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Clinical Research Study

Development of a New Malnutrition Screening Tool for Patients: Human Key Tool of Nutrition

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ABSTRACT

Background and aims: Malnutrition is related to increased mortality and poor outcome. Therefore, early diagnosis and intervention of malnutrition are recommended. However, the optimal nutrition screening tool for diagnosing malnutrition remains undetermined. This study aimed to verify the discrimination and difficulty of nutrition screening items through item response theory (IRT) analysis and develop a simpler malnutrition screening tool.

Methods: This study enrolled 10,375 patients aged ≥18 years who were admitted at Tokushima University Hospital. Patients who were pregnant had short-term hospitalization (≤3 days), were hospitalized only in the weekend, could not hear clearly, and were hospitalized merely for examination were excluded. A skilled dietitian performed the Subjective Global Assessment, rating a good nutritional status as A, moderate malnutrition as B, and severe malnutrition as C.

Results: According to Subjective Global Assessment, we classified 7119 patients as A, 2892 as B, and 364 as C. Between these classes, the total number of application items was significantly lower in class A but significantly higher in class C. In the discrimination of each item calculated by IRT analysis, the highest discrimination item was "Has your food intake been less than usual?", followed by "Have you had anorexia?", "Have you had vomiting?", "Have you had nausea?", "Have you had dehydration?", and "Have you lost weight?".

Conclusions: Human Key Tool of Nutrition, which is based on the IRT analysis results, is a new simple nutrition screening tool developed by us. Human Key Tool of Nutrition can contribute to the widespread use of nutrition screening.

Introduction

Malnutrition has been associated with increased mortality, hospitalization duration, readmission, and poor outcome, resulting in increased hospitalization cost, decreased physical function, and decreased quality of life.[1] In a study conducted in an acute care hospital in Singapore, malnourished patients had a significantly longer hospitalization duration (6.9 ± 7.3 days) than well-nourished patients (4.6 ± 5.6 days).[2] These malnourished patients also had an increased risk of readmission by 60% within 15 days as well as a significantly higher 3-year mortality (48.5%) than the well-nourished patients (9.9%); the cost of hospitalization also increased by 24% in the malnourished group. Similarly, a study conducted at 25 Brazilian hospitals reported that the length of hospitalization duration was longer in malnourished patients (16.7 ± 24.5 days) than in well-nourished patients (10.1 ± 11.7 days).[3] The malnourished group also had a significantly higher mortality rate (4.7%) than the well-nourished group (12.4%), with a 60.5% increase in hospitalization cost in the former compared with that in the latter. Therefore, malnutrition should be diagnosed and intervened early.

Nutrition risk can be assessed using various nutrition screening tools, such as malnutrition screening tool (MST),[4] malnutrition universal screening tool,[5] Mini-Nutritional Assessment,[6] and Nutritional Risk Score (NRS2002).[7] Moreover, Subjective Global Assessment (SGA)[8] and Global Leadership Initiative on Malnutrition criteria[9] are both screening and assessment tools. We use these tools appropriately, depending on the target. For example, when we want to subjectively assess one's nutritional status, we use SGA, which contains questions about changes in dietary intake and gastrointestinal symptoms. Further, SGA is primarily intended for patients of all ages, except children and the elderly aged ≥70 years. Hence, it is one of the widely used methods worldwide.

Abbreviations: IRT, Item response theory; SGA, Subjective Global Assessment; MST, Malnutrition screening tool; NRS2002, Nutritional risk score; BMI, Body mass index; H-KTN, Human Key Tool of Nutrition.

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Table 1
Nutritional Screening Tool for Patients ≥18 Years

Nutrition Screening Question Items Used in the Study		
Nutrition Screening Question Item	Answer	
Is your BMI less than 18.5 kg/m^2 or more than 35 kg/m^2? (BMI)	Yes	No
Have you lost weight? (Body weight loss)	Yes	No
Have you gain weight? (Body weight gain)	Yes	No
Has your food intake been less than usual? (Dietary intake loss)	Yes	No
Has your food intake been higher than usual? (High dietary intake)	Yes	No
Have you had nausea? (Nausea)	Yes	No
Have you had vomiting? (Vomiting)	Yes	No
Have you had diarrhea? (Diarrhea)	Yes	No
Have you had constipation? (Constipation)	Yes	No
Have you had anorexia? (Anorexia)	Yes	No
Have you had dysphagia? (dysphagia)	Yes	No
Have you had dysgeusia? (Dysgeusia)	Yes	No
Have you had edema? (Edema)	Yes	No
Have you had ascites? (Ascites)	Yes	No
Have you had dehydration? (Dehydration)	Yes	No
Have you had pleural effusion? (Pleural effusion)	Yes	No
Do you have any physical barriers? (Physical barriers)	Yes	No
Is it possible to walk despite physical disabilities? (Walkable)	Yes	No
Are you bedridden? (Bedridden)	Yes	No
Number of "yes"		

At Tokushima University Hospital, a dietitian conducts nutrition screening to all patients. Every month, approximately 1300 new patients are admitted to this hospital, which extensively performs nutrition screening. In this study, we aimed to verify the discrimination and difficulty of nutrition screening items in the malnutrition screening sheet by item response theory (IRT) analysis and develop a simpler MST.

Materials and Methods

Participants

All patients aged ≥18 years admitted at Tokushima University Hospital between September 2019 and August 2020 were enrolled in this study. We excluded those who were pregnant, had short-term hospitalization (≤3 days), were hospitalized only in the weekend, could not hear clearly, and were hospitalized merely for examination. The Tokushima University Hospital Clinical Research Ethics Committee approved this study.

Data Collection

Two dietitians conducted nutrition screening to all patients. The nutrition screening sheet we used was based on SGA (Table 1), which is a nutritional assessment tool that uses subjective indicators developed by Detsky et al[8] in the 1980s. These subjective indicators include body weight changes, dietary intake changes, gastrointestinal symptoms, limited physical function, the presence or absence of a disease that changes nutritional requirements, and physical findings. The screening method evaluates and classifies nutritional status into three stages: good nutritional status, moderate malnutrition, and severe malnutrition. As shown in Table 1, the screening sheet has 19 questions about physical findings and symptoms that are associated with malnutrition such as body mass index (BMI; BMI < 18.5 or ≥35 kg/m^2) change, body weight change, dietary intake change, gastrointestinal symptoms and physical findings (nausea, vomiting, diarrhea, constipation, anorexia, dysphagia, dysgeusia, edema, ascites, dehydration, and pleural effusion), and physical functionality (physical barrier, walkable, and bedridden). The two dietitians visited the patient within 3 days of hospitalization to conduct nutrition screening using the screening sheet and subsequently evaluated the nutritional status. They rated a good nutritional status as A, moderate malnutrition as B, and severe malnutrition as C.

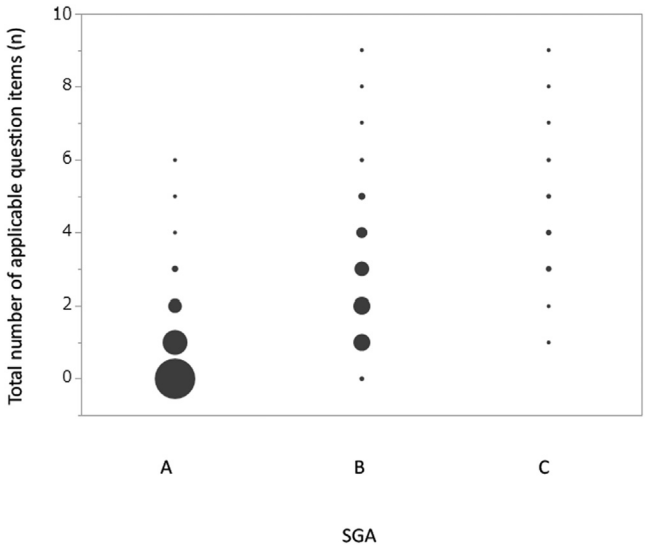


Figure 1. Distribution of the total number of applicable question items. The vertical axis shows the total number of questions answered "yes," and the size of the circle shows the number of patients. The number of questions answered "yes" was significantly lower in class A but significantly higher in class C. A significant difference was observed in all pairs (A vs C [$P < .0001$], A vs B [$P < .0001$], B vs C [$P < .0001$]).

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation. We used one-way ANOVA for comparison between three groups and Tukey–Kramer's HSD test for comparison between each pair of groups. The discrimination (ability to discriminate latent trait) and difficulty (item difficulty) of nutritional screening items were verified by IRT analysis. Statistical significance was set at $P < .05$. All statistical data were analyzed using JMP version 14 (SAS Institute, Cary, NC, USA).

Results

Patient Characteristics

During the study period, 15,189 patients were hospitalized. Among them, 10,375 were eligible to participate in the study. Table 2 lists the characteristics of the patients. According to SGA, 7119 (68.6%), 2892 (27.9%), and 364 (3.5%) patients were classified as A, B, and C, respectively. Sex was not significantly different between these three groups. Class B and class C were significantly shorter in body height than class A. Body weight and BMI were lowest in class C, followed by class B and class A, with a statistically significant difference. Furthermore, 47% of patients had a history or present illness of cancer, 7% had cardiovascular diseases, 3% had cerebrovascular disease, and 2% had pneumonia including infectious disease.

Applicability to Question Items

Table 3 shows the number and percentage of patients who answered "yes" to each of the 19 questions shown in Table 1 by nutritional status. In addition, Figure 1 shows the total number of questions answered "yes" on the vertical axis and the number of patients as the circle size. In class A, the majority of patients did not answer "yes" to any questions. The number of questions answered "yes" was significantly lower in class A but significantly higher in class C.

Table 2
Characteristics of Patients by Each Nutritional Status

	Total n = 10,375	SGA-A n = 7119	SGA-B n = 2892	SGA-C n = 364
Age (y old)	63.2 ± 16.3	61.7 ± 16.9*,**	66.8 ± 14.2*	65.6 ± 14.3**
Sex				
Male, n (%)	5247 (50.6)	3598 (50.5)	1474 (51.0)	175 (48.1)
Female, n (%)	5128 (49.4)	3521 (49.5)	1418 (49)	189 (51.9)
Body height (cm)	159.8 ± 9.3	160.1 ± 9.3*,**	159.0 ± 9.4*	158.5 ± 8.3*,**
Body weight (kg)	60.0 ± 13.6	62.8 ± 13.3*,**	55.0 ± 11.7*,***	44.7 ± 10.5**,***
BMI (kg/m^2)	23.5 ± 4.9	24.5 ± 4.7*,**	21.8 ± 4.5*,***	17.7 ± 3.7**,***

$P < .05$: A vs B*, A vs C**, B vs C***.

Table 3
Applicability to Question Items in Each Nutritional State

	Total n = 10,375 n, (%)	SGA-A n = 7119 n, (%)	SGA-B n = 2892 n, (%)	SGA-C n = 364 n, (%)
BMI	1067 (10.3)	294 (4.1)	539 (18.6)	234 (64.3)
Body weight loss	2833 (27.3)	520 (7.3)	2011 (69.5)	302 (83.0)
Body weight gain	1323 (12.8)	1126 (15.8)	179 (6.2)	18 (4.9)
Dietary intake loss	2031 (19.6)	196 (2.8)	1534 (53.0)	301 (82.7)
High dietary intake	232 (2.2)	184 (2.6)	43 (1.5)	5 (1.4)
Nausea	325 (3.1)	38 (0.5)	226 (7.8)	61 (16.8)
Vomiting	151 (1.5)	10 (0.1)	94 (3.3)	47 (12.9)
Diarrhea	224 (2.2)	53 (0.7)	146 (5.0)	25 (6.9)
Constipation	654 (6.3)	327 (4.6)	285 (9.9)	42 (11.5)
Anorexia	1059 (10.2)	64 (0.9)	808 (28.0)	187 (51.4)
Dysphagia	299 (2.9)	55 (2.5)	158 (5.5)	86 (23.6)
Dysgeusia	323 (3.1)	64 (0.2)	228 (7.9)	31 (8.5)
Edema	426 (4.1)	177 (2.5)	215 (7.4)	34 (9.3)
Ascites	119 (1.1)	12 (0.2)	80 (2.8)	27 (7.4)
Dehydration	54 (0.5)	2 (0.0)	27 (0.9)	25 (6.9)
Pleural effusion	112 (1.1)	27 (0.4)	70 (2.4)	15 (4.1)
Physical barriers	171 (1.6)	68 (1.0)	92 (3.2)	11 (3.0)
Walkable	63 (0.6)	22 (0.3)	28 (1.0)	13 (3.0)
Bedridden	236 (2.3)	59 (0.8)	124 (4.3)	53 (3.6)

Table 4
Discrimination and Difficulty of Each Item

	Discrimination	Difficulty
BMI	1.1295	2.1724
Body weight loss	2.5808	0.6367
Body weight gain	−1.2401	−1.7167
Dietary intake loss	7.9978	0.6837
High dietary intake	−1.0210	−3.8938
Nausea	3.1539	1.7226
Vomiting	3.2895	1.9846
Diarrhea	1.7399	2.6215
Constipation	0.7530	3.7890
Anorexia	5.0926	1.0505
Dysphagia	1.4759	2.7536
Dysgeusia	1.8415	2.3038
Edema	0.5774	5.6328
Ascites	2.0492	2.6790
Dehydration	2.9438	2.4705
Pleural effusion	1.1429	4.2673
Physical barriers	0.8706	4.9465
Walkable	1.0825	5.0133
Bedridden	1.2040	3.4425

BMI = body mass index; SGA = Subjective Global Assessment.

IRT Analysis

Each question item was analyzed by IRT analysis. Figure 2a–s show the item characteristic curves of each item, and Table 4 lists the discrimination (a) and difficulty (b) values of each item. "Discrimination" indicates how effectively the item can distinguish a patient's nutritional status, while items with high "difficulty" are more likely to be selected only for patients with severe malnutrition. The highest discrimination was found in the item "Has your food intake been less than usual?" ($a = 7.9978$), followed by "Have you had anorexia?" ($a = 5.0926$), "Have you had vomiting?" ($a = 3.2895$), "Have you had nausea?" ($a = 3.1539$), "Have you had dehydration?" ($a = 2.9438$), and "Have you lost weight?" ($a = 2.5808$). Figure 3 depicts the information curve of the malnutrition screening sheet. This information curve shows the level of ability that the tool can measure. In this study, ability (θ) means nutritional status. The information curve peaks at $\theta = 0$-1; thus, patients with a nutritional status of $\theta = 0$-1 had the most information in this sheet.

Discussion

Malnutrition is prevalent in the hospital setting, with 20%-50% of patients identified as malnourished at admission.[10] In 228 acute care hospitals in Australia, 42.3% of patients were classified as moderate malnutrition or severe malnutrition based on SGA.[11] Similarly, 34.1% of 883 patients in six general public hospitals in Vietnam were classified as moderate malnutrition or severe malnutrition according to SGA.[12] Using the same nutritional assessment tool, our study also found that 31.4% of the patients were classified as moderate malnutrition or severe malnutrition. Hence, our results are consistent with the abovementioned reports on malnutrition prevalence.

Malnutrition in adults is closely associated with increased mortality and poor prognosis.[1] This is particularly evident in the elderly and has serious health consequences.[13,14] Malnutrition weakens immune function and increases the risk of infection, leading to longer hospital stays and higher mortality rates. The relationship between chronic disease and malnutrition is also important, and chronic diseases such as cancer, cardiovascular disease, and respiratory disease exacerbate nutritional deficiencies through increased metabolic demand and reduced appetite, creating a vicious cycle. Furthermore, rapid disease-related skeletal muscle wasting reduces physical function and increases the risk of frailty.[1,13,14] As malnutrition is closely related to poor prognosis and mortality, early diagnosis and intervention of malnutrition are important in clinical practice. Busy healthcare professionals should have a nutritional screening tool that is simple and quick to implement. Hence, we aimed to develop a simpler MST. The screening sheet currently used consists of 19 items that focus on physical findings and symptoms associated with malnutrition. As shown in the total number of applicable items by nutritional status in Figure 1, the more applicable items, the higher the severity of nutritional disorders. Thus, the current screening sheet correlated with nutritional status by SGA. In addition, the sheet has question items showing high discrimination such as "Has your food intake been less than usual?" Results showed that this screening sheet has malnutrition discrimination. On the other hand, items with high discrimination and those with low discrimination were mixed, suggesting the possibility of simplifying the screening tool.

On the basis of our study results, we developed a new nutrition screening tool, which is a modified version of the current screening sheet. Items with higher discrimination are more suitable for a screening tool. We considered the item "Has your food intake been less than

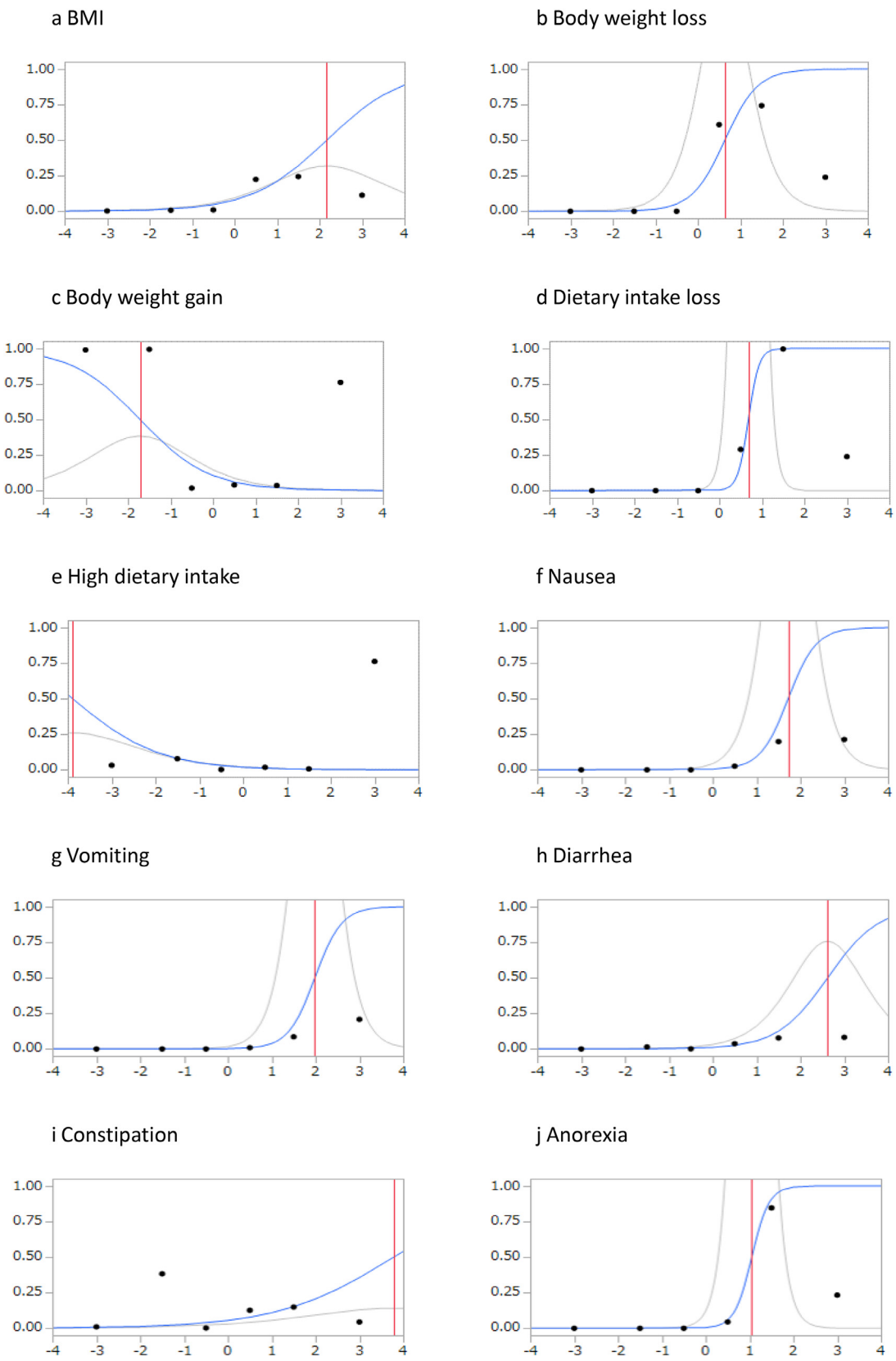
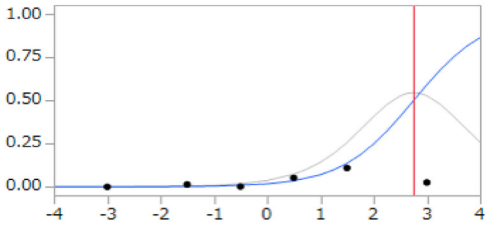
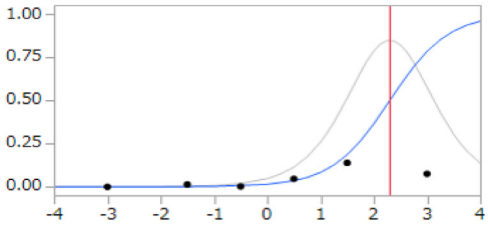


Figure 2. Characteristic curves of each item. Ability shows the intensity of the latent trait, which, in this study, means nutritional status. IRT scales with a mean of 0 and a standard deviation of 1. The item "Dietary intake loss" (d) showed the highest discrimination, followed by "Anorexia?" (j), "Vomiting" (g), "Nausea" (f), "Dehydration" (o), "Body weight loss" (b), "Ascites" (n), "Dysgeusia" (l), "Diarrhea" (h), "Dysphagia" (k), "Bedridden" (s), "Pleural effusion" (p), "BMI" (a), "Walkable" (r), "Physical barriers" (q), "Constipation" (i), "Edema" (m), "High dietary intake" (e), and "Body weight gain" (c).

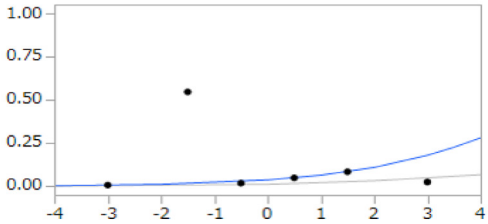
k Dysphagia



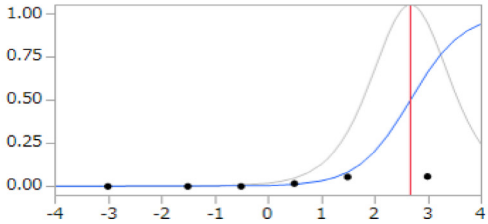
l Dysgeusia



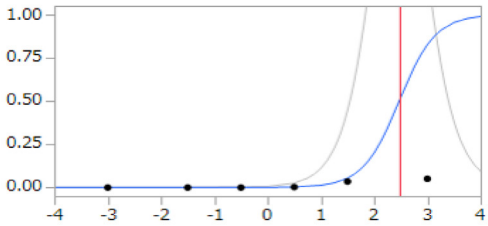
m Edema



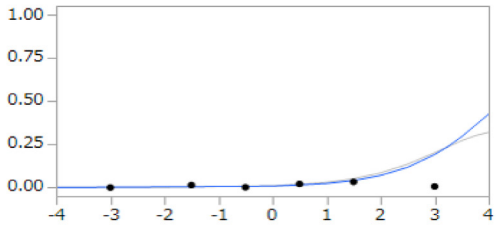
n Ascites



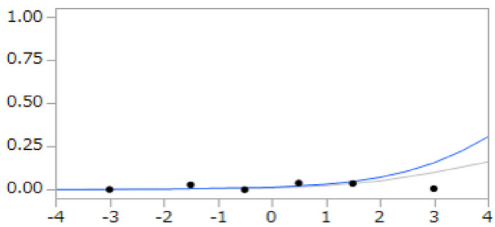
o Dehydration



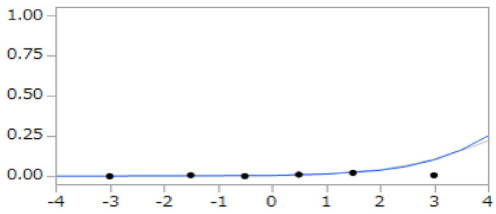
p Pleural effusion



q Physical barriers



r Walkable



s Bedridden

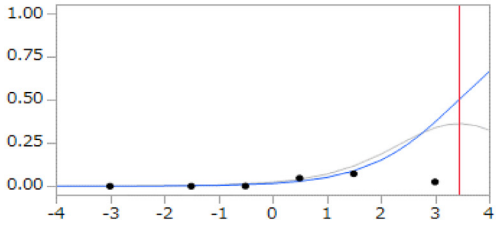


Figure 2. Continued

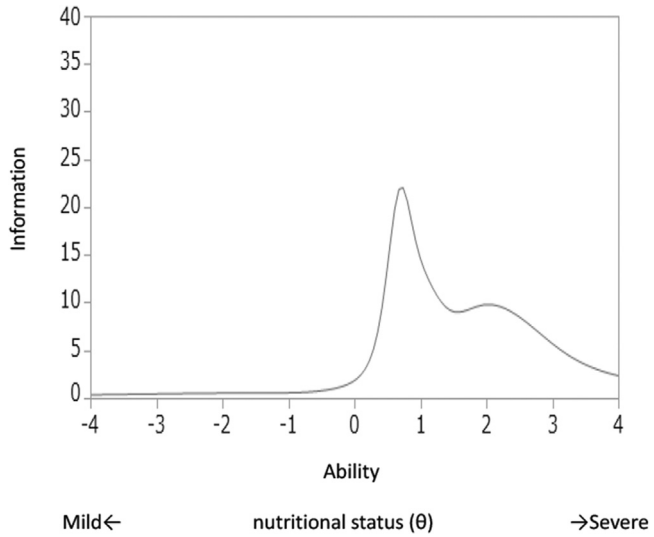


Figure 3. Information curve of the malnutrition screening tool indicated in Table 1. Patients with a nutritional status of θ = 0-1 had the most information in this tool.

Table 5
New Nutrition Screening Tool: Human Key Tool of Nutrition (H-KTN)

Nutrition Screening Question	Answer	
Have you lost weight?	Yes	No
and/or		
Has your food intake been less than usual?	Yes	No

Only one "Yes" is needed to trigger further evaluation for malnutrition.

usual?" to be a useful nutrition screening item for patients at Tokushima University Hospital because the item has the highest discrimination and a difficulty value of $b = 0.6837$, which was close to 0. The items "Have you had anorexia?" and "Have you lost weight?" had higher discrimination and a difficulty of approximately $b = 0$, but "Have you had anorexia?" is similar to "Has your food intake been less than usual?" Therefore, we created a nutrition screening tool consisting of two questions and named it as Human Key Tool of Nutrition (H-KTN), which is shown in Table 5. If any of the two abovementioned items is applicable, malnutrition risk is considered. Thus, compared with the existing screening sheet with 19 items, H-KTN has overwhelmingly few questions, which are easy to ask and answer. Therefore, the assessment can be done easily and quickly by all healthcare professionals. Considering that H-KTN is a simplified version of the current screening sheet, healthcare professionals can not only work efficiently but can also easily introduce it to other facilities.

Meanwhile, this study has some limitations. First, we could not verify whether the subjects were below 18 years or not. Second, patient characteristics may differ from those recorded in other medical institutions. To successfully utilize H-KTN, future studies need to verify its usefulness according to prognosis and evaluate the optimal question items according to difficulty.

Conclusion

Through IRT analysis, we have developed a new nutrition screening tool named H-KTN. Although further verification is needed, H-KTN, which can be conducted easily and quickly, will contribute to the widespread application of nutrition screening and the improvement of prognosis by early nutrition intervention.

Author Contributions

Conception and design of study: Kotono Oishi, and Yasuhiro Hamada. Acquisition of data: Kotono Oishi, Arisa Inoue-Hamano, and Yasuhiro Hamada. Analysis and/or interpretation of data: Kotono Oishi, Arisa Inoue-Hamano, and Yasuhiro Hamada. Drafting the manuscript: Kotono Oishi, Yasuhiro Hamada. Revising the manuscript critically for important intellectual content: Arisa Inoue-Hamano. Approval of the version of the manuscript to be published: All authors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Kotono Oishi: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation. **Arisa Inoue-Hamano:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis. **Yasuhiro Hamada:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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