Fabiane Soria Texeira

GLIM Criteria for Undernutrition Diagnosis in Hospitalized Patients - a Validation Study

Ciências da Nutrição
Faculdade de Ciências da Saúde
Universidade Fernando Pessoa
Porto, 2023

Fabiane Soria Texeira

GLIM Criteria for Undernutrition Diagnosis in Hospitalized Patients - a Validation Study

Ciências da Nutrição
Faculdade de Ciências da Saúde
Universidade Fernando Pessoa
Porto, 2023

Fabiane Soria Texeira

GLIM Criteria for Undernutrition Diagnosis
in Hospitalized Patients - a Validation Study

Declaro para os devidos efeitos ter atuado com integridade na elaboração deste Trabalho de Projeto, atesto a originalidade do trabalho, confirmo que não incorri em plágio e que todas as frases que retirei de textos de outros autores foram devidamente citadas ou redigidas com outras palavras e devidamente referenciadas na bibliografia.

(Fabiane Soria Texeira)

Trabalho apresentado à Universidade Fernando Pessoa como parte dos requisitos para obtenção do grau de licenciado em Ciências da Nutrição.

Orientadora: Prof. Doutora Rita Guerra
Co-orientadora: Prof. Doutora Ana Sofia Sousa

Agradecimentos

Dedico este trabalho ao meu marido Samuel e meus filhos, Luísa, Leonardo e Letícia.

Agradeço ao meu marido pelo apoio e incentivo, pelas palavras de ânimo e encorajamento, por todo amor e companheirismo. Agradeço aos meus filhos por entenderem a minha ausência em vários momentos, e por serem meu incentivo durante toda jornada, vocês são e serão sempre, a razão de ser e para quem dedico as minhas conquistas.

Agradeço a todos os professores, em especial a Professora Doutora Catarina Simões, que sempre auxiliava, ouvia nossas dificuldades e buscava soluções.

Um agradecimento especial às minhas orientadoras, Professora Doutora Rita Guerra e Professora Doutora Ana Sofia, pela paciência e pela generosidade na partilha dos conhecimentos, ao longo desse trabalho e durante o percurso acadêmico.

Index

Index of tables and figures.....III
List of abbreviations and acronyms IV
Title/Authors/ Academic affiliation.....V
Resumo VI
Abstract VII
Introduction 1
Methods 2
Study Design 2
Ethical Declaration..... 3
Data Collection 3
Statistical Analysis 5
Results 6
Discussion 7
Conclusions 10
References 11
Table 1 16
Table 2 17
Table 3 18
Table 4 ……19
Figure 1……20
Appendix…….21

Index of tables and figures

Table 1. Sociodemographic Characterization of 430 portuguese inpatientis participanting in a prospective observational study acording to GLIM nutritional status 16

Table 2. Nutritional status and health status assessment parameters associated with undernutrition of 430 portuguese inpatientis participanting in a prospective observational study acording to GLIM nutritional status..... 17

Table 3. Concurrent validity of GLIM for identifying undernutrition based on the classification by Patient-Generated Subjective Global Assessment (PG-SGA), for 430 inpatients participating in a prospective observational study..... 18

Table 4. Hazard Ratios (HR) and corresponding confidence intervals (95% CI) for being discharged home according to GLIM, for 430 inpatients participating in a prospective observational study……..... 19

Figure 1. Kaplan-Meier curves for being discharge-free over time for 430 Portuguese inpatients participating in a prospective observational study, according to GLIM criteria. ……. 20

List of abbreviations and acronyms

ASPEN – American Society for Parenteral and Enteral Nutrition

APNDH – Adductor Pollicis No Dominant Hand

BMI – Body mass index

CCI – Charlson Comorbidity Index

CI – Confidence intervals

ESPEN - European Society for Clinical Nutrition and Metabolism

FFMI – Free Fat Mass Index

GLIM – Global Leadership Initiative on Malnutrition

HGS – Handgrip strength

HR – Hazard ratios

IQR – Interquartile range

LOS – Length of stay

MUAC – Mid Upper Arm Circunference

NRS-2002 – Nutritional Risk Screening

PG-SGA – Patient-Generated Subjective Global Assessment

SD – Standard deviation

Title/Authors/ Academic affiliation

GLIM Criteria for Undernutrition Diagnosis in Hospitalized Patients - a Validation Study

Fabiane Soria Texeira[1], Rita S. Guerra[2], Ana Sofia Sousa[3]

[1] Estudante finalista do 1º Ciclo de Ciências da Nutrição, Faculdade Ciências da Saúde

[2] FP-I3ID, Faculdade Ciências da Saúde, Universidade Fernando Pessoa; LAETA, INEGI – Laboratório Associado em Energia, Transportes e Aeroespacial, Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial, Campus da FEUP

[3]FP-I3ID, FP-BHS, Faculdade de Ciências da Saúde, Universidade Fernando Pessoa, Porto, Portugal; Center for Innovative Care and Health Technology (ciTechcare), Polytechnic of Leiria, Portugal

Fabiane Soria Texeira
Morada: Av. Do Emigrante, 149, Bl B3, 2º Dto, Ovar, 3880-351
Email: 40152@ufp.edu.pt
Instituição responsável: Faculdades de Ciências da Saúde, Universidade Fernando Pessoa, Porto

Contagem de palavras: 3881
Número de figuras/tabelas: 5
Número de referências bibliográficas: 44

Conflito de interesses: Nada a declarar

RESUMO

Objetivo: A desnutrição é motivo de preocupação em ambientes hospitalares, devido à sua elevada prevalência e ao impacto desta condição nos resultados do tratamento. Os critérios da *Global Leadership Initiative on Malnutrition* (GLIM) foram recentemente propostos com o objetivo de padronizar o diagnóstico da desnutrição. O objetivo deste estudo foi avaliar a validade concorrente e preditiva do GLIM, através da associação com o tempo de internamento, numa amostra de adultos e idosos hospitalizados.

Metodologia: Estudo observacional prospetivo realizado numa amostra de adultos e idosos internados num Hospital Universitário do Porto. O NRS-2002 foi aplicado para rastreio da desnutrição. A validade concorrente entre o GLIM e o PG-SGA foi avaliada pelo cálculo da concordância, Kappa de Cohen (k), sensibilidade e especificidade. A validade preditiva foi avaliada através da associação independente do GLIM, com o tempo de internamento, utilizando a Regressão Proporcional de Cox.

Resultados: A sensibilidade e especificidade do GLIM foram de 70,1% e 79,4%, respectivamente. A concordância entre GLIM e PG-SGA foi de 58,4% e Kappa 0.484. Os desnutridos, segundo o GLIM, têm maior probabilidade de um tempo de internamento prolongado, uma vez que desnutrição moderada 0,564 (IC 95%: 0,431; 0,738) e desnutrição grave, 0,639 (IC 95% 0,505- 0,809), associam-se a menor probabilidade de alta para domicílio.

Conclusões: O GLIM apresentou concordância moderada com o PG-SGA e especificidade satisfatória. O presente estudo mostrou que apresentar desnutrição moderade ou grave diminui a probabilidade de ter alta para domicílio e, portanto, a desnutrição de acordo com o GLIM está associada a um tempo de internamento mais longo. O GLIM pode ser utilizado na prática clínica para diagnosticar desnutrição em doentes hospitalizados.

PALAVRAS-CHAVE: Desnutrição, tempo de internamento hospitalar, GLIM, Validade Concorrente, Validade Preditiva

ABSTRACT

Aim: Undernutrition is a cause for concern in hospital environments due to its high prevalence and the impact of this condition on treatment outcomes.

The *Global Leadership Initiative on Malnutrition* (GLIM) criteria were recently proposed, with the aim of standardising the diagnosis of undernutrition. The present study aims to determine the concurrent validity of GLIM and its predictive validity, through the association with LOS, in a sample of adults and older adults hospitalized patients.

Methods: Prospective observational study, in a sample of adults admitted to a University Hospital in Porto. NRS-2002 was applied for undernutrition screening. Concurrent validity between the GLIM and the PG-SGA was assessed by calculating agreement, Cohen´s Kappa, sensitivity and specificity. The predictive validity was studied through the independent association of the GLIM criteria, with the length of stay, using Cox Proportional Regression.

Results: GLIM had a sensitivity of 70.1% and a specificity of 79.4%; agreement between GLIM and PG-SGA was 58.4 %, Kappa 0.484. Undernutrition according to GLIM decreased the probability of discharge to usual residence: 0.564 (95% CI: 0.431; 0.738) for moderate undernutrition and 0.639 (95% CI 0.505- 0.809), for severe undernutrition.

Conclusions: GLIM showed a moderate agreement with PG-SGA and a satisfying specificity. The findings of the present study also showed that being undernourished according to the GLIM criteria, both moderately and severely, decreases the probability of being discharged home or to usual residence, and thus undernutrition according to GLIM is associated with longer LOS. The GLIM criteria can be used in clinical practice to diagnose undernutrition in hospitalized patients.

KEY-WORDS: undernutrition, length of hospital stay, GLIM, concurrent vailidity, predictive validity.

INTRODUCTION

Malnutrition is any condition that interferes with the balance of nutrients, either due to excess or lack. (1) When the deficiency is due to the catabolism of protein-energy reserves or of other nutrients, as a result of illness or ageing, this refers to disease-related undernutrition. (2)

Disease-related undernutrition in adult patients who have been hospitalized is a syndrome associated with substantially increased morbidity, disability, short-term and long-term mortality, impaired recovery from illness,increased hospital length of stay (LOS) and cost of care (3) Undernutrition is a cause of concern in hospital settings, due to its high prevalence and the impact of this condition on treatment results. (4,5)

A late intervention, due to the lack of a timely and accurate diagnosis, is associated with worse clinical outcome, when it comes to disease-related undernutrition. (6,7)

The prevalence of undernutrition in hospitalized patients varies between 10%-60% in developed countries and this broad range depends on the age of the patients, comorbidities, and the different screening and diagnostic tools used. (8)

To standardise diagnostic criteria with the aim of promoting the dissemination and use of consensus criteria at a global level, and in the search for the adoption of these criteria by the World Health Organization (WHO) and International Classification of Diseases (ICD) (9), Global Leadership Initiative on Malnutrition (GLIM) launched a consensus in 2018 for the diagnosis of undernutrition in adults. (10)

The GLIM defines a set of phenotypic and etiological criteria for diagnosing undernutrition and also assessing its severity.

According to GLIM, the phenotypic criteria include unintentional weight loss, low body mass index and reduced muscle mass. The etiological criteria include reduced food intake or assimilation and burden of disease/inflammatory condition. At least one phenotypic criterion and one etiological criterion must be present for the diagnosis of malnutrition, and severity is assessed based on the phenotypic criteria. (8)

GLIM seeks to achieve global consensus on the identification and adoption of criteria for diagnosing malnutrition in clinical settings. (9) Similar to any new instrument and because it is based on consensus, the GLIM criteria requires validation, and several studies have already been carried out in this regard. (4,10–14)

Indeed, validation and applicability studies in clinical practice have been carried out. The predictive validity has been assessed through the association of undernutrition evaluated

with GLIM with clinical results, quality of life after hospital discharge, readmission time after hospital discharge and LOS. Concurrent validity of GLIM was assessed mainly using the PG-SGA as a reference method. Previous studies were conducted in patients with esophageal carcinoma and elective gastrointestinal surgery and in critically ill patients hospitalized with COVID-19. (6,10,12,15–19)

However, most studies were codcuted in sample with specific heatlh diagnoses and thus more information on the concurrent and predictive validity of GLIM is needed in a varied sample of hospitalised adults and elderly people.

The present study aims to determine the concurrent validity of GLIM and its predictive validity, through the association with LOS, in a sample of adults and older adults hospitalized patients.

METHODS

STUDY DESIGN

This is a prospective observational study carried out in a University Hospital in Porto, with hospitalized patients, whose sample was selected between july 2011 and december 2014.

The selection of participants occurred through daily consultation of the list of hospitalized patients and those who met the inclusion criteria were invited to participate in the study. Data collection occurred within the first 72 hours of hospitalization.

Eligibility criteria were: ≥18 years of age; caucasian; expected length of stay > 24 hours; conscious and cooperative; ability to provide written informed consent.

Patients with critical illness, i.e. failure of at least one vital organ and admission to intensive care units, pregnant women, individuals in isolation, admitted for procedures involving absolute bed rest (e.g. biopsies), in which the study could place them clinically at risk and those with hemodynamic instability at the time of assessment were excluded from the study. Thus, patients in angiology and vascular surgery; cardiology; digestive, non-digestive and hepatobiliary surgeries; endocrinology; gastroenterology; internal medicine; nephrology; orthopedics; otolaryngology; and urology wards were recruited for this study. The concurrent validity of the GLIM was assessed using the PG-SGA (20), an instrument already validated and considered a reference for the diagnosis of undernutrition.Predictive validity was achieved through the independent association of the GLIM Criteria with LOS. (6)

ETHICAL DECLARATION

The research presented here was carried out in accordance with the guidelines established by the Declaration of Helsinki and was approved by the Research Ethics Board and the Ethics Committee of Centro Hospitalar do Porto. (Appendix) All study participants signed an informed consent form.

DATA COLLECTION

Sex, date of birth, clinical history and diagnoses, date of admission and discharge from hospital, destination of discharge (home, another ward, another hospital, discharge due to medical indication or death), serum concentrations of albumin and C-Reactive Protein (CRP) were obtained from the medical record.

All remaining data were collected using a structured questionnaire: education (≤ 4; ≥ 5); marital status (married/civil union; divorced/widowed/single); occupation (no professional activity/professional activity). The Katz Index was used to assess functional activity in the last month (21). The disease severity index, Charlson Index (CCI), was determined using the discharge diagnoses in the patient's medical record. This index considers the number and severity of comorbidities, each scored from 0 to 6. (22)

The Nutritional Risk Screening 2002 (NRS-2002) was used for nutritional risk screening, using the first four questions from the "initial screening", according to European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines. (23,24)

After nutritional screening, PG-SGA and GLIM criteria were applied (6) to patients who were identified as being at nutritional risk. (6)

Anthropometric measurements were taken by two trained nutritionists and included: weight, standing height, triceps skinfold thickness, adductor pollicis of the no dominant hand (APNDH) and mid-upper arm circumference (MUAC) (25). Body weight (kg) (25) was measured with a calibrated portable beam scale with 0.5 kg resolution, with the individuals wearing light pyjamas. Standing height (cm) and mid-upper arm circumference were measured with a metal measuring tape (Rosscraft ® Innovations Incorporated, Surrey, Canada) with 0.1cm resolution. A headboard was also used for measuring height. To measure triceps skinfold and APNDH, the Harpenden® Skinfold Caliper was used.

For bedbound patients, those presenting limitations to their ability to stand or presenting

visible kyphosis, hand length, obtained using a small bone calliper with a 0.1 cm resolution (Kennon Instruments, Vignola, Italy) (25), was used as a surrogate of height (n=298) (26). When it was impossible to measure hand length, height was estimated from half-span (n=2) (27), measured with the metal tape measure from Rosscraft® Innovations Incorporated.

Dry body weight registered in the clinical file or, when unavailable, referred by the patient (n = 13) was used for participants on dialytic therapies. When it was not possible to weigh a patient, body weight predicted from height and mid-upper arm circumference (28)was used (n = 156).The Jamar Plus+ Digital Hand Dynamometer (Sammons Preston) was used to measure handgrip Strenght (HGS) (29).

Whole-body resistance (ohm) and reactance (ohm) were measured by unifrequency tetrapolar BIA, with equipment from Biodynamics Model 450 (Biodynamics Corporation, Shoreline, WA) with 0.1 Ω resolution. BIA was conducted with subjects in supine position, with upper and lower limbs apart so as not to have contact with the torso (30). Electrodes were placed on the non-dominant side except for the patients with atrophy, hemiplegia, metal pros- thesis or implants on the non-dominant side, for whom the dominant side was used (30).

Body mass index (BMI) was calculated as [weight (kg)/height² (m)] and participants were grouped in the following BMI classes: <18.5 and ≥18.5 kg/m², <20 and ≥ 20 kg/m² (if age < 70 years) or <22 and ≥ 22 kg/m² (if age >70 y) (31). Fat-free mass was calculated using the equation: [- 4.104 + (0.518 height²/resistance) + (0.231 x weight) + (0.13 x reactance) + (4.229 x sex)], resistance and reactance were obtained with BIA, sex = 0 for women, sex = 1 for men (32). Fat-free mass index (FFMI) was calculated as [fat-free mass (kg)/height²(m)]. Participants were grouped in two FFMI categories, <15 and <17 kg/m² or ≥ 15 and ≥ 17 kg/ m², for women and men, respectively (33).

The intra and inter-observer technical error for standing height, body weight, mid-upper arm circumference, half-span and hand length measurements were obtained in 17 and 18 individuals, respectively. The intra-observer error varied between 0.2% and 0.6% whereas the inter-observer error varied between 0 and 1.4%, errors acceptable for trained anthropometrics (34).

Physical Examination included the search for three elements: loss of subcutaneous fat, muscle wasting, presence of edema/ascites, and participants were grouped in three categories: no change, mild/moderate depletion, and severe depletion (20).

STATISTICAL ANALYSIS

For assessing the nature of variables distribution, the Kolmogorov and Smirnov test was used. Accordingly, continuous variables were expressed as mean and standard deviation (SD) or as median and interquartile range (IQR), and categorical variables were expressed as absolute (n) and relative frequencies (%).

Participants were compared for several sociodemographic, clinical and nutritional characteristics according to GLIM categories, without undernutrition, moderate undernutrition and severe undernutrition, using the t- student for normality distributed variables, the Mann- Whitney test for variables with a different from normal distribution, and Chi-square test for categorical variables.

Due to the small number of people with dependence, Katz Index was evaluated in two categories, independence and dependence for activities of daily living.

To investigate the concurrent validity of the GLIM criteria, sensitivity, specificity, positiveand negative predictive values were determined, using the PG-SGA as the reference method. In order to conduct these analyses, participants with moderate and severe undernutrition, with both tools, were merged into one category. Agreement between the GLIM criteria and PG-SGA was calculated, as well as the weighted Cohen's Kappa coefficient.

For predictive validity, the Kaplan-Meier method and Cox regression were used to evaluate the probability of discharge to the home, according to GLIM criteria categories (without undernutrition, moderate undernutrition and severe undernutrition). For both analysis, length of stay was censored at 30 days, since 97% of the sample was in this range, and discharge to home was defined as the event of interest.

Cox proportional hazards regression models were used to respectively determine the unadjusted and adjusted hazard ratios (HR) and corresponding Confidence Intervals (95% CI); age [$\leq$ 64 years (reference) vs. $\geq$ 65 years] and Katz Index [independence (reference) vs. moderate and severe dependence] were used in the adjusted model.

Statistical significance considered $p < 0.05$. For data analysis, the Software Package for 28.0.1.0 (142) SPSS, inc. Chicago, IL.

RESULTS

During the period of data collection, 1053 patients were invited to participate and 804 entered the study. Of those, NRS-2002 initial screening could not be completed for 285 subjects, 217 were not nutritionally at-risk and 551 were at-risk. Additionally, 121 of the at-risk participants had missing data for variables essential for answering present study purposes and thus, this study final sample is composed of 430 hospitalized patients.

Of these, according to the PG-SGA criteria, 189 (44.0%) were without undernutrition, 108 (25.1%) were moderately undernourished and 133 (30.9%) were severely undernourished. According to the GLIM Criteria, 222 (51.6%) were not undernourished, 86 (20.0%) were moderately undernourished and 122 (28.4%) were severely undernourished.

Sociodemographic variables, according to GLIM nutritional status categories are presented in Table 1. A higher proportion of patients aged ≥ 65 years were found to be moderately or severely undernourished (Table 1).

In table 2, inflammatory, clinical, anthropometric and functional parameters associated with undernutrition were analysed. Patients with severe undernutrition had a lower albumin value compared to participants in the other two categories.

The results showed that being undernourished according to GLIM resulted in longer hospital stays, compared to those who were not undernourished.

Undernourished women had significantly lower mean values for HGS, Triceps Skinfold, MUAC, APNDH, when compared to those without undernutrition.

Men with severe undernutrition had lower HGS, MUAC and APNDH mean values compared to men in the other two categories.

It is shown that the largest proportion of dependent patients were severely undernourished (46.2%). Through the Physical Examination, it was found that the highest proportion of participants with severe depletion are severely undernourished, according to the GLIM criteria (52.3%).

The agreement between the GLIM criteria and PG-SGA was 58.4%, and Kappa Coefficient (k) was 0.464 (0.404 - 0.567), $p < 0.001$ (Table 3).

In comparison with the PG-SGA, GLIM criteria showed a sensitivity of 70.1%, a specificity of 79.4%. Positive and negative predictive values were 81.2% and 67.2%, respectively.

The probability of being discharged home over time, according to the GLIM criteria, was

tested by Kaplan-Meier curves, which showed that being undernourished increases hospital LOS.

According to the Cox regression models conducted, presenting moderate and severe undernutrition according to GLIM was associated with a lower probability of being discharged home, in both the crude and adjusted models. (Table 4).

DISCUSSION

This study has shown that the GLIM Criteria, when compared to the PG-SGA reference method, has good specificity, and demonstrates that being moderately and severely undernourished according to the GLIM, was associated with a longer LOS, as it was shown that undernutrition by GLIM independently reduced the likelihood of being discharged home.

Although the sensitivity value obtained (70.1%) is lower than the one recommended for validation, >80%, the specificity value found (79.4%) is very close to this recommended value (6). The positive predictive value and negative predictive value were 81.2% and 67.2%, respectively. According to ESPEN, in a paper related to diagnostic criteria for undernutrition: "screening must be sensitive, while diagnosis must be specific". Taking also in consideration that a high positive predictive value results in assertively treating true patients (10), the present study results contribute to the evidence regarding the validity of GLIM for the diagnosis of undernutrition.

As there is no gold standard for diagnosing undernutrition, there is a possibility that many patients will not be considered eligible to receive a diagnosis of undernutrition. The PG-SGA is considered a "semi-gold" standard and for this reason it was used to establish concurrent validity, after the application of screening, using the NRS-2002. (4)

In other studies, involving hospitalized patients who were diagnosed with undernutrition by the GLIM criteria, using the PG-SGA as the reference method, the prevalence of undernutrition varied between 10% and 80%. This variation can be explained by whether nutritional screening is done, which screening tool is used, and the individual and clinical characteristics of the participants. The methods used to assess the phenotypic criteria, namely how was low fat free mass determined, and the methods used to assess etiological criteria – inflammation, may also interfere with the results. (12,13,17,18,35–38)

In a study of patients with esophageal cancer, when compared to PG-SGA, GLIM revealed a Kappa value of 0.519 ($p < 0.001$), sensitivity equal to 79.5% and specificity

equal to 80.5% (39). In another study of 601 hospitalized patients, agreement between PG-SGA and GLIM criteria was 41.6%, with kappa = 0.589 ($p < 0.001$), sensitivity = 86.6% and specificity = 81.6% (12). In a study carried out in Norway and using once more PG-SGA as reference, agreement determined by the kappa value was 0.49 (0.38-0.60), sensitivity = 63% specificity = 90% (15). An Australian study of 246 patients undergoing outpatient treatment for cancer found, for GLIM, a sensitivity of 76 % and specificity of 73 %, with k = 0.323, were found. In this study, nutritional screening was done using the PG-SGA short-form (40).

In the studies presented, of those with the highest sensitivity, specificity and Kappa results, screening was not carried out (12,39) . In the Norwegian study, whose results of Kappa were close to those achieved in our study, the NRS-2002 was used for screening (15) .

To calculate agreement with the PG-SGA, Kappa was calculated and found to be lower than the recommended value, which should be > 0.8 for validation, but indicates moderate agreement (k = 0.484) with the reference method. This result can be justified by the criteria used to calculate Kappa, in which the three categories of the PG-SGA and GLIM Criteria were used (no undernutrition, moderate undernutrition and severe undernutrition). The classification into moderate and severe undernutrition can be influenced by the different methods used to assess muscle mass. In fact, more patients were classified as moderately and as severely undernourished by PG-SGA compared to GLIM.

The PG-SGA does not use objective criteria such as anthropometric measurements, it uses subjective criteria generated by the patient or the professional. Although the Physical Examination is an important indicator of undernutrition when assessing muscle depletion, it is based on the professional's judgement and not on cut-off points and objective data (19,20,41).

In this study, FFMI was used to assess loss of muscle mass. The FFMI cut-off points are those recommended by the GLIM consensus for assessing low muscle mass, <15 and <17 kg/m², for women and men respectively (42). The ideal FFMI cut-off points for identifying malnutrition have not yet been defined and it is recognized by GLIM panel of experts that more studies are needed to define these cut-off points.

Kaplan-Meier and Cox analysis revealed that undernutrition according to the GLIM Criteria was associated with longer LOS. Cox regression models were adjusted for the potential confounding variables, age and Katz index, and small changes in HR and

respective 95% CI were observed between crude (unadjusted) and adjusted Cox proportional hazard models. These results show that the association between undernutrition identified by the GLIM criteria and LOS was not weakened by the adjustment.

Many studies have been carried out to analyse the ability of the GLIM Criteria to predict negative outcomes such as postoperative complications, time between hospital discharge and readmission, LOS, and mortality (12,17–19,37,38,43) However, none of these findings analysed the association between undernutrition according to the GLIM Criteria and LOS by survival analysis, with discharge to usual residence as the event of interest, as is the case in this study.

Hospital LOS was truncated ate 30 days and was arbitrarily chosen. In our study, only 14 patients (3.25%) remained hospitalized for more than 30 days, and so this procedure probably did not affected the study results.

The present study has some limitations that must be considered when interpreting the results. In this study, FFMI was used to assess loss of muscle mass. Although recommended by the GLIM consensus, no evidence show if a FFMI <15 and <17 kg/m², for women and men respectively, is indicative of moderate or severe low muscle mass (42), which can lead to some degree of misclassification

In fact, the lack of definition of cut-off points for muscle mass reduction, categorising it as moderate or severe, is a limitation that could compromise the results, since phenotypic variables are needed to classify the degree of undernutrition as moderate or severe, and requires these muscle mass parameters to establish the result. Therefore, more studies are needed to define the FFMI cut-off points and better establish the concurrent validity of the GLIM Criteria.

Another possible limitation of this study is the large number of missing albumin and CRP data, which may also have influenced some of the results.

This study has several strengths. Undernutrition in hospitalized patients has long been linked to worse outcomes for patients, including increased LOS (13,18,36,44). The statistical analysis used allowed to treat LOS as a continuous variable, and it was possible to censor the data. In this way, it was possible to include hospitalized patients who would otherwise have been excluded from the data analysis. In addition, the characteristics of the sample are another strength of the study, since a large and representative number of inpatients were included, aged between 18 and 90, with various pathologies and diagnoses, from different medical and surgical wards.

CONCLUSION

GLIM showed a moderate agreement with PG-SGA and a satisfying specificity. The findings of the present study also showed that being undernourished according to the GLIM criteria, both moderately and severely, decreases the probability of being discharged home or to usual residence, and thus undernutrition according to GLIM is associated with longer LOS.

The GLIM criteria can be used in clinical practice to diagnose undernutrition in hospitalized patients.

REFERENCES:

1. World Health Organization. Malnutrition [Internet]. [cited 2023 Oct 29]. Available from: https://www.who.int/health-topics/malnutrition
2. Maleta K. Undernutrition in Malawi 190 Malawi Medical Journal Special Edition on Burden of the Disease in Malawi II [Internet]. Blantyre, Malawy; 2006 Dec [cited 2023 Oct 28]. Available from: pmc/articles/PMC3345626
3. Schuetz P, Seres D, Lobo DN, Gomes F, Kaegi-Braun N, Stanga Z. Management of disease-related malnutrition for patients being treated in hospital. Vol. 398, The Lancet. Elsevier B.V.; 2021. p. 1927–38.
4. Correia MITD, Tappenden KA, Malone A, Prado CM, Evans DC, Sauer AC, et al. Utilization and validation of the Global Leadership Initiative on Malnutrition (GLIM): A scoping review. Vol. 41, Clinical Nutrition. Churchill Livingstone; 2022. p. 687–97.
5. Guerra RS, Sousa AS, Fonseca I, Pichel F, Restivo MT, Ferreira S, et al. Comparative analysis of undernutrition screening and diagnostic tools as predictors of hospitalisation costs. Journal of Human Nutrition and Dietetics. 2016 Apr 1;29(2):165–73.
6. Cederholm T, Jensen GL, Correia MITD, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM criteria for the diagnosis of malnutrition – A consensus report from the global clinical nutrition community. Clinical Nutrition. 2019 Feb 1;38(1):1–9.
7. Guerra RS, Fonseca I, Sousa AS, Jesus A, Pichel F, Amaral TF. ESPEN diagnostic criteria for malnutrition – A validation study in hospitalized patients. Clinical Nutrition. 2017 Oct 1;36(5):1326–32.
8. Trollebø MA, Skeie E, Revheim I, Stangeland H, Erstein MAH, Grønning MK, et al. Comparison of nutritional risk screening with NRS2002 and the GLIM diagnostic criteria for malnutrition in hospitalized patients. Sci Rep. 2022 Dec 1;12(1).
9. Cederholm T, Jensen GL. To create a consensus on malnutrition diagnostic criteria. Vol. 41, Journal of Parenteral and Enteral Nutrition. SAGE Publications Inc.; 2017. p. 311–4.

10. de van der Schueren MAE, Keller H, Cederholm T, Barazzoni R, Compher C, Correia MITD, et al. Global Leadership Initiative on Malnutrition (GLIM): Guidance on validation of the operational criteria for the diagnosis of protein-energy malnutrition in adults. Clinical Nutrition. 2020 Sep 1;39(9):2872–80.
11. Allard JP, Keller H, Gramlich L, Jeejeebhoy KN, Laporte M, Duerksen DR. GLIM criteria has fair sensitivity and specificity for diagnosing malnutrition when using SGA as comparator. Clinical Nutrition. 2020 Sep 1;39(9):2771–7.
12. Brito JE, Burgel CF, Lima J, Chites VS, Saragiotto CB, Rabito EI, et al. GLIM criteria for malnutrition diagnosis of hospitalized patients presents satisfactory criterion validity: A prospective cohort study. Clinical Nutrition. 2021 Jun 1;40(6):4366–72.
13. Contreras-Bolívar V, Sánchez-Torralvo FJ, Ruiz-Vico M, González-Almendros I, Barrios M, Padín S, et al. Glim criteria using hand grip strength adequately predict six-month mortality in cancer inpatients. Nutrients. 2019 Sep 1;11(9).
14. Fontane L, Reig MH, Garcia-Ribera S, Herranz M, Miracle M, Chillaron JJ, et al. Validity and Applicability of the Global Leadership Initiative on Malnutrition (GLIM) Criteria in Patients Hospitalized for Acute Medical Conditions. Nutrients. 2023 Sep 16;15(18):4012.
15. Henriksen C, Paur I, Pedersen A, Kværner AS, Ræder H, Henriksen HB, et al. Agreement between GLIM and PG-SGA for diagnosis of malnutrition depends on the screening tool used in GLIM. Clinical Nutrition. 2022 Feb 1;41(2):329–36.
16. Galindo Martín CA, Aportela Vázquez VA, Becerril Hernández F, Aguilar Medina CR, Ayala Carrillo SL, Chávez Flores A, et al. The GLIM criteria for adult malnutrition and its relation with adverse outcomes, a prospective observational study. Clin Nutr ESPEN. 2020 Aug 1;38:67–73.
17. Lima J, Brizola Dias AJ, Burgel CF, Bernardes S, Gonzalez MC, Silva FM. Complementarity of nutritional screening tools to GLIM criteria on malnutrition diagnosis in hospitalised patients: A secondary analysis of a longitudinal study. Clinical Nutrition. 2022 Oct 1;41(10):2325–32.
18. Liu Y, Kang J, Qi Z, Yang Y, Bai M, Yi H. Comparison of GLIM and PG-SGA for predicting clinical outcomes of patients with esophageal squamous carcinoma resection. Nutr Hosp. 2023 May 1;40(3):574–82.

19. Yang W, Guo G, Cui B, Li Y, Sun M, Li C, et al. Malnutrition according to the Global Leadership Initiative on Malnutrition criteria is associated with in-hospital mortality and prolonged length of stay in patients with cirrhosis. Nutrition. 2023 Jan 1;105.
20. Ottery FD. Patient-generated subjective global assessment. The American Dietetic Association. 2000;11–23.
21. Katz S. Assessing self-maintenance: Activities of daily living, mobility, and instrumental activities of daily living. Vol. 31, Journal of the American Geriatrics Society. 1983. p. 721–7.
22. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A New Method of Classifying Prognostic Comorbidity in Longitudinal Studies: Development And Validation. Vol. 40, J Chron Dis. 1987.
23. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M. ESPEN guidelines for nutrition screening 2002. Clinical Nutrition. 2003;22(4):415–21.
24. Kondrup J, Ramussen HH, Hamberg O, Stanga Z, Camilo M, Richardson R, et al. Nutritional risk screening (NRS 2002): A new method based on an analysis of controlled clinical trials. Vol. 22, Clinical Nutrition. Churchill Livingstone; 2003. p. 321–36.
25. Marfell-Jones MJ, SAD, & de RJHWNZ. International standards for anthropometric assessment. . International Society for the Advancement of Kinanthropometry. 2012;
26. Guerra RS, Fonseca I, Pichel F, Restivo MT, Amaral TF. Hand length as an alternative measurement of height. Eur J Clin Nutr. 2014 Feb;68(2):229–33.
27. Kwok JT, Whitelaw MN. The Use of Armspan in Nutritional Assessment of the Elderlv. Vol. 39, JAGS. 1991.
28. Powell-Tuck J, Hennessy EM. A comparison of mid upper arm circumference, body mass index and weight loss as indices of undernutrition in acutely hospitalized patients. Clinical Nutrition. 2003;22(3):307–12.
29. American Society of Hand Therapists Clinical. [cited 2023 Oct 30]; Available from: https://www.researchgate.net/publication/303400806
30. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Gómez JM, et al. Bioelectrical impedance analysis - Part II: Utilization in clinical practice. Clinical Nutrition. 2004;23(6):1430–53.

31. Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clinical Nutrition. 2015 Jun 1;34(3):335–40.
32. Kyle UG, Genton L, Karsegard L, Slosman DO, Pichard C. Single Prediction Equation for Bioelectrical Impedance Analysis in Adults Aged 20-94 Years.
33. Schutz Y, Kyle U, Pichard C. PAPER Fat-free mass index and fat mass index percentiles in Caucasians aged 18-98. Int J Obes [Internet]. 2002;26:953–60. Available from: www.nature.com/ijo
34. Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Vol. 82, British Journal of Nutrition. CAB International; 1999. p. 165–77.
35. Matsumoto Y, Iwai K, Namikawa N, Matsuda S, Wakano C, Heya H, et al. The relationship between existing nutritional indicators and Global Leadership Initiative on Malnutrition (GLIM) criteria: A one-institution cross-sectional analysis. Clinical Nutrition. 2020 Oct 1;39(10):3099–104.
36. Ouaijan K, Hwalla N, Kandala NB, Mpinga EK. Prevalence of Malnutrition in Hospitalized Patients in Lebanon Using Nutrition Risk Screening (NRS-2002) and Global Leadership Initiative on Malnutrition (GLIM) Criteria and Its Association with Length of Stay. Healthcare (Switzerland). 2023 Mar 1;11(5).
37. Zhang Y, Zhang L, Gao X, Dai C, Huang Y, Wu Y, et al. Validation of the GLIM criteria for diagnosis of malnutrition and quality of life in patients with inflammatory bowel disease: A multicenter, prospective, observational study. Clinical Nutrition. 2022 Jun 1;41(6):1297–306.
38. Shahbazi S, Hajimohammadebrahim-Ketabforoush M, Vahdat Shariatpanahi M, Shahbazi E, Vahdat Shariatpanahi Z. The validity of the global leadership initiative on malnutrition criteria for diagnosing malnutrition in critically ill patients with COVID-19: A prospective cohort study. Clin Nutr ESPEN. 2021 Jun 1;43:377–82.
39. Yin L, Cheng N, Chen P, Zhang M, Li N, Lin X, et al. Association of Malnutrition, as Defined by the PG-SGA, ESPEN 2015, and GLIM Criteria, With Complications in Esophageal Cancer Patients After Esophagectomy. Front Nutr. 2021 Apr 26;8.
40. De Groot LM, Lee G, Ackerie A, van der Meij BS. Malnutrition screening and assessment in the cancer care ambulatory setting: Mortality predictability and validity of the patient-generated subjective global assessment short form (PG-SGA SF) and the GLIM criteria. Nutrients. 2020 Aug 1;12(8):1–13.

41. Detsky AS, McLauglin JR, Baker JP, Johnston N, Whittaker S, Mendelson RA, et al. What is Subjective Global Assessment of Nutritional Status? JPEN. 1987 May 13;8–13.
42. Compher C, Cederholm T, Correia MITD, Gonzalez MC, Higashiguch T, Shi HP, et al. Guidance for assessment of the muscle mass phenotypic criterion for the Global Leadership Initiative on Malnutrition diagnosis of malnutrition. Journal of Parenteral and Enteral Nutrition. 2022 Aug 1;46(6):1232–42.
43. Henrique JR, Pereira RG, Ferreira RS, Keller H, de Van der Schueren M, Gonzalez MC, et al. Pilot study GLIM criteria for categorization of a malnutrition diagnosis of patients undergoing elective gastrointestinal operations: A pilot study of applicability and validation. Nutrition. 2020 Nov 1;79–80.
44. Shimizu A, Maeda K, Wakabayashi H, Nishioka S, Nagano A, Kayashita J, et al. Predictive Validity of Body Mass Index Cutoff Values Used in the Global Leadership Initiative on Malnutrition Criteria for Discriminating Severe and Moderate Malnutrition Based on In-Patients With Pneumonia in Asians. Journal of Parenteral and Enteral Nutrition. 2021 Jul 1;45(5):941–50.

Table 1. Sociodemographic characterization of 430 Portuguese inpatients participating in a prospective observational study according to GLIM nutritional status.

	Whithout Undernutrition	Moderate Undernutrition	Severe Undernutrition	*p*
	n (222)	*n (86)*	*n (122)*	
Sex				
Female	163 (53.4)	59 (19.3)	83 (27.2)	0.499[a]
Male	59 (47.2)	27 (21.6)	39 (31.2)	
Age (years)				
≤64	161 (55.9)	56 (19.4)	71 (24.7)	**0.024[b]**
≥ 65	61 (43.0)	30 (21.1)	51 (35.9)	
Education (years)				
≤ 4	95 (51.9)	41 (22.4)	47 (25.7)	0.419[a]
≥ 5	127 (51.4)	45 (18.2)	75 (30.4)	
Marital Status				
Married/civil union	148 (54.6)	55 (20.3)	68 (25.1)	0.130[a]
Divorced/widowed/single	74 (46.5)	31 (19.5)	54 (34.0)	
Occupation				
No professional activity	146 (49.3)	62 (20.9)	88 (29.7)	0.365[a]
Professional activity	76 (56.7)	24 (17.9)	34 (25.4)	
	Median (interquartile range)			
	n *(222)*	*n (86)*	*n (122)*	
Age (years)	56 (20)	59 (22)	58 (27)	0.139[c]

[a]Chi-squared test was used for categorical variables; [b]*t*-Test for independent samples.; [c]Mann–Whitney test was used for variables with a different from normal distribution.

Table 2. Nutritional status assessment parameters associated with malnutrition of 430 Portuguese inpatients, in a prospective observational study, according to GLIM nutritional status.

	Whithout undernutrition		Moderate undernutrition	Severe undernutrition	*p*
	n		*Mean (standard deviation)*		
Albumin (g/l)	289	3.5 (0.5)	3.7 (0.6)	3.3 (0.5)	**0.022**[b]
C Reactive – Protein (g/l)	289	67.6 (71.5)	59.0 (73.3)	48.4 (50.1)	0.303[a]
Charlson Index	430	1.8 (2.0)	1.6 (1.9)	1.9 (2.1)	0.515[a]
LOS (days)	430	7.4(5.3)	11.3 (8.0)	10.2 (6.8)	**< 0.001**[b]
Katz index			*n* (%)		
Independent		206 (54.5)	74 (19.6)	98 (25.9)	**< 0.001**[a]
Dependent		16 (30.8)	12 (23.1)	24 (46.2)	
Handgrip Strength (kg)		***n***		*Mean (standard deviation)*	
Female	286	28.5 (10.7)	24.6 (12.4)	22.9 (9.5)	**< 0.001**[b]
Male	121	23.4 (12.1)	23.5 (11.3)	17.8 (10.1)	**< 0.026**[b]
Triceps skinfold (mm)					
Female	286	16.8 (8.6)	14.3 (8.7)	13.1 (7.6)	**0.010**[b]
Male	121	18.5 (10.0)	16.7 (7.8)	14.2 (6.4)	0.508[c]
Mid Upper Arm Circumference (cm)					
Female	286	29.7 (3.2)	28.4 (4.1)	26.1 (4.1)	**< 0.001**[b]
Male	121	29.3 (3.6)	29.3 (3.9)	26.3 (3.7)	**0.017**[b]
Adductor Pollicis No Dominant Hand (mm)					
Female	286	22.4 (4.3)	20.6 (4.0)	19.4 (4.2)	**< 0.001**[b]
Male	121	21.7 (4.3)	22.2 (4.0)	18.8 (3.4)	**0.002**[b]
Physical Examination			*n (%)*		*p*
No change		165 (58.7)	54 (19.2)	62 (22.1)	
Mild to moderate depletion		43 (41.3)	25 (24.0)	36 (34.6)	**< 0.001**[b]
Severe depletion		14 (31.8)	7 (15.9)	23 (52.3)	

*LOS: length of stay. [a]Chi-squared test was used for categorical variables; [b]*t*-Test for independent samples; [c]Mann–Whitney test was used for variables with a different from normal distribution.

Table 3. Concurrent validity of GLIM Criteria for Undernutrition Identification on the basis of undernutrition classification by Patient-generated Subjective Global Assessment (PG-SGA).

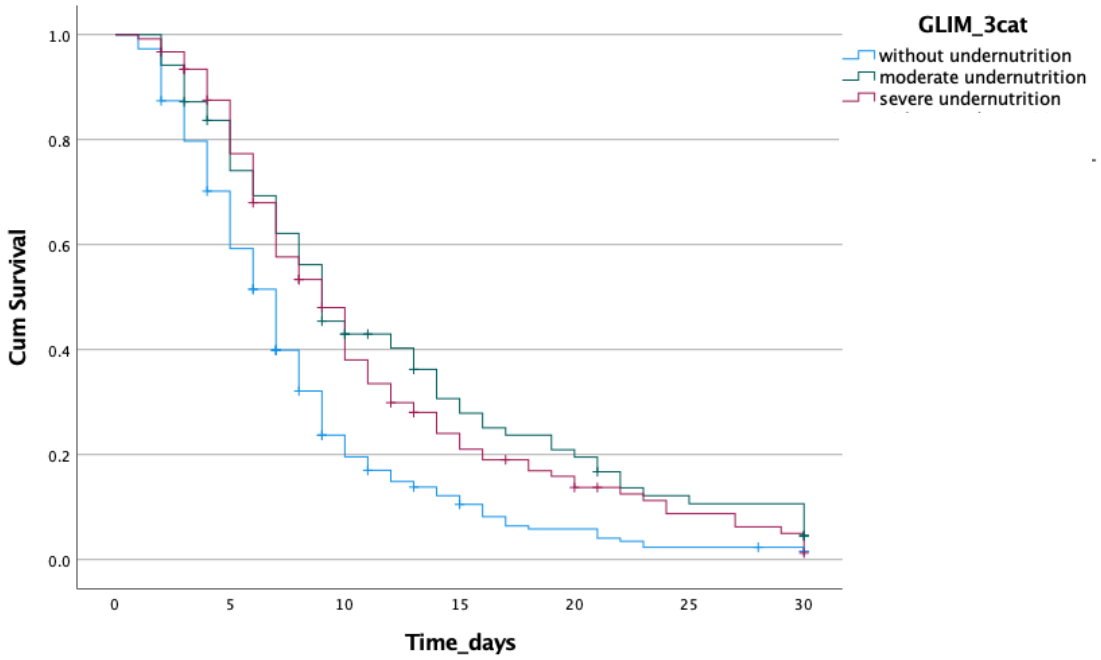
Kappa	0.484 ($p < 0.001$)
Agreement (%)	58.4
Sensitivity (%)	70.1
Specificity (%)	79.4
PPV (%)*	81.2
NPV (%)*	67.2

*PPV= Positive Predictive Value; NPV = Negative Predictive Value

Table 4. Hazard Ratios (HR) and corresponding confidence intervals (95% CI) for being discharged home according to GLIM criteria, for 430 inpatients participating in a prospective observational study.

	Model 1[a]	Model 2[b]
	Crude HR (Cl 95%)	Adjusted HR (Cl 95%)
Whitouth undernutrition		
Moderate undernutrition	0.564 (0.431 – 0.738)	0.569 (0.435 – 0.745)
Severe undernutrition	0.639 (0.505 – 0.809)	0.656 (0.516 – 0.833)

Model 1[a]: crude Cox proportional regression models.
Model 2[b] was adjusted for Katz index [dichotomic: independence (reference) vs. moderate and severe dependence] and age [dichotomic, $\leq$ 64 years (reference) vs. $\geq$65 years].

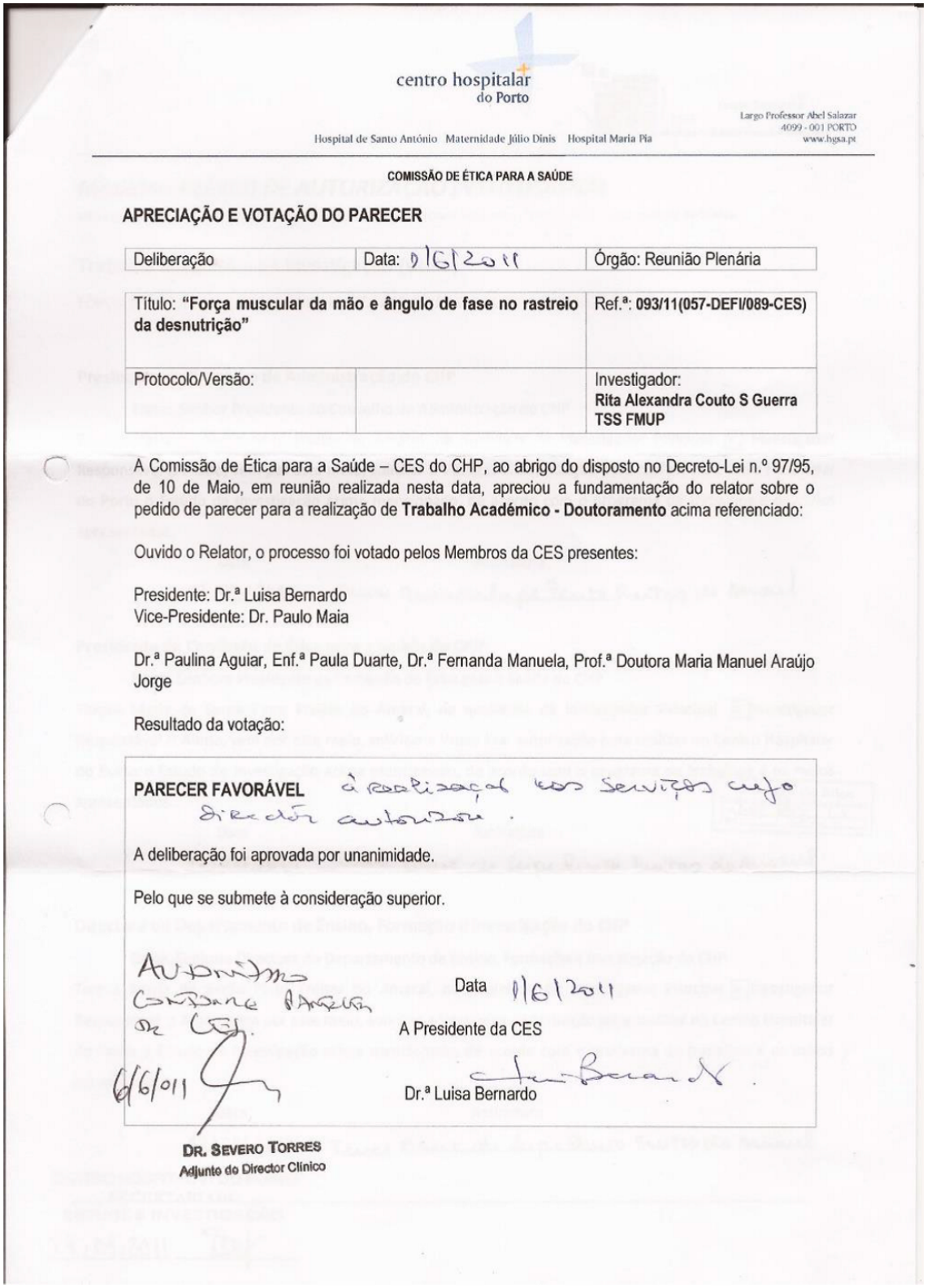


p < 0,001

Fig.1 Kaplan-Meier curves for being discharge-free over time for 430 Portuguese inpatients participating in a prospective observational study, according to GLIM criteria.

Higher values of being discharge-free over time represent a lower probability of hospital discharge; in-hospital deaths, transfers and discharge against medical advice were censored at time of those events; length of hospital stay was censored at 30 days.

Appendix



centro hospitalar do Porto

Hospital de Santo António Maternidade Júlio Dinis Hospital Maria Pia

Largo Professor Abel Salazar
4099 - 001 PORTO
www.hgsa.pt

COMISSÃO DE ÉTICA PARA A SAÚDE

APRECIAÇÃO E VOTAÇÃO DO PARECER

Deliberação	Data: 01/6/2011	Órgão: Reunião Plenária
Título: **"Força muscular da mão e ângulo de fase no rastreio da desnutrição"**		Ref.ª: **093/11(057-DEFI/089-CES)**
Protocolo/Versão:		Investigador: **Rita Alexandra Couto S Guerra TSS FMUP**

A Comissão de Ética para a Saúde – CES do CHP, ao abrigo do disposto no Decreto-Lei n.º 97/95, de 10 de Maio, em reunião realizada nesta data, apreciou a fundamentação do relator sobre o pedido de parecer para a realização de **Trabalho Académico - Doutoramento** acima referenciado:

Ouvido o Relator, o processo foi votado pelos Membros da CES presentes:

Presidente: Dr.ª Luisa Bernardo
Vice-Presidente: Dr. Paulo Maia

Dr.ª Paulina Aguiar, Enf.ª Paula Duarte, Dr.ª Fernanda Manuela, Prof.ª Doutora Maria Manuel Araújo Jorge

Resultado da votação:

PARECER FAVORÁVEL à realização nos serviços cujo director autorizou.

A deliberação foi aprovada por unanimidade.

Pelo que se submete à consideração superior.

Autorizo conforme parecer da CES.
6/6/011

Data 1/6/2011

A Presidente da CES

Dr.ª Luisa Bernardo

DR. SEVERO TORRES
Adjunto do Director Clínico