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ORIGINAL

Accuracy of the Global Leadership Initiative on Malnutrition to identify malnutrition in hospitalized patients

Acurácia do Global Leadership Initiative on Malnutrition *para identificar a desnutrição em pacientes hospitalizados*

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ABSTRACT

Objective

The Global Leadership Initiative on Malnutrition, introduced as a useful method in the diagnosis of malnutrition, is supported by little evidence in hospitalized individuals. Therefore, we reviewed this method with two objectives: 1) to compare the diagnostic accuracy of the Global Leadership Initiative on Malnutrition criteria with the Patient-Generated Subjective Global Assessment; 2) to determine the prevalence of malnutrition and its associated factors.

Methods

Cross-sectional study, conducted with individuals hospitalized between April 2019 and July 2021. Sociodemographic, clinical and anthropometric information was investigated. Global Leadership Initiative on Malnutrition was the index

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Article based on the master's dissertation of FG SOUZA, entitled "*Comparação do* Global Leadership Initiative on Malnutrition *(GLIM) com a Avaliação Subjetiva Global Produzida Pelo Paciente (ASG-PPP) para diagnosticar a desnutrição em pacientes hospitalizados*", Universidade Federal da Grande Dourados; 2021.

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test and Patient-Generated Subjective Global Assessment the standard reference to assess malnutrition. For diagnostic accuracy, measurements of sensitivity, specificity, area under the curve and kappa agreement were considered.

Results

A total of 105 individuals participated (age 65.9±9.9 years). The prevalence of malnutrition in the total sample was 48.6% and 67.6% according to the Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment criteria, respectively. An association was observed between malnutrition and the variables that stand behind hospitalization, metabolic stress and anthropometric indicators ($p<0.05$). The comparison showed sensitivity and specificity values for the Global Leadership Initiative on Malnutrition criteria of 67.6% (95% CI: 56.1-77.3) and 91.2% (95% CI: 77.0-96.9) (total sample) and 71.7% (95% CI: 58.4-82.0) and 95.5% (95% CI: 78.2-99.2) (elderly), respectively. An agreement of 49% was observed, raising to 55% when the elderly were assessed separately.

Conclusion

The Global Leadership Initiative on Malnutrition criteria presented adequate sensitivity conditions and specificity to diagnose malnutrition, moderate agreement with the reference standard and good applicability in hospitalized patients' clinical practice. Prevalence of malnutrition was high, regardless of the method used, and was associated with the reason for hospitalization, metabolic stress and anthropometric indicators.

Keywords: Aged. Anthropometry. Data accuracy. Hospitalization. Nutrition assessment.

RESUMO

Objetivo

O Global Leadership Initiative on Malnutrition*, apresentado como um método útil no diagnóstico de desnutrição, possui poucas evidências acerca de indivíduos hospitalizados. Portanto, exploramos esse método com dois objetivos: 1) comparar a acurácia diagnóstica dos critérios* Global Leadership Initiative on Malnutrition *com a Avaliação Subjetiva Global Produzida pelo Paciente; 2) determinar a prevalência de desnutrição e seus fatores associados.*

Métodos

Estudo transversal, realizado com indivíduos hospitalizados entre abril de 2019 a julho de 2021. Informações sociodemográficas, clínicas e antropométricas foram investigadas. Global Leadership Initiative on Malnutrition *foi o index test e Avaliação Subjetiva Global Produzida pelo Paciente a referência padrão para avaliar desnutrição. Para acurácia diagnóstica considerou-se as medições de sensibilidade, especificidade e área sob a curva e concordância kappa.*

Resultados

Participaram 105 indivíduos (65,9±9,9 anos). A prevalência de desnutrição na amostra total foi de 48,6% e 67,6% de acordo com os critérios Global Leadership Initiative on Malnutrition *e Avaliação Subjetiva Global Produzida pelo Paciente, respectivamente. Associações foram encontradas entre desnutrição e as variáveis motivo de internação, estresse metabólico e indicadores antropométricos (p<0,05). A comparação mostrou valores de sensibilidade e especificidade para os critérios* Global Leadership Initiative on Malnutrition *de 67,6% (IC 95%: 56,1-77,3) e 91,2% (IC 95%: 77,0-96,9) (amostra total) e 71,7% (IC 95%: 58,4-82,0) e 95,5% (IC 95%: 78,2-99,2) (idosos), respectivamente. Observou-se concordância de 49,0%, sendo 55,0% quando os idosos foram analisados separadamente.*

Conclusão

Os critérios Global Leadership Initiative on Malnutrition *apresentaram condições adequadas de sensibilidade e especificidade para diagnosticar desnutrição, concordância moderada com o padrão de referência e boa aplicabilidade na prática clínica em hospitalizados. A prevalência de desnutrição foi elevada, independentemente do método utilizado, e apresentou relação com o motivo de internação, estresse metabólico e indicadores antropométricos.*

Palavras-chave: *Idosos. Antropometria. Acurácia dos dados. Hospitalização. Avaliação nutricional.*

INTRODUCTION

Prevalence of malnutrition in hospitalized individuals is high, with variation depending on the diagnostic method used [1]. The importance of using adequate methods and tools to determine hospital malnutrition

and improve the prognosis of patients is highlighted. In studies that used the traditional Subjective Global Assessment (SGA), or its form generated by the patient (PG-SGA), prevalence of malnutrition falls between 31% and 73% [2-4]. In contrast, for the Global Leadership Initiative on Malnutrition (GLIM) criteria proposed in 2018/2019, the observed prevalence is between 18 and 46% [5,3,4,6-8]. It is still necessary to identify and determine the best method of diagnosing malnutrition for in-patients, given the new criteria proposed by the most important international societies in the field of clinical nutrition.

The GLIM initiative is characterized by the assessment of "phenotypic" (unintentional weight loss, low Body Mass Index [BMI], reduced muscle mass) and "etiologic" (reduced food intake or assimilation/absorption and inflammation/disease severity) criteria, severity being determined by the phenotypic criteria [5]. In addition, in order to use the GLIM criteria, it is necessary to use a prior screening tool that is capable of assessing the risk of malnutrition so that, subsequently, the diagnosis and classification of the severity of the condition can be carried out.

The PG-SGA is a nutritional status assessment tool widely used in the hospital setting and studies demonstrate a good capacity to recognize the possible development of complications associated with the nutritional status [9-11]. Characterized by its low cost of application and good replicability, the SGA-PPP encompasses the assessment of changes in the patient's body and functional composition, enabling adequate and early identification of the risk of developing complications associated with malnutrition [12,13].

There are similarities between the GLIM criteria and the PG-SGA regarding the investigation of food intake, gastrointestinal symptoms, metabolic demand or the presence of inflammation, and the assessment of muscle mass loss determined by physical examination or by the measurement itself. However, differences are observed in the results of their application in the hospital setting, both in prevalence and in diagnostic accuracy [3,10].

The use of GLIM criteria in clinical practice is recent, but national and international studies have shown good results when comparing GLIM to other methods, such as SGA. Allard *et al.* [3] in a retrospective review of 1,022 adult patients, in 18 hospitals in Canada, compared the GLIM criteria with the SGA's and obtained sensitivity of 61.3%, specificity of 89.8%, Positive Predictive Value of 83.14% and Negative Predictive Value of 73.8%. Good sensitivity (82.6%) was found only in comparison with SGA category C (severely malnourished).

Comparing the GLIM criteria with the PG-SGA, Rosnes *et al.* [14] conducted a study with 144 Norwegian adult outpatients (median 58 years) and found Cohen's kappa agreement of 0.37 and 0.51, sensitivity of 51% and 76% and specificity of 98% and 80%, with and without screening, respectively. There is also evidence about the ability of the GLIM criteria to predict unfavorable clinical and nutritional outcome such as sarcopenia and mortality [4,6,15].

Considering that the initiative to standardize malnutrition diagnosis proposed by the GLIM criteria is relatively new and the literature lacks studies in connection with in-patients, we conducted this study with the following objectives: (i) to compare the diagnostic accuracy of the GLIM criteria with the Patient-Generated Subjective Global Assessment (PG-SGA); (ii) to determine the prevalence of malnutrition diagnosed based on the GLIM criteria and PG-SGA; (iii) to recognize the factors associated with malnutrition in this population.

METHODS

This was a cross-sectional, single-center study with a non-probabilistic sample design, carried out at the *Hospital Universitário da Universidade Federal da Grande Dourados* between June 2019 and June 2021.

The study was approved by the *Universidade Federal da Grande Dourados* Ethics Committee for Human Research (CAAE nº 06426818.0.0000.5160) All participants signed the Free and Informed Consent Form.

Patients aged ≥50 years, of both genders, admitted during the first 48 hours in the clinical and surgical wards were included. Patients under respiratory precaution, with cognitive impairment, neurodegenerative diseases, indigenous population that require the opinion of other committees and competent bodies, patients with edema and/or impaired hands assessment and those who could not walk were excluded.

Information on sociodemographic and clinical aspects was obtained through personal interviews and consultation of the patient's medical records, respectively.

Sociodemographic aspects considered included: age (years completed), age group (adults/elderly aged 60 years and over), gender (male/female), work activity (no/yes), marital status (single, married, widowed and divorced), and the socioeconomic level was evaluated according to the Brazilian Economic Classification Criteria [16] and stratified into levels A (R$ 22,749.24; USD 4.445,5553), B (R$ 5,721.72 - R$ 10,788.56; USD 1.118,1131 - USD 2.108,2524), C (R$1,894.95 - R$ 3,194.33; USD 370,3027 - USD 624,2218), D and (R$ 862.41; USD 168,5283). The values reported in US dollars were calculated through the central bank's currency converter on the date of August 25, 2022 <https://www.bcb.gov.br/conversao>.

The clinical aspects evaluated were: reason for hospitalization ("clinical" or "surgical"), metabolic stress ("without stress" or "with stress") and the presence of previous chronic diseases (classified as "none", "<3" and ≥3"). Metabolic stress was assessed from the following inflammation indicators: fever (low stress: >37.2ºC< and <38.3ºC, less than 72 hours; moderate stress: ≥38.3ºC and <38.9ºC, during 72 hours; high stress: ≥38.9ºC, more than 72 hours), prescription of corticosteroids (prednisone) (low stress: <10mg/day; moderate stress: ≥10 and <30 mg/day; high stress: ≥30 mg/day) arranged in PG-SGA, biochemical marker C-Reactive Protein (CRP) (>5mg/dL) and clinical diagnosis (chronic kidney disease, chronic obstructive pulmonary disease, major surgeries, congestive heart failure, pneumonia and neoplasms). For the sake of data analysis, individuals who presented low, medium or high stress were placed in the "stressed" category.

Conventional and unconventional anthropometric assessment was considered. Conventional anthropometry consisted of current weight (kg) and height (m) measurements to obtain BMI, Arm Circumference (AC) (cm), Calf Circumference (CC) (cm) and Triceps Skinfold (TSF) (mm). These data were collected following the procedures of Lohman *et al.* [17]. Body weight was measured using a Wiso® digital scale and height with an MD® wall stadiometer. To take the measurements, individuals were positioned standing, feet together, arms relaxed along the body, wearing light clothes and no shoes. Circumferences were measured with an inelastic and flexible anthropometric tape, with the CC measured at the greatest prominence of the calf of the right leg and the AC on the right arm, at the determined midpoint, as well as the TSF, verified with a professional adipometer and using the mean value of three repetitions.

As unconventional measurements, the adductor pollicis muscle thickness (APMT) (mm) was used; it was obtained according to Lameu *et al.* [18], as well as Handgrip Strength (HGS). Adductor pollicis muscle thickness was taken with the patient sitting, forearm and hand resting on the knee, and with the aid of an adipometer, the adductor muscle was pinched, located in the extension of the thumb and index finger. The procedure was performed on both hands and the value used was the average of three measurements. The HGS was evaluated in both hands using a Saehan® brand manual hydraulic dynamometer, which indicates the HGS value in kilograms, and the greatest measure was considered as the HGS [19].

The diagnosis of malnutrition was established by two methods: (a) Patient-Generated Subjective Global Assessment (PG-SGA); and (b) GLIM criteria.

The PG-SGA used in the study was the version translated and validated for the Brazilian population by Gonzalez *et al.* [13]. The tool is composed of two parts, the first is for patients to fill in (with or without

the help of the caregiver), where they answer questions related to their usual and current weight, food intake, signs and symptoms, activity and function, and the second by the health professional, who evaluates weight loss, chronic diseases and their relationship with nutritional needs, metabolic demand, physical examination and global assessment of the characteristics assessed.

In this study, patients were classified according to the categories proposed by the tool: A = well nourished, B = moderately malnourished and C = severely malnourished. In addition to obtaining the results in the three categories, categories B and C were added to describe the patients classified as malnourished.

In order to use the GLIM criteria, first a nutritional screening tool must be applied, and after the identification of the nutritional risk the criteria are used [5]. The method consists of evaluating the individual according to two criteria: (a) etiologic: 1- reduced food intake and/or food assimilation/absorption; 2- inflammation/disease severity and (b) phenotypic: 1- unintentional weight loss; 2- low BMI; and 3- reduced muscle mass. Reduced muscle mass was determined by CC at cutoff points ≤33 cm for women and ≤34 cm for men [20]. Patients were considered malnourished when they presented one or more etiologic and phenotypic criteria(s). The classification of malnutrition severity is given by the phenotypic criteria.

It should be clarified that all patients were evaluated by both methods and by the same evaluator; initially the PG-SGA was applied, followed by the GLIM criteria, and the initial screening tool was not used for the GLIM criteria. Therefore, data derived from the GLIM criteria were compiled to assume that all patients were at nutritional risk.

The SPSS®IBM® Statistics (version 22, SPSS An IMB Company, Chicago, IL) program was used for statistical analyses. The Kolmogorov-Smirnov test was used to verify the normality of the data. A descriptive analysis was performed to describe continuous variables and percentages for categorical variables. For comparisons between the "non-malnourished" and "malnourished" groups, Student's t and Pearson's chi-square (χ^2) tests were used. The GLIM and PG-SGA criteria were compared using the Receiver Operating Characteristic (ROC) analysis, considering sensitivity and specificity measurements. An area under the ROC curve above 0.70 was considered satisfactory. Separate ROC curves were established for the total sample and elderly population. Also to compare the methods, values of sensitivity, specificity, Positive Predictive Value (PPV) and negative predictive value were calculated and when >80% were interpreted as good validity [21].

For the agreement of the methods, Cohen's kappa coefficient (k) was calculated, considering values >0.80 as being almost perfect agreement; between 0.61 and 0.80 being substantial agreement; between 0.41 to 0.60 moderate agreement; 0.21 to 0.40 fair agreement, 0.00 to 0.20 mild agreement, and <0.00 poor agreement [22]. For the analyses, a significance level of 5% was considered.

RESULTS

A total of 134 patients were invited to participate in the survey and 105 patients (78.4%) agreed to participate and, therefore, composed the analytical sample. The reasons why patients refused to participate were indisposition, malaise and pain. Patients were on average 65.9±9.9 years old, with a minimum of 50 and a maximum of 91 years. There was a predominance of elderly people (71.4%), men (56.2%), with no work activity (69.5%), married (64.7%), belonging to economic level C (68.5%), presence of <3 comorbidities (60.0%) and hospitalized mainly for clinical treatment (56.2%).

The prevalence of malnutrition in the total sample was 48.6% and 67.6% and in the elderly 52.0% and 70.7%, according to the GLIM and PG-SGA criteria, respectively.

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Among the malnourished individuals according to the GLIM criteria, 76.5% were older adults, 58.8% were male, and the malnourished individuals evaluated by the PG-SGA were also predominantly older adults (74.6%) and male gender (57.7%) (Figure 1).

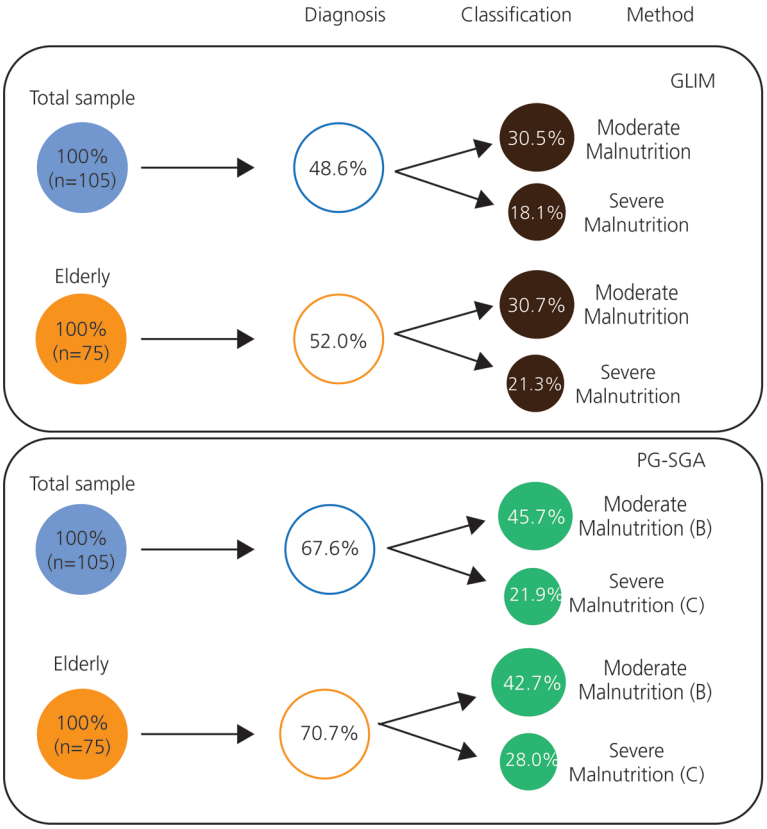

Figure 1 – Comparison of the prevalence of malnutrition diagnosed by the Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment criteria, in the total sample and the elderly.
Note: The blue circles (with and without filling) represent the total sample and the orange circles (with and without filling) represent the sub-sample of elderly people. The black circles represent the malnutrition classification according to the Global Leadership Initiative on Malnutrition (GLIM) criteria and the green circles according to the Patient-Generated Subjective Global Assessment (PG-SGA).

The detailed sociodemographic, clinical and anthropometric characteristics of the total sample, stratified according to the diagnosis of malnutrition according to the GLIM and PG-SGA criteria are shown in Table 1.

When the non-malnourished and malnourished groups were compared according to sociodemographic and clinical variables, only the variables metabolic stress and reason for hospitalization were associated with the two diagnostic methods ($p<0.05$), with the majority of malnourished patients having metabolic stress and was hospitalized for clinical treatment. All anthropometric measurements, conventional and unconventional, were lower in malnourished patients both when evaluated by the GLIM criteria and by the PG-SGA tool (Table 1). In the diagnosis by PG-SGA, the highest proportion of malnourished patients belonged to the economic level C ($p=0.019$).

As in the total sample, metabolic stress and the reason for hospitalization were also significant among the elderly, regardless of the diagnostic method used. When elderly patients were diagnosed by

Table 1 – Sociodemographic, clinical and anthropometric characteristics of the total sample, stratified according to the Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment. *Dourados* (MS) Brazil, 2019-2020.

Characteristics	GLIM		p^*	PG-SGA		p^*
	Not malnourished (n=54)	Malnourished (n=51)		Not malnourished (n=34)	Malnourished (n=71)	
Age (years)	64.72±9.06	67.22±10.78	0.202	63.38±8.69	67.15±10.36	0.069
Age group Adults/Elderly – n (%)	18/36 (33.3/66.7)	12/39 (23.5/76.5)	0.266	12/22 (35.3/64.7)	18/53 (25.4/74.6)	0.291
Gender M/F – n (%)	29/25 (53.7/46.3)	30/21 (58.8/41.2)	0.597	18/16 (52.9/47.1)	41/30 (57.7/42.3)	0.642
Work activity N/Y – n (%)	35/19 (64.8/35.2)	38/13 (74.5/25.5)	0.281	20/14 (58.8/41.2)	53/18 (74.6/25.4)	0.099
Marital status – n (%)			0.157			0.472
Married	37 (68.5)	31 (60.8)		25 (73.5)	43 (60.6)	
Single	4 (7.4)	4 (7.8)		2 (5.9)	6 (8.5)	
Widower	10 (18.5)	6 (11.8)		5 (14.7)	11 (15.5)	
Divorced	3 (5.6)	10 (19.6)		2 (5.9)	11 (15.5)	
Economic level – n (%)			0.639			0.019
A	-	-		-	-	
B	8 (14.8)	6 (11.8)		9 (26.5)	5 (7)	
C	38 (70.4)	34 (66.7)		21 (61.8)	51 (71.8)	
D and E	8 (14.8)	11 (21.6)		4 (11.8)	15 (21.1)	
Reason for hospitalization – n (%)			0.035			0.010
Surgical	29 (53.7)	17 (33.3)		21 (61.8)	25 (35.2)	
Clinical	25 (46.3)	34 (66.7)		13 (38.2)	46 (64.8)	
Metabolic stress – n (%)			<0.001			<0.001
No stress	41 (75.9)	17 (33.3)		28 (82.4)	30 (42.3)	
With stress	13 (24.1)	34 (66.7)		6 (17.6)	41 (57.7)	
Comorbidities – n (%)						0.341
None	16 (29.6)	13 (25.5)		11 (32.4)	18 (25.4)	
<3	33 (61.1)	30 (58.8)		21 (61.8)	42 (59.2)	
>3	5 (9.3)	8 (15.7)		2 (5.9)	11 (15.5)	
Anthropometry						
Weight (kg)	78.67±16.72	62.20±11.67	<0.001	80.18±16.43	66.11±14.77	<0.001
BMI (kg/m²)	29.80±5.80	24.35±5.10	<0.001	29.95±5.10	25.82±6.10	<0.001
AC (cm)	32.26±3.73	28.33±4.46	<0.001	32.28±3.78	29.43±4.60	0.001
CC (cm)	37.13±3.75	32.30±3.41	<0.001	37.65±3.64	33.41±3.93	<0.001
TSF (mm)	19.81±6.53	16.31±7.13	0.010	20.89±5.47	16.78±7.31	0.002
APMT (mm)	17.75±4.98	14.18±4.08	<0.001	18.33±4.38	14.94±4.76	0.001
HGS (kg)	26.88±10.16	20.40±10.07	0.002	28.16±10.78	21.68±9.89	0.004

Note: *t test for continuous and chi-square for categorical. AC: Arm Circumference; APMT: Adductor Pollicis Muscle Thickness; BMI: Body Mass Index; CC: Calf Circumference; F: Female; GLIM: Global Leadership Initiative on Malnutrition; HGS: Handgrip Strength; M: Male; N: No; PG-SGA: Patient-Generated Subjective Global Assessment; TSF: Triceps Skinfold; Y: Yes.

GLIM, all anthropometric measurements were associated with malnutrition. And, when diagnosed by PG-SGA, only the BMI and AC measurements were not significant, with p values of 0.060 and 0.077, respectively (Table 2).

Also in Table 2, it is noted that the malnourished individuals were predominantly men both according to the GLIM criteria (59.0%, n=23) and to the PG-SGA tool (56.6%, n=30). Regarding the prevalence of malnutrition, the PG-SGA tool surpasses the GLIM criteria also in the elderly, with 70.7% (n=53) versus 52.0% (n=39).

Patients in this study did not undergo the initial screening proposed by the GLIM criteria. Based on the results without risk screening, the proportion of malnourished patients identified by the GLIM and PG-SGA diagnostic methods as well as the malnutrition classification are illustrated in Figure 1.

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Table 2 – Sociodemographic, clinical and anthropometric characteristics of the elderly, stratified according to the Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment. *Dourados* (MS) Brazil, 2019-2020.

Characteristics	GLIM		p^*	PG-SGA		p^*
	Not malnourished (n=36)	Malnourished (n=39)		Not malnourished (n=22)	Malnourished (n=53)	
Age (years)	69.56±6.82	71.33±8.75	0.328	67.95±7.03	71.53±8.04	0.074
Gender M/F – n (%)	21/15 (58.3/41.7)	23/16 (59.0/41.0)	0.955	14/8 (63.6/36.4)	30/23 (56.6/43.4)	0.573
Work activity N/Y – n (%)	26/10 (72.2/27.8)	32/7 (82.1/17.9)	0.310	15/7 (68.2/31.8)	43/10 (81.1/18.9)	0.223
Marital status – n (%)			0.475			0.822
Married	22 (61.1)	26 (66.7)		15 (68.2)	33 (62.3)	
Single	2 (5.6)	2 (5.1)		1 (4.5)	3 (5.7)	
Widower	10 (27.8)	6 (15.4)		5 (22.7)	11 (20.8)	
Divorced	2 (5.6)	5 (12.8)		1 (4.5)	6 (11.3)	
Economic level			0.634			0.094
A	-	-		-	-	
B	4 (11.1)	2 (5.1)		4 (18.2)	2 (3.8)	
C	25 (69.4)	29 (74.4)		15 (68.2)	39 (73.6)	
D and E	7 (19.4)	8 (20.5)		3 (13.6)	12 (22.6)	
Reason for hospitalization – n (%)			0.030			0.040
Surgical	21 (58.3)	13 (33.3)		14 (63.6)	20 (37.7)	
Clinical	15 (41.7)	26 (66.7)		8 (36.4)	33 (62.3)	
Metabolic stress – n (%)			0.007			0.001
No stress	25 (69.4)	15 (38.5)		18 (81.8)	22 (41.5)	
With stress	11 (30.6)	24 (61.5)		4 (18.2)	31 (58.5)	
Comorbidities – n (%)			0.634			0.476
None	7 (19.4)	9 (23.1)		5 (22.7)	11 (20.8)	
<3	24 (66.7)	22 (56.4)		15 (68.2)	31 (58.5)	
≥3	5 (13.9)	8 (20.5)		2 (9.1)	11 (20.8)	
Anthropometry						
Weight (kg)	76.88±15.61	61.00±10.26	<0.001	77.84±15.97	64.80±13.33	0.001
BMI (kg/m²)	29.31±5.70	24.27±5.08	<0.001	28.68±4.89	25.86±6.15	0.060
AC (cm)	31.81±3.42	27.85±4.30	<0.001	31.13±3.27	29.18±4.64	0.077
CC (cm)	36.81±3.31	31.76±3.07	<0.001	36.73±3.19	33.13±3.93	<0.001
TSF (mm)	19.79±6.29	15.77±6.97	0.011	20.12±5.15	16.70±7.34	0.025
APMT right (mm)	17.70±5.08	14.11±3.91	0.001	18.72±4.85	14.67±4.35	0.001
HGS right (kg)	27.64±10.36	18.81±8.62	<0.001	29.55±10.61	20.43±9.19	0.001

Note: *t test for continuous and chi-square for categorical. AC: Arm Circumference; APMT: Adductor Pollicis Muscle Thickness; BMI: Body Mass Index; CC: Calf Circumference; F: Female; GLIM: Global Leadership Initiative on Malnutrition; HGS: Handgrip Strength; M: Male; N: No; PG-SGA: Patient-Generated Subjective Global Assessment; TSF: Triceps Skinfold; Y: Yes.

Tables 3 and 4 show the comparison between the GLIM criteria and the PG-SGA tool for the diagnosis of malnutrition in the total sample (n=105) and in the elderly (n=75), respectively.

The GLIM criteria were able to detect malnutrition in the total sample and in the elderly when this condition was present in 67.6% (95% CI: 56.1-77.3) and 71.7% (95% CI: 58.4- 82.0) of cases, respectively, and the indication that the individual was not malnourished, diagnosed with a negative result was 57.4% in the total sample and 58.3% in the elderly.

The probability of an individual with malnutrition evaluated by the GLIM criteria and, in fact, being really malnourished is 94.1% in the total sample and 97.4% in the elderly. The ability of an individual assessed by the GLIM as not malnourished and, in fact, not being malnourished was 91.2% (95% CI: 77.0-96.9) in the total sample and 95.5% (95% CI: 78.2-99.2) in the elderly. The accuracy in the total sample and in the elderly was 75.2% and 78.7%, respectively.

Table 3 – Statistical comparison of the values of the Global Leadership Initiative on Malnutrition criteria and Patient-Generated Subjective Global Assessment tool for nutritional diagnosis at hospital admission of the total sample. *Dourados* (MS) Brazil, 2019-2020.

Diagnosis Method	Patient-Generated Subjective Global Assessment		
	Malnourished (n)	Not malnourished (n)	Total
Global Leadership Initiative on Malnutrition			
Malnourished	48	3	51
Not malnourished	23	31	54
Total	71	34	105
	%	95 CI%	
Sensibility	67.6	56.1-77.3	
Specificity	91.2	77.0-96.9	
Positive Predictive Value (PPV)	94.1		
Negative Predictive Value (NPV)	57.4		
Accuracy	75.2		
Kappa coefficient (k)	0.49	0.30-0.68	

Note: 95 CI%: 95% confidence interval; k: Kappa coefficient – statistic for agreement between Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment.

Table 4 – Statistical comparison of the Global Leadership Initiative on Malnutrition criteria and Patient-Generated Subjective Global Assessment tool for nutritional diagnosis at hospital admission of the elderly. *Dourados* (MS) Brazil, 2019-2020.

Diagnosis Method	Patient-Generated Subjective Global Assessment		
	Malnourished (n)	Not malnourished (n)	Total
Global Leadership Initiative on Malnutrition			
Malnourished	38	1	39
Not malnourished	15	21	36
Total	53	22	75
	%	95 CI%	
Sensibility	71.7	58.4-82.0	
Specificity	95.5	78.2-99.2	
Positive Predictive Value (PPV)	97.4		
Negative Predictive Value (NPV)	58.3		
Accuracy	78.7		
Kappa coefficient (k)	0.55	0.32-0.78	

Note: 95 CI%: 95% confidence interval; k: Kappa coefficient – statistic for agreement between Global Leadership Initiative on Malnutrition and Patient-Generated Subjective Global Assessment

The agreement between the diagnosis of malnutrition using the GLIM criteria and the PG-SGA to detect malnutrition in the total sample was 49% (k = 0.49 [95% CI: 0.30-0.68]) while in the elderly it was 55% (k = 0.55 [95% CI: 0.32-0.78]), both indicating moderate agreement.

Comparison between the diagnosis of malnutrition using the GLIM criteria and the PG-SGA showed an area under the curve for the total sample (AUC=0.79 [95% CI: 0.71-0.88], $p<0.001$) and for the elderly (AUC=0.84 [95% CI: 0.74-0.93], $p<0.001$).

DISCUSSION

This study compared the ability to diagnose malnutrition of the GLIM criteria with the PG-SGA as a reference standard in hospitalized patients, for clinical and surgical procedures, in the first 48 hours. In addition, we determined the prevalence of malnutrition, by both methods, as well as their associated factors.

Our main finding was that the GLIM criteria offered satisfactory diagnostic conditions, with reasonable sensitivity, good specificity and PPV, when compared with PG-SGA in hospitalized patients. Our results were similar for the total sample and for the elderly, when they were assessed separately. It should be noted that the agreement between the methods was moderate both for the total sample and for the elderly. Our finding for the elderly corroborates the study by Bellanti *et al.* [6] that evaluated 152 hospitalized elderly (78.7±7.3 years) and obtained a kappa agreement of 0.53 (moderate).

Studies with similar results compared the GLIM criteria with the SGA or PG-SGA, but on an outpatient basis. De Groot *et al.* [9] in a cross-sectional study conducted with 246 cancer patients, found 76% sensitivity, 73% specificity and a kappa agreement of 0.32. López-Gómez *et al.* [23] with patients diagnosed with amyotrophic lateral sclerosis, found a kappa agreement of 0.30. Rosnes *et al.* [14] in adult patients with mixed conditions (various diseases), the kappa agreement was 0.37 [95% CI: 0.26-0.49]. In that same study, the investigators observed an improved outcome when the initial screening was excluded from the assessment (k=0.51 [95% CI: 0.36-0.65]). In the framework of hospitalized patients, Allard *et al.* [3] in a retrospective assessment of 1022 adult patients from 18 hospitals in Canada, obtained 61.3% sensitivity, 89.8% specificity and 83.14% PPV.

Furthermore, the present study showed important differences between the PG-SGA and GLIM criteria in obtaining the prevalence of malnutrition in the total sample and in the elderly, with the GLIM method detecting malnutrition in approximately half of the patients, while the PG-SGA detected malnutrition in two thirds of them. This draws a lot of attention, as it can directly impact clinical practice. This discrepancy is of concern, because depending on the diagnostic method chosen, there may be a risk of patients who are already malnourished to fail to be diagnosed.

Allard *et al.* [3] obtained 45.15% and 33.29% of malnutrition by SGA and GLIM, respectively. In the same study, the authors draw attention to the prevalence of severe malnutrition obtained by SGA (about 12%) and GLIM (about 19%). Based on prevalence, the authors reported that the GLIM criteria may globally underrepresent malnutrition, while it is likely to more accurately identifying severe malnutrition. Rosnes *et al.* [14] found 69% by PG-SGA and 59% by GLIM criteria and even lower prevalence was found when an initial screening was used (36%). Yilmaz *et al.* [24], Beaudart *et al.* [25] and Lindqvist *et al.* [26] identified in their samples the prevalence of 25.8%, 17.6% and 32.0%, respectively, when applying the GLIM criteria. In contrast, in the study by De Groot *et al.* [9] with cancer patients, the prevalence differed greatly from the previous findings, and the diagnosis with the GLIM criteria identified twice the number of malnourished individuals compared to the PG-SGA (35.0% vs. 16.0%).

In our study, the prevalence, although different between the methods, was high. This fact may have occurred due to the fact that the population studied belonged, for the most part, to the economic class C, had up to 3 associated diseases, was hospitalized for clinical treatment and, above all, because it was a sample composed of 100% of in-patients who usually have recurrent problems with poor diet acceptance and weight loss [6,27]. As expected, this study found an association between malnutrition and metabolic stress.

In addition to the particularities of the sample, another factor that may have influenced the prevalence of malnutrition can be attributed to each method dimensions related to nutrition. The PG-SGA, in addition to assessing weight loss, reduced muscle mass, food intake and disease characteristics, also has questions regarding symptoms of nutritional impact and functional capacity; thus, when compared to the GLIM criteria, it can be more accurate in the diagnosis. Therefore, the importance of patients' clinical and global diagnosis stands out.

Originally proposed for application in cancer patients, PG-SGA has also been validated for other populations and, for over a decade, has been referred to as the "gold standard" for assessing malnutrition

[13,28]. Although the literature has this well established and consolidated, in 2018 experts from world recognized societies in the field of Clinical Nutrition recommended new criteria (GLIM), but our results enhance that future investigations need to be conducted based on this new proposal and, in addition, it is important to consider that the GLIM criteria allow association of malnutrition with its cause and, therefore, can be a mean to assess the patient's prognosis [5]. Since the GLIM criteria do not involve a comprehensive and robust nutritional assessment, the nutritional diagnosis through this method must be complemented by a more accurate assessment, such as the PG-SGA, which in addition to offering excellent diagnostic accuracy, suggests the basis for plans of individualized care and treatment. This could be confirmed in a recent systematic review that found PG-SGA to have excellent diagnostic accuracy (AUC: 0.92 to 0.975; SE: 88.6 to 98%; ES: 82 to 100%) [29].

There is a variety of tools proposed in the literature that are used to assess the nutritional status of hospitalized patients [30-32]. The main similarity between them is the evaluation through anthropometry, especially in obtaining weight and BMI measurements. In our study, in addition to the necessary measures to fill in the adopted tools, other conventional and unconventional measures were also used in order to compare them between the malnourished and non-malnourished groups. It was noted that lower anthropometric measurement values were found in the group of malnourished patients. This confirms the studies by Skeie *et al.* [27] and Beaudart *et al.* [25], especially with regard to BMI.

The findings of our study, as well as those reported in the literature so far, motivate a concern with the diagnosis of malnutrition that will be configured in practice, especially for elderly patients who require hospitalization for clinical treatment, since the vast majority is susceptible to the process of malnutrition during or after hospital discharge.

The limitations of this study are the performance of the investigation in a single center, which limited the sample size; the fact that we considered all individuals at nutritional risk for the application of the GLIM criteria, and also because the muscle mass was evaluated by measuring the CC (phenotypic criterion), as we recognize that more robust methods such as magnetic resonance imaging and Dual-energy X-ray Absorptiometry are considered more accurate for this assessment, but the strong points should also be emphasized, namely this is a clinical relevant study, within a framework of few studies that have explored the GLIM criteria in the context of hospitalized patients and we still use accessible and reproducible assessment methods both in research and in clinical practice.

We recommend that further studies be conducted to compare the GLIM criteria with PG-SGA and/or other tools, in order to define the most appropriate method in relation to populations (adults, elderly, outpatients, in-patients) for the diagnosis of malnutrition. Studies of this nature are essential for the development of multidisciplinary strategies and early therapeutic initiatives to reverse malnutrition. Thus, our study is in accordance with the guidelines of health agencies, which recommend that professionals monitor cases of malnutrition, especially severe and moderate ones, and ensure adequate care for the recovery of malnourished individuals.

CONCLUSION

The GLIM criteria presented adequate sensitivity and specificity conditions for the diagnosis of malnutrition when compared with the PG-SGA reference standard, both in the total sample and in the elderly, as well as demonstrating good applicability in clinical practice for the diagnosis of malnutrition in hospitalized patients. The agreement between the GLIM and PG-SGA methods was moderate in our study, both for the total sample and for the elderly.

It is also concluded that the GLIM method detected malnutrition in approximately half of the patients, while the PG-SGA in two thirds of them, but in both methods the numbers were high and could serve as a warning for the investigators and professionals working in clinical-nutritional care.

In this population, the reason for which the individual was hospitalized (clinical or surgical), metabolic stress and anthropometric indicators were associated with malnutrition diagnosed by both methods, and the individual economic level when PG-SGA was used.

CONTRIBUTORS

FG SOUZA contributed to the data collection, writing of the first version of the article, interpretation of data, review and approval of the final version. FA MARIN to the review and approval of the final version. WR SILVA contributed to the analysis and interpretation of data, review and approval of the final version. MCB SPEXOTO contributed to the conception and design of the study, analysis and interpretation of data, review and approval of the final version.

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