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Sensitivity, Specificity, Predictive Value and Inter-Rater Reliability of Malnutrition Screening Tools in Hospitalised Adult Patients

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ABSTRACT

Introduction: Nutrition screening is recommended as a first step of nutrition care to allow early identification and intervention of malnourished patients. The present study determined the validities and reliabilities of two malnutrition screening tools namely, the Malnutrition Universal Screening Tool (MUST) and Malnutrition Screening Tool (MST) among adult patients at the Hospital Kuala Lumpur. **Methods:** The sensitivity, specificity and predictive value of MUST and MST were conducted against the Subjective Global Assessment (SGA), anthropometric parameters including body mass index (BMI), calf circumference (CC), mid-upper arm circumference (MUAC) and energy intake. Inter-rater reliability was evaluated using kappa value (κ) to determine the level of agreement between raters. **Results:** A total of 151 subjects with mean age of 45.2 ± 13.7 years participated in this study. Prevalence of malnutrition according to MUST, MST and SGA was 34.4%, 33.8% and 19.9%, respectively. As compared to SGA, MUST and MST had a sensitivity of 96.6% and 93.3% respectively, whereas the specificity was 80.9% for both tools. The sensitivity and specificity of MUST against the anthropometric parameters (BMI, CC and MUAC) were between 53.8% to 88.8% and 67.4% to 69.9%, respectively. The sensitivity values for MST were between 46.1% to 63.6% and specificity values were between 64.4% to 67.6%. The inter-rater reliability of MUST was higher (substantial, mean (κ) = 0.78) than for MST (moderate, mean (κ) = 0.52). **Conclusions:** In conclusion, MUST was found to have similar validity levels but higher reliability result than MST. Based on our result, MUST is recommended for use in identifying adult patients who are at high risk of malnutrition. It can be used as a malnutrition screening tool but there is a need to evaluate the cost effectiveness of its implementation.

Key words: Inter-rater reliability, Malnutrition Screening Tool, Malnutrition Universal Screening Tool, validity

INTRODUCTION

The prevalence of malnutrition among hospitalised patients has been reported to be up to 40% depending on the population and nutritional parameters used (Lim *et al.*, 2012; Wyszynski, Perman & Crivelli, 2003). Despite the high prevalence, half of the malnourished patients remain unrecognised and thus untreated by health staff (Kruizenga, 2003). Nutrition screening is

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advisable as a first step of nutrition care to allow for early identification and intervention of malnourished patients. Nutrition screening can be defined as a rapid and simple process to identify an individual who has malnutrition or at risk of developing malnutrition and to determine whether further assessment and intervention are required (Mueller, Compher & Ellen, 2011). Implementation of routine nutrition screening is recommended as poor nutritional status has been associated with a number of adverse events such as prolonged hospitalisation, high rates of infections, poor wound healing, increased hospital costs and higher mortality rates (Elia, Zellipour & Stratton, 2005; Watterson *et al.* 2009). A simple, easy-to use, valid and reliable screening tool is strongly recommended to identify those who at risk (Anthony, 2008).

A number of nutrition screening tools have been developed for early recognition of malnutrition problems in specific patient groups or for particular health care settings. A review by Green & Watson (2005) discovered that there were seventy-one nutritional screening and assessment tools which incorporate biochemical index, anthropometry measurements, clinical and subjective evaluation available for use by health care staff. In Malaysia, a Malnutrition Risk Screening Tool - Community (MRST-C) and Malnutrition Risk Screening Tool - Hospital (MRST-H) have been developed and validated to identify elderly people aged 65 years and above who are at high risk of malnutrition (Sakinah *et al.*, 2012; Suzana, Dixon & Earland, 1999). However, local studies on validation of screening tools in detecting malnutrition among adult patients under the age of 65 years are still limited.

Malnutrition Universal Screening Tool (MUST) is a tool that was introduced by the Malnutrition Advisory Group of the British Association for Parenteral and Enteral Nutrition (BAPEN) which consists of three independent criteria: body mass index (BMI), unplanned weight loss and food intake to detect protein-energy malnutrition in adult hospitalised patients (Elia, 2003). The Malnutrition Screening Tool (MST) is another screening tool that does not involve invasive procedures and is composed of two components: unintentional weight loss and appetite to identify adult acute patients at risk of malnutrition during hospital admission(Ferguson *et al.*, 1999).

Both MUST and MST have been developed and validated on the basis of clinical data gathered from the Western population. Considering the differences between Asian and Western populations and health care systems, , testing the validity and reliability of a screening tool in a specific population for which the tool is intended would be greatly useful. This study aimed to determine the validity and reliability of two malnutrition screening tools namely; Malnutrition Universal Screening Tool (MUST) and Malnutrition Screening Tool (MST) against three indicators, i.e. Subjective Global Assessment (SGA), anthropometric parameters and intake of energy in determining malnutrition risk among adult patients at Hospital Kuala Lumpur.

METHODS

This validation study was conducted at medical and surgical wards and outpatient clinics of the Hospital Kuala Lumpur. Ethical approval was obtained from the Universiti Kebangsaan Malaysia Medical Research Ethics and National Research Ethics Committees, Ministry of Health. Consent was given by patients or their relatives. Sample size calculation for sensitivity and specificity was done and convenience sampling was adopted for this study (Naing, 2004). Adult patients aged 18 to 65 years who were admitted to the wards within 48 hours or outpatients who were receiving treatment at the clinics during the study period (September to November 2012) were eligible for inclusion in this study. Subjects were excluded if they were critically ill, receiving enteral or parenteral nutrition, bedridden, having dementia or confusion and had communication problems that could not be overcome. Information on socio-demographics, medical history and treatment of patients was obtained from the patient's medical record. Nutritional screening, dietary intake and anthropometric measurements were carried out during the face-to-face interview and collected by a single trained dietitian to avoid bias in data collection and interpretation. Clinical diagnoses were coded according to the major disease categories included in the International Classification of Diseases and Related Health Problems version 10 (ICD-10). The process of data collection took about 45 minutes to complete.

Two malnutrition screening tools, MUST and MST, were used in this study to identify the risk of malnutrition. In this study, convergent validity was established by comparing the MUST and MST against Subjective Global Assessment (SGA), and anthropometric parameters: body mass index (BMI), calf circumference (CC), mid-upper arm circumference (MUAC) and energy intake. Each of the screening tools had different parameters to identify risk of malnutrition. A total score of ≥ 2 in both tools indicate patient is at risk of malnutrition. The items in the tools were translated to Malay language using back to back translation. Face validity was evaluated through a panel discussion with a few experts in the area, i.e., dietitians and nurses. The assessment of nutritional status using Subjective Global Assessment (SGA) was performed as described by Detsky *et al.* (1987). The SGA questionnaire includes two aspects: the subject's history (weight loss, change in dietary intake, gastrointestinal symptoms that have persisted for more than two weeks and change in functional capacity), and physical examination (loss of subcutaneous fat, muscle wasting, ankle/sacral edema and ascites). Subjects were then categorised as being well nourished (SGA A) and moderately or severely malnourished (SGA B and C), respectively, by the clinician's overall judgment.

Anthropometric indicators which were included in this study were height, weight, body mass index (BMI), calf circumference (CC) and mid-upper arm circumference (MUAC). They were measured according to the standardised methods (Lee & Nieman, 2007). If the subject was unable to stand upright, arm span measurement was used to estimate height using the formula for local population (Suzana & Ng, 2003). The subject's bodyweight was measured to the nearest 0.1 kg using a digital weighing scale (TANITA Model HD319). Height was measured to the nearest 0.1 cm with a stadiometer (Seca Bodymeter 206) while the subject was standing upright with the head placed in the Frankfort plane. Body weight and standing height were used to calculate BMI (kg/m^2) and subjects were considered at high risk of malnutrition if they had a BMI<18.5 kg/m^2 (WHO, 2000). The CC and MUAC were measured using a flexible measuring tape. The CC and MUAC reflect body muscle mass and subcutaneous adipose tissue and are reliable indicators of nutritional status, functional activity and predictor of mortality risk (Tsai, Lai & Chang, 2012). For MUAC, the cut-off points of less than 23.0 cm for men and 22.0 cm for women indicate loss of peripheral muscle mass (Ferro-Luzzi & James, 1996). As for CC, the cut-off points of less than 30.1 cm for men and 27.3 cm for women indicate at risk of muscle wasting based on the local classification (Sakinah *et al.*, 2004).

This study applied the Diet History Questionnaire (DHQ) to obtain information on habitual food intake for the seven days before admission (Suzana, Earland & Abd Rahman, 2000). Nutrient intake was analysed using Nutritionist Pro (Axxya System LLC 2009). Individual recommendation for energy requirement was calculated using Harris Benedict formula multiplied by activity and stress factors while individual recommendation for protein requirement was calculated based on patient's diagnosis or treatment (Bussell *et al.*, 1997). Adequate energy and protein intake was defined as achieving 100% of energy and protein intake as compared to the recommended requirements.

Twenty three patients were selected from the overall subjects using random sampling for inter-rater reliability determination. These subjects had the MUST and MST completed by a trained dietitian and two nurses independent of one another, on the same day.

Statistical data analysis was conducted using SPSS statistical software package (version20.0). Continuous variables were expressed as mean ± standard deviation (Mean ± SD), while categorical variables were expressed as number of subjects and percentage. Pearson Chi- square test was used to test for different between genders. *P*-value was based on a two-sided test and statistical significant was reported at $p<0.05$. The sensitivity, specificity and predictive values were calculated using a cross-tabulation table to evaluate the validity of MUST and MST. Sensitivity was defined as the probability of malnutrition screening tools correctly identifying subjects at risk of malnutrition, whereas specificity refers to the probability of malnutrition screening tools correctly identifying well-nourished subjects. The positive predictive value (PPV) was defined as the probability of subjects being classified as malnourished when malnutrition screening tools indicate a positive value. Conversely, the negative predictive value (NPV) was defined as the probability of subjects being classified as well-nourished when malnutrition screening tools showed a negative value. Inter-rater reliability was evaluated using the Cohen's kappa (κ) statistic and the 95% confidence interval (CI). In this study, kappa values were interpreted based on Landis & Koch (1977). A kappa value of <0.2 was considered as poor agreement, a value of 0.2-0.4 as fair agreement, 0.4-0.6 as moderate agreement, 0.6-0.8 as substantial agreement and >0.8 was categorised as almost excellent agreement.

RESULTS

A total of151 subjects comprising 72.2% inpatients and 27.8% outpatients participated in this study. The mean age for all the subjects was 45.2±13.7 years. Most of the subjects (19.8%) were diagnosed with endocrine, nutritional and metabolic diseases, followed by diseases of the genitourinary system (17.9%) and diseases of the circulatory system (17.2%) as shown in Table 1.

Nutritional status

The MUST and MST identified 34.4% and 33.8% of the subjects, respectively as being at high risk of malnutrition (Table 2). According to SGA, 19.9% of the subjects were detected as having moderate or severe malnutrition (SGA B and C). A total of 7.3% of the subjects was underweight (BMI<18.5 kg/m^2). Malnutrition was detected among 6.0% and 8.6% based on CC and MUAC respectively. The mean individual energy intake of both men (1621 ±371 kcal/day) and women (1561 ±317 kcal/day) was lower than their mean requirement (79.3% and 88.6%, respectively). The mean individual protein intake of both men (56.2 ±16.0 g) and women (53.2 ±12.0 g) was also lower than their requirement (84.3%, 86.6%).

Validity of the MUST and MST

As shown in Table 3, MUST and MST had high sensitivity and specificity when compared with SGA. The sensitivity of MUST and MST was 96.6% and 93.3%, respectively, and the specificity was 80.9% for both tools. MUST had a PPV of 55.7% and NPV of 98.8% as compared to SGA, whereas PPV and NPV value of MST were 54.9% and 98.0%, respectively. The sensitivity of MUST was over 80% against BMI and MUAC but only 53.8% against CC. The sensitivity and specificity of MST was

Table 1. Subjects' characteristics (N=151) [expressed as number (%)]

Age (years), mean (SD)	*45.2 (13.7) n (%)*
Men	60 (39.7)
Women	91(60.3)
Ethnicity	
Malays	75 (49.7)
Chinese	25 (16.6)
Indian	39 (25.8)
Others	12 (7.9)
Marital status	
Single	56 (39.1)
Married	95 (62.9)
Educational level	
No education	3 (2.0)
Had education	148 (98.0)
Occupational status	
Working	85 (56.3)
Not working	65 (43.7)
Living arrangements	
Alone	11 (7.3)
With family or friend	140 (92.7)
Diagnosis	
Endocrine, nutritional and metabolic diseases	30 (19.8)
Genitourinary diseases	27 (17.9)
Circulatory diseases	26 (17.2)
Digestive diseases	25 (16.5)
Others	43 (28.6)

around 45% to 70% against anthropometry parameters. Both MUST and MST were found less sensitive on validation against energy intake, indicating that there were no suitable screening tools that could accurately recognise those patients with adequate or inadequate energy intakes. The study has also evaluated the sensitivity and specificity of MUST and MST according to different clinical scenarios, i.e. outpatients and inpatients, but no significant differences were noted (table not shown).

Reliability of MUST and MST

A subsample of 23 patients (11 male patients, 12 female patients) was included in the inter-rater reliability study. Table 4 shows that the kappa (κ) value of the MUST by a dietitian versus nurse A and the same dietitian versus nurse B were 0.91 (95.6% agreement) and 0.65 (82.6% agreement) respectively. The kappa value of the MUST rater for nurse A and nurse B was 0.75 with 86.9% agreement. The inter-rater reliability of MUST was substantial with a mean kappa value of 0.78. The kappa value of the MST by a dietitian versus nurse A was 0.71 (86.9% agreement), a dietitian versus nurse B was 0.55 (82.6% agreement) and nurse A versus nurse B was 0.32 (69.5% agreement). The inter-rater reliability of MST was moderate with a mean kappa value of 0.52.

Table 2. Nutritional risk and status according to MUST, MST, SGA, anthropometry and energy intake [expressed as number (%)]

	Men (n=60)	*Women (n=91)*	*Total (N=151)*
Malnutrition Universal Screening Tool (MUST)			
Not at risk	40 (66.7)	59 (64.8)	99 (65.6)
At risk of malnutrition	20 (33.3)	32 (335.2)	52 (34.4)
Malnutrition Screening Tool (MST)			
Not at risk	42 (70.0)	58 (63.8)	100 (66.2)
At risk of malnutrition	18 (30.0)	33 (36.3)	51 (33.8)
Subjective Global Assessment			
Well nourished (SGA A)	47 (78.3)	74 (81.3)	121(80.1)
Malnourished (SGA B and C)	13 (21.6)	17 (18.7)	30 (19.9)
Body Mass Index			
< 18.5 kg/m^2	5 (8.3)	6 (6.6)	11 (7.3)
18.5-24.9 kg/m^2	24 (40.0)	39 (42.9)	43 (41.7)
25-29.5 kg/m^2	22 (36.7)	31 (34.1)	53 (35.1)
> 30.0 kg/m^2	9 (15.0)	15 (16.5)	24 (15.9)
Mid-upper arm circumference			
Well nourished	55 (91.7%)	87 (95.6%)	142 (94.0%)
Malnourished (<23.0 cm for men; <22.0 cm for women)	5 (8.3%)	4 (4.4%)	9 (6.0%)
Calf circumference			
Well nourished	51 (85.0%)	87 (95.6%)	138 (91.4%)
Malnourished (< 30.1cm for man ; <27.3 cm for women)	9 (15.0%)[a]	4 (4.4%)	13 (8.6%)
Energy intake			
Achieved requirement	15 (25.0%)	13 (14.3%)	28 (18.5%)
Did not achieve requirement	45 (75.0%)	78 (85.7%)	123 (81.5%)

[a]$p < 0.05$, significant difference between gender, Pearson Chi-square test

DISCUSSION

This study assessed the validity and reliability of two malnutrition screening tools in hospitalised adult patients. Our study has shown that the prevalence of malnutrition or at risk of malnutrition varied greatly depending on the nutritional screening and assessment tools used. The MUST and MST screened more patients at risk of malnutrition than SGA did. This finding is expected as MUST and MST have been used as screening instruments while SGA has been used as the preferred instrument for nutritional assessment (Muller *et al.*, 2011). Factors that may associate with the presence of malnutrition were age, gender and disease (Saunders, Smith & Stroud, 2010).

This present study shows that MUST and MST have high sensitivity and specificity when validated against the SGA, indicating that both screening tools are highly valid in recognising patients at risk of malnutrition and correctly identifying well-nourished patients. Based on Nahid *et al.* (1999), good screening tools should have a sensitivity and specificity value of at least 80% to show their usefulness. MUST has been validated previously among 348 inpatients and 50 outpatients at five hospitals in UK (Stratton *et al.*, 2004). It was proven to have high internal validity and was reliable in a clinical setting. A recent study of 894 hospitalised patients in Russia reported high sensitivity and specificity of MUST when compared with the SGA

Table 3. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of MUST and MST compared to various parameters [expressed as percentage](N=151)

	Malnutrition Universal Screening Tool (MUST)	*% Malnutrition Screening Tool (MST) %*
Subjective Global Assessment		
Sensitivity	96.6	93.3
Specificity	80.9	80.9
PPV	55.7	54.9
NPV	98.8	98.0
Body Mass Index		
Sensitivity	81.8	63.6
Specificity	69.2	66.4
PPV	17.3	7.8
NPV	97.9	93.0
Mid-upper arm circumference		
Sensitivity	88.8	55.5
Specificity	69.9	67.6
PPV	15.4	9.8
NPV	98.9	96.0
Calf circumference		
Sensitivity	53.8	46.1
Specificity	67.4	67.3
PPV	13.5	11.7
NPV	93.9	93.0
Energy intake		
Sensitivity	38.2	35.7
Specificity	82.1	75.0
PPV	90.3	86.2
NPV	23.2	21.0

Table 4. Inter-rater reliability of MUST and MST

	Agreement (%)	*Kappa value (κ)*	*95 % CI*
Malnutrition Universal Screening Tool (MUST)			
Dietitian versus Nurse A	95.6	0.91^{c}	0.82-0.99
Dietitian versus Nurse B	82.6	0.65^{b}	0.50-0.81
Nurse A versus Nurse B	86.9	0.75^{c}	0.61-0.87
Malnutrition Screening Tool (MST)			
Dietitian versus Nurse A	86.9	0.71^{c}	0.60-0.86
Dietitian versus Nurse B	82.6	0.55^{b}	0.35-0.67
Nurse A versus Nurse B	69.5	0.32	0.12-0.52

$^{b}p<0.01$, $^{c}p<0.001$ significant difference between rates, Pearson Chi-square test

(Lomivorotov *et al.*, 2013). Boleo-Tomea *et al.* (2012) also showed that MUST was a good screening tool among oncology patients with 80% sensitivity and 80.9% specificity compared to PG-SGA tool. However, a lower sensitivity and specificity of MUST as compared to the SGA has been reported in identifying malnourished patients in 995 patients admitted to Geneva University Hospital (Kyle *et al.*, 2006). This could be due to the different populations studied, differences in nutritional problems and the purpose or the variables in the screening tools. MST was previously validated in an Australian hospitalised population and had been reported to have high sensitivity and specificity when compared with SGA (Ferguson *et al.*, 1999). The sensitivity of MST against SGA in this study was 93.3% which is similar to the 93.0% reported in a previous validation study done on 50 oncology outpatients receiving chemotherapy (Isenring *et al.*, 2006). Moreover, Raja *et al.* (2004) reported high specificity (91.8%) using a simple and quick screening tool which was related to changes in weight and oral intake, when compared with the SGA in 658 patients at a hospital in Singapore.

According to our analysis, MUST demonstrates high sensitivity but low specificity when validated against BMI< 18.5 kg/m^2. This may due to the use of BMI as one of the component of MUST and hence high sensitivity was expected. Conversely, MST showed low sensitivity and low specificity when compared against BMI, indicating MST failed to detect patients at high risk of malnutrition as determined by BMI<18.5 kg/m^2. Similarly, a study comparing malnutrition screening tools against BMI<18.5 kg/m^{2}and unintentional weight loss in 275 adult hospital inpatients showed MUST had higher sensitivity (96%) and specificity (80%), whereas MST had lower sensitivity (76%) but higher specificity (90%) (Neelemaat *et al.*, 2011). A study by Almeida *et al.* (2012) reported that BMI had a weak ability to detect patients at risk of malnutrition and had misclassified a high number of patients who were actually at risk of malnutrition, when validated against SGA. Both tools, MUST and MST, showed lower specificity and PPV when validated with MUAC and CC. This result can be due to the fact that both MUAC and CC reflect subcutaneous fat and body muscle mass and size decreases during functional decline or inactivity in the long-term *(Tsai et al.,*2012).

Our study found that most subjects had inadequate energy intakes, thus, lower sensitivity and specificity were found in both malnutrition screening tools. This is in line with a study of 134 inpatients, at least 65 years old in Australia, which revealed that no screening tools were able to accurately recognise those patients with adequate or inadequate energy intakes (Young *et al.*, 2012). Therefore, a closer dietary assessment probably involving observation of intake is suggested for future studies. Inadequate dietary intake during hospitalisation may be related to the quality of hospital food, decreased appetite due to medical reasons, hospital environment and interruption during mealtimes (Ross *et al.*, 2011).

MUST was found to be a more reliable tool than MST since it had substantial agreement (mean kappa ((κ)= 0.78) as compared to the MST tool which showed a moderate agreement (mean kappa=0.52). The reproducibility of MUST between users (nurses, doctors, health care assistance and medical student) in hospital inpatients, outpatients and homes care had been shown by a reported kappa value ranging from 0.809 to 1.000 (Elia, 2003). However, the inter-rater agreement of MST found in this study was lower than those previously reported (the kappa value ranged from 0.84 to 0.97) after assessment by dietitians and nutrition assistants in an Australian hospital (Ferguson *et al.,* 1999). Training of nurses regarding the use of nutritional screening may improve the reliability of the tools. MUST shows higher reliability probably because the assessment involved more objective measures as compared to MST.

The absence of a generally accepted gold standard to establish the diagnosis of malnutrition in assessing the validity of the nutritional tools is a point of discussion in every study. The discrepancy between the definitions of malnutrition based on different parameters points to the complexity of the definition of nutritional status. SGA has been used as the preferred method of nutritional assessments but still has some limitations. The use of SGA may fail to identify some cases of malnutrition, particularly in early and acute malnutrition (Sungurtekin *et al.*, 2004). BMI<18.5 kg/m^2 is generally accepted as underweight and patients with BMI>25 are usually not recognised as malnourished. However, screening malnutrition by registering only low BMI may overlook patients with BMI>25 kg/m^2, despite significant weight loss (Kruizenga, 2003). This highlights the limitations of using BMI as the sole measure of nutrition assessment in identifying malnutrition. A further limitation was the use of energy requirements of individual participants, rather than a measurement using indirect calorimetry. The true validity of nutrition screening tools can only be discussed when its implication in clinical outcomes have been studied such as length of hospital stay, re-admission rates and mortality rates.

Early identification and treatment of malnourished patients improves quality of health care. Based on our results, MUST was found to have similar validity and higher reliability than MST for detecting risk of malnutrition in adult patients, probably due to its comprehensiveness and inclusion of an objective measure in the assessment of nutritional risk. On the other hand, MST is a quick (i.e., takes only 5 minutes) and simple screening tool which consists of three short questions to indicate risk of malnutrition. Whereas, MUST may require a slightly longer time, i.e., 10 to 15 minutes. However, selection of the most appropriate malnutrition screening tools for use should be based on hospital preferences; either a more comprehensive screening tool or a quick and simple screening tool and the availability of the resources and manpower. Challenges facing the implementation of a screening tool such as policy change, training, human resources and infrastructure may need to be addressed further.

CONCLUSION

MUST was found to have similar validity and higher reliability than MST. Therefore this tool can be recommended for use in identifying hospitalised adult patients at high risk of malnutrition. A further study to evaluate the effectiveness of the implementation of malnutrition screening tools in improving health outcomes is highly recommended.

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Conflict of Interest

There is no conflict of interest for any of the authors with regard to the content of this paper.

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