Title page

Title: Concurrent and predictive validity of the Mini Nutritional Assessment Short-Form and the Geriatric Nutritional Risk Index in elderly stroke rehabilitation patients

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Abstract

Background: Malnutrition might worsen the clinical outcomes in stroke patients, although few nutritional screening tools have assessed their validity.

Methods: We assessed clinical data of consecutive stroke patients aged ≥65 years in rehabilitation hospital from 2015 to 2017 using the Mini Nutritional Assessment Short-Form (MNA-SF) and the Geriatric Nutritional Risk Index (GNRI) for index testing. The European Society for Parenteral and Enteral Nutrition diagnostic criteria for malnutrition (ESPEN-DCM) was used as a reference standard. The receiver-operating characteristics curve was illustrated by the sensitivity (Se) and specificity (Sp). The Youden index was used to define the cut-off value for malnutrition detection or screening. The Functional Independence Measure (FIM) and discharge destination were compared for verifying predictive validity.

Results: We enrolled 420 patients for the analysis. Of them, 125 patients were included in malnutrition group (mean age: 80 years) and 295 in non-malnutrition group (mean age: 77 years) by the ESPEN-DCM. The area under the curve of the MNA-SF and the GNRI were 0.890 and 0.865, respectively. Se and Sp cut-off values to detect or screen malnutrition were 5 (Se: 0.78; Sp: 0.85) and 7 (Se: 0.96; Sp: 0.57) for the MNA-SF and 92 (Se: 0.74; Sp: 0.84) and 98 (Se: 0.93; Sp: 0.50) for the GNRI, respectively. The GNRI were associated with discharge destination, whereas no correlation was observed between the MNA-SF and outcomes by multivariable analysis.

Conclusions: The MNA-SF and GNRI have fair concurrent validity if appropriate cut-off values were used. The GNRI exhibits good predictive validity in stroke patients.

Introduction

Individuals with stroke often experience malnutrition, with the prevalence of up to 62% [1]. The prevalence of malnutrition in rehabilitation hospitals/facilities is three times higher than that in acute care hospitals [2]. Undernutrition accounts for decreased survival rate, prolonged hospital stay, inflated healthcare cost and diminished recovery of physical and swallowing function [3–6]. In addition, nutritional improvement in stroke patients with malnutrition correlates with the resumption of activities of daily living [7,8]. Thus, early screening and detecting of malnutrition in stroke rehabilitation patients are imperative to regain the functional capacity, activities of daily living and quality of life.

Despite the growing awareness of malnutrition, screening tools have rarely been validated in patients with stroke [1]. The Malnutrition Universal Screening Tool (MUST) [9] is the only nutrition screening tool that has been used to assess the predictive validity [5]; thus, its use is recommended in recent clinical guidelines by the European Society for Clinical Nutrition and Metabolism (ESPEN) [10]. Although there is no gold standard for determining malnutrition, the ESPEN has proposed operative, diagnostic criteria for malnutrition [11], which are in good agreement with the MUST [12]. However, none of the tools have been used to investigate the concurrent validity in stroke survivors to date.

The Mini Nutritional Assessment (MNA) and its shortened form (MNA-SF) are some of the leading tools for the assessment or screening in elderly older individuals with or at risk of malnutrition [13, 14]. Despite its efficacy and adequate concurrent and predictive validity, the MNA-SF could potentially overestimate malnourished elderly rehabilitation patients with the prevalence of 92%–99% [3, 15], possibly attributing to stroke sequela, including hemiparesis, aphasia and muscle atrophy [3]. Conversely, the Geriatric Nutritional Risk Index (GNRI) could be useful to estimate the survival of or

complication in elderly patients [16]. In addition, the efficacy of the GNRI has been reported for estimating activities of daily living, discharging to home and recovery of full oral intake in patients with stroke [6, 7, 17, 18], although it is inconsistent with the validated nutritional assessment method [19].

Thus, this study aims to confirm the concurrent and predictive validity of the MNA-SF and GNRI in elderly individuals with stroke in the convalescent stage and evaluate the optimal cut-off value for detecting or screening malnourished patients.

Materials and Methods

We conducted this retrospective, observational cohort study in three convalescent rehabilitation wards of a single hospital in Japan. A multidisciplinary rehabilitation team provided the comprehensive rehabilitation in the wards, which was covered by the public healthcare insurance. The detail of the wards was provided elsewhere [20]. This study protocol complied with the principles outlined in the Declaration of Helsinki, and it was approved by the Ethics Committee of the University of Nagasaki (approval number: 287) and Nagasaki Rehabilitation Hospital. As we used only anonymous clinical data in the daily clinical practice in this study, we supplied information about this study to all patients and explained the opt-out option, allowing patients to withdraw from the study dataset at any time.

Data source and selection criteria

In this study, we analysed the clinical data of consecutive patients aged ≥ 65 years who were admitted to the convalescent rehabilitation wards for post-stroke rehabilitation from 16 May 2015 to 16 May 2017. The exclusion criteria were as follows: missing data for the serum albumin concentration (Alb) within 7 days on the admission day, no definitive diagnosis of the stroke type and unclear data for the usual body weight (other than apparently non-

malnourished: individuals who had the body mass index [BMI] or fat-free mass index [FFMI] above the reference standard). We extracted all data by a medical chart or the facility's dataset that were entered by a registered dietitian or a medical secretary from the medical chart. In addition, we collected the following basic characteristics of patients: age, sex, days from stroke onset to admission, length of hospital stay, stroke subtype (e.g. cerebral infarction, intracranial haemorrhage or subarachnoid haemorrhage), disabilities, comorbidities, history of stroke onset and pre-stroke need of long-term care. Notably, medical doctors in acute care hospitals or convalescent rehabilitation wards diagnosed the stroke subtype, comorbidities and disabilities. In addition, the need for long-term care was verified by the certification of the long-term care insurance (LTCI) before a stroke. The LTCI is a public, universal, long-term care system in Japan [21]. Moreover, the height of patients was measured by a stadiometer or tape measure by nursing staff. Of note, if their methods could not be applied because of marked contracture of the limbs or humpback, the knee height was measured by a knee-height calliper and, then, the height was calculated using a race-specific equation [22].

Index tests

We set the MNA-SF and GNRI as index tests. The MNA-SF was the malnutrition screening tool that exhibited good validity and reliability in elderly individuals [13, 23]. The MNA-SF comprises the six following domains: appetite loss, weight loss, mobility, stress/acute disease, neuropsychological problems and BMI. The total score of the MNA-SF ranges from 0 to 14 points, where a score of 0–7 signifies malnourished, 8–11 at risk of malnutrition and 12–14 denotes well-nourished [13]. Trained registered dietitians scored the MNA-SF at admission.

The GNRI is a nutritional risk indicator in elderly individuals who has been developed from the Nutritional Risk Index [24]. The equation of the GNRI is as follows:

$$GNRI = [14.89 \times Alb\ (g/dL)] + \{41.7 / [body\ weight\ (kg) / ideal\ body\ weight\ (kg)]\}$$

Although the Lorenz formula was used for evaluating the ideal body weight in the original equation of GNRI, we used the BMI (22 kg/m^2) for the ideal body weight in this study because it exhibited a substantial correlation with the Lorenz formula [25]. If the body weight exceeded the ideal body weight, the ratio of the body weight to the ideal body weight was set as 1. The malnutrition risk can be defined by the GNRI as follows: <92, severe/moderate risk; 92–98, low risk; >98, no risk [17, 26].

Reference standard

In the absence of a gold standard to diagnose malnutrition, this study used the ESPEN diagnostic criteria for malnutrition (ESPEN-DCM) as a reference standard of malnutrition. The ESPEN-DCM is consensus-based criteria proposed by the ESPEN to diagnose malnutrition [12], is in good agreement with the MUST [13] and predicts the survival or functional outcome [27, 28]. The criteria comprise two alternative ways to define malnutrition in patients at risk of malnutrition screened by a validated tool: (1) BMI <18.5 kg/m^2, (2) unintentional body weight loss (>5% per 3 months or >10% indefinite of time) and low BMI (<20 kg/m^2 for individuals aged <70 years or <22 kg/m^2 for those aged ≥70 years) or low FFMI (<15 kg/m^2 for females; <17 kg/m^2 for males). As the instrumental assessment of body composition was not used in the facilities during the study period, we used the estimated fat-free mass (eFFM) based on the estimated creatinine excretion rate (eCER) by following equations [29, 30]:

eCER = 879.89 + [12.51 × body weight (kg)] + (6.19 × age) + (34.51 if black)–
(379.42 if female)
eFFM (kg) = 13.0 + 0.03 × eCER
estimated FFMI (eFFMI, kg/m^2) = eFFM/height (m)^2

Of note, the MUST was used for malnutrition screening in the ESPEN-DCM process to avoid incorporation bias. In addition, an independent, experienced registered dietitian performed the MUST, defined malnutrition by the ESPEN-DCM post hoc and was blinded to the results of the MNA-SF and GNRI or any other outcome measures based on the medical chart. We enrolled all patients who had a BMI or eFFMI above the ESPEN-DCM in the analysis irrespective of the availability of the usual body weight and their result of the MUST was set as 'uncertain'.

Sample size calculation

We evaluated the sample size by using the following equation:

$$\text{Sample size } (N) = 4\, Z_\alpha^2 P\,(1 - P) / W^2$$

Where Z_α is the standard normal deviate; P is the expected sensitivity of the MNA-SF and W is the width of the confidence interval.

In this study, we set the sensitivity of the MNA-SF at 85%, which was reported previously [13]. If the standard normal deviate was 1.96 (with a 95% confidence level), the width of the confidence interval being ±0.10, the required

sample size of individuals with malnutrition was 196. Based on our previous study, the expected prevalence of malnutrition was 42% [3]. Hence, we set 2 years of the study period to collect a sample of 467 participants.

Statistical analysis

All statistical analyses were performed using the IBM Statistical Package for the Social Sciences, version 21 (IBM Corporation, Armonk, NY). In this study, two dimensions of validity (concurrent and predictive) were assessed. We divided all study participants into the malnutrition group (M) and non-malnutrition group (non-M) based on the results of the ESPEN-DCM to test the concurrent validity. Then, we plotted the receiver-operating characteristics curves by using the MNA-SF and GNRI to define malnutrition and evaluated area under the curve. We adopted the following two approaches to determine the optimal cut-off value: (1) the value with the maximum Youden index (sensitivity [Se] + specificity [Sp] − 1) [31], which might be optimal for detecting malnutrition and (2) the value with >90% of the sensitivity and >50% of the specificity, which might be appropriate for screening malnutrition. Furthermore, we used the criteria [32], good (both Se and Sp: >0.8), fair (either Se and Sp: <0.8; both Se and Sp: >0.5) and poor (either Se and Sp: <0.5) to assess the overall capacity for malnutrition screening of each tool. Furthermore, we evaluated the kappa value (κ) to confirm the accuracy.

We used two outcome measures to test the predictive validity, [1] the Functional Independence Measure (FIM) at discharge, as an indicator of ADL and [2] discharging destination (home, long-term care facilities or hospitals/acute care hospitals). The FIM is one of the leading indicators of ADL [33], which comprises 18 domains (13 motor domains and 5 cognitive domains) and each domain is scored between 1 (total assistance) and 7 (complete independence). The total FIM score ranges from 18 to 126. Furthermore, we classified the

individual data by using the ESPEN-DCM (M and non-M groups), MNA-SF and GNRI (based on the predetermined cut-off value for detecting and screening malnutrition) and compared the outcome measures between the groups.

In this study, the parametric data are expressed as mean (SD), whereas non-parametric data are presented as the median and interquartile range (IQR). We compared the basic characteristics and outcome measures between two groups by using the unpaired *t*-test, χ^2 test, Fisher's exact test and Mann–Whitney U-test and Kruskal-Wallis test appropriately, followed by Bonferroni correction or Dunn test for multiple comparison (>2 groups). In addition, we performed multivariable regression analyses to assess the impact of malnutrition on the outcomes by the linear regression analysis and binary logistic regression analysis appropriately. Variables exhibited a marked difference between the M and non-M groups in the univariate analysis and were included for the multivariable analysis. We considered the statistical significance at $P < 0.05$.

Results

Figure 1 outlines the flow diagram of the malnutrition diagnosis. During the study period, data from 520 patients were obtained. Of these, we excluded 26 patients because of no Alb data, 2 because of the uncertain diagnosis of stroke and 72 owing to the unavailability of the usual body weight. Finally, we enrolled 420 patients for the data analysis. Based on the ESPEN-DCM, 125 patients were assigned to the M group and 295 to the non-M group.

Table 1 presents patients' demographic data. Patients in the M group were older, had a higher proportion of females, subarachnoid haemorrhage, dysphagia and certification of LTCI than those in the non-M group. In addition, the M group exhibited

longer onset-admission duration, less frequency of cerebral infarction and dyslipidaemia and lowered FIM than those in the non-M group. The receiver-operating characteristics curves suggested that the area under the curve of both the MNA-SF and GNRI were 0.890 and 0.865, respectively (Figure 2). Based on the Youden index, the MNA-SF scores of 5 (Se: 0.784; Sp: 0.847) and 7 points (Se: 0.960; Sp: 0.570) were optimal to detect and screen malnutrition, respectively. Conversely, the well-established cut-off value for 'at risk of malnutrition' (≤11 points) revealed the markedly low Sp (0.017; Table 2). Furthermore, the optimal cut-off value of the GNRI to detect malnutrition was 92 (Se: 0.744; Sp: 0.841) and 98 (Se: 0.928; Sp: 0.502), which were equal to the well-established cut-off value for moderate or severe and mild malnutrition risk, respectively.

At discharge, the M group exhibited a lower FIM (median: 80 vs. 114; $P < 0.001$), higher frequency of discharge for acute care hospitals (26% vs. 14%; $P < 0.001$) and fewer returning home (49% vs. 77%; $P < 0.001$). Likewise, individuals with the lowest score of the MNA-SF and GNRI exhibited a markedly lower FIM and less opportunity to return to home (Table 3). After adjustment for covariates, a GNRI score of <92 was considerably associated with the discharge to acute care hospitals (odds ratio [OR]: 3.12, 95% confidence interbal [CI]: 1.09–8.92), whereas we observed no correlation between the MNA-SF or ESPEN-DCM and the outcome measures (Table 4). In addition, we observed differences in the predictive capacity between two criteria of the ESPEN-DCM on outcome measures; malnutrition defined by BMI <18.5 kg/m^2 markedly predicted a low FIM at discharge (B: -4.85, 95%CI: -9.61–-0.08), high tendency for a transfer to acute care hospitals (OR: 2.76, 95%CI: 1.29–5.89) and low possibility for return to home (OR: 0.30, 95%CI: 0.15–0.58), whereas such predictive ability was not found when malnutrition was confirmed by weight loss and low BMI or FFMI.

Discussion

This study presented two clinical findings. Firstly, when the cut-off values of 5 and 7 points were applied, the MNA-SF exhibits fair concurrent and predictive validity for malnutrition and rehabilitation outcomes in patients with stroke in convalescent rehabilitation wards, although its predictive nature disappeared after the multivariable analysis. Secondly, the GNRI also exhibits fair concurrent validity and predictive validity for a worsened clinical condition.

In this study, the MNA-SF exhibited high accuracy with malnutrition defined by the ESPEN-DCM, whereas the appropriate cut-off value (5 or 7 points) was far from the well-established one (7 or 11 points). A cross-sectional study reported that the MNA-SF might pose a risk of overestimation of malnutrition when using a cut-off value of 11 points because of markedly low specificity in elderly adults in a rehabilitation unit [15] or geriatric care hospital [34]. In addition, we previously reported that 99% of convalescent stroke patients assessed as 'at risk of malnutrition' if 11 points of the MNA-SF was used for malnutrition screening [3]. Perhaps, the lower cut-off score of the MNA-SF might be appropriate for patients with stroke because some of the sub-scores of this tool, such as mobility or neuropsychological problems, could also be diminished by stroke sequela *per se* (i.e. hemiparesis or aphasia). From the perspective of the clinical practice, we recommended that elderly adults after stroke during the rehabilitation period should be screened by ≤7 points of the MNA-SF, whereas malnutrition can be identified by ≤5 points in this population.

Initially, the GNRI was developed as the indicator for nutritional risk [16]. However, it is not assumed as an indicator of the nutritional status [16, 19] because of its dependence on objective biomarkers and low accuracy for the reference standard of malnutrition [19]. Conversely, this study demonstrated that the GNRI with the established criteria (92 and 98 points) is useful for detecting and screening malnutrition

in geriatric patients with stroke in the rehabilitation phase. Perhaps, characteristics of malnutrition of stroke survivors and timing of the nutritional assessment partially explain this explain this inconsistency. As malnutrition in patients with stroke is primarily caused by dysphasia [1], it is classified as 'disease-related malnutrition without inflammation' [35]. In addition, this study enrolled only patients with stroke in the rehabilitation phase. Thus, the effect of factors affecting the Alb (i.e. components of the GNRI), such as inflammation and disease stress, in this population might be weaker than acute or inflammatory diseases. However, cautious interpretation is warranted because the serum albumin does not represent the nutritional status in elderly adults with low ADL [36]. Hence, comprehensive assessment of the nutritional status, including inflammation and hydration status, must be followed when applying the GNRI for nutritional screening.

Consistent with the concurrent validity, this study demonstrated the predictive validity of the tools and definitive malnutrition for the ADL at discharge or discharge destination. However, the predictive nature of malnutrition disappeared after adjusting confounding factors, except for the GNRI against transfer to acute care hospital. In addition, only one criterion of the ESPEN-DCM (BMI <18.5 kg/m^2) was an independent explanatory factor for the discharge FIM and return to home, although other criteria (weight loss and low BMI or FFMI) did not exhibit the predictive capacity. Often, patients with stroke experience a reduction in their body weight, with approximately 3 kg in the acute phase, particularly in those with higher than the normal body weight [37]. A decreased body weight could be attributed to muscle atrophy that is primarily caused in paretic limbs [38] and the diminished nutritional intake because of dysphasia [39]. Thus, it could be hypothesised that a combination of the loss of the body weight during the acute phase and the current BMI or FFMI reflect not only the nutritional status but also the severity of hemiparesis or a favourable loss of the body weight in overweight/obese patients, which could often be caused unintentionally. Conversely, the malnourished status at the time

of onset can predict clinical outcomes [4, 5]. Probably, individuals with BMI <18.5 kg/m^2 in this study included one who had developed malnutrition before the stroke onset; thus, the ESPEN-DCM based on the low BMI solely exerted more impact on rehabilitation outcomes.

This study has several limitations. Firstly, we did not acquire the measured FFMI by the bioimpedance analysis or dual-energy X-ray absorptiometry in this study because of its retrospective nature. Instead, we substituted the eFFMI for the measured FFMI. Secondly, we could not adjust all potential confounders, such as the severity of the stroke, in the multivariable analysis because these were not included in the original dataset. However, we used the admission FIM, which correlates with the stroke severity [40].

In conclusion, the MNA-SF (using 5 points for detecting malnutrition and 7 points for malnutrition screening) and GNRI (using a score of 92 and 98, respectively) exhibit fair concurrent validity in elderly patients with stroke during the rehabilitation phase. Although the predictive validity of these tools was partially indicated, their capacity might also be caused as a proxy of the confounders, such as the severity of a functional limitation by stroke itself. Different characteristics of two criteria used in the ESPEN-DCM might contribute to this inconsistent relationship. The findings of this study can be generalised to all patients with stroke in the sub-acute or rehabilitation setting; however, whether it can be applied to patients with acute stroke or patients other than the Asian population remains unclear. Hence, further studies are warranted to verify the cut-off value of the MNA-SF and GNRI derived from our study for broader patients.

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Figure legends

Figure 1. Flow diagram of study participants

Figure 2. The receiver-operating characteristics curve of two malnutrition screening tools for malnutrition based on the reference standard. A, the Mini Nutritional Assessment Short-Form (MNA-SF); B, the Geriatric Nutritional Risk Index (GNRI).

Transparency Declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with STARD guidelines.

Table 1. Demographic characteristics of 420 elderly patients with stroke in the convalescent rehabilitation wards

	Overall	M	non-M	*P*
Number of subjects	420	125	295	
Age, years, mean (SD)	78.1 (7.9)	80.1 (8.0)	77.2 (7.6)	<0.001[b]
Female, *n* (%)	171 (40.7)	61 (48.8)	110 (37.3)	0.028[c]
Onset-admission duration, days, median (IQR)	24 (18–34)	28 (20–40.5)	23 (17–32)	<0.001[d]
Stroke subtype, *n* (%)				0.019[c]
Cerebral infarction	296 (70.5)	78 (62.4)*	218 (73.9)*	
Intracerebral hemorrhage	105 (25.0)	37 (29.6)	68 (23.1)	
Subarachnoid hemorrhage	19 (4.5)	10 (8.0)*	9 (3.1)*	
Stroke region, *n* (%)				0.095[c]
Supratentorial	321 (76.4)	95 (76.0)	226 (76.6)	
Infratentorial	39 (9.3)	8 (6.4)	31 (10.5)	
Both	41 (9.8)	12 (9.6)	29 (9.8)	
Not classifiable	19 (4.5)	10 (8.0)	9 (3.1)	
Paralysis, *n* (%)				0.173[c]
Hemiplegia	316 (75.2)	99 (79.2)	217 (73.6)	
Tetraplegia	18 (4.3)	7 (5.6)	11 (3.7)	
Absence	86 (20.5)	19 (15.2)	67 (22.7)	
Disabilities, *n* (%)				
Dysphagia	162 (38.6)	76 (60.8)	86 (29.2)	<0.001[c]
Aphasia	94 (22.4)	34 (27.2)	60 (20.3)	0.123[c]
Dysarthria	94 (22.4)	46 (36.8)	124 (42.0)	0.318[c]
Comorbidities, *n* (%)				
Diabetes mellitus	104 (24.8)	26 (20.8)	78 (26.4)	0.221[c]
Dyslipidemia	151 (36.0)	25 (20.0)	126 (42.7)	<0.001[c]
Hypertension	347 (82.6)	98 (78.4)	249 (84.4)	0.137[c]

Artificial fibrillation	130 (31.0)	39 (31.2)	91 (30.8)	0.943[c]
Chronic kidney disease	48 (11.4)	9 (7.2)	39 (13.2)	0.076[c]
Recurrent stroke, *n* (%)	113 (26.9)	31 (24.8)	82 (27.8)	0.527[c]
Pre-stroke ADL, dependent, *n* (%)[a]	82 (19.5)	33 (26.4)	49 (16.6)	0.021[c]
Total-FIM, median (IQR)	70 (40.3–93)	45 (25–75)	79 (54–101)	<0.001[d]
BMI, kg/m^{2,} mean (SD)	22.1 (3.6)	18.2 (2.1)	24.0 (2.6)	<0.001[b]
eFFMI, kg/m^2, median (IQR)	16.6 (14.7–18.3)	14.9 (12.3–16.3)	17.6 (15.4–18.8)	<0.001[d]

M, malnutrition group; non-M, non-malnutrition group; SD, standard deviation; IQR, interquartile range; ADL, activities of daily living; FIM, the Functional Independence Measure; BMI, body mass index; eFFMI, estimated fat-free mass index.

[a]Defined by the pre-stroke certification for the public long-term care insurance 'care level 1' or more.

[b]Unpaired *t*-test, [c]Chi-square test, [d]Mann–Whitney *U*-test.

*P <0.05 for other group by Bonferroni correction

Table 2. The accuracy of the MNA-SF and GNRI using various cut-off values against the diagnostic criteria for malnutrition

	Se	Sp	The Youden index
MNA-SF			
≤5[a]	0.784	0.847	0.631
≤7[b]	0.960	0.573	0.533
≤11	1.000	0.017	0.017
GNRI			
<92[a]	0.744	0.841	0.585
<98[b]	0.928	0.502	0.430

MNA-SF, Mini Nutritional Assessment Short-Form; GNRI, Geriatric Nutritional Risk Index; Se, sensitivity; Sp, specificity.

[a]Optimal cut-off value for definitive malnutrition determined by the Yonden index.

[b]Optimal cut-off value for malnutrition screening determined by Se > 90% and Sp >50%.

Table 3. The predictive capacity of the MNA-SF and GNRI based on the new cut-off value

	MNA-SF			GNRI		
	0–5	6–7	8–14	< 92	92– < 98	> 98
Number of subject	143	103	174	139	124	157
Discharge FIM	71 (36–105)*	105 (69–119)*	119.5 (109.8–123)*	71 (35–102)*	109 (79.3–120)*	120 (110.5–123)*
Discharge destination, *N* (%)						
Home	66 (46.1)†	71 (68.9)†	152 (87.4)†	62 (44.6)†	91 (73.4)†	136 (86.6)†
Long-term care	40 (28.0)†	13 (12.6)†	6 (3.4)†	34 (24.5)†	15 (12.1)	10 (6.4)
Acute care hospital	37 (25.9)‡	19 (18.4)	16 (9.2)	43 (30.9)†	18 (14.5)	11 (7.0)

MNA-SF, Mini Nutritional Assessment Short-Form; GNRI, Geriatric Nutritional Risk Index; FIM, Functional Independence Measure.

*$P < 0.001$ for other groups by Kruskal-Wallis test and Dunn test

†$P < 0.05$ for other groups by chi-squared test and Bonferroni correction

‡$P < 0.05$ for the group with a score of 8–14 by chi-squared test and Bonferroni correction

Table 4. The multivariable analysis for the various outcome measures using the ESPEN-DCM, MNA-SF and GNRI

Outcome measures	ESPEN-DCM			MNA-SF[b]		GNRI[c]	
	Overall	Criterion 1[a]	Criterion 2[a]	0–5	6–7	<92	92-<98
FIM at discharge (Continuous)							
B	−2.20 (−6.22 to 1.81)	−4.85 (−9.61 to −0.08)*	2.12 (−3.19 to 7.43)	−0.48 (−5.57 to 4.61)	0.15 (−4.42 to 4.72)	−3.56 (−8.66 to 1.54)	2.11 (−2.26 to 6.47)
Discharge destination							
Home							
OR[d]	0.63 (0.37–1.09)	0.30 (0.15–0.58)*	2.12 (0.98–4.60)	0.68 (0.33–1.40)	0.80 (0.40–1.63)	0.59 (0.29–1.22)	0.92 (0.46–1.87)
Long-term care							
OR[d]	1.58 (0.81–3.08)	1.39 (0.67–2.88)	1.41 (0.59–3.39)	2.04 (0.69–6.04)	1.47 (0.49–4.42)	0.80 (0.30–2.12)	0.86 (0.33–2.28)
Acute care							
OR[d]	1.46 (0.73–2.93)	2.76 (1.29–5.89)*	0.37 (0.11–1.28)	1.16 (0.44–3.05)	1.48 (0.59–3.70)	3.12 (1.09–8.92)*	1.89 (0.69–5.14)

ESPEN-DCM, European Society for Parenteral and Enteral Nutrition diagnostic criteria for malnutrition; MNA-SF, Mini Nutritional Assessment Short-Form; GNRI, Geriatric Nutritional Risk Index; FIM, Functional Independence Measure; OR, odds ratio; BMI, body mass index.

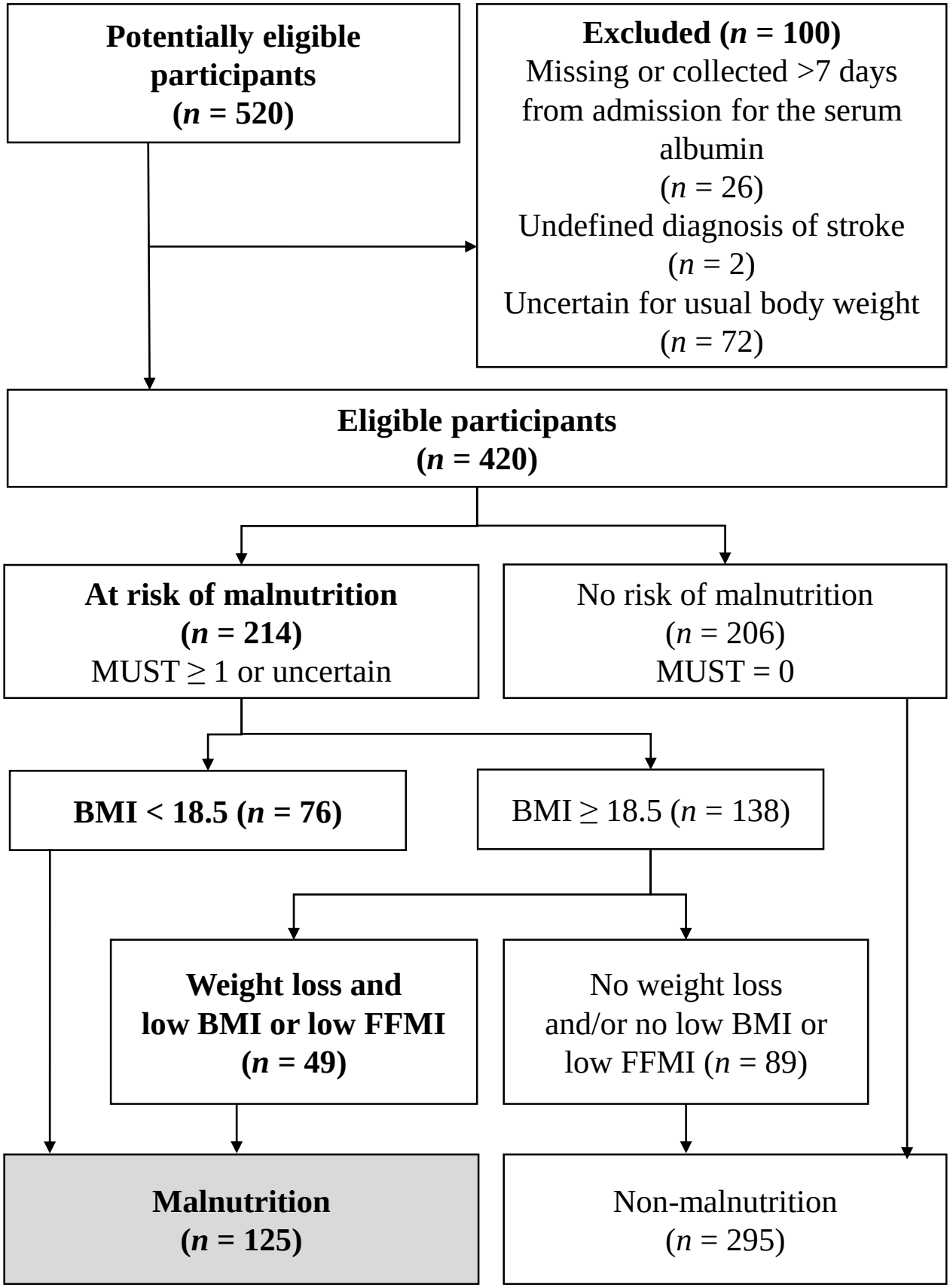
[a]Alternative ways for identifying malnutrition by the ESPEN-DCM: criterion 1, BMI < 18.5 kg/m^2; criterion 2, unintentional weight loss (>5% per 3 months or >10% for undefined time) and low BMI (<20 kg/m^2 for individuals aged <70 years or < 22 kg/m^2 for those aged ≥70 years) or low fat-free mass index (<15 kg/m^2 for females or <17 kg/m^2 for males).

[b]Reference value: 8–14 points, [c]Reference value: ≥98.

[d]Adjusted for age, sex, onset-admission duration, stroke type (reference: cerebral infarction) dysphagia, dyslipidemia and FIM at admission.

*P < 0.05

Figure 1


Potentially eligible participants (n = 520)
Excluded (n = 100)
Missing or collected >7 days from admission for the serum albumin (n = 26)
Undefined diagnosis of stroke (n = 2)
Uncertain for usual body weight (n = 72)
Eligible participants (n = 420)
At risk of malnutrition (n = 214)
MUST ≥ 1 or uncertain
No risk of malnutrition (n = 206)
MUST = 0
BMI < 18.5 (n = 76)
BMI ≥ 18.5 (n = 138)
Weight loss and low BMI or low FFMI (n = 49)
No weight loss and/or no low BMI or low FFMI (n = 89)
Malnutrition (n = 125)
Non-malnutrition (n = 295)

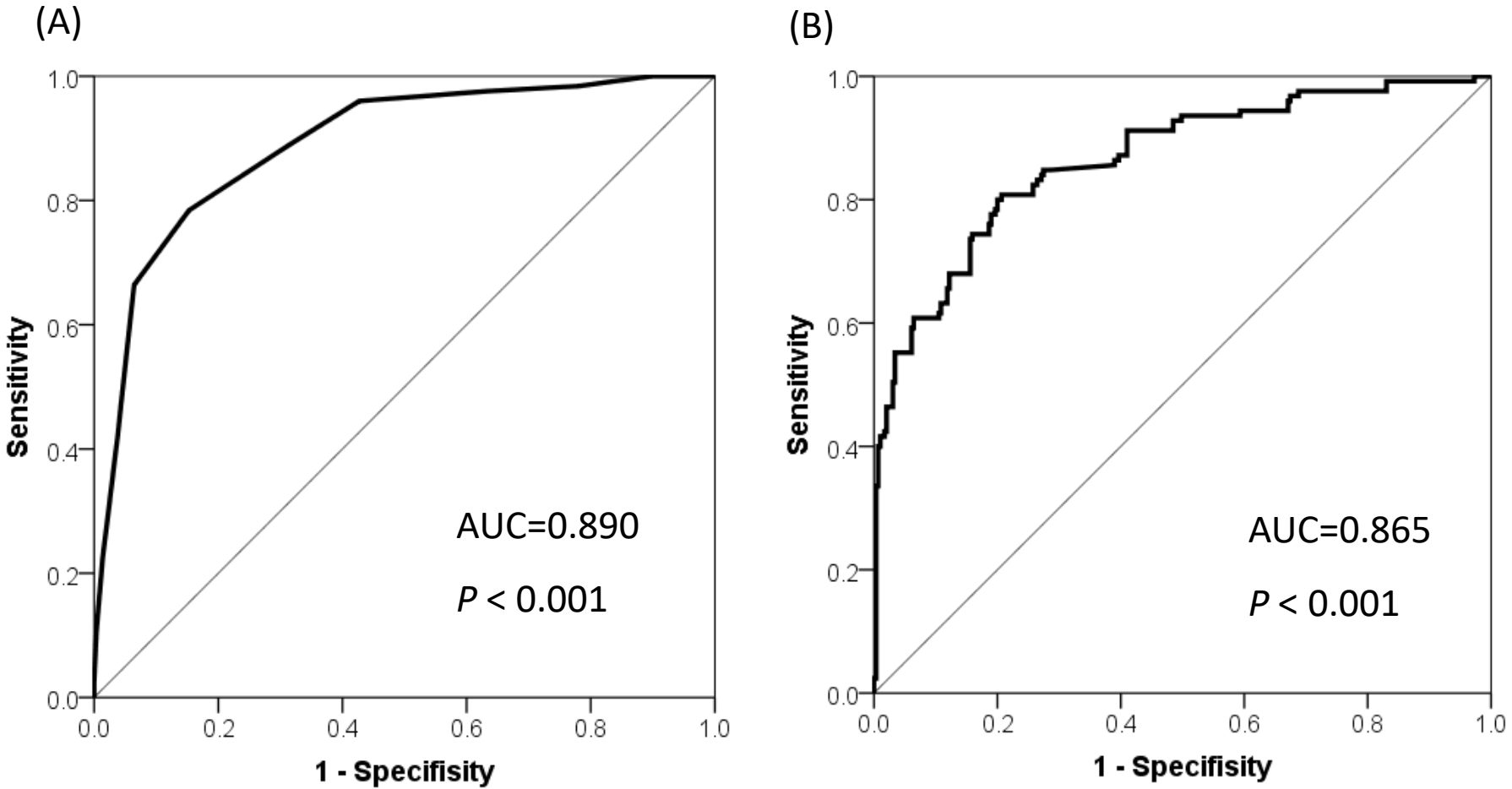

(A)
Sensitivity
1 - Specifisity
AUC=0.890
P < 0.001
(B)
Sensitivity
1 - Specifisity
AUC=0.865
P < 0.001

Figure 2