ARTICLE

Protein, malnutrition and wasting disorders

Validity of four nutritional screening tools against subjective global assessment for inpatient adults in a low-middle income country in Asia

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Abstract

Background/objectives Hospital malnutrition is a common problem worldwide. This study aims to assess the validity of widely used nutritional screening tools for hospitalized adults in acute care settings in Ho Chi Minh City, Vietnam.

Subjects/methods Participants in this study were 693 adult patients from six general public hospitals, in a multi-center survey undertaken in April and May, 2016. The criterion validity of the Malnutrition Screening Tool (MST), Malnutrition Universal Screening Tool (MUST), Nutrition Risk Screening (NRS-2002) and Mini Nutrition Assessment—Short Form (MNA-SF), modified MST (MST combined with low BMI), and BMI as independent tools were assessed using Subjective Global Assessment (SGA) or low BMI ($<18.5 \, \text{kg/m}^2$) as the reference method. Area under curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using the ROC curve method to determine the validity of screening tools.

Results NRS-2002, modified MST (MST + low BMI), MUST, and BMI at $21 \, \text{kg/m}^2$ showed moderate/fair validity compared to the reference method (SGA or BMI). MST alone and MNA-SF showed poor validity due to low sensitivity (41.8 and 35.0% for MST and MNA-SF, respectively).

Conclusions Based on specificity and sensitivity, the first choice for the most appropriate screening tool for use in Vietnam is the NRS-2002, following by the MST + BMI, MUST, and BMI alone at the cut-off value of $21 \, \text{kg/m}^2$. Further investigation on the feasibility and acceptability are required to determine the most appropriate screening tools for use within the Vietnamese context.

Introduction

Malnutrition in acute care settings is a common problem worldwide with prevalence varies from 20.0 to 50.0% [1]. According to a survey in Ho Chi Minh city (HCMC) Vietnam, at least one in three adults (34.1%) in acute care settings were malnourished, representing a significant health issue [2]. Many studies have confirmed the severe impact of malnutrition during hospitalization on morbidity and mortality [3, 4].

In order to identify, prevent, and manage malnutrition, all patients should be screened for risk of malnutrition as soon as possible on or after hospital admission. Nutrition screening should be conducted using validated screening tools ensuring that it is simple enough to enable it to be used by general trained non-nutrition hospital staff [5]. In Western countries, there are a variety of validated screening tools recommended for use in acute care settings such as the: Malnutrition Screening Tool (MST) [6]; Malnutrition Universal Screening Tool (MUST) [7]; Mini Nutrition Assessment Short-Form (MNA-SF) [8]; and Nutrition Risk Screening 2002 (NRS-2002) [9]. However, most of these validated screening tools have been developed for Caucasian populations, such as Australia (MST), United Kingdom (MUST), European countries (NRS-2002), and the United States (MNA-SF). In Asia, NRS-2002 and MNA-SF have been validated in one study in Singapore but only within

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Table 1 Details on the criteria used in screening tools and modified screening tools used in this study

Criteria	MUST	NRS-2002	MNA-SF	MST	MST + BMI	BMI alone
Body mass index	✓	✓	✓		✓	✓
Weight loss	✓	✓	✓	✓	✓	
Decreased dietary intake	✓	✓	✓	✓	✓	
Severity of diseases		✓				
Mobility			✓			
Psychological stress			✓			
Neuropsychological problems			✓			
Cut-off values of risk of malnutrition	≥2	≥3	≤7	≥2	≥2 or BMI <18.5 kg/m^2	From 18.5 kg/m^2 To 22 kg/m^2

MUST Malnutrition Universal Screening Tool, *NRS-2002* Nutrition Risk Screening, *MNA-SF* Mini Nutrition Assessment—Short Form, *MST* Malnutrition Screening Tool, *BMI* body mass index

elderly populations[10]. For adult populations in Asian countries, although international screening tools have been used [11], studies on their validity are limited. In Vietnam no malnutrition screening tools have been developed, validated, or recommended for use. With differences in body composition [12], cultural context, variability in accessing hospital resources and differences in population-wide nutrition issues, the validity of international screening tools in the Vietnamese hospital context are unknown. The validity of a screening tool can also be influenced by other local factors, such as a higher prevalence of underweight before hospital admission; disease patterns and socioeconomic status [2].

In order to improve the nutritional status of patients in hospitals, health authorities in HCMC need to know the most valid screening tools for identifying risk of malnutrition in hospitalized patients that are relevant to this population for development of policies related not only to screening for malnutrition but also to the nutritional assessment and treatment of hospitalized patients in HCMC.

Materials and methods

Patients

Participants in this study were adult patients from six general public hospitals in HCMC who were a subsample of a multi-center survey on the prevalence and associated risk factors of hospital malnutrition undertaken in April and May 2016 [2]. General hospitals can be divided into three levels (one, two, or three), based on the technical qualifications of medical staff, specialities catered for, equipment and infrastructure, with Level on the highest. This survey used a stratified multi-stage cluster sampling strategy. First, general public hospitals in HCMC were divided into three strata: Level 1 general public hospitals, Level 2 general pubic hospitals, and Level 3 general public hospitals.

Second, in each stratum, two hospitals were selected on a convenience basis that represented three geographic zones (urban, semi-urban, and rural) of the city. Third, in each of the selected hospitals, internal medicine and surgical wards were selected on a convenience basis to cover wards from different medical specialities. Finally, In each of the selected wards, the number of patients proportionate to the number of beds in that hospital strata were recruited. Participants were adult patients over 18 years old who presented at selected wards during the study period except those who were critically ill, palliative, pregnant, or unable to give informed consent. The invitation to participate, written information sheet and consent forms were given to all eligible patients one day prior to data collection.

Measurements

Body weight was measured using Tanita™ electronic scales to the nearest 100 g and body height was measured using a portable World Health Organization (WHO) recommended standard height scales to the nearest 0.1 cm. All measurements were taken using standard procedures according to WHO guidelines [13]. If height or weight were not measurable, participants were excluded from the analysis of this study.

Risk of malnutrition was measured using the MST [6], MUST [7], NRS-2002 [9], and MNA-SF [8]. These screening tools were selected because they were found to be validated to predict malnutrition in hospitalized patients in acute care settings [4, 14–17]. The parameters, as well as the cut-off values, to define risk of malnutrition for each of the screening tools are presented in Table 1. Questions that were duplicated across tools (BMI, weight loss, and poor dietary intake) were only asked once and then inferred in different tools to reduce the burden for participants.

The cross-cultural adaption process from Beaton et al. [18] which comprises six steps, including translation, synthesis, back translation, expert committee review, and

Table 2 Characteristics related to malnutrition among hospitalized adults by nutritional status

Characteristics	n	%
Gender		
Male	263	38.0
Female	430	62.0
Weight loss recently without trying		
Yes	321	46.8
No	318	46.4
Unsure	47	6.9
Duration of weight loss		
In the last 1 month	150	46.3
In the last 2 months	32	9.9
In the last 3 months	53	16.4
In the last 6 months	56	17.3
Can not specify	33	10.2
Percentage of weight lost		
<5%	186	57.9
5–10%	76	23.7
>10%	59	18.4
Poor dietary intake		
Yes	369	53.8
No	317	46.2
Duration of poor dietary intake		
In the last 1 week	161	45.9
In the last 1 month	82	23.4
In the last 3 months	90	25.6
Can not specify	18	5.1
Food intake in preceding week compared to normal requirement		
<75%	83	23.0
<50%	186	51.5
<25%	76	21.1
Can not specify	16	4.4
Functional capacity		
Goes out	597	86.2
Able to get out of bed/chair, but does not go out	75	10.8
Bed or chair bound	21	3.0
Muscle and fat wasting		
Normal	512	73.9
Mild loss	163	23.5
Severe loss	18	2.6
Gastrointestinal symptoms		
Normal	442	87.7
Some symptoms lasting for >2weeks	62	12.3
Neuropsychological problems		
Dementia	67	9.7
No psychological problem	626	90.3
Characteristics	n	Mean ± SD
Age (years)	693	57.7 ± 18.7

committee appraisal, was used to translate all questions into Vietnamese for this study.

Data was collected by medical doctors, nurses, and bachelor of public health staff of the Nutrition Centre, HCMC Vietnam. Inter-rater reliability on the use of the screening tools among different research assistants was evaluated through a pilot on 30 patients in one hospital and all research assistants show consistent reliability (with interclass correlation coefficient = 0.72). SGA was assessed by the principal researcher, who is a medical doctor with clinical nutrition training employed by the Nutrition Centre HCMC. The principal researcher was trained and had experience in using SGA [19]. All screening tools were assessed in each participant by a single researcher.

Determination of malnutrition

Nutritional status of participants was measured using the assessment tool Subjective Global Assessment (SGA) [20]. SGA was used as the diagnostic tool as its parameters align with elements in diagnostic criteria from the American Society for Parenteral and Enteral Nutrition (ASPEN) [21]. In addition, according to the diagnostic criteria from the European Society for Parenteral and Enteral Nutrition (ESPEN), patients are diagnosed with malnutrition if they also have a BMI < 18.5 kg/m^2 [22]. Therefore, participants were defined as malnourished if they were classified as a "B" or "C" on SGA, or they had a BMI < 18.5 kg/m^2 (SGA or BMI).

Statistical methods

Data were analyzed using the statistical package STATA version 10.0 (2007, Stata corporation, TX, US) [23] and weighted for the strata and cluster sampling design. Sampling weights for the number of participants in each hospital were calculated to account for the difference in stratified cluster sampling design. The weights were calculated by using W1 × W2 where W1 is the weight of hospital in each hospital level stratum and W2 is the weight of patients in each selected hospital. W1 of each of hospital was calculated by using the total number of beds in that hospital divided to the average number of bed per hospital in that stratum. Similarly, the W2 of each of hospital ward was calculated by using the number of patients in that wards divided the average number of patients per wards in that hospital. Sampling weight process helps to provide more representative prevalence.

Receiver operator characteristic (ROC) curve analysis, area under the ROC curve (AUC), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and percentage of correctly classified were

calculated for each screening tool using SGA or BMI as reference standards.

AUC was utilized to determine the criterion validity of a screening tool, and to compare the two screening tools on the same subject [24]. The screening tools with the highest AUC, acceptable sensitivity, specificity, PPV, NPV, and percentage of correctly classified participants were considered as the most valid screening tools for use.

Regarding the validity rating, a screening tool was classified as "good" if both sensitivity and specificity were >80% or AUC was >0.8;"moderate/fair" if sensitivity or specificity are <80% but both were >50% or AUC was in the range of 0.6–0.8. The tool was classified as poor if sensitivity or specificity was <50%, or AUC was <0.6 [15].

Ethics

The protocol was approved by the Human Research Ethics Committee of Queensland University of Technology, Australia (Approval number 1500001156) and by Health Department HCMC Vietnam with approval number 2157/SYT-NVY.

Results

Among 887 participants in the survey, 194 (21.9%) participants, who had incomplete data or could not be measured weight and height directly (due to being bedridden, their medical condition or a severe decrease in functional capacity), were excluded from the analysis. The final sample size is 693 participants. In this survey, participants were more likely to be female (62.0%), and had lower socio-economic status compared to the general population, with 63.4% completing primary school or below, 24.4% belonging to households experiencing poverty or marginal poverty, and 56.3% not working in the last 6 months.

Characteristics related to malnutrition

Characteristics related to malnutrition among participants are presented in Table 2. The majority of participants had problems with acute weight loss and poor dietary intake. Almost half of participants had lost weight recently without trying (46.8%) and this mostly took place within the last month (46.3%). However, a majority of the weight losses were <5% of body weight (57.9%). Similarly, poor dietary intake was identified as an important issue with half of participants indicating a poor dietary intake (53.8%), and a majority of this decrease had occurred in the last week (44.9 %) with one-half (51.5%) consuming <50% of their normal requirement.

Gastrointestinal symptoms and neuropsychological problem were not a significant issue among the hospitalized adults sampled, and the prevalence of these issues was 12.3% and 9.7%, respectively.

Validity of screening tools

Sensitivity, specificity, PPV, and NPV, and percent of correct classification for each nutrition screening tool, different cut-off values of BMI as an independent tool and the modified screening tools (MST + BMI) are presented in Table 3.

Among the available screening tools, MUST and NRS-2002 showed moderate/fair validity compared to the reference method (SGA or BMI) in this study. While MST and MNA-SF showed poor validity compared to the reference method because of the low sensitivity (with sensitivity of MST and MNA-SF 41.8% and 35.0%, respectively).

Table 3 Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), and percentage of correctly classified measures of the nutrition screening tools and nutritional parameters using SGA or BMI as a reference method

Nutrition parameter	Cut-off value	AUC	Sensitivity	Specificity	PPV	NPV	Correctly classified
MST	2	0.62	41.8	82.0	55.0	72.7	69.3
MST + BMI (<18.5 kg/m^2)	2	0.74	66.8	82.0	65.2	82.1	77.2
MUST	2	0.74	63.4	85.2	70.0	80.8	78.4
NRS-2002	3	0.78	74.6	80.6	64.9	84.4	78.6
MNA-SF	7	0.65	35.0	95.8	77.3	75.1	76.5
Body mass index	18.5	0.70	39.6	100	39.4	100	80.8
	20	0.71	53.2	89.2	72.5	78.0	77.8
	20.5	0.72	60.5	84.1	66.9	79.3	76.6
	21	0.73	64.6	81.0	64.3	80.5	75.8
	21.5	0.72	67.7	75.7	59.2	80.8	73.2
	22	0.70	71.8	68.1	54.9	81.6	69.3

AUC area under the curve, *PPV* positive predictive value, *NPV* negative predictive value

When MST was combined with low BMI (<18.5 kg/m^2), findings indicated moderate/fair validity with significant improvements in AUC (0.74 vs. 0.62), sensitivity (66.8 vs. 41.8%), PPV (65.2 vs. 55.0%), NPV (82.1 vs. 72.7%), and percent of correctly classified (77.2 vs. 69.3%).

When BMI was examined as an independent tool, the AUC reached the highest level (0.73) at BMI 21 kg/m^2. At this cut-off value, BMI also yielded the most optimal levels for sensitivity (64.6%), specificity (81.0%), PPV (64.3%), NPV (80.5%), and percentage of correctly classified (75.8%) compared to other cut-off levels.

Prevalence of risk of malnutrition

Prevalence of malnutrition (using SGA or BMI), risk of malnutrition using nutrition screening tools (MST, MUST, NRS-2002, and MNA-SF), and the risk of malnutrition using a modified tool (MST + BMI) and BMI alone (at the optimal cut-off of 21 kg/m^2) are presented in Table 4. Prevalence of malnutrition risk varied significantly between different screening tools. The risk of malnutrition was highest with NRS-2002 (38.5%) and lowest with MNA-SF (18.1%). The prevalence of MST combined with BMI (36.0%) was closer to the prevalence from the reference (SGA or BMI) compared to prevalence from MST alone (27.2%). The prevalence BMI (at the cut-off of 21 kg/m^2) (36.0%) was close to the prevalence of malnutrition using SGA or BMI as the reference method. The prevalence of malnutrition risk using a majority of the screening tools was lower than the prevalence of malnutrition (34.1%) except for the NRS-2002 (38.5%).

Discussion

The finding of moderate/fair validity of MUST and NRS-2002 in this study was comparable with other validity studies worldwide, where MUST and NRS-2002 were the most commonly tested tools, and showed fair to good validity in nutritional risk screening [14]. In Asia, this finding was also comparable to the finding from a validity study for an elderly Singaporean population in which NRS-2002 showed moderate/fair validity with AUC, sensitivity and specificity being 0.78, 69, and 79%, respectively [10]. Similarly, NRS-2002 also showed moderate/fair validity among cancer patients in Korea, with 62% sensitivity and 93% specificity [25].

In contrast, the results on the validity of the MST were different to those from the literature. While MST was also the most commonly tested tool and showed fair to good validity in a majority of validated studies internationally [14], it showed poor validity in this study. The poor validity of MST may be explained by the lack of BMI parameters in the tool compared to MUST and NRS-2002. This was a significant issue considering the high prevalence of low BMI (<18.5 kg/m^2) among Vietnamese hospitalized adults in this study (14%). This explanation was confirmed when the validity of MST improved significantly by combining it with BMI. The high prevalence of low BMI (<18.5 kg/m^2) among Vietnamese hospitalized adults was also the explanation for the possibility of BMI as an independent screening tool in this study with moderate/fair validity.

MNA-SF showed poor validity in this study, with low sensitivity (35.0%). This may be due to the long reference duration (3 months) for the parameter on poor dietary intake. MNA-SF was not sensitive enough for this population where a majority of participants had short-term poor dietary intake (within 1 week). In addition, MNA-SF lacked sensitivity due to a majority of participants having a low prevalence of neuropsychological problems (9.7%). This was further explained by the exclusion of rehabilitation wards in this study.

When examining sensitivity, the sensitivity of NRS-2002 (74.6%), and MST + BMI (66.8%) were superior to the sensitivity of a BMI at 21 kg/m^2 (64.6%) and MUST (63.4%). In ideal circumstances, higher sensitivity is preferred to enable the identification of malnourished patients as soon as possible for further assessment and intervention. This is especially important in acute care settings where patient length of stay routinely measured in days. Therefore, NRS-2002 and MST + BMI are more desirable compared to BMI alone and MUST.

Table 4 Weighted malnutrition risk among hospitalized patients using different criteria

	Weighted malnutrition risk % (95CI)
Subjective Global Assessment or BMI (<18.5 kg/m^2)	34.1 (28.8–39.8)
Malnutrition screening tool (MST)	27.2 (20.9–34.6)
Malnutrition screening tool (MST) + BMI (<18.5 kg/m^2)	36.0 (32.6–39.6)
Malnutrition universal screening tool (MUST)	30.1 (24.1–36.9)
Nutrition risk screening (NRS-2002)	38.5 (33.4–44.0)
Mini Nutrition Assessment—Short Form (MNA-SF)	18.1 (12.4–25.6)
Body mass index (<21 kg/m^2)	36.0 (32.2–40.1)

95%CI 95% confident interval

When examining specificity, the specificity of MUST (85.2%) was better than the specificity of MST + BMI (82.0%), BMI at 21 kg/m^2 (81.0%), and NRS-2002 (80.6%). In the context of limited resources, higher specificity is preferred because it will assist in reducing false positive cases, enabling resources to be mobilized to higher priority cases.

Regarding the structure of screening tools, NRS-2002 has been developed with two parts that serve as both screening and assessment. This means, it can be mobilized as an assessment tool in environments with limited resources to perform both screening and assessment. Regarding the determination of unintentional weight loss, MST is more practical than MUST as it provides direct weight loss categories rather than requiring calculation of percentage weight loss as seen in MUST.

Considering sensitivity, specificity and the structure of the screening tools, NRS-2002 would be the preferred choice following by MUST + BMI, with MUST and BMI alone at 21 kg/m^2 in order of preference.

Body mass index at cut-off value 18.5 kg/m^2 is currently the commonly used indicator for malnutrition screening in hospitals in Vietnam. This study, however, demonstrates that the routine use of BMI alone at this cut-off value is absolutely not appropriate to identify malnutrition in hospitals in Vietnam due to its very low sensitivity (39.6%) and low PPV (39.4%). BMI at 21 kg/m^2 had better validity compared to BMI at cut-off value 18.5 kg/m^2 although it had lower validity compared to screening tools. This study, therefore, showed that a screening tool is better than BMI alone to identify malnutrition among hospitalized adults in Vietnam. The use of BMI if applicable, should be at the cut-off value of 21 kg/m^2 and should be reserved in a very rare circumstances/ environments where the resources are very constrained and/or works are overload.

Although MST, NRS-2002 and MUST have all been used as nutrition screening tools for adult populations in acute care settings in Asian countries [11], they were rarely validated for use in these populations. Instead, most of studies in Asian countries focused on the development and validation of screening tools for use in predominantly elderly populations as seen in the Chinese Nutrition Screen CNS (China) [26], the Malnutrition Risk Screening Tool – Hospital or MRST-H (Malaysia) [27], and the validation of NRS-2002 and MNA-SF in Singapore elderly [10]. In our study, we found some widely used international screening tools and their modification were valid for use among Vietnamese adult populations. Their validity and applicability among other adult populations in Asian countries needs further exploration.

For adult population in Asian countries, a nutritional screening tool was developed for use in acute care setting in Singapore (the 3-min nutrition screening or 3-min NS) [28].

This screening tool contains three questions on unintentional weight loss, nutritional intake and muscle wastage. BMI was not included in this tool due to the practical issues associated with measuring BMI. Although being used at different cut-off points, the 3-min NS showed that questions on unintentional weight loss and nutrition intake were valid for use in nutritional screening in a hospitalized Singaporean population. In addition, the 3-min NS also showed that the use of only two questions on unintentional weight loss and nutritional intake did not demonstrate adequate validity unless combined with a question on muscle wastage. This is similar to our findings where the combination of unintentional weight loss and nutritional intake with BMI increased the validity of screening tools for use in a Vietnamese population.

Validity in terms of specificity and sensitivity is not the only issue to be considered in deciding on an appropriate screening tools for hospitalized adults in HCMC Vietnam. Currently the resources for and focus on nutrition care in general and nutrition screening specifically are very limited in healthcare facilities in HCMC Vietnam. Therefore, selection of an appropriate screening tool for use in Vietnam hospitals will not only depend on the validity of the screening tools themselves but will also depend on other factors such as the acceptability and feasibility of the screening tools as administered by the proposed administrators (in this case medical doctors and nurses) in hospitals. This study has established the validity of the most used international screening tools, however, acceptability, and feasibility need to be further investigated.

The current study had some strengths, such as using a highly representative sample for hospital patients population, a high response rate (98.7%), data collection by staff with experience in nutrition and research, and strong support from leaders, staff, and patients from participating hospitals, weight, and height were taken directly by research team rather than collected from medical notes. The results from nutritional assessments (using SGA) were not blinded to the nutrition screening results (using screening tools) was limitation.

In conclusion, based on specificity and sensitivity, the first choice for the most appropriate screening tool for use in Vietnam is the NRS-2002, following by the MST + BMI, MUST, and BMI alone at the cut-off value of 21 kg/m^2. A prospective study is required to validate the screening tools found in this study.

Author contribution This study was done as part of PhD project of TQC and was supervised by DG, MHJ, MB, and DTND. The Project was planned and designed by TQC, DG, MB, MHJ, and DTND. Data was collected, analyzed by TQC. The original manuscript was written by TQC and then all authors participating in editing and revision. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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