  $\geq 65$  years admitted to the participating rehabilitation units, community-dwelling  
88 residents prior to admission, if they were admitted with the expectation they would return to the  
89 community, and had an informal caregiver. This study was conducted as part of the MARRC  
90 (Malnutrition in the Australian Rural Rehabilitation Community) Study (Trial version 2.0, 9 May  
91 2013) which has been registered at the Australian New Zealand Clinical Trials Registry  
92 (ACTRN12613000518763) and has received ethical and governance approval (North Coast NSW  
93 Human Research Ethics Committee: LNR 063, G108; School of Human Movement Studies Ethics  
94 Committee: HMS13/0731). Written informed consent was obtained from all participants and/or  
95 their guardians.

### 96 Data collection

97 Data used in this observational, prospective cohort study were collected from August 2013 to  
98 February 2014. Participant characteristics and nutrition screening and assessment tools were all  
99 collected or completed on behalf of the participant by the primary researcher during an interview at  
100 the bedside (median of two days following admission) and were further supported by information  
101 from medical records, rehabilitation staff or the patient's informal caregiver.

### 102 *Nutrition screening*

103 The MST consists of two questions relating to recent unintentional weight loss and eating poorly,  
104 and was scored according to the Queensland Government's resource "Malnutrition. Is your patient  
105 at risk?" <sup>15</sup>. A score of 2 or higher indicates the patient should be referred to a dietitian to attend  
106 nutrition assessment and intervention as appropriate <sup>8</sup>. Therefore, for the assessment of criterion

107 validity, a score of 0-1 was used to indicate “well-nourished” and  $\geq 2$  was used to indicate “risk of  
108 malnutrition”. The MST was not completed as a separate tool for each participant, but rather a range  
109 of data were obtained during a full nutrition assessment including the two MST questions, which  
110 were later used to complete the MST, a method reported by previous researchers <sup>16</sup>. Weight loss  
111 was considered in the six months leading up to the assessment.

112 The MNA-SF was completed as a separate tool. The MNA-SF consists of six questions and is  
113 scored 0 – 14 where a score of 0 – 7 indicates ‘malnourished’, 8 – 11 indicates ‘at risk of  
114 malnutrition’ and 12 – 14 indicates normal nutrition status <sup>17</sup>. For this study, an MNA-SF score of  
115 12 – 14 was considered ‘well-nourished’ and 0 – 11 ‘risk of malnutrition’.

116

#### 117 *Nutrition assessment*

118 There is no gold standard for diagnosing malnutrition. The *International Statistical Classification of*  
119 *Diseases and Health Related Problems 10<sup>th</sup> revision Australian Modification* (sixth edition, ICD-  
120 10-AM) criteria are the recognized standard diagnostic criteria for the identification, documentation  
121 and coding of protein-energy malnutrition and are used to provide case-mix funding  
122 reimbursements (table 1). For this reason, the ICD-10-AM classification for malnutrition is an  
123 appropriate benchmark to establish the concurrent validity of a nutrition screening tool, and has  
124 been used as the standard against which nutrition screening and assessment tools have been  
125 validated <sup>18,19</sup>. The ICD-10-AM classification involves an evaluation of body mass index (BMI)  
126 ( $<18.5 \text{ kg/m}^2$ ) to detect chronic malnutrition, or weight loss with suboptimal dietary intake resulting  
127 in fat and/or muscle wasting to detect acute malnutrition. Failure to identify patients at risk of  
128 malnutrition in the health care setting can negatively impact funding <sup>20</sup>; therefore, the nutrition  
129 screening and assessment method used must be in agreement with the ICD-10-AM criteria to ensure  
130 resources are available for treatment. During nutrition assessment, the components of BMI, weight  
131 loss in the six months prior to assessment, a physical evaluation of fat stores and muscle status, and  
132 a brief dietary assessment were recorded and used to inform the ICD-10-AM classification of

133 malnutrition for each participant. Any participant meeting the ICD-10-AM criteria of mild,  
134 moderate or severe malnutrition (as per table 1) was considered to have the condition  
135 ‘malnutrition’, and if they did not meet any ICD-10-AM criterion they were considered ‘well-  
136 nourished’.

137 Weight (kg) was measured to the first decimal point by Tanita InnerScan Body Composition  
138 Monitor scales model: BC-541 (2005, Tanita Corporation, Tokyo, Japan) by the researcher. If a  
139 participant was non-weight bearing or unable to stand unassisted then the rehabilitation wards  
140 scales were used (chair or roll-on scales). All three scales were within 0.1kg calibration. Weights  
141 recorded for amputees were adjusted <sup>21</sup>. Due to the expected high number of bed- or chair- bound  
142 participants admitted to rehabilitation, height was calculated by knee height. A sliding knee height  
143 caliper was used to measure the knee height, which was then entered into a population specific  
144 formula to estimate the true height <sup>21</sup>. BMI ( $\text{kg}/\text{m}^2$ ) was calculated using measured weight and  
145 estimated height. For describing this sample of older adults, a normal BMI was considered 22 –  
146  $27\text{kg}/\text{m}^2$ ,  $<22\text{ kg}/\text{m}^2$  was considered underweight and  $>27\text{kg}/\text{m}^2$  overweight/obese <sup>22,23</sup>.

#### 147 *Health and aged care service use*

148 Increased health and aged care service use have been associated with malnutrition in the geriatric  
149 rehabilitation setting and reflects patient wellbeing and health and aged care costs <sup>5</sup>. Therefore,  
150 discharge location (home/other), rehospitalization (total length of stay of subsequent rehabilitation  
151 and acute care admissions) and institutionalization (admission to RACF; yes/no) were chosen to  
152 evaluate predictive validity. Discharge location was measured at the time of discharge.  
153 Rehospitalization and admission to an RACF were measured three months post-discharge to the  
154 community. Data were obtained from the health service’s electronic admissions database and  
155 confirmed by telephone or in-home interviews.

#### 156 *Statistical approach*

157 All statistical analysis was completed using SPSS Version 22.0 2013 (IBM SPSS Statistics for  
158 Windows. Armonk, NY: IBM Corp.). Significance was considered at the  $P < 0.05$  level. Descriptive  
159 statistics (mean  $\pm$  standard deviation, median and interquartile range) were used to characterize the  
160 sample population. Chi-squared and independent sample t-tests (or Mann-Whitney if  
161 nonparametric) were used to assess for a significant difference in descriptors of the sample  
162 population by rehabilitation center.

163 Criterion validity represents how well a particular variable predicts an outcome compared to other  
164 variables, and encompasses concurrent and predictive validity<sup>24</sup>. Concurrent validity is determined  
165 by comparing the score of a new measurement to the score of a well-established measurement for  
166 the same construct, in this case comparing the MST and MNA-SF nutrition risk categories with a  
167 malnutrition diagnosis as per ICD-10-AM classification of malnutrition. Predictive validity is  
168 established when the score of a particular measurement makes an accurate prediction about the  
169 construct they represent, in this case we determine if the MST and MNA-SF “risk of malnutrition”  
170 categories are able to detect the difference in rates of rehospitalization, institutionalization and  
171 discharge location, all of which are health-related outcomes which are associated with malnutrition.

172 To determine the concurrent validity of the MST and MNA-SF in this sample, measures of  
173 diagnostic accuracy were determined. The sensitivity (malnourished/risk of malnutrition correctly  
174 identified as such), specificity (well-nourished correctly identified as such), positive predictive  
175 value (PPV, correctly identified as malnourished/risk of malnutrition within the malnourished  
176 sample), negative predictive value (NPV, correctly identified as well-nourished within well-  
177 nourished sample), a weighted kappa statistic and diagnostic odds ratio (DOR) with the 95%  
178 confidence intervals (CI) were determined using contingency tables against the ICD-10-AM  
179 classification of malnutrition. Sensitivity was considered of higher importance than specificity and  
180 *a-priori* values of 80% or more for sensitivity and 60% or more for specificity were considered to  
181 indicate a good nutrition screening tool<sup>8</sup>. The DOR is a global measure of diagnostic accuracy,

182 where a score of one indicates the test is equally likely to predict a positive outcome whatever the  
183 true condition and the higher the ratio the better the test performance <sup>25</sup>.

184 To evaluate the predictive validity of the MST and MNA-SF, the categories of ‘well-nourished’ and  
185 ‘risk of malnutrition’ were tested for significance with the longitudinal outcomes of  
186 rehospitalization length of stay, discharge location and admission to an RACF using the Mann-  
187 Whitney U test and chi-squared test.

188 **Results**

189 *Study participants*

190 Over the study recruitment period, 57 consecutive rehabilitation inpatients consented to participate  
191 in the study (response rate of 98%). The mean age was 79.1y ( $\pm 7.3$ y); however there was a  
192 significant difference in age between sites (77.5y versus 81.4y). Fifty-four percent of participants  
193 were at risk of malnutrition according to the MST, 88% according to the MNA-SF and 46% were  
194 malnourished according to the ICD-10-AM criteria. Site B had a significantly higher proportion of  
195 participants considered “at risk of malnutrition” than site A according to the MST. Ad hoc analysis  
196 reveals this is due to a higher proportion of participants at site B with decreased dietary intake as  
197 well as losing a larger amount of weight. Participant characteristics are shown in table 2.

198 *Concurrent and predictive validity of the Malnutrition Screening Tool and Mini Nutritional*  
199 *Assessment - Short Form*

200 In evaluating its concurrent validity, the MST exceeded *a-priori* values for sensitivity and  
201 specificity and had strong PPV (67.7, 95%CI: 48.6-83.3) and NPV (80.8, 95%CI: 60.6-93.4) (table  
202 3). The MNA-SF showed perfect sensitivity and NPV but only 22.6% (95%CI: 11.4-39.8)  
203 specificity and 52% (95%CI: 37.4-66.3) PPV. The DOR of the MST and MNA-SF were similar,  
204 showing the screening tools have some diagnostic value; however the wide 95% confidence interval  
205 of the MNA-SF DOR shows this variable may be underpowered and is unreliable. The kappa  
206 statistic for the MST showed ‘moderate agreement’ with the ICD-10-AM classification of  
207 malnutrition, whereas the kappa statistic for the MNA-SF was considered ‘fair agreement’. In  
208 regards to predictive validity, neither tool was able to detect a significant difference in  
209 rehospitalization length of stay, admission to an RACF or discharge location in this sample.  
210 Prevalence of these outcomes will be reported elsewhere (Marshall et al., 2015, unpublished data).

211 **Discussion**

212 This is the first study to evaluate the criterion validity of the MST in the rehabilitation setting, and  
213 to evaluate the concurrent validity of the MNA-SF in the rehabilitation setting using a benchmark  
214 unrelated to the MNA <sup>1</sup>. The MST showed strong concurrent validity when compared to the ICD-  
215 10-AM classification of malnutrition in this sample of older adults admitted to rehabilitation.  
216 However, the MNA-SF may overestimate risk of malnutrition when compared to ICD-10-AM  
217 criteria. Neither tool was able to predict health and aged care use.

218 The MST performed stronger in this geriatric rehabilitation sample than reported in an acute hip-  
219 fracture population (kappa 0.363, sensitivity 60% and specificity 76%), which also used the ICD-  
220 10-AM classification as a benchmark <sup>19</sup>. This difference in sensitivity and specificity between the  
221 two similar populations may be due to how the MST was scored, where the hip-fracture study only  
222 scored points for decreased oral intake due to decreased appetite, as opposed to decreased oral  
223 intake for any reason, as used in this study. These results suggest that the current method of scoring  
224 the MST in older adults may be superior. In the study by Isenring et al. <sup>10</sup> which scored the MST to  
225 include decreased oral intake for any reason, the MST also showed strong concurrent validity when  
226 compared to the Subjective Global Assessment (kappa 0.806, sensitivity 89% and specificity 94%)  
227 and MNA (kappa 0.501, sensitivity 94% and specificity 81%) in an RACF setting. There has only  
228 been one study evaluating the predictive validity of the MST, where it was found to predict length  
229 of stay in 408 adult acute hospital patients <sup>8</sup>.

230 The low specificity of the MNA-SF was unexpected, as this tool performed better in the acute hip-  
231 fracture population, though it still tended to over-estimate risk of malnutrition when using <12 as  
232 the cut-off value (sensitivity 89%, specificity 49%) <sup>19</sup>. As mentioned previously, the MNA-SF  
233 showed ‘substantial agreement’ (kappa 0.626) in a previous study evaluating the validity of the  
234 MNA-SF in the rehabilitation setting; however, the study did not report sensitivity and specificity  
235 and the full MNA was used as the benchmark <sup>13</sup>. A poor performance of the MNA-SF against other

236 nutrition assessments may be due to the focus of the MNA/MNA-SF being on early identification of  
237 malnutrition risk, whereas assessments such as SGA and ICD-10-AM focus on diagnosing existing  
238 malnutrition<sup>26</sup>. Therefore an over-classification of well-nourished patients as at risk of malnutrition  
239 may be appropriate for some well-resourced settings, where prevention of malnutrition is the focus  
240 as opposed to treatment<sup>26-28</sup>. Despite the MNA-SF's poor specificity, 'fair' kappa statistic and not  
241 being able to predict patient outcomes in this study, nutritional risk determined by the MNA-SF has  
242 previously found to be associated with increased risk of institutionalization and decreased physical  
243 function and quality of life in geriatric rehabilitation<sup>29</sup>. Furthermore, the original authors suggested  
244 lowering the cut-off value of the MNA-SF if an improvement in specificity is required<sup>11</sup>.

245 The inability of the MST and MNA-SF to detect a difference in health and aged care service use  
246 may be due to a relatively small sample size. However, as the current sample size had enough  
247 power to detect the difference in these outcomes following a diagnosis of malnutrition using the  
248 ICD-10-AM criteria (Marshall et al., 2015, unpublished data), it may have clinical implications that  
249 the MST and MNA-SF did not display predictive validity. These results emphasize the importance  
250 of following nutrition screening with a full nutrition assessment in order for resources to be used  
251 appropriately and to ensure adequate funding of health care facilities.

#### 252 *Limitations*

253 There is risk of bias with the same researcher conducting the screening and assessment; however,  
254 independent review of assessments by experienced practitioners were conducted to limit bias. As  
255 both the MST and MNA-SF were completed by a trained dietitian (Accredited Practising Dietitian)  
256 during a full nutrition assessment, the accuracy of tool completion by a person without a nutrition  
257 background, such as nursing staff, may not be as high. The next step in evaluating the validity of the  
258 MST and MNA-SF should be a larger study with tools completed by trained non-dietetic staff  
259 during admission and/or by patient self-completion. Further research comparing the Rapid Screen  
260 with the MST and MNA-SF would also be of interest. A limitation of using the ICD-10-AM

261 classification of malnutrition as the standard in this population is the BMI cut-off of  $<18.5\text{kg/m}^2$ ,  
262 which is likely to be too low for an older population, where a BMI of  $\leq 22\text{ kg/m}^2$  is generally  
263 considered underweight<sup>22,23</sup>. This may increase the rate of type II errors, where a chronically  
264 malnourished participant was considered well-nourished, and may have caused a decrease in the  
265 sensitivity of the nutrition screening tools when compared to the ICD-10-AM classifications.

266

267 **Conclusions**

268 The MST is appropriate for use as a nutrition screening tool in geriatric rehabilitation; however, the  
269 MNA-SF may overestimate the risk of malnutrition. Neither the MST nor the MNA-SF displayed  
270 predictive validity in this sample of older adults admitted to rural rehabilitation units. Nutrition  
271 screening should be followed by a full nutrition assessment to identify patients in need of nutrition  
272 intervention so that resources may be used efficaciously and patient outcomes improved.

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## **Conflict of interest disclosure**

The authors declare no conflicts of interest. SM was employed as a dietitian for New South Wales Health which occasionally involved 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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## **Practice implications**

*What is the current knowledge on this topic?*

In the geriatric rehabilitation setting, the Malnutrition Screening Tool (MST) and the MNA-SF require further assessment of criterion (concurrent and predictive) validity.

*How does this research add to knowledge on this topic?*

This is the first study to evaluate the criterion validity of the MST in the rehabilitation setting, and to evaluate the concurrent validity of the MNA-SF in the rehabilitation setting using a benchmark unrelated to the MNA.

*How might this knowledge impact current dietetics practice?*

This study provides the first evidence in support of the MST in the geriatric rehabilitation setting. The MNA-SF overestimated risk of malnutrition in geriatric rehabilitation and may not be appropriate for use.

**Table 1:** The International Statistical Classification of Diseases and Health Related Problems 10<sup>th</sup> Revision Australian Modification (sixth edition, ICD-10-AM) classifications for protein-energy malnutrition in adults <sup>30</sup>.

Classification	Definition
E43: Unspecified severe protein-energy malnutrition	In adults, BMI <sup>a</sup> <18.5 kg <sup>b</sup> /m <sup>c2</sup> 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 <sup>2</sup> 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 <sup>2</sup> or unintentional loss of weight (5-9%) with evidence of suboptimal intake resulting in mild loss of subcutaneous fat and/or mild muscle wasting

<sup>a</sup> BMI, body mass index

<sup>b</sup> kg, kilogram

<sup>c</sup> m, meters

**Table 2:** Characteristics of a cohort of 57 older adults admitted to rural rehabilitation facilities in New South Wales, Australia, overall and by facility

Variable	Site A (n=33)	Site B (n=24)	Total participants (n=57)
Age (years, mean±SD <sup>a</sup> )	77.5±7.5	81.4±6.4*	79.1±7.3
Female (%)	39.4	62.5	49.1
Weight (kg <sup>b</sup> , mean±SD)	70.5±18.9	68.3±19.8	69.6±19.1
BMI <sup>c</sup> (mean±SD)	25.4±6.4	24.5±4.6	25.0±5.7
Underweight: BMI <22 (%)	30.3	29.2	29.8
Overweight/obese: BMI >27 (%)	30.3	29.2	29.8
Admission source:			
- Acute health care facility (%)	81.8	91.7	86.0
- Community (%)	18.2	8.3	14.0
Reason for admission:			
- Acute illness (%)	69.7	79.2	73.7
- Chronic illness (%)	30.3	20.8	26.3
Cognitive impairment <sup>d</sup> :			
- MMSE <sup>e</sup> (n=14) (mean±SD)	-	23.1±3.4	-
- 3MS <sup>f</sup> Test (n=20) (mean±SD)	79.0±15.9	-	-
Risk of malnutrition (%)			
- MST <sup>g</sup> (score ≥2)	39.4	75.0*	54.4
- MNA-SF <sup>h</sup> (score <12)	84.5	91.7	87.7
Malnourished (%) <sup>i</sup>	42.4	50.0	45.6

\*Significant difference between sites ( $P<0.05$ )

<sup>a</sup> SD, standard deviation

<sup>b</sup> kg, kilogram

<sup>c</sup> BMI, body mass index

<sup>d</sup> Not compared between sites due to difference in measurement tools

<sup>e</sup> MMSE, mini-mental state examination

<sup>f</sup> 3MS, modified mini-mental state

<sup>g</sup> MST, malnutrition screening tool

<sup>h</sup> MNA-SF, mini nutritional assessment short-form

<sup>i</sup> Malnourished according to ICD-10-AM classification of protein-energy malnutrition

**Table 3:** Measures of diagnostic accuracy of the Malnutrition Screening Tool (MST) and Mini Nutritional Assessment-Short Form (MNA-SF) against the ICD-10-AM classification of protein-energy malnutrition in a cohort of 57 older adults admitted to rural rehabilitation facilities in rural New South Wales, Australia

	Kappa statistic	Sensitivity (%)	Specificity (%)	PPV <sup>a</sup> (%)	NPV <sup>b</sup> (%)	DOR <sup>c</sup>	Rehospitalization LOS <sup>d</sup> p-value	Admission to RACF <sup>e</sup> p-value	Discharge location p-value
MST <sup>f</sup>									
- value	0.478 <sup>h</sup>	80.8	67.7	67.7	80.8	8.8	<i>P</i> =0.975	<i>P</i> =0.493	<i>P</i> =0.556
-	0.193-	62.1-	50.1-	48.6-	60.6-	2.6-			
95% CI <sup>g</sup>	0.677	91.5	81.4	83.3	93.4	30.2			
MNA-SF									
- value	0.210 <sup>*</sup>	100	22.6	52.0	100	15.2 <sup>i</sup>	<i>P</i> =0.174	<i>P</i> =0.167	<i>P</i> =0.125
-	0.020-	87.1-	11.4-	37.4-	58.9-	0.9-			
- 95% CI	0.210	100	39.8	66.3	100	233.3			

\* *P* < 0.05, “fair agreement” as per Landis and Koch kappa statistic classification <sup>31</sup>.

<sup>a</sup> PPV, positive predictive value

<sup>b</sup> NPV, negative predictive value

<sup>c</sup> DOR, diagnostic odds ratio

<sup>d</sup> LOS, length of stay

<sup>e</sup> RACF, residential aged care facility

<sup>f</sup> MST, malnutrition screening tool

<sup>g</sup> CI, confidence interval

<sup>h</sup> *P* < 0.0001, “moderate agreement” as per Landis and Koch kappa statistic classification <sup>30</sup>.

<sup>i</sup> The false negative values for the MNA-SF compared with the ICD-10-AM criteria were zero. However, due the problems with computation of odds ratios with a zero value, each cell in the contingency table had 0.5 added <sup>32-34</sup>.