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Dissertação de Mestrado

Critérios do GLIM para diagnóstico de desnutrição em pacientes adultos hospitalizados críticos e não críticos: evidências acerca da sua aplicação, viabilidade e validade concorrente e preditiva

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Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Ciências da Nutrição da Universidade Federal de Ciências da Saúde de Porto Alegre, como requisito parcial para obtenção do título de Mestre em Ciências da Nutrição.

Orientadora: Profª Dra. Flávia Moraes Silva

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AMIB	Associação de Medicina Intensiva Brasileira
AND	Academy of Nutrition and Dietetics
ASG	Avaliação subjetiva global
ASPEN	American Society for Parenteral and Enteral Nutrition
AUC	Area under the curve
BIA	Impedância bioelétrica
CB	Circunferência do braço
CMB	Circunferência muscular do braço
CP	Circunferência da panturrilha
EMAP	Espessura do músculo adutor do polegar
EN	Estado nutricional
ESPEN	European Society for Clinical Nutrition and Metabolism
FELANPE	Federação Latino-Americana de Terapia Nutricional, Nutrição Clínica e Metabolismo
FPP	Força de Preensão Palma
GI	Gastrointestinal
GLIM	Global Leadership Initiative on Malnutrition
HR	Hazard ratio
IC	Intervalo de confiança
IMC	Índice de massa corporal
IMMA	Índice de massa magra apendicular
K	Coeficiente Kappa
MM	Massa muscular
NPT	Nutrição Parenteral Total
OR	Odds ratio
PA	Peso atual
PENSA	Sociedade de Nutrição Parenteral e Enteral da Ásia
PP	Perda ponderal ou Perda de peso (sinônimos)
PU	Peso usual
ROC	Receiver operating characteristics
RR	Risco relativo
UTI	Unidade de Terapia Intensiva
TNE	Terapia Nutricional Enteral
TIH	Tempo de internação hospitalar
VM	Ventilação Mecânica

RESUMO

Introdução: Um grupo de especialistas em terapia nutricional de diferentes sociedades internacionais constituiu o Global Leadership Initiative on Malnutrition (GLIM) recentemente e publicou uma proposta com critérios para diagnóstico de desnutrição mais específica e objetiva em comparação a outras alternativas, como a Avaliação Subjetiva Global (ASG). Os critérios do GLIM para diagnóstico de desnutrição envolvem a avaliação de três critérios fenotípicos e dois critérios etiológicos, sendo o paciente diagnosticado quando pelo menos um de cada tipo estiver presente. Porém, esses critérios requerem validação nos diferentes cenários, sendo evidenciado um crescente aumento no número de estudos publicados envolvendo pacientes hospitalizados com a aplicação dos mesmos. A avaliação detalhada da metodologia desses estudos é essencial para que se possa avaliar a certeza da evidência acerca da aplicabilidade e validade dos critérios do GLIM para diagnóstico de desnutrição no ambiente hospitalar. Dentre os pacientes hospitalizados, o paciente crítico apresenta uma resposta metabólica mediada por citocinas pró-inflamatórias e hormônios contrarreguladores, que contribuem para o comprometimento do estado nutricional, sendo o diagnóstico de desnutrição um desafio na unidade de terapia intensiva (UTI) considerando-se os métodos tradicionais como a ASG. Sendo assim, os critérios do GLIM surgem como uma alternativa para o ambiente de terapia intensiva, contudo a sua validade de critério em pacientes críticos foi pouco explorada até o presente momento.

Objetivos: Mapear a literatura acerca da aplicação dos critérios GLIM em pacientes hospitalizados e investigar a validade de critério dos mesmos para diagnóstico de desnutrição em pacientes críticos.

Métodos: Foram conduzidos dois estudos independentes para compor a presente dissertação. Realizamos uma revisão de escopo de acordo com a metodologia proposta pelo Instituto *Joanna Briggs*, com protocolo registrado no *Open Science Framework* (DOI 10.17605/OSF.IO/TGQU8). A busca da literatura foi conduzida em quatro bases de dados (até 16 de abril de 2022) para identificar estudos de acordo com o acrônimo PCC ('População': adultos ou idosos, 'Conceito': diagnóstico de desnutrição pelos critérios GLIM e 'Contexto ': ambiente hospitalar). Títulos e resumos foram selecionados e os dados foram extraídos dos estudos elegíveis através de um formulário padronizado por dois revisores independentes. Os resultados foram resumidos em tabelas e figuras por meio de estatística descritiva. Conduzimos também um estudo de coorte envolvendo pacientes adultos e idosos admitidos em seis UTIs de um complexo hospitalar do Sul do Brasil. Os dados necessários para o diagnóstico de

desnutrição a partir da ASG e dos critérios GLIM foram coletados prospectivamente em até 24 horas após a admissão na UTI, assim como dados clínicos e laboratoriais. Os pacientes foram acompanhados até a alta hospitalar para avaliação dos desfechos intra-hospitalares (mortalidade e tempo de internação na UTI e no hospital, duração da ventilação mecânica e readmissão na UTI). Os pacientes foram contatados pelo telefone para obtenção dos dados dos desfechos 3 meses após a alta hospitalar (óbito e readmissão hospitalar). Testes de concordância e acurácia e regressão de Cox e logística foram realizados para avaliar a validade concorrente e preditiva, respectivamente.

Resultados: Um total de 96 estudos foram elegíveis para revisão de escopo (54,2% publicados em 2021 e 96% em inglês, 35,4% da China, 30,2% incluindo pacientes oncológicos e 30,5% coortes prospectivas). A frequência dos critérios do GLIM variou de 22,2% (índice de massa corporal reduzido) a 84,7% (inflamação), e a prevalência de desnutrição variou de 0,96% a 87,9% entre os estudos. Menos de 30% (n=26) dos estudos tiveram como objetivo avaliar a validade concorrente e/ou preditiva dos critérios do GLIM. Para o estudo de validação dos critérios do GLIM na UTI avaliamos 450 pacientes (64 [54–71] anos, 52,2% homens), e os critérios do GLIM puderam ser aplicados em 83,7% (n=377) dos participantes. A desnutrição foi diagnosticada em 47,8% e 65,5% dos pacientes pelos critérios do GLIM e pela ASG, respectivamente. Os critérios do GLIM apresentaram área sob a curva ROC de 0,835 (IC 95%, 0,790–0,880), sensibilidade de 96,6% e especificidade de 70,3%. O diagnóstico de desnutrição de acordo com os critérios do GLIM aumentou a chance de permanência prolongada na UTI em 1,75 vezes (IC 95%, 1,08–2,82) e de readmissão na UTI 2,66 vezes (IC 95%, 1,15–6,14).

Conclusão: O mapeamento de estudos sobre os critérios do GLIM em ambiente hospitalar demonstrou sua aplicação de forma heterogênea, refletindo em uma ampla faixa de prevalência de desnutrição, falta de detalhamento sobre os métodos aplicados para avaliar cada critério, com número reduzido de estudos que se propuseram a avaliar a sua validade de critério. Em pacientes críticos, os critérios do GLIM apresentaram factibilidade superior a 80%,, sensibilidade superior a 90%, especificidade superior a 70% e concordância substancial com a ASG. A desnutrição diagnosticada pelos critérios do GLIM foi um preditor independente de permanência prolongada na UTI e readmissão na UTI.

Palavras-chave: estado nutricional, desnutrição, hospital, cuidados intensivos, acurácia, concordância, validade, notificação, transparência.

ABSTRACT

Introduction: A group of specialists in nutritional therapy from different international societies constituted the Global Leadership Initiative on Malnutrition (GLIM) recently and published a proposal with more specific and objective criteria for the diagnosis of malnutrition compared to other alternatives such as the Global Subjective Assessment (SGA). The GLIM criteria for diagnosing malnutrition require validation in different scenarios, with a growing increase in the number of published studies involving hospitalized patients with the application of these criteria being evidenced. A detailed evaluation of the methodology of these studies is essential in order to assess the certainty of the evidence about the applicability and validity of the GLIM criteria for diagnosing malnutrition in the hospital environment. Among hospitalized patients, the critically ill patient presents a metabolic response mediated by pro-inflammatory cytokines and counterregulatory hormones, which contribute to the impairment of nutritional status, and the diagnosis of malnutrition is a challenge in the intensive care unit (ICU) considering the traditional methods such as ESG. The GLIM criteria emerge as an alternative for the intensive care environment, however, its criterion validity in critically ill patients has yet to be explored to date.

Objectives: To map the literature on the application of the GLIM criteria in hospitalized patients and to investigate the validity of their criteria for the diagnosis of malnutrition in critically ill patients.

Methods: Two independent studies were conducted to compose this thesis. We performed a scoping review according to the methodology proposed by the Joanna Briggs Institute, with a protocol registered in the Open Science Framework (DOI 10.17605/OSF.IO/TGQU8). A literature search was conducted in four databases (until April 16, 2022) to identify studies according to the PCC acronym ('Population': adults or elderly, 'Concept': diagnosis of malnutrition by the GLIM criteria, and 'Context ': hospital environment). Titles and abstracts were selected and data were extracted from eligible studies using a standardized form by two independent reviewers. The results were summarized in tables and figures using descriptive statistics. We also conducted a cohort study involving adult and elderly patients admitted to six ICUs of a hospital complex in southern Brazil. The data necessary for the diagnosis of malnutrition from the SGA and the GLIM criteria were prospectively collected within 24 hours of ICU admission, as well as clinical and laboratory data. Patients were followed up until discharge to assess in-hospital outcomes (mortality and length of stay in the ICU and hospital, duration of mechanical ventilation, and ICU readmission). Patients were contacted by telephone

to obtain outcome data 3 months after hospital discharge (death and hospital readmission). Agreement and accuracy tests and Cox and Logistic regression tests were performed to assess concurrent and predictive validity, respectively.

Results: A total of 96 studies were eligible for scoping review (54.2% published in 2021 and 96% in English, 35.4% from China, 30.2% including cancer patients, and 30.5% prospective cohorts). The frequency of the GLIM criteria ranged from 22.2% (reduced body mass index) to 84.7% (inflammation), and the prevalence of malnutrition ranged from 0.96% to 87.9% between studies. Less than 30% (n=26) of the studies aimed to assess the concurrent and/or predictive validity of the GLIM criteria. For the validation study of the GLIM criteria in the ICU, we evaluated 450 patients (64 [54–71] years, 52.2% men), and the GLIM criteria could be applied to 83.7% (n=377) of the participants. Malnutrition was diagnosed in 47.8% and 65.5% of patients by GLIM and SGA, respectively. The GLIM criteria had an area under the ROC curve of 0.835 (95% CI, 0.790–0.880), sensitivity of 96.6% and specificity of 70.3%. The diagnosis of malnutrition according to the GLIM criteria increased the chance of prolonged ICU stay by 1.75 times (95% CI, 1.08–2.82) and ICU readmission by 2.66 times (95% CI, 2.66 times). 1.15–6.14).

Conclusion: The mapping of studies on the GLIM criteria in a hospital environment showed its application in a heterogeneous way, reflecting in a wide range of malnutrition prevalence, lack of detail on the methods applied to evaluate each criterion, with a small number of studies that proposed to assess its criterion validity. In critically ill patients, the GLIM criteria showed feasibility greater than 80%, sensitivity greater than 90%, specificity greater than 70% and substantial agreement with the SGA. Malnutrition diagnosed by the GLIM criteria was an independent predictor of prolonged ICU stay and readmission.

Keywords: nutritional status, malnutrition, hospital, intensive care, accuracy, agreement, validity, notification, transparency.

REFERENCIAL TEÓRICO

1. Relevância do problema "doença crítica"

A doença crítica é decorrente de qualquer insulto que leva o paciente à necessidade de cuidados intensivos para manutenção da vida. Independente da agressão sofrida, a doença é seguida por insulto fisiológico que leva à resposta neuro-endócrina e inflamatória mediada por citocinas e hormônios contrarreguladores para reparo dos tecidos lesionados. Essa resposta ao estresse desvia as rotas metabólicas levando ao catabolismo acelerado e resistência aos sinais anabólicos e resulta em alterações no gasto energético, no tipo de substrato utilizado e na composição corporal (**Figura 1**). As alterações na composição corporal são consequência do desequilíbrio da homeostase proteica e consequente perda de massa, funcionalidade e força muscular.[1,2] Estudos apontam que o paciente crítico apresenta perda de massa muscular (MM) precoce e rápida na primeira semana de internação na Unidade de Tratamento Intensivo (UTI), podendo esta perda chegar a 1kg de MM por dia [3,4].

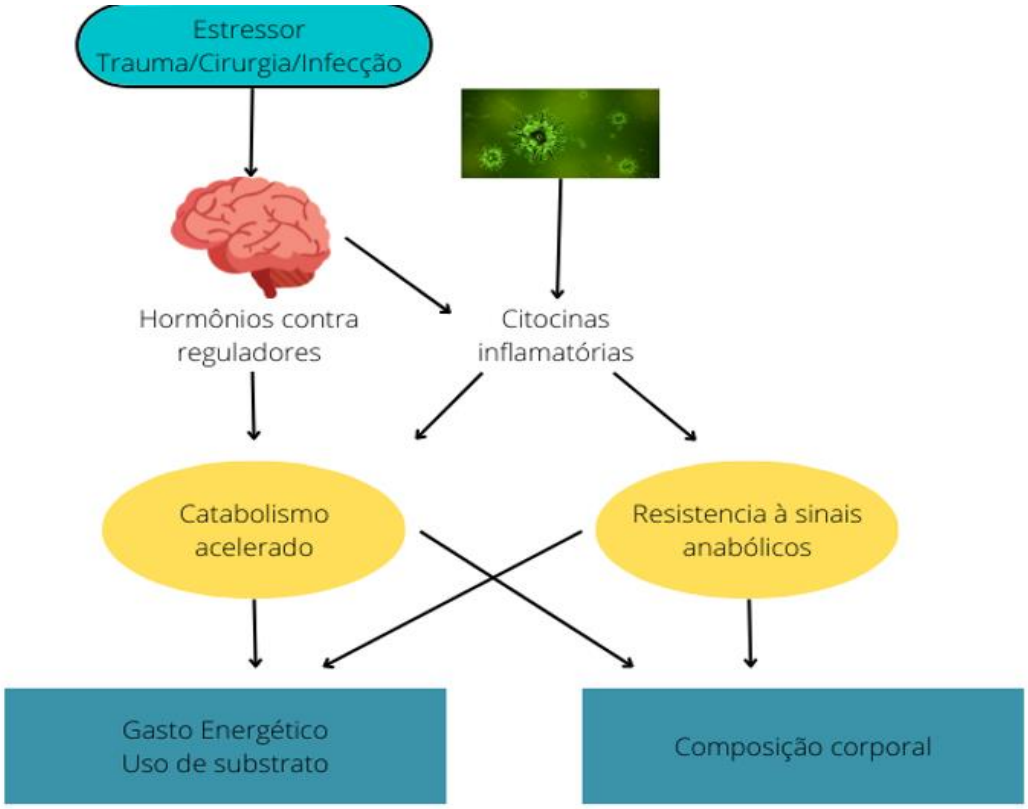

Figura 1: Diferentes níveis da resposta metabólica ao estresse. Uma vez que um estressor foi detectado, a resposta é ativada, mediadores são liberados após esta ativação e irão aumentar o catabolismo e induzir uma resistência aos fatores anabólicos,, resultando em alterações no gasto energético, no tipo de substratos utilizados e na composição corporal.
Fonte: adaptado de Preiser et al. 2

As consequências clínicas da resposta metabólica ao estresse incluem alterações sequenciais no gasto energético, composição corporal, comportamentais e cognitivas. Durante o curso da doença crítica o paciente atravessa fases com diferentes alterações metabólicas e necessidades nutricionais. Na fase precoce da doença crítica ocorre a produção de hormônios que estão relacionados ao hipermetabolismo, com o principal objetivo de sobrevivência, ofertando aos órgãos vitais substratos necessários para manutenção do seu funcionamento através da produção energética endógena. Por outro lado, na fase tardia há respostas adaptativas, com produção prejudicada e resistência hormonal que visam proteção a longo prazo do organismo, entretanto podem levar à disfunção orgânica, imunossupressão e perda de peso, o que contribui para aumento da mortalidade [2].

De acordo com pesquisa realizada pela Associação de Medicina Intensiva Brasileira, (AMIB) a taxa de mortalidade nas UTIs brasileiras é de aproximadamente 12% [5]. Devido ao avanço das tecnologias e tratamentos da doença crítica, houve uma redução significativa da mortalidade, entretanto houve aumento, também significativo, de pacientes encaminhados para ambientes de reabilitação. Em decorrência disso, a doença crítica é comparada com uma guerra, na qual o paciente enfrenta batalhas catabólicas que consomem reservas fisiológicas e levam a comprometimentos cognitivos, funcionais e do estado nutricional. Neste sentido, questiona-se: "Estamos criando sobreviventes da UTI, ou estamos criando vítimas?" [6].

O estado de saúde a longo prazo dos sobreviventes da UTI vêm se tornando uma grande preocupação nos últimos anos, haja vista a ocorrência frequente de sequelas pós cuidados intensivos que incluem distúrbios físicos (fraqueza e dificuldade de realização das atividades diárias), mentais (ansiedade e depressão) e cognitivos (perda da memória), os quais contribuem para uma pior qualidade de vida dos pacientes, além de gerar aumento dos custos tanto para os pacientes e sua família, quanto para a comunidade, uma vez que a readmissão hospitalar é frequente, bem como o aumento da utilização dos serviços de saúde. Embora a fisiopatologia seja complexa, há algumas estratégias que podem contribuir para mitigar o desenvolvimento dessas sequelas, dentre as quais está o aporte nutricional adequado a fim de minimizar o comprometimento do estado nutricional do paciente [7].

2. Comprometimento nutricional do paciente crítico

A desnutrição em pacientes hospitalizados tem alta prevalência e ainda é considerada um problema de saúde pública. Revisão sistemática que incluiu 66 estudos em 12 países da América Latina, demonstrou uma variação de desnutrição hospitalar de 40 a 60% [8]. No ambiente de UTI esta prevalência pode atingir até 82% dos pacientes, conforme demonstrado em revisão sistemática envolvendo 20 estudos observacionais. Os autores também evidenciaram em diversos estudos primários que pacientes críticos com desnutrição apresentam maior risco de morte, maior tempo de internação hospitalar e na UTI quando comparados aos pacientes sem desnutrição [9].

A avaliação nutricional no paciente hospitalizado é feita através da coleta de informações sobre história nutricional combinada com exame físico, antropometria, avaliação do consumo alimentar e da dosagem de proteínas plasmáticas. Contudo, a avaliação nutricional na UTI é um grande desafio pois os métodos tradicionais têm aplicabilidade limitada nessa população [10] devido ao comprometimento sensório e ao uso de sedação o que inviabiliza a realização de anamnese nutricional detalhada. Além disso, distúrbios do fluido corporal são comuns em pacientes críticos e podem causar a superestimativa do peso aferido e de outras medidas antropométricas, tais como circunferência do braço e da panturrilha. Ainda, os exames bioquímicos para dosagem de albumina ou de outras proteínas plasmáticas não são confiáveis na presença de inflamação, doença grave e/ou trauma e não devem ser usados para avaliação nutricional de acordo com posicionamento da Associação Americana de Nutricao Parenteral e Enteral [11]. Ademais, a desnutrição é uma condição complexa e multifatorial, o que torna imprescindível que diferentes indicadores que sinalizem a presença de comprometimento nutricional sejam combinados com indicadores que sinalizem a potencial etiologia do mesmo, o que é contemplado por diferentes métodos integrativos para diagnóstico de desnutrição [12-14].

3. Métodos diagnóstico de desnutrição no doente crítico

Os critérios que permeiam os pilares da avaliação nutricional incluem medidas antropométricas, exames laboratoriais, avaliação do consumo alimentar e exame físico. Os métodos integrativos para o diagnóstico de desnutrição do paciente hospitalizado compreendem diferentes combinados desses critérios e contemplam a Avaliação subjetiva global (ASG) [12], a proposta da Academia de Nutrição e Dietética juntamente com a ASPEN [13] e os critérios GLIM[14], os quais serão descritos a seguir.

3.1 Avaliação Subjetiva Global

A Avaliação Subjetiva Global (ASG) é considerada o método de referência para o diagnóstico da desnutrição em pacientes hospitalizados e leva em consideração a história clínica e nutricional e exame físico do paciente. Para aplicação da ASG é necessário obter informações relacionadas à alteração de peso nos últimos seis meses, da ingestão alimentar e da presença de sintomas gastrointestinais nas últimas duas semanas, bem como alterações funcionais e demanda metabólica da doença, além da identificação de sinais de perda de massa muscular e de gordura e de acúmulo de fluidos a partir de um exame físico detalhado. Com base nessas informações faz-se um diagnóstico subjetivo dos pacientes como bem nutridos (ASG A), moderadamente desnutridos/ suspeita de desnutrição (ASG B) ou gravemente desnutridos (ASG C). A ASG na íntegra está apresentada na **Figura 2**[12]. Essa ferramenta foi desenvolvida e validada inicialmente em pacientes cirúrgicos não críticos, entretanto a sua validade em pacientes hospitalizados com diferentes condições clínicas já foi amplamente demonstrada na literatura [15].

AVALIAÇÃO SUBJETIVA GLOBAL (ASG)
Selecione a categoria apropriada com uma marca de seleção ou digite o valor numérico onde indicado.
A- HISTÓRIA
1. Alteração de Peso
Perda geral nos últimos 6 meses: Perda de peso total = _____ Kg; _____%
Alteração do peso nas duas últimas semanas: ( ) aumentou peso ( ) não alterou ( ) diminuiu
2. Alteração na Ingestão alimentar em relação ao habitual
( ) sem alteração ( ) houve alteração

Se houve alteração: Duração: _____ semanas
Tipo de dieta: ( ) sólida em quantidade menor ( ) líquida completa ( ) líquidos hipocalóricos ( ) inanição
3. Sintomas gastrointestinais (persistentes por > 2 semanas)
( ) nenhum ( ) náusea ( ) vômito ( ) diarreia ( ) anorexia
4. Capacidade funcional
( ) sem disfunção – Exemplo: capacidade total ( ) disfunção

Se disfunção: Duração: _____ semanas
Tipo de disfunção: ( ) trabalho sub-ótimo ( ) deambulando ( ) acamado
5. Doença e sua relação com necessidades nutricionais
Diagnóstico principal (especifique): _____

Demanda metabólica (estresse): ( ) sem estresse ( ) estresse baixo ( ) estresse moderado ( ) estresse elevado

B- EXAME FÍSICO
(Para cada característica, especifique: 0 = normal, 1+ = perda leve, 2+ = perda moderada, 3+ = perda grave)
( ) perda de gordura subcutânea (tríceps e tórax)
( ) perda muscular (quadríceps e deltoides)
( ) edema de tornozelo
( ) edema sacral
( ) ascite

C- CLASSIFICAÇÃO ASG (selecione uma)
( ) A= Bem nutrido
( ) B= Moderadamente (ou suspeita de ser) desnutrido
( ) C= Gravemente desnutrido

Figura 2. Avaliação Subjetiva Global.
Fonte: Adaptada de Detsky e colaboradores[12].

Estudos envolvendo pacientes críticos são menos frequentes, porém também confirmam existir uma associação entre desnutrição identificada pela ASG e piores desfechos clínicos, sugerindo que a ferramenta também apresenta validade preditiva satisfatória no ambiente de terapia intensiva [16-18]. Em estudo brasileiro prospectivo que incluiu 185 pacientes adultos/idosos, os autores demonstraram que a ASG é capaz de predizer readmissão na UTI e mortalidade em pacientes críticos [16]. Estudo retrospectivo envolvendo 57 pacientes internados na UTI necessitando de ventilação mecânica se propôs a avaliar a capacidade da ASG em predizer desfechos clínicos e também demonstrou que a desnutrição identificada pela ASG está associada ao aumento da mortalidade [17]. Ainda, em outro estudo brasileiro prospectivo envolvendo 76 pacientes críticos cirúrgicos a desnutrição diagnosticada pela ASG aumentou a chance de internação hospitalar prolongada em 5,94 vezes (IC95% 2,06 - 17,13) [18].

Contudo, a ASG apresenta limitações e não é universalmente aceita para o diagnóstico de desnutrição devido aos desafios relacionados à sua aplicabilidade. A ASG depende da interação do paciente com o examinador, sendo um grande desafio no paciente crítico devido ao rebaixamento do sensório, utilização de sedação e bloqueadores neuromusculares. Além disso, por ser um método subjetivo, sua precisão diagnóstica é dependente da experiência do examinador, e por ser baseada em critérios qualitativos pequenas alterações do estado nutricional (EN) dificilmente são detectadas pela ASG [19].

3.2 Ferramenta proposta pela AND - ASPEN

A Academia de Nutrição e Dietética (AND) e a Associação Americana de Nutrição Parenteral e Enteral (ASPEN) elaboraram um novo modelo conceitual para diagnóstico de desnutrição, que considera a etiologia e a resposta inflamatória e classifica o paciente como tendo desnutrição moderada ou grave a partir da presença de pelo menos dois de seis critérios: perda ponderal, consumo alimentar reduzido, perda de massa muscular, perda de gordura subcutânea, acúmulo de fluidos e funcionalidade reduzida através da força de preensão palmar (FPP). Considerando-se o estado patológico do paciente (doença aguda ou doença crônica ou contexto social/ambiental prejudicado), ele será diagnosticado com desnutrição moderada ou grave; sendo considerada doença crônica aquela com duração igual ou superior a três meses **(Tabela 1)**[13].

Tabela 1. Características clínicas recomendadas pela *Academy of Nutrition and Dietetics – American Society for Parenteral and Enteral Nutrition* (AND-ASPEN) para diagnóstico de desnutrição.

	Desnutrição no contexto de doença ou injúria aguda		**Desnutrição no contexto de doença crônica**		**Desnutrição no contexto de circunstâncias Sociais ou Ambientais**	
Característica Clínica	**Desnutrição Moderada**	**Desnutrição grave**	**Desnutrição moderada**	**Desnutrição grave**	**Desnutrição moderada**	**Desnutrição grave**
(1) Ingestão energética A desnutrição é resultado da ingestão ou assimilação inadequada de alimentos e nutrientes. Portanto, comparar a ingestão energética recente com o requerimento energético estimado é o primeiro critério para a definição de desnutrição. O profissional de saúde deve avaliar a história alimentar e nutricional, estimar o requerimento energético ideal, compará-lo com a estimativa de ingestão energética e descrever a ingestão energética inadequada como o percentual do requerimento energético estimado de acordo com a duração da mesma.	<75% do requerimento energético estimado por ≥7 dias	≤ 50% do requerimento energético estimado por ≥ 5 dias	<75% do requerimento energético estimado por ≥1 mês	≤ 50% do requerimento energético estimado por ≥1 mês	< 75% do requerimento energético estimado por ≥ 3 meses	≤ 50% do requerimento energético estimado s estimadas por ≥1 mês
(2) Interpretação da perda ponderal O profissional de saúde deve avaliar o peso com o suporte de outros critérios clínicos, dentre os quais a presença de desidratação ou hiperhidratação. O clínico pode avaliar a mudança de peso de acordo com o período de tempo, e descrevê-la como percentual de perda ponderal em relação ao peso usual.	% Tempo 1-2 1 semana 5 1 mês 7,5 3 meses	% Tempo >2 1 semana > 5 1 mês >7,5 3 meses	% Tempo 5 1 mês 7,5 3 meses 10 6 meses 20 1 ano	% Tempo >5 1 mês >7,5 3 meses >10 6 meses >20 1 ano	% Tempo 5 1 mês 7,5 3 meses 10 6 meses 20 1 ano	% Tempo >5 1 mês > 7,5 3 meses >10 6 meses >20 1 ano
Achados no exame físico Desnutrição resulta em alterações no exame físico. O profissional de saúde deve realizar o exame físico e documentar qualquer um dos achados abaixo como						

indicador de desnutrição.						
(3) Massa Gorda Perda de gordura subcutânea (por exemplo: orbital, tríceps, gordura sobre as costelas, etc.).	Leve	Moderada a grave	Moderada	Grave	Moderada	Grave
(4) Massa Magra Perda muscular (por exemplo: temporal, clavicular [peitoral, deltoide], ombros [deltoide], músculos interósseos, escápula [latíssimo do dorso, trapézio, deltoide], coxa [quadríceps] e panturrilha).	Leve	Moderada a grave	Moderada	Grave	Moderada	Grave
(5) Acúmulo de fluido O clínico pode avaliar o acúmulo evidente localizado ou generalizado de fluidos no exame (extremidades, edema sacral, ascite). Perda de peso é frequentemente mascarada por acúmulo de líquido generalizado (edema) e ganho de peso pode ser observado.	Leve	Moderado a grave	Moderado	Grave	Moderado	Grave
(6) Força da pressão palmar reduzida Consultar manual de instrução do fabricante sobre o dispositivo de medição (dinamômetro).	NA	Redução mensurável	NA	Redução mensurável	NA	Redução mensurável

NA= não aplicável. Notas: O peso deve ser aferido ao invés de estimado; o peso usual deve ser obtido para determinar o percentual de perda ponderal e interpretar sua significância; proteínas séricas como albumina e pré-albumina sérica não estão incluídas como características definidoras de desnutrição pois análises de evidências recentes demonstraram que os níveis séricos destas proteínas não respondem a mudanças na ingestão de nutrientes. Fonte: Adaptada de White e colaboradores[12].

Até o presente momento, apenas quatro estudos utilizando a ferramenta AND-ASPEN em pacientes críticos foram identificados na literatura. Estudo de coorte retrospectivo com 5.606 pacientes críticos realizado em cinco UTIs demonstrou que pacientes com desnutrição grave de acordo com a ferramenta da AND-ASPEN apresentaram maior tempo de internação hospitalar e internação na UTI, bem como maior risco de morte em comparação a pacientes sem desnutrição. Destaca-se que o estudo não avaliou a redução da capacidade funcional através da FPP, um dos parâmetros contemplados pela ferramenta [20]. Por sua vez, um estudo brasileiro envolvendo 327 pacientes demonstrou que a proposta da AND-ASPEN para diagnóstico de desnutrição é viável em pacientes na UTI, considerando que 94% dos pacientes puderam ser avaliados de acordo com a ferramenta - ou seja, tinham as informações necessárias ao diagnóstico disponíveis. Os autores apontaram como limitações à aplicabilidade da ferramenta na prática clínica a coleta de informação referentes à ingestão de energia e a perda de peso devido ao viés de memória, sendo necessário confirmar os dados fornecidos pelos pacientes e familiares. Neste estudo a FPP também não foi aferida, não sendo considerada a característica capacidade funcional reduzida para o diagnóstico [21]. Outro estudo brasileiro, de coorte prospectivo envolvendo 414 pacientes críticos de trauma, demonstrou que a ferramenta AND-ASPEN (sem avaliação da capacidade funcional devido à impossibilidade de aferição da FPP) é um método viável e acurado para diagnosticar desnutrição e predizer mortalidade hospitalar [22]. Em contrapartida, estudo retrospectivo envolvendo 120 pacientes críticos não demonstrou associação da desnutrição diagnosticada pela AND-ASPEN e mortalidade na UTI e em 60 dias após a alta hospitalar. Porém, os autores consideraram apenas os pacientes com desnutrição grave na análise dos dados [23].

Apesar dos estudos citados não terem aplicado a ferramenta na íntegra, já que não consideraram a medida da FPP para avaliar capacidade funcional reduzida, foram estudos pragmáticos nesse quesito. Isso, devido a aferição da FPP em ambiente de terapia intensiva, especialmente em pacientes em ventilação mecânica e sedados, ser inviável. Possivelmente isso não deve ter afetado a validade preditiva da ferramenta, uma vez que estudo prospectivo realizado pelo nosso grupo de pesquisa com 600 pacientes hospitalizados demonstrou concordância substancial e acurácia satisfatória mesmo quando o diagnóstico de desnutrição foi estabelecido sem considerar o critério FPP reduzida. A validade da ferramenta da AND-ASPEN com e sem aferição da FPP em predizer desfechos clínicos também foi semelhante, sugerindo que a mesma pode ser aplicada na prática clínica sem o critério capacidade funcional quando a avaliação do mesmo não for factível [24].

A ferramenta AND/ASPEN é mais objetiva que a ASG, tendo em vista a identificação de pelo menos dois critérios daqueles recomendados para concluir o diagnóstico, e também pelos pontos de corte claros estratificados por períodos para avaliação dos critérios consumo alimentar reduzido e perda de peso, além de fornecer o diagnóstico com base etiológica que incorpora a influência da resposta inflamatória na etiologia da desnutrição [13]. Entretanto há algumas limitações na utilização desta ferramenta: o diagnóstico de desnutrição pode ser realizado apenas através do exame físico, uma vez que a perda de gordura subcutânea e de massa magra compõem dois critérios. O exame físico para identificar perda de gordura subcutânea, perda de massa muscular e acúmulo de líquidos requer experiência e treinamentos dos profissionais, podendo levar à uma superestimativa do diagnóstico de desnutrição.

3.3 Critérios propostos pelo GLIM

Em janeiro de 2016, durante a conferência da ASPEN foi reconhecida a necessidade em alcançar consenso global para o diagnóstico de desnutrição em ambientes clínicos. Com este objetivo, foi formado um comitê com representantes das principais sociedades globais de nutrição clínica: ASPEN, Sociedade Europeia de Nutrição Parenteral e Enteral (ESPEN), Federação Latino-Americana de Terapia Nutricional, Nutrição Clínica e Metabolismo (FELANPE) e Sociedade de Nutrição Parenteral e Enteral da Ásia (PENSA). Este comitê foi denominado Global Leadership Initiative on Malnutrition (GLIM). Após realização de reuniões, o comitê GLIM definiu os critérios mais comuns presentes nas ferramentas de triagem e avaliação nutricional e os cinco melhores critérios classificados pelos participantes foram divididos em critérios fenotípicos e etiológicos que deveriam ser avaliados para o diagnóstico de desnutrição [14].

De acordo com o GLIM, o diagnóstico de desnutrição é em duas etapas: inicialmente deve-se realizar uma triagem de risco nutricional a partir de alguma ferramenta validada e naqueles pacientes identificados como tendo risco nutricional devem ser avaliados os critérios fenotípicos e etiológicos. O diagnóstico de desnutrição é realizado através da combinação de pelo menos um critério fenotípico e um critério etiológico, e a severidade da desnutrição é definida com base nos critérios fenotípicos, podendo o diagnóstico ser definido como estágio 1 - desnutrição moderada, ou estágio 2 - desnutrição grave, conforme demonstrado na **Tabela 2.** Cabe destacar que o próprio comitê que propôs os critérios do GLIM reforça a importância da

realização de estudos de validação desta nova abordagem, uma vez que foi desenvolvida através do consenso de especialistas [14].

Tabela 2 - Critérios fenotípicos e etiológicos para o diagnóstico de desnutrição propostos pelo GLIM.

Critérios Fenotípicos	
Perda de Peso (%)	5%- 10% nos últimos 6 meses ou 10%-20% além de 6 meses - Moderada >10% nos últimos 6 meses ou >20% além de 6 meses - Grave
IMC Reduzido (Kg/m²)	IMC <20Kg/m² se <70 anos ou <22 se ≥70 anos - Moderada IMC ≤18.5 kg/m^2 se <70 anos ou IMC ≤20 kg/m$^{2\ se}$ idade ≥70 anos - Grave
MM Reduzida	Déficit leve a moderado* - Moderada (por métodos de avaliação validados e veja abaixo) Déficit grave* - Grave (por métodos de avaliação validados e veja abaixo)
Critérios Etiológicos	
Ingestão alimentar reduzida ou assimilação	50% do requerimento energético > 1 semana, ou qualquer redução por > 2 semanas, ou qualquer condição GI crônica que afeta negativamente a assimilação de alimentos ou absorção
Inflamação	Doença/lesão aguda ou relacionada à doença crônica

Abreviações: IMC = índice de massa corporal; GI = gastrointestinal; GLIM = Global Leadership Initiative on Malnutrition; MM= massa muscular; . Fonte: Adaptada de Cederholm T et al.[14]

*índice de massa magra apendicular (IMMA, kg/m2) por absorciometria de dupla energia ou padrões correspondentes usando outros métodos de composição corporal como bioimpedância elétrica (BIA), tomografia computadorizada ou ressonância magnética. Quando não estiver disponível ou por preferência regional, o exame físico ou medidas antropométricas padrão como o músculo do braço médio ou circunferências da panturrilha podem ser usados. Avaliações funcionais, como força de preensão manual, podem ser usadas como medida de suporte.

Em 2020 o comitê GLIM publicou um artigo no qual foram apresentadas orientações acerca da condução de estudos prospectivos e retrospectivos para validação dos critérios do GLIM. Para avaliação da validade concorrente os autores sugerem a comparação dos critérios do GLIM com um método de referência como a ASG e recomendam que a sensibilidade e especificidade sejam superiores a 80% e a concordância seja substancial (kappa > 0,80). Para avaliação da validade preditiva é necessário que os estudos conduzidos com pacientes hospitalizados demonstrem associação significativa entre a desnutrição diagnosticada pelos critérios do GLIM e desfechos como mortalidade intra-hospitalar, internação prolongada, reinternação e morte em 30 dias, sendo recomendável que a magnitude dessa associação seja forte (OR/HR/RR > 2,0). Ainda, para estudos com coleta de dados prospectivos o Comitê recomenda que todos os critérios fenotípicos e etiológicos sejam avaliados e ainda pondera que o critério fenotípico massa muscular reduzida seja avaliado por meio de diferentes indicadores [25]. Ainda, o Comitê publicou um guia norteador de como o critério fenotípico massa muscular reduzida deve ser avaliado. São apresentadas alternativas de métodos mais sofiisticados, como a tomografia computadorizada, a densitometria e a impedância bioelétrica, mas também métodos mais simples como a antropometria - a partir da aferição da circunferência da panturrilha e do cálculo da circunferência muscular do braço e do exame físico [26].

Embora haja um aumento linear das publicações acerca dos critérios do GLIM para diagnóstico de desnutrição desde que os mesmos foram divulgados, os estudos publicados aplicam os critérios do GLIM de forma heterogênea e apresentam uma descrição pouco detalhada da metodologia e da forma de aplicação dos critérios avaliados, o que impede o estabelecimento de evidências de alto nível relacionadas à validade desta nova abordagem. Uma revisão de escopo publicada recentemente com o intuito de avaliar como os critérios do GLIM estavam sendo aplicados em estudos conduzidos em diferentes cenários e com pacientes com diversas condições clínicas demonstrou que o IMC foi o critério fenotípico mais utilizado, enquanto a redução da ingestão alimentar e a inflamação foram frequentemente empregados como critérios etiológicos. Apenas 57% dos 79 estudos revisados aplicaram os cinco critérios do GLIM para diagnóstico de desnutrição, 67% dos estudos foram conduzidos no ambiente hospitalar e a validação dos critérios do GLIM foi descrita em 77% das publicações. Destaca-se o potencial para viés de idioma e de tempo dessa revisão, já que a busca foi realizada 12 meses antes da publicação e foi limitada a estudos publicados em inglês [27].

Considerando-se que o Comitê do GLIM pondera que os critérios para diagnóstico de desnutrição sejam avaliados a cada cinco anos para que a literatura possa apresentar as

evidências acerca da sua validade [25], o mapeamento atualizado da literatura sobre essa nova abordagem proposta para diagnóstico de desnutrição se faz necessária. Além disso, a literatura envolvendo a população de pacientes críticos é escassa, conforme sumarizado a seguir.

4. Evidências sobre os critérios do GLIM para diagnóstico de desnutrição na UTI

Em busca da literatura realizada na base de dados Pubmed, usando os termos relacionados a paciente crítico, desnutrição e GLIM, nós identificamos até o momento sete estudos envolvendo pacientes críticos que aplicaram os critérios do GLIM para diagnóstico de desnutrição [23,28-33]. Porém, poucos estudos tiveram como objetivo avaliar a validade concorrente e preditiva desta nova proposta [22,26-29]. As características, delineamento e resultados de cada estudo estão detalhados na **Tabela 3**.

Tabela 3 - Evidência científica sobre os critérios GLIM para diagnóstico de desnutrição em pacientes críticos

Autor (ano)	**Delineamento (local)**	**Amostra**	**Aplicação dos critérios. fenotípico**	**Aplicação dos critérios etiológicos**	**Prevalência de desnutrição**	**Validade concorrente**	**Validade preditiva**
Rattanachaiwong e cols.[23] (2020)	Retrospectivo (Israel) UTI geral	N: 120 Idade: 53 (29 - 67) Apache: 19,4 ± 7,8 SOFA: 6,3 ± 3,8	**IMC** - peso aferido (cama balança) e altura estimada pelo comprimento da ulna **PP** - informado **MM** - IMLG (BIA)	**IA** - questionário médico **Inflamação** - NR	**ASG:** 35,8% ASG-C **Critérios do GLIM**: 26,7% desnutrição grave	**S**= 65,1% **E** = 94,8% **kappa** = 0,64	Desnutrição não foi preditora independente de óbito quando diagnosticada pela ASG ou pelos critérios do GLIM.
Theilla e cols[28] (2020)	Retrospectivo (Israel) UTI geral	N: 84 Idade: 50,5 ± 20,9 Apache: 20,5 ± 7.7 SOFA: 6.3 ± 3.9	**IMC** - Peso aferido – (cama balança) e altura estimada pelo comprimento da ulna **PP** – informado **MM** – BIA	**IA** - não avaliada **Inflamação** – considerado para todos	**ASG** - 47,6% (40/84) **Critérios do GLIM** - 40,4% (34/84)	**S=** 85% **E=** 79% **AUC - ROC=** 0.85 (desn. moderada) **AUC - ROC=** 0.79 (desn. grave)	Não avaliada
Shahbazi e cols[29] (2021)	Prospectivo (Iran) UTI Covid	N: 109 Idade: 60.90 ± 13.7 Apache: 14.87 ± 3.87	**IMC** - Peso e altura referidos pelos pcts ou familiares **PP** – informado **MM** – realizado CMB (< p5)	**Inflamação** – considerado para todos	**ASG** - 62.4% (68) **Critérios do GLIM** - 61.5% (66)	S= 92% E= 93% K = 0,85 **AUC - ROC=** 0.927 (95% CI: 0.868-0.985)	Desnutrição diagnosticada pelos critérios do GLIM aumentou em 4.01 a chance de óbito *Análise ajustada para comorbidades e idade

Hajimohammadebrahim-Ketabforoush e cols[32] (2021)	Prospectivo (Iran) UTI Covid	N: 126 Idade: 60.21 ± 13.78 Apache: 15.73 ± 3.36	**IMC** - Peso e altura referidos pelos pcts ou familiares **PP** – informado **MM** – não foi avaliada	**IA** – VO enfermeira coletava os dados / TNE ou NPT registros de prontuário **Inflamação** - NR	**Critérios do GLIM** - 63%	Não avaliada	Não avaliada
Rives-Lange e cols[33] (2021)	Prospectivo (França) UTI Covid	N: 38 Idade: 66 [59, 72]	**IMC** - Peso aferido na cama balança **PP** - calculado atraves do peso habitual e peso admissão UTI **MM** – só foi avaliada no mês 3 (BIA + FPP)	**Inflamação** – todos considerado	**Critérios do GLIM** - 18%	Não avaliada	Não avaliada
Rodrigues e cols[31] (2020)	Prospectivo (Brasil) UTIU geral	N: 60 Idade: 57.5 ± 14.8	**IMC** - NR **MM** - CB reduzida: <p5 CP reduzida: < 34cm H | <33cm M	**Inflamação** – todos considerados com inflamação moderada ou grave	**ASG** - 75% **GLIM 1(IMC + IFM)** - 28,3% **GLIM 2(CB + IFM)** - 15% **GLIM 3 (CP + IFM)** - 68,3%	Não avaliada	Desnutrição não foi preditora independente de óbito quando diagnosticada pela ASG ou pelos critérios do GLIM.

Santos e Ceniccola[30] (2022)	Análise secundária coorte prospectiva (Brasil) UTI trauma	N:407 Idade: 36 (25 - 47)	NR	NR	**ASG** - 28,3% **Critérios do GLIM** - 18,2% **AND/ANSPEN** - 25,8%	**S=** 82,9% **E=** 72,4% **K** = 0,504 **AUC - ROC=** 0.725 (95% CI: 0.663 – 0.786)	Não avaliada

Abreviações: APACHE II: Acute Physiology And Chronic Health Evaluation; ASG: Avaliação Subjetiva Global; AUC-ROC: Área sob a curva ROC; BIA: Bioimpedância; CB: circunferência do braço; CMB: circunferência muscular do braço; CP: circunferência da panturrilha; E: especificidade; FPP: Força de prensão palmar.; GLIM: Global Leadership Initiative on Malnutrition; IA: ingestão alimentar; IMC: indice de massa corporal; IFM: inflamação; K: coeficiente kappa; MM: massa muscular; NPT: Terapia Nutricional Parenteral; NR: não reportado; OR: Oddis Ratio; PP: perda de peso; S: sensibilidade; TIH: tempo de internação hospitalar; TNE: Terapia Nutricional Enteral; VM: ventilação mecânica

A descrição dos métodos de aplicação de cada um dos critérios GLIM para avaliação da sua aplicabilidade na prática clínica é de suma importância. Nos estudos identificados, o critério etiológico inflamação foi considerado presente para todos os pacientes em quatro estudos [28,29,31,32] enquanto que nos demais estudos não foi descrito o método de avaliação deste critério. O critério etiológico redução da ingestão alimentar foi avaliado em apenas dois estudos [23,30], no entanto em nenhum dos estudos este critério foi avaliado por um profissional nutricionista. Quanto aos critérios fenotípicos, a avaliação da massa muscular reduzida foi realizada através de diferentes métodos, incluindo impedância bioelétrica [23,28,33] e medidas antropométricas [29,31].

A prevalência de desnutrição segundo os critérios do GLIM em pacientes críticos variou entre 18% e 68% [22,27-32]. Três estudos evidenciaram uma prevalência inferior a 20% , porém podemos destacar algumas limitações: um estudo envolvendo pacientes com excesso de peso com COVID-19 (média de IMC, 27,8 kg/m²) que não avaliou MM reduzida (18%) [32], um estudo brasileiro envolvendo vítimas de trauma (18,2%) que não descreveu os critérios utilizados para o diagnóstico de desnutrição [30], e outro estudo brasileiro que definiu desnutrição apenas pela redução da circunferência muscular do braço, pois considerou inflamação para todos os pacientes críticos incluídos no estudo (15%) [31].

Em relação à avaliação da validade de critério, quatro estudos avaliaram a validade concorrente [23,28-30], sendo que a sensibilidade e a especificidade dos estudos variaram de 65 a 92% e de 72 a 93%, respectivamente. A validade preditiva foi avaliada em três estudos [23,29,31], e apenas um estudo demonstrou associação entre desnutrição diagnosticada pelos critérios do GLIM e aumento da mortalidade [29], enquanto nos outros dois estudos os autores não evidenciaram associação entre desnutrição e os desfechos de interesse [23,31].

JUSTIFICATIVA

O comprometimento do estado nutricional no paciente crítico é intrínseco ao processo da doença, e diretamente proporcional a sua severidade. No entanto, observa-se elevada prevalência de pacientes que ingressam na UTI com risco nutricional e com desnutrição já instalada. O cuidado nutricional deve englobar a identificação daqueles em risco nutricional e, posteriormente, a identificação daqueles com desnutrição, para que a terapia nutricional adequada possa ser instituída. Contudo, não há consenso na literatura acerca do método mais acurado para diagnóstico de desnutrição em pacientes hospitalizados críticos e não críticos.

Embora a ASG seja um método válido para diagnosticar desnutrição, a sua subjetividade limita a sua aplicação à necessidade de profissionais treinados. Isso faz com que a mesma não seja universalmente aceita. Com o propósito de ter um método universalmente aceito para diagnóstico de desnutrição em diferentes cenários, os critérios do GLIM foram propostos. Considerando-se que o Comitê do GLIM pondera que os critérios fenotípicos e etiológicos para diagnóstico de desnutrição sejam avaliados a cada cinco anos para que a literatura possa apresentar as evidências acerca da sua validade [25], o mapeamento atualizado da literatura sobre essa nova abordagem proposta para diagnóstico de desnutrição se faz necessária.

Com base no que identificamos na literatura acerca da aplicabilidade e validade dos critérios do GLIM para diagnóstico de desnutrição em pacientes de UTI, algumas lacunas podem ser listadas a serem preenchidas por conhecimento gerado em estudos futuros: 1) aplicação dos cinco critérios para diagnóstico de desnutrição, 2) avaliação da factibilidade da aplicação de cada critério no ambiente de terapia intensiva, 3) confirmação da validade concorrente e preditiva dos critérios do GLIM em uma amostra heterogênea de pacientes críticos.

OBJETIVO GERAL

Avaliar o estado da arte acerca da aplicação dos critérios do GLIM em pacientes hospitalizados e investigar a validade de critério dessa proposta para diagnóstico de desnutrição em pacientes críticos adultos e idosos.

OBJETIVOS ESPECÍFICOS

1. Identificar e mapear a literatura sobre diagnóstico de desnutrição pelos critérios do GLIM em pacientes hospitalizados, explorando sua metodologia de aplicação, os objetivos dos estudos publicados e a adesão dos mesmos às orientações sobre validação dos critérios do GLIM, bem como a frequência de desnutrição e de cada critério para seu diagnóstico.
2. Avaliar a validade concorrente e preditiva bem como a factibilidade da aplicação dos critérios do GLIM para o diagnóstico de desnutrição em pacientes críticos adultos e idosos.

METODOLOGIA E RESULTADOS

Para responder ao primeiro objetivo específico acima apresentado foi conduzida uma revisão de escopo apresentada como primeiro artigo da presente dissertação, o qual foi aceito para publicação no periódico Clinical Nutrition (*Milanez DSJ, Razzera EL, Knobloch IS, Lima J, Bernardes S, Silva FM. A scoping review on the GLIM criteria for malnutrition diagnosis: understanding how and for which purpose it has been applied in studies on hospital settings. Clin Nutr. 2022. doi.org/10.1016/j.clnu.2022.10.022*)

Para responder ao segundo objetivo específico acima apresentado, foi conduzido um estudo de coorte com coleta de dados prospectiva, o qual está apresentado como segundo artigo da presente dissertação. O mesmo será submetido para publicação no periódico *Journal of Parenteral and Enteral Nutrition* (ISSN: 1941-2444; fator de impacto: 4.016, qualis A1), cujas diretrizes podem ser consultadas em https://onlinelibrary.wiley.com/page/journal/19412444/homepage/forauthors.html

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ARTIGO CIENTÍFICO I

A scoping review on the GLIM criteria for malnutrition diagnosis: understanding how and for which purpose it has been applied in studies on hospital settings

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ABSTRACT

Aims: This scoping review aimed to identify and map the literature on malnutrition diagnosis made using the GLIM criteria in hospitalized patients.

Methods: The scoping review was conducted using the Joanna Briggs Institute's methodology. We searched PubMed, Embase, Scopus, and Web of Science (until 16 April 2022) to identify studies based on the 'population' (adults or elderly patients), 'concept' (malnutrition diagnosis by the GLIM criteria), and 'context' (hospital settings) framework. Titles/abstracts were screened, and two independent reviewers extracted data from eligible studies.

Results: Ninety-six studies were eligible (35.4% from China, 30.2% involving oncological patients, and 30.5% with prospective data collection), 32 followed the two-step GLIM approach, and 50 applied all the criteria. All the studies evaluated body mass index (BMI), while 92.7% evaluated weight loss; 77.1%, muscle mass; 93.8%, inflammation; and 70.8%, energy intake. A lack of details on the methods adopted for criterion evaluation was observed in five (muscle mass evaluation) to 40 studies (energy intake evaluation). The frequency of the use of the GLIM criteria ranged from 22.2% (frequency of low BMI) to 84.7% (frequency of inflammation), and the malnutrition prevalence ranged from 0.96% to 87.9%. Less than 30% of studies aimed to assess the GLIM criterion validity, eight studies cited the guidance on validation of the GLIM criteria, and a minority implemented it.

Conclusions: This map of studies on the GLIM criteria in hospital settings demonstrated that they are applied in a heterogeneous manner, with a wide range of malnutrition prevalence. Almost 50% of the studies applied all the criteria, while one-third followed the straightforward two-step approach. The recommendations of the guidance on validation of the criteria were scarcely adhered to. The gaps that need to be explored in future studies have been highlighted.

Keywords: malnutrition, hospital, GLIM, validity, reporting, transparency.

INTRODUCTION

Malnutrition remains a prevalent condition in hospital settings, affecting more than 40% of the general hospitalized patients in Latin America [1]. Malnutrition can be diagnosed in a larger number of patients, depending on the clinical condition and method adopted for its diagnosis (up to 76% of patients with traumatic injury, 100% of patients with cirrhosis, 78% of patients with acute medical conditions requiring intensive care, and 90% of patients with heart failure) [2]. Its prognostic value has been recognized because the length of hospital stay (LOS), incidence of major complications, and risk of death are higher in patients with malnutrition than in those without malnutrition [2-4]. Additionally, it is an independent predictor of hospital readmission and mortality after discharge and is associated with higher healthcare costs [3,5-7]. The prognostic value of malnutrition is independent of the underlying clinical condition, and the patient's nutritional status declines during hospital stay [8]. Therefore, there is no doubt that the detection of malnutrition at hospital admission is an essential element of patient care in all medical wards [9].

Malnutrition is a complex and multifactorial condition that can result from a combination of the following factors: compromised nutrient intake or assimilation, disease-associated inflammatory processes, immobility-associated muscle wasting, older age, and social isolation. These factors lead to altered body composition and diminished biological function [9,10]. Therefore, its diagnosis requires a detailed nutritional assessment [11]. Subjective global assessment (SGA) is one of the oldest available tools for malnutrition diagnosis in hospitalized patients [12], and its predictive validity is well recognized in hospital settings [13]. However, it is a subjective tool and is susceptible to malnutrition diagnosis-related errors when used by a non-trained professional [14]. Consequently, the agreement and reliability of this tool in diagnosing malnutrition are graded as moderate [15].

The lack of simple and unequivocal criteria for diagnosing malnutrition with high specificity and sensitivity has been an obstacle in reducing the heterogeneity in the literature in this field. The Global Leadership Initiative on Malnutrition (GLIM) has published the most recent proposal to facilitate more specific and objective malnutrition diagnosis. It involves a straightforward two-step approach with nutritional risk screening, followed by a more in-depth assessment for diagnosing malnutrition. It is composed of three phenotypic (reduced body mass index [BMI], unintentional weight loss, and reduced muscle mass [MM]) and two etiological criteria (reduced food intake/impaired nutrient assimilation and inflammation or disease burden). The presence of at least one of each type of criteria can aid in establishing a diagnosis of malnutrition, and the phenotypic criteria can be used to grade its severity [10]. Validation of

the GLIM criteria is necessary to support their dissemination and uptake in clinical practice, as these criteria were based solely on expert opinion. The GLIM group has published guidance on the validation of the operational criteria for protein-energy malnutrition diagnosis in adults; this guidance includes recommendations for studies aiming to determine the criterion and construct validity, as well as the reliability of the GLIM criteria [16].

The GLIM criteria have been extensively studied since their publication, as demonstrated by a recent scoping review of 79 studies that identified BMI as the most frequently used phenotypic criterion, while reduced food intake and inflammation were frequently employed as etiological criteria for malnutrition diagnosis in different health settings. However, the authors conducted the literature search in January 2021 and have not updated the review. In addition, the authors only considered English publications and excluded 54 reports due to language [17]. Thus, an evaluation of the studies published since January 2021 is necessary to add evidence in this field. Furthermore, it is important to determine whether the methodology of studies using GLIM criteria for malnutrition diagnosis has improved after the introduction of the validation guidance because more than 40% of the studies included in the aforementioned scoping review did not apply all the criteria. Therefore, we aimed to identify and map the literature on malnutrition diagnosis made using the GLIM criteria in hospitalized patients and to explore how the criteria were applied, the study proposals, and the adherence to the guidance on GLIM validation. Moreover, we aimed to determine the prevalence of malnutrition and frequency of the use of each criterion in this approach.

METHODS

We conducted this scoping review using the Joanna Briggs Institute's (JBI) methodology [18] and registered its protocol in the Open Science Framework (OFS, DOI 10.17605/OSF.IO/TGQU8). The first five stages proposed by the JBI were followed, as described below.

Stage 1: Identifying the research question

The main research question of this scoping review was as follows: What is the evidence on the use of the GLIM criteria for malnutrition diagnosis in hospitalized patients? This question was composed of the following subquestions.

a) What was the purpose of the studies that used the GLIM criteria for malnutrition diagnosis in hospitalized adult or elderly patients?

b) How were the GLIM criteria for malnutrition diagnosis applied in studies using this approach?

c) What were the main reporting-related limitations associated with the application of the GLIM criteria for malnutrition diagnosis in the relevant studies?

e) What was the frequency of the use of each phenotypic and etiological criterion and malnutrition diagnoses made according to the GLIM criteria?

The research question was structured based on the population, concept, and context (PCC) framework; the population included adult or elderly patients, the concept was malnutrition diagnosis reached through the GLIM criteria, and the context was the use of the criteria in hospital settings. We modified the population of our previous PCC framework described in the protocol, limiting it to hospital settings instead of using any other settings, since the number of previously retrieved records would not be manageable. Additionally, we believe that inpatients and outpatients have particularities related to the determinants of nutritional status, and the validity of the GLIM criteria should be investigated separately in both groups of patients.

Stage 2: Identifying relevant studies

Primary studies that were conducted in hospital settings on adult or elderly patients, regardless of their clinical condition, and that applied the GLIM criteria for malnutrition diagnosis were eligible for this scoping review. We did not restrict the language or date of publication. We excluded qualitative studies, reviews, editorials, and commentaries because they are not primary studies. We also excluded randomised clinical trials if they did not report on the prevalence of malnutrition according to the GLIM criteria. Abstracts published in the Annals of Congress were excluded because this type of publication precludes a detailed assessment of the study.

We conducted an initial search on PubMed, in which we checked the words within the title, abstract, and keywords of the retrieved papers in order to confirm whether these words should be included in the search strategy. In the second step, we conducted a comprehensive search on PubMed using all the relevant identified terms (only one new term, ‘Scored GLIM’). Subsequently, we adjusted the final search strategy for use on Embase, Scopus, and Web of Science (see all search strategies in Supplementary Box 1). We conducted the search in all the databases on 10 February 2022 and updated it on 15 April 2022.

Grey literature was reviewed through the abstracts of the European Society for Clinical Nutrition and Metabolism (ESPEN) and American Society of Parenteral and Enteral Nutrition (ASPEN) scientific meetings conducted over the last 3 years. Therefore, we confirmed whether articles of potentially eligible studies were published at a later date. We also checked the references of the two reviews in this field published previous [17,19].

Stage 3: Selection of eligible studies

Endnote® was used as the reference management software to assist in data management. We removed duplicates using the automated deduplication feature of the software. Two independent reviewers (FMS and JL) determined the eligibility of each report using a two-stage process. First, they screened titles and abstracts and selected all potentially eligible papers. Subsequently, three pairs of reviewers (FMS and ISK, JL and ELR, DSJM and SB) read the full text to confirm eligibility. Disagreements between reviewers were resolved by consensus, and if necessary, a third reviewer was consulted (FMS).

Stage 4: Data extraction

The same three pairs of reviewers (FMS and ISK, JL and ELR, DSJM and SB) independently extracted data from all eligible studies using a standardized data extraction form created on Google Forms®, and any disagreements were resolved by consensus. We conducted a pilot test of this form using five randomly selected full texts before proceeding with the data extraction to ensure that all the reviewers extracted data consistently while avoiding ambiguity and errors. Box 1 summarizes the extracted data. Supplementary Figure 1 illustrates the GLIM framework for malnutrition diagnosis, which was used as a reference in this scoping review.

Stage 5: Summarizing and reporting the results

We used descriptive statistics to describe the features of the studies on the GLIM criteria for malnutrition diagnosis and used tables and graphs to present the collected data. This scoping review is presented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) checklist [21].

RESULTS

Studies selection and general features of the selected studies

Figure 1 presents the flowchart of study selection. We identified 1386 records in all the databases. After automated deduplication and title and abstract screening, 134 records remained for full-text examination and data extraction. Among these, the following records were excluded: four abstracts, 30 articles because the study population did not meet our criteria, and five articles because the GLIM criteria were not applied. Additionally, five reports were not retrieved because we did not find the full text for three, and the other two were not free to access. Thus, 94 studies were eligible [22-115]. Among the references of two previously published reviews [17,19], we identified an additional two eligible studies [116,117]. Subsequently, 96 studies [22-117] were included in this scoping review. **Supplementary Table 1** presents a list of the excluded studies with justifications.

The detailed features of each study are presented in **Supplementary Table 2**. The majority of studies were published in 2021 (n=52, 54.2%) [24,25,29,30,38,39,42-44,49-52,54,56,58-61,64-67,70-73,75,76,79,82,84,86,88-90,95,97,99,101,103,105,110, 112,113,115,117] in English (n=94, 96.0%), had a longitudinal design with prospective data collection (n=29, 30.2%) [25,26,29,31,32,34,36,39,41,45,47,50,54,56,58,69,71-75,79,84,85,88,89,103,113,114], and were conducted in a unique centre (n=68, 70.8%) [23-32,34,36,37,39-41,43-50,53,54,56-77,79-81,84-89,91,93-95,104,105,111,113,114, 116,117], mainly in China (n=34, 35.4%) [37,40,43-45,51-53,55,70,77,85,89-93,95-103,105-111,115]. The smallest sample size was 38 patients [71], and the largest was 31,029 patients [38]. The most frequently observed clinical condition in the studied participants was cancer (n=29, 30.5%) [43,44,47,51-53,70,74,75,85,89,93-103,106-111,114,115], the participants' mean age ranged from 37.8 [45] to 86 [76] years, and 62 studies included a larger number of male patients (> 50% of the total sample).

Registered dieticians collected data in 30 studies [30,32,34,36,37,40,45-48, 51,56,57,60,63,66,71,72,77,87,91,94,95,97-100,103,108,113], but 53 did not provide information regarding who collected data. Most studies (n=47, 47.5%) did not describe the timing of nutritional assessment, while it was conducted within the first 24 h of hospitalization in 19 studies [27,39,41,46,47,52,55-57,59,66,68,73,74,75,76,86,95,114]. A summary of the study features in terms of publication, design, patients' clinical condition, and data collection is provided in **Figure 2**. Most studies were published in journals with impact factors ranging from 3.0 to 4.5 (39.1%). **Supplementary Figure 2** presents the outcomes evaluated in the reviewed studies; the most frequently assessed outcome was mortality after discharge (n=32) [23,24,29,42-44,46,47,49-51,53,54,62,69,72,75,78,83,85,89,96,99,102107,108,113,115].

Additionally, 57 studies evaluated at least one health outcome that was meaningful in hospital settings [23,24,26,29,31,32,36,38,39,41-44,46,47,49-56,58,59,62,65,66,69,72,75,78,79,82,85,88, 89, 92-99,102,105-108,112-116].

The majority of studies screened the patients for nutritional risk (n=70), mainly using the nutritional risk screening (NRS)-2002 system (n=45), whereas the remaining studies did not report any information on nutritional risk screening [25,26, 29,30,32,38,39,41,47,54,58,65,69-72,74,75,79,82,83,87,88,104,107]. Thirty-five studies [22,24,27,29,30,32,34,41,42,46,49,50,52,58,59,61,70,72,79,80,85-87,93,95,99-102,106-109,111,114] also diagnosed malnutrition using other tools, with SGA or Patient Generated-SGA (PG-SGA) used in 29 studies.

Details of the application of the GLIM criteria for malnutrition diagnosis

Table 1 presents a detailed explanation of the application of the GLIM criteria. The straightforward two-step GLIM approach was used for diagnosing malnutrition in patients with identified nutritional risk in 32 studies [31,35,37,40,43-45,51-53,55,59,76, 80,85,89,90,92,94,96-99,102,105,106,108,110,112,113,115,116].

In 26 studies, malnutrition was diagnosed in all patients using the GLIM criteria, without previous nutritional risk screening [22,25,26,29,30,32,38,39,41,42, 47,54,58,65,69,70-72,74, 75,79,82,83,87,88,107]. Fifty studies (52.1%) evaluated the five GLIM criteria [2,24,27-33,36,41,45-47,49-51,55,57-61,63,64,74,75,77-81,84,85,87-90,93,94,97-100,103,105,109,114-116], whereas in two studies, it was unclear how the GLIM criteria were applied [54,104]. The number of studies without assessments for BMI, unintentional weight loss, and MM was 0, six [35,65,66,69,72,82], and 22 [22,25,26,34,35,37-40,56,65,67,68,71,73,82,83,91,92,111,112,117], respectively. By contrast, 28 studies did not evaluate the energy intake criterion [38,42-44,48,52,53,60,62,65,66,69-72,76,82,86,95,96,101,102,106,107,110-113], while four [34,35,83,108] did not consider the inflammation criterion (Figure 3A).

Figure 4 illustrates the major limitations of the studies in terms of reporting the methods used for evaluating each phenotypic and etiological criterion. In 43 (44.8%) studies, the description of how the body weight and height data used in the BMI calculation were obtained was unclear [24,35,51,53,63,69,71,72,76,80,83,91,98, 100,115] or unreported [23,33,38,40,42,43,44,48,56,58,59,61,62,65, 68,82,89,92,93,97, 104-107,110,111,113,116]. In 55 (61.1%) studies, information related to the method used for evaluating unintentional weight

loss was unclear [27,45,46,51,57,60,73,77,80, 85,89,91,117] or unreported [23,24,33,37-40,43,44,48,49,52,55,56,58,61-64,68,70,71, 74-76,78,81,88,90,92-94,97,100,104,107,110,111,113,114]. In five (6.8%) studies, the method adopted to assess MM was not reported [54,90,104,107] or not described clearly [94].

Among the 69 studies that considered the MM criteria and reported on how these criteria were evaluated, only nine used three or more indicators of reduced MM [29,30,41,51,64,97,106,108,113], while 12 used two indicators [52,59,62,72,75,78,84, 99,103,110,114], and the remaining used a single indicator. Anthropometric measurements were the most frequently adopted methods (n=34), followed by impedance bioelectric (BIA) (n=26) and handgrip strength (HGS) (n=12) measurements. Among the studies that used anthropometric measurements, 33 measured calf circumference (CC) [28-31,41,47,51,52,57,59,64,69,72,78-80,84,95-101,103,105,106, 108,113,115,116], and the most frequently used cutoff point for the classification of low MM was CC < 30.5 cm in men and < 29 cm in women.

The description of the food intake assessment was either unclear or unreported in 40 of the 68 studies (58.8%) that evaluated this criterion, while 18 [28-30,32,34-36,41,49,59,61,73,74,80,81,85,92,114], six [22,46,84,88,115,116], and three studies [23,24,67] adopted a semi-quantitative (i.e., % of usual intake), qualitative (i.e., whether intake was reduced or not), and quantitative (i.e., 24-h dietary recall) method, respectively.

Disease burden was predominantly defined as inflammation (n=57), and in 39 studies, this criterion was considered isolated [23-26,41-44,46,48-53,55,62,66,69-72,76,79,82,86,90,92,95,96,102,105-107,110-113,115]. Twenty-five studies [22,29,30, 32,45,47,56,58-61,63-65,67,68,84,85,87,97-101,103] used C-reactive protein at different cutoff levels, as detailed in **Supplementary Table 3.** In 33 studies, the authors considered that this etiological criterion would be present in all patients based on disease understanding, and 16 of these studies involved patients with cancer [43,44, 51,53,70,85,96,97,100,102,103,107,108,111,112,116].

Almost 50% of the studies graded the severity of malnutrition [22-33, 36,37,41,45,47,51,52,57-60,63,65,71-73,78,82,83,85,89,90,93,96,101,103,105,108,112, 113,115,116], but 13 did not describe or clearly report on how the severity grade was assessed [23,25,27,28,31,32,36,45,63,94,104,105,113]. Most of these studies used BMI and/or unintentional weight loss to define the severity of malnutrition (**Supplementary Table 3)**.

Details of the data analysis in the studies on the use of the GLIM criteria for malnutrition diagnosis

The sample size calculation was described in 17 studies [24,28,29,32,34,41,44, 54,63,66,72,81,86,87,93,107,113]. It was based on the following approaches: measurement of agreement between the GLIM criteria and other malnutrition diagnosis tools [24,28,86], sensitivity and specificity metrics [34,87,107], the differences in the occurrence of death or other outcomes between patients with and without malnutrition [29,32,44,63,81], and expected prevalence of malnutrition [41,54,66]. Two studies calculated the sample size based on MM quantity [72] or strength [113]. All studies presented descriptive statistics, including data on malnutrition prevalence, according to the GLIM criteria.

Less than one-third of the studies aimed to validate the GLIM criteria (n=26) [22,27,29,32,34,36,41-44,46,47,49,58,59,70,79,86,87,90,93,94,98,107,109,117]. A total of 37 studies were published before the guidance on validation of the GLIM criteria was introduced, and a minority of studies published later [29,59,84,86,88,97,99,100] referenced it. The adherence to this guidance in each study is summarized in **Table 3**. Among the 37 studies that collected data prospectively (after GLIM approach publication), 18 assessed the five GLIM criteria [27-33,41,47,57,59,61,63,64,79, 85,89,103]. Only four of these studies provided a detailed definition of the etiological criteria and evaluated MM using more than one marker [29,30,41,59]. Two studies that completely adhered to the guidance on validation of the GLIM criteria conducted an agreement analysis [29, 59], and four calculated the sensitivity and specificity of the GLIM criteria using a semi-gold standard tool as a reference [29,30,41,59]. Among the 57 studies that collected data retrospectively (before GLIM approach publication), 14 conducted an agreement analysis [24,46,52,58, 59,87,90,93,95,99-101,106,109], and 11 calculated the sensitivity and specificity of the GLIM criteria using a semi-gold standard tool as a reference [22,24,46,52,58, 86,87,93,95,106,109]. Considering the predictive validity of the GLIM criteria, more than half of the studies (n=57) used regression models and presented association measures (i.e. odds or hazard ratio). Among them, 48 studies considered at least one meaningful outcome for hospital settings [23,24, 26,29,31,32,36,38,42,43,44,46,47,49-55,59,62,69,75,78,79,82-84,88,89,92,99,102,105-108,112-115].

Malnutrition prevalence and frequency of each GLIM criterion

Table 2 presents the relative frequency of each GLIM criterion, malnutrition diagnosis, and malnutrition severity grades. The prevalence of malnutrition ranged from 0.96% [78] to

87.9% [75]. Among the studies that graded the severity of malnutrition (n=38), the prevalence of moderate and severe malnutrition ranged from 6.7% [37] to 45.0% [103] and from 4.0% [103] to 72.9% [58], respectively (Figure 5). Figure 3B illustrates the mean, minimum, and maximum relative frequencies of the use of each criterion. Low BMI (mean = 22.2%) and inflammation were the least and most frequently (mean = 84.7%) used criteria, respectively.

DISCUSSION

This scoping review mapped the literature on the GLIM criteria used in hospital settings and included 96 studies. Our findings raise some concerns related to the application of the GLIM approach in this context, which will be discussed in the following.

The GLIM approach involves a straightforward two-step approach, with nutritional risk screening as the first step [10]. The minority of studies followed the two-step approach: although 70 studies applied a nutritional screening tool (mainly NRS-2002) only 32 studies diagnosed malnutrition in patients at nutritional risk. In a previous scoping review on GLIM criteria applicability, 62% of included studies reported malnutrition screening by a validated tool, mainly MNA and NRS-2002. The authors did not describe if these studies followed or not the GLIM straightforward two-step approach [17]. Although the GLIM group recommends the use of any validated screening tool as the first step, the selected tool must adequately complement the GLIM criteria. Few studies explored it until now and the results are heterogeneous [27,85,118]. Indeed, studies focused on the sensitivity of the screening tools and/or on comparing the two-step GLIM approach with other diagnostic tools, such as SGA. However, tools with higher negative predictive values and specificity would be more appropriate for application in the first step because the intention is not to fail in the second step and to correctly identify well-nourished patients. In a previous study, we demonstrated that MUST had higher values of these accuracy metrics in comparison to NRS-2002, MST, SNAQ, and NRE-2017 in a sample of 601 hospitalized patients [119].

Approximately 50% of the studies evaluated the five GLIM criteria, such as demonstrated by Correia et al in a scoping review on GLIM criteria applicability in different settings (57% of the included studies considered all GLIM criteria) [17]. Which raises an important question: is the validity of the GLIM criteria dependent on the number and combination of criteria evaluated? Three studies considered only low BMI as the phenotypic criterion, and the mean prevalence of malnutrition among these studies was 30.9% [35,65,82]. This underreported malnutrition prevalence coincides with the low frequency of low BMI

criterion in most studies, and it results from the inaccuracy of isolated BMI measurement in identifying nutritional status impairment. On the other hand, reduced MM and inflammation were the most frequent criteria present among patients in the revised studies, suggesting its relevance for diagnosing malnutrition.

In addition, reduced MM and inflammation bring a challenge. Several studies, especially those involving cancer, considered inflammation present in all patients due to the understanding of the disease burden. In the scoping review conducted by Correia et al 67% of included studies also reported inflammation using disease burden/ diagnosis [17]. However, the question arises regarding whether this approach overestimates the frequency of malnutrition. Another question is whether it would be necessary as an objective marker of inflammation in all patients. Further, it is also unclear whether a severity score could be used for this proposal (e.g. Glasgow score or Charlson comorbidity index) or whether C-reactive protein should be used (the most accurate cutoff point and appropriate measurement timepoint are also unclear). Regarding the assessment of reduced MM, most studies described the method adopted, and a wide variety of assessment techniques was identified, with anthropometry and impedance bioelectrical the most frequent. In studies conducted in other settings, the anthropometric parameters, especially CC, also prevailed for the assessment of reduced MM [17]. The frequency of malnutrition can depend on the reduced MM criterion adopted: in a study including 118 general patients, it ranged from 46.7% (skeletal muscle index [SMI]) to 75% (HGS) [64], while in another study involving 282 oncological patients, it ranged from 8.0% (HGS) to 77.6% (SMI) [114]. Recently, a guide was published to promote the evaluation of MM and recommend the adoption of a technical approach (BIA, DXA, computerized tomography, and ultrasonography) or clinical approach, such as anthropometry (CC and mid-arm muscle circumference) and physical examination. HGS should not be used as a criterion for reduced MM [19], and it was considered in 11 studies. Most studies used CC to evaluate reduced MM, which is supported by the simplicity, brevity, and low cost of the measurement. Indeed, several studies have already shown that reduced CC is associated with worse outcomes, such as increased mortality and LOS, suggesting that the use of this measure to assess MM in the GLIM approach can be appropriate [120-122] even though excess adiposity and fluid retention can mask loss of MM and lead to the misclassification of reduced CC.

Most studies using the GLIM criteria for malnutrition diagnosis in hospitalized patients did not aim to investigate the criterion validity. Correia et al identified reporting of GLIM criterion validity in 77% of publications reviewed, but it is not described if it was the

aim of them [17]. Only a few studies adhered to the guidance on validation of the GLIM criteria. Among the studies that collected data prospectively, the number of criteria evaluated, limited reporting of methods adopted to evaluate the etiological criteria, and use of a unique indicator of reduced MM were the main reasons for non-adherence. Indeed, only 15 of 96 studies calculated sensitivity and specificity while considering a semi-gold standard tool as a reference. A recent meta-analysis of 20 studies, of which ten were in hospital settings and included in the current scoping review, found satisfactory accuracy of GLIM criteria (receiver operating characteristics [ROC] curve, 0.82; sensitivity, 0.72; specificity, 0.82) and better performance when SGA was adopted as a standard semi-gold tool (ROC curve, 0.84; sensitivity, 0.80; specificity, 0.81) [21]. However, the authors did not address or discuss the effects of the application of the GLIM criteria on accuracy. Regarding the predictive validity of the GLIM criteria, only 48 studies considered at least one meaningful health outcome for hospital settings. In line with the findings from another scoping review of studies on GLIM applicability in various health settings, in which 57% of studies specify meaningful health outcomes for predictive validity testing [17]. In a narrative review including six studies with cancer patients, five of them evaluated major complications and all evaluated mortality or overall survival [123]. Indeed, a meta-analysis of 11 studies including patients with cancer demonstrated an increased risk of death (RR= 1.90) in patients classified as malnourished by GLIM criteria in comparison to these without malnutrition [124].

The prevalence of malnutrition according to the GLIM criteria ranges from 0.96% [40] to 87.9% [75]. Previous reviews evaluating malnutrition in hospitalized patients revealed a wide variety of patients with malnutrition, depending on the clinical characteristics of the investigated population. Malnutrition tends to be more frequent in cancer patients than in those with neurological diseases [1,2]. Indeed, advanced age, immobilization, and low income can increase the risk of malnutrition [2]. Also, the discrepancy observed in the prevalence of malnutrition between the revised studies may also be related to the diversity in GLIM criteria application. Inflammation was the most frequently criteria observed and the lack of its evaluation as well as the method adopted for it will influence on the malnutrition prevalence like as the assessment of reduced MM. Moreover, the evaluation of all criteria or not results in different prevalence of malnutrition: among the studies that evaluated all criteria (n=50) the prevalence of malnutrition was higher than 50% in half of them, while it was higher than 50% only on eight studies that incompletely applied the GLIM criteria (n= 45). A narrative review of six studies on malnutrition diagnosed by the GLIM criteria in patients with gastrointestinal

cancer also demonstrated a wide prevalence range (11.9 to 75.7%), but the authors did not discuss it [123].

This scoping review has some strengths: it followed the JBI methodology [18] and did not limit the literature search by language or date of publication, thereby avoiding language and time biases, respectively. Indeed, the protocol was previously registered on the OSF and was reported according to the PRISMA-ScR checklist [20]. On the other hand, we need to point out that we included only studies published in journals indexed in four databases; therefore, the review may not have covered all the literature on the GLIM criteria used in hospital settings. In addition, we did not have access to five studies. Regardless of these limitations, this scoping review provides a relevant and wide map of the evidence related to GLIM criteria application in studies in hospital settings, and it complements the previous scoping review in this field [17]. The reasons for this are as follows: 1) the previous review included 53 studies involving hospitalized patients, and we complemented it by including 43 additional studies involving this population. 2) the previous review described the frequency of studies evaluating the concurrent and predictive validity of the GLIM criteria, while we investigated how many studies aimed to evaluate the criterion validity of the GLIM approach (this is important since the sample size should be defined based on the primary aim of the study); 3) we checked how many studies followed the validation guidance to evaluate the predictive and concurrent validity; 4) we described the frequency of each GLIM criterion reported in the primary studies and detailed the methods applied for their evaluation.

The major findings of our scoping review are: a) Only a few studies followed the two-step approach; b) Almost 50% of the studies used the five GLIM criteria for malnutrition diagnosis; c) An unclear or insufficient description of the methods applied to evaluate each criterion was frequently seen; d) Less than one-third of the studies aimed to validate the GLIM criteria for malnutrition diagnosis; e) Most studies were published after the guidance on validation of the GLIM criteria, and from minority that referenced it (n=8), only one-quarter filled all the recommendations of the guidance on validation of the GLIM criteria. Therefore, this map of evidence suggests that several challenges need to be addressed in future studies before the GLIM approach can be adopted in clinical practice as a validated method for malnutrition diagnosis. We can highlight the following: 1) Evaluate the complementarity of different nutritional screening tools to GLIM criteria for following the two-step approach. We understand that it should focus on specificity and predictive negative value as accuracy metric and on the predictive validity of the combination or not of nutritional risk and malnutrition; 2)

Test the criterion validity of different combinations of phenotypic and etiological criteria of GLIM approach; 3) Investigate the accuracy of different methods for assessing reduced muscle mass and inflammation and define universal cut-off points for them; 4) Design the study for GLIM criteria validation, calculating the sample size based on the primary outcome, planning to evaluate meaningful clinical outcomes to test the predictive validity and using a semi-gold standard method to test the concurrent validity. It means, follow the guidance on GLIM criteria validation [16]. Indeed, living systematic reviews could be appropriate in this field until the evidence related to the GLIM approach can be consolidated [125]. In addition, the results of studies that appropriately applied the GLIM criteria should be pooled in future systematic reviews in order to determine the real concurrent and predictive validity of the approach. Supplementary Box 2 summarizes our review suggestions for future studies.

CONCLUSIONS

This scoping review provides a map of 96 studies involving hospitalized patients, which applied the GLIM criteria for malnutrition diagnosis, and the results reveal that these criteria have been applied in a heterogeneous manner, and the recommendations of the guidance on GLIM validation have seldom been adhered to. Almost 50% of the studies applied all the criteria, while one-third followed the straightforward two-step approach. These aspects partially justify the wide range of the malnutrition prevalence that was identified (0.96 to 87.9%). Indeed, in addition to the limited reporting of methods applied for evaluating each GLIM criterion, the gaps to be explored in future studies were highlighted.

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Conflict of interest

The authors declare no conflicts of interest.

Authorship

FMS contributed to the conception of the study. DSJM, ELR, ISK, JL, SB, and FMS contributed to the acquisition of data. FMS, DSJM, JL, SB, and ELR contributed to the interpretation of data. FMS and ELR constructed the figures. FMS, ELR and DSJM drafted the manuscript. All authors critically revised the manuscript, provided their final approval, and agreed to be accountable for all aspects of the work ensuring its integrity and accuracy. DSJM and ELR should be both considered as first author due to their equal contribution for this manuscript.

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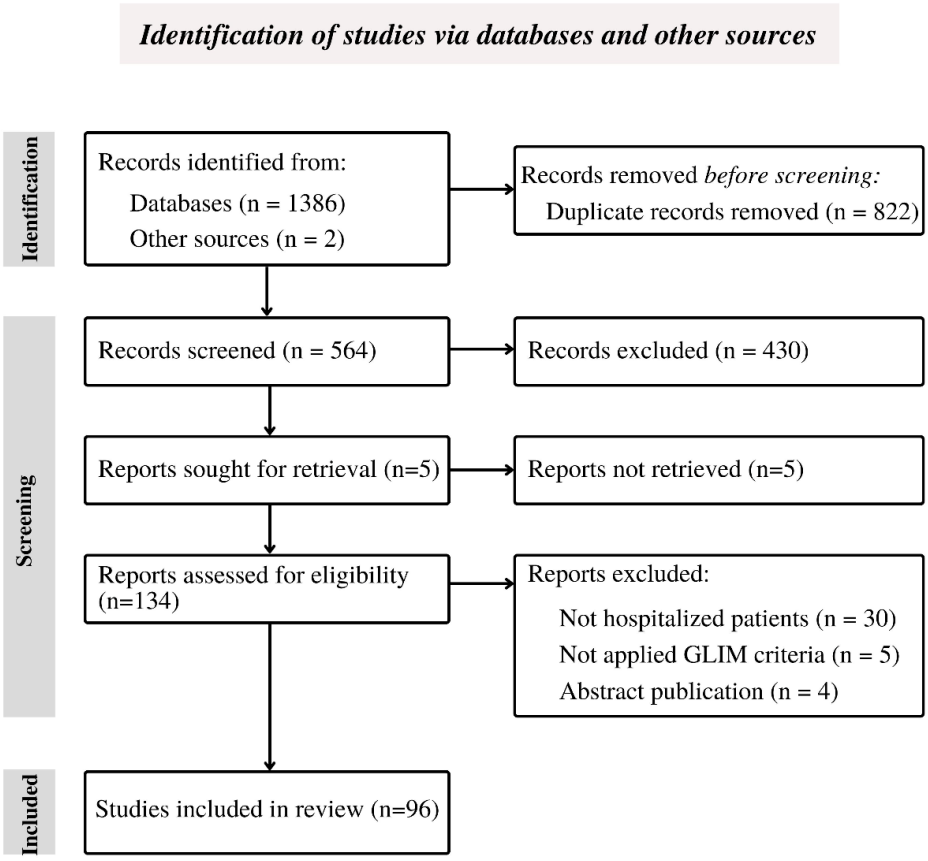
Figure 1. Flow chart of studies selection for the current scoping review

Figure 2. General features of studies on GLIM criteria application in hospitalized patients. Abbreviations: IF = impact factor.

Figure 3. A. Phenotypic and etiological criteria evaluated on studies applying GLIM criteria in hospitalized patients. B. Mean relative frequency (minimum and maximum) of each phenotypic and etiological criterion among studies applying GLIM criteria in hospital settings.

Figure 4. Frequency of studies evaluating each phenotypic and etiological criterion of GLIM and the methods adopted by them.

Figure 5. Prevalence of malnutrition among studies with complete and incomplete diagnosis according to GLIM criteria.



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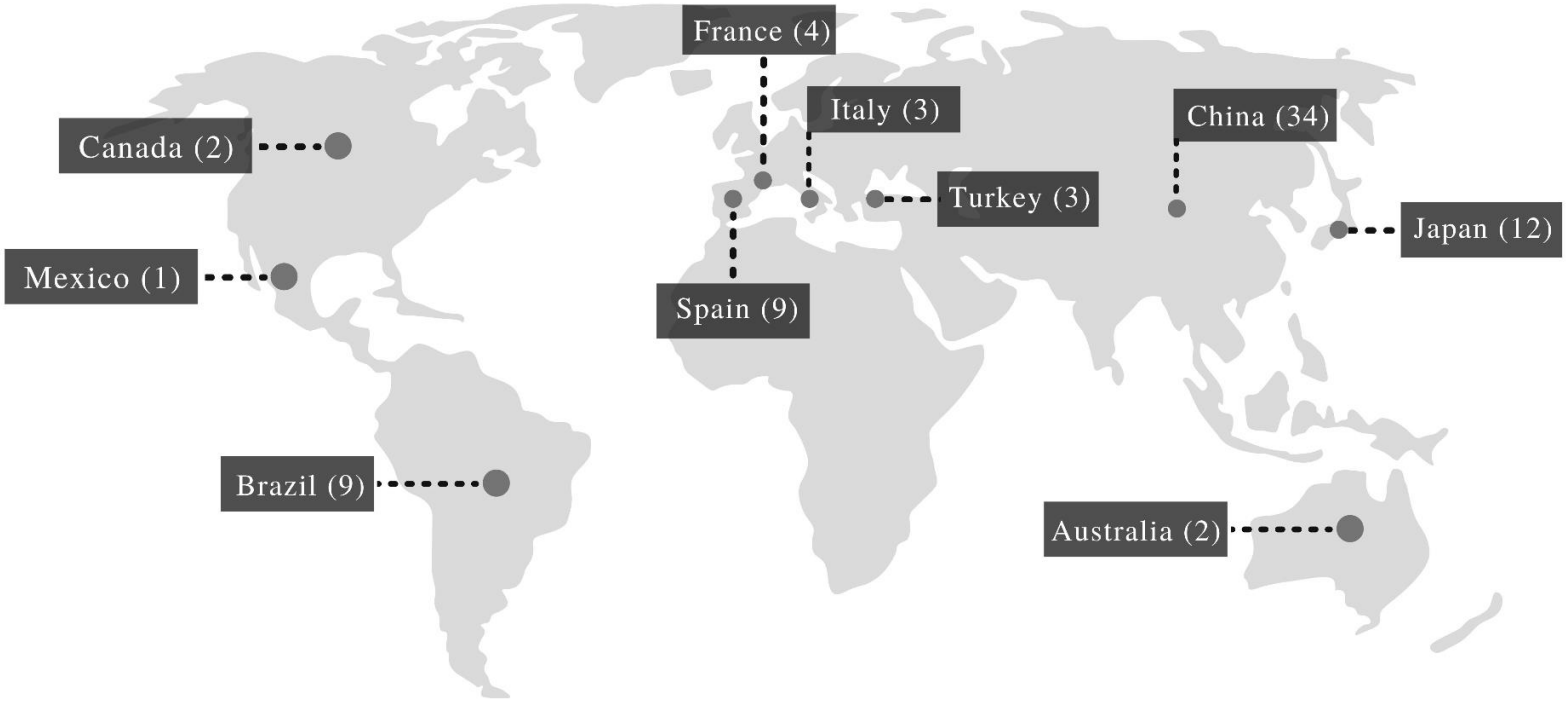

Year	Journal	Language	Design	Patients	Data collection
2019 (3.1%)	IF < 1.5 (16.4%)	English (96%)	Cohort prospective (30.5 %)	Cancer (30.2 %)	Reported period (94.8 %)
2020 (21.9%)	IF 1.5 – 3.0 (13%)	Chinese (3%)	Cohort retrospective (15.8%)	General (19.8 %)	Reported assessor (47.9%)
2021 (54.2 %)	IF 3.0 – 4.5 (39.1%)	Spanish (1 %)	Cross-sectional (25.3 %)	Elderly (18.8 %)	Reported moment (53.1%)
2022 (20.8 %)	IF > 4.5 (31.5%)		Secondary analysis (28.4 %)	COVID-19 (10.4%)	

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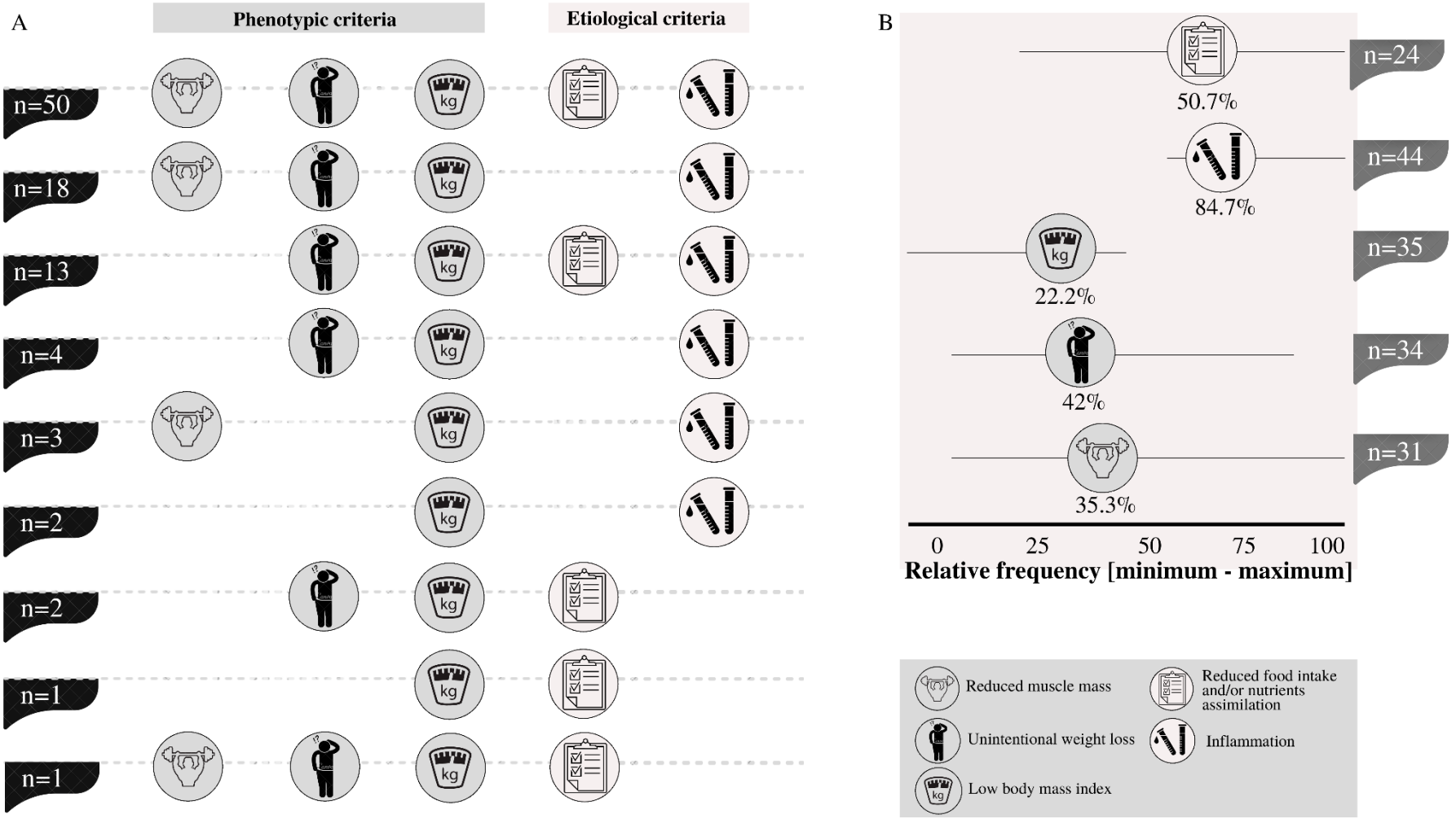

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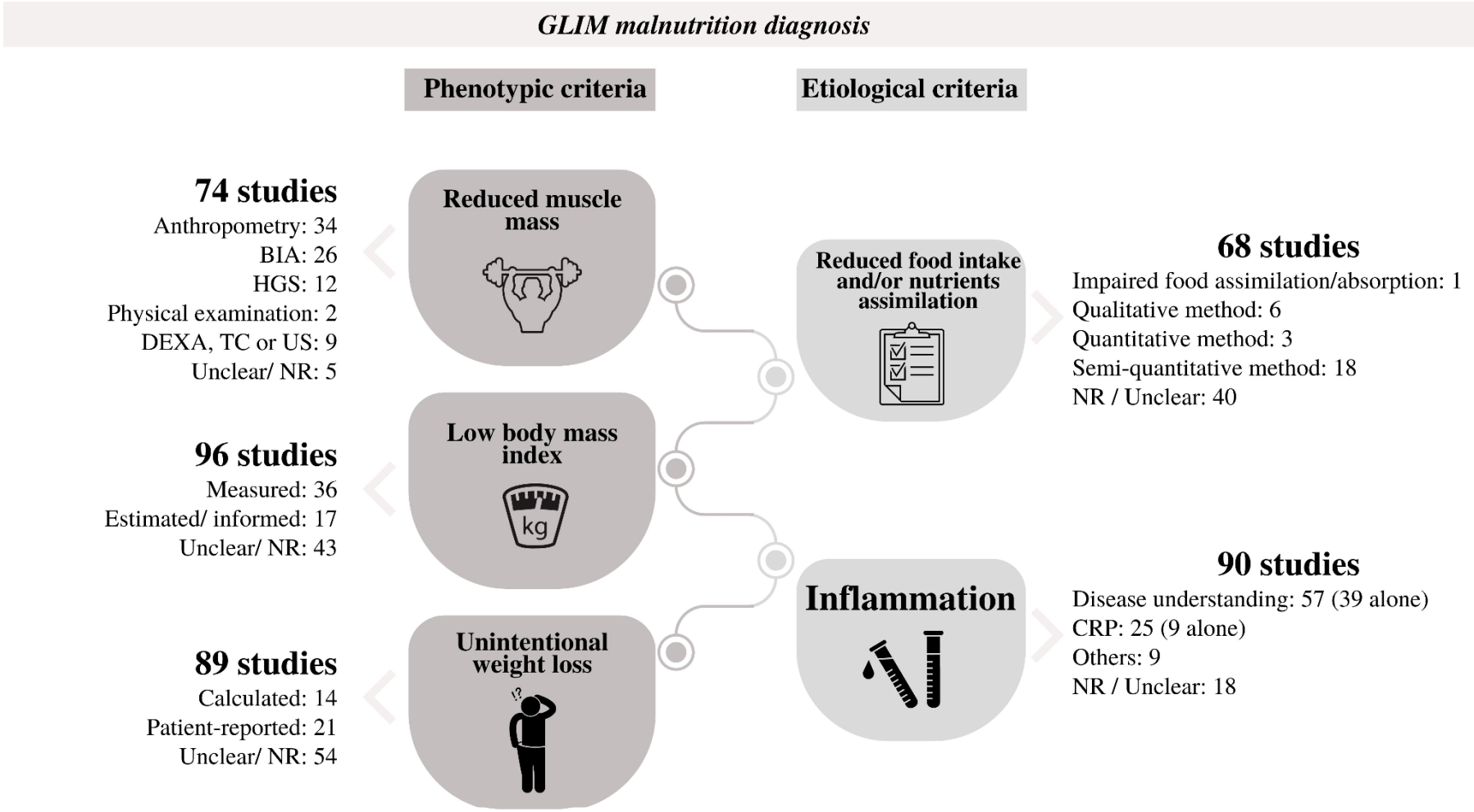

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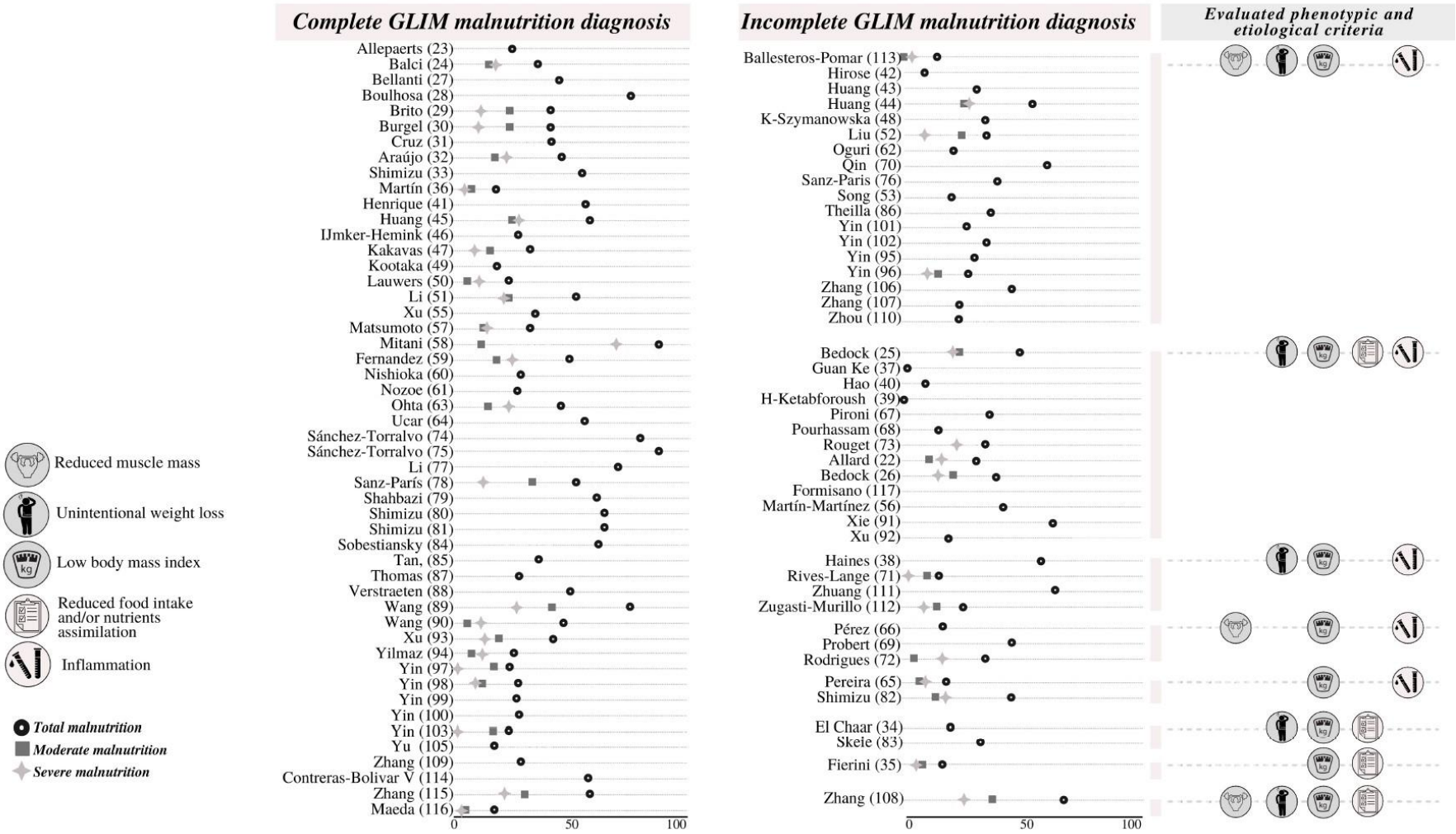

Figure 5. Prevalence of malnutrition among studies with complete and incomplete diagnosis according to GLIM criteria

Box 1. Summary of data extraction

Publication information: date, journal title, language, and impact factor.
Study aims: whether validation of the GLIM criteria was or not a primary objective [16].
Study design: secondary analysis or not; as prospective or retrospective; cohort or cross-sectional design, and unicentric or multicentric study.
Data collection details: period, assessors, moment.
Patients features: number of patients, age, gender, clinical condition.
Malnutrition diagnosis: evaluation of nutrition risk (performed or not and, if applicable, which tool was applied), details on each GLIM phenotypic and etiological criterion evaluation and definition (number of criteria and method to measure each criterion and cut-off point defined for its classification), application of another methods for malnutrition diagnosis, prevalence of malnutrition and frequency of each GLIM phenotypic and etiological criterion. We assessed if the phenotypic criteria low muscle mass was evaluated as recommended by GLIM Steering Committee [20].
Outcomes: definition and classification of them as potential meaningful health for hospital setting or not [16].
Statistical analyses: descriptive statistics (prevalence of malnutrition and frequency of each criterion of GLIM); agreement, sensitivity, and specificity for comparison of GLIM criteria and other tools for malnutrition diagnosis (to confirm if they could provide data of concurrent validity of GLIM approach); multivariate analyses (to confirm if they could provide data of predictive validity of GLIM approach); sample size calculation.
Study Results: malnutrition prevalence by GLIM criteria, frequency of each phenotypic and etiological criteria, and malnutrition severity.
Adherence to guidance on GLIM validation: inclusion of this guidance on the reference list, adherence to its recommendations, considering the particularities pointed for retrospective (evaluation of at least one phenotypic and one etiological criteria) and prospective studies [a) evaluation of all phenotypic and etiological criteria; b) inclusion of more than one marker of muscle mass loss; c) description in detail how etiological criteria were defined], the analyses performed to test the concurrent validity, the outcomes evaluated and analyses conducted to test the predictive validity [16].

Table 1. A detailed explanation on GLIM criteria for malnutrition diagnosis application in studies involving hospitalized patients.

First Author, year (ref)	*GLIM malnutrition diagnosis*							
			Phenotypic criteria			Etiological criteria		
	Steps	**Completeness of diagnose**	**Low BMI**	**WL**	**Low MM**	**Reduced FI**	**Nutrients assimilation**	**Inflammation**
Allard, 2020 (22)	2º (in all patients)	Incomplete	√	√	Ø	√	Ø	√
Allepaerts, 2020 (23)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Balci, 2021 (24)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Bedock, 2021 (25)	2º (in all patients)	Incomplete	√	√	Ø	√	√	√
Bedock, 2020 (26)	2º (in all patients)	Incomplete	√	√	Ø	√	Ø	√
Bellanti, 2020 (27)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Boulhosa, 2020 (28)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Brito, 2021 (29)	2º (in all patients)	Complete	√	√	√	√	√	√
Burgel, 2021 (30)	2º (in all patients)	Complete	√	√	√	√	√	√
Cruz, 2022 (31)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Araújo, 2022 (32)	2º (in all patients)	Complete	√	√	√	√	√	√
Shimizu, 2022 (33)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
El Chaar, 2022 (34)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	√	Ø
Fierini, 2020 (35)	1º and 2º (in those at risk)	Incomplete	√	Ø	Ø	√	Ø	Ø
Martín, 2020 (36)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Guan Ke, 2020 (37)	1º and 2º (in those at risk)	Incomplete	√	√	Ø	√	√	√
Haines, 2021 (38)	2º (in all patients)	Incomplete	√	√	Ø	Ø	Ø	√
H-Ketabforoush, 2021 (39)	2º (in all patients)	Incomplete	√	√	Ø	√	√	√
Hao, 2019 (40)	1º and 2º (in those at risk)	Incomplete	√	√	Ø	√	√	√

Henrique, 2020 (41)	2º (in all patients)	Complete	√	√	√	√	√	√
Hirose, 2021 (42)	2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Huang, 2021 (43)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Huang, 2021 (44)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Huang, 2022 (45)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
IJmker-Hemink, 2022 (46)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Kakavas, 2020 (47)	2º (in all patients)	Complete	√	√	√	√	Ø	√
K-Szymanowska, 2022 (48)	1º and 2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Kootaka, 2021 (49)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Lauwers, 2021 (50)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Li, 2021(51)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Liu, 2021 (52)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Song, 2022 (53)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
López-Valverde, 2021 (54)	2º (in all patients)	Unclear	?	?	?	?	?	?
Xu, 2020 (55)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Martín-Martínez, 2021 (56)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	Ø	√
Matsumoto, 2020 (57)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Mitani, 2021 (58)	2º (in all patients)	Complete	√	√	√	√	√	√
Fernandez, 2021 (59)	1º and 2º (in all patients and in those at risk)	Complete	√	√	√	√	√	√
Nishioka, 2021 (60)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Nozoe, 2021 (61)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Oguri, 2022 (62)	1º and 2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√

Ohta, 2022 (63)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Ucar, 2021 (64)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Pereira, 2021 (65)	2º (in all patients)	Incomplete	√	Ø	Ø	Ø	Ø	√
Pérez, 2021 (66)	1º and 2º (in all patients)	Incomplete	√	Ø	√	Ø	Ø	√
Pironi, 2021 (67)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	√	√
Pourhassam, 2020 (68)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	√	√
Probert, 2020 (69)	2º (in all patients)	Incomplete	√	Ø	√	Ø	Ø	√
Qin, 2021 (70)	2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Rives-Lange, 2021 (71)	2º (in all patients)	Incomplete	√	√	Ø	Ø	Ø	√
Rodrigues, 2021 (72)	2º (in all patients)	Incomplete	√	Ø	√	Ø	Ø	√
Rouget, 2021 (73)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	√	√
Sánchez-Torralvo, 2022 (74)	2º (in all patients)	Complete	√	√	√	√	√	√
Sánchez-Torralvo, 2021 (75)	2º (in all patients)	Complete	√	√	√	√	√	√
Sanz-Paris, 2021 (76)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Li, 2022 (77)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Sanz-París, 2020 (78)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Shahbazi, 2021 (79)	2º (in all patients)	Complete	√	√	√	√	√	√
Shimizu, 2020 (80)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Shimizu, 2019 (81)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Shimizu, 2021 (82)	2º (in all patients)	Incomplete	√	Ø	Ø	Ø	Ø	√
Skeie, 2020 (83)	2º (in all patients)	Incomplete	√	√	Ø	Ø	√	Ø
Sobestiansky, 2021 (84)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√

Tan, 2022 (85)	1º and 2º (in all and in those at risk)	Complete	√	√	√	√	√	√
Theilla, 2021 (86)	1º and 2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Thomas, 2022 (87)	2º (in all patients)	Complete	√	√	√	√	√	√
Verstraeten, 2021 (88)	2º (in all patients)	Complete	√	√	√	√	√	√
Wang, 2021 (89)	1º and 2º (in all and in those at risk)	Complete	√	√	√	√	√	√
Wang, 2021 (90)	1º and 2º (in all and in those at risk)	Complete	√	√	√	√	√	√
Xie, 2022 (91)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	Ø	√
Xu, 2020 (92)	1º and 2º (in those at risk)	Incomplete	√	√	Ø	√	Ø	√
Xu, 2022 (93)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Yilmaz, 2020 (94)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Yin, 2021 (95)	1º and 2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Yin, 2022 (96)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Yin, 2021 (97)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Yin, 2021 (98)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Yin, 2021 (99)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Yin, 2022 (100)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Yin, 2021 (101)	1º and 2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Yin, 2022 (102)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Yin, 2021 (103)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Yoshida, 2022 (104)	Unclear	Unclear	√	√	?	?	?	?
Yu, 2021 (105)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Zhang, 2021 (106)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√

Zhang, 2021 (107)	2º (in all patients)	Incomplete	√	√	√	Ø	Ø	√
Zhang, 2021 (108)	1º and 2º (in those at risk)	Incomplete	√	√	√	√	Ø	Ø
Zhang, 2021 (109)	1º and 2º (in all patients)	Complete	√	√	√	√	Ø	√
Zhou, 2021 (110)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Zhuang, 2020 (111)	1º and 2º (in all patients)	Incomplete	√	√	Ø	Ø	Ø	√
Zugasti-Murillo, 2021 (112)	1º and 2º (in those at risk)	Incomplete	√	√	Ø	Ø	Ø	√
Ballesteros-Pomar, 2021 (113)	1º and 2º (in those at risk)	Incomplete	√	√	√	Ø	Ø	√
Contreras-Bolivar, 2019 (114)	1º and 2º (in all patients)	Complete	√	√	√	√	√	√
Zhang, 2021 (115)	1º and 2º (in those at risk)	Complete	√	√	√	√	√	√
Maeda, 2020 (116)	1º and 2º (in all and in those at risk)	Complete	√	√	√	√	√	√
Formisano, 2021 (117)	1º and 2º (in all patients)	Incomplete	√	√	Ø	√	Ø	√

Abbreviations: BMI = body mass index; EI = energy intake; MM = muscle mass; WL = weight loss. Legend: √ = criteria evaluated. Ø = criteria not evaluated. ? = Unclear.

Table 2. Prevalence of malnutrition and each phenotypic and etiological criterion in hospitalized patients reported by studies on GLIM criteria.

First Author, year (ref)	Phenotypic criteria			Etiological criteria		Malnutrition prevalence	Severity malnutrition prevalence
	Low BMI	WL	Low MM	Reduced EI	Inflammation		
Allard, 2020 (22)	13.3%	32,8%	NA	35.3%	74.4%	33.3%	13.5% moderate /19.8% severe
Allepaerts, 2020 (23)	NR	NR	NR	NR	NR	26.6 %	NR
Balci, 2021 (24)	11.7%	32%	22.6%	47.6%	69.1%	35.93%	17.7% moderate / 18.2% severe
Bedock, 2021 (25)	NR	NR	NA	NR	NR	52.3%	27.3% moderate / 25% severe
Bedock, 2020 (26)	17.5%	57%	NA	NR	NR	42.1%,	23.7% moderate/ 18.4% severe
Bellanti, 2020 (27)	17.8%	31.6%	27.6%	70.4%	63.1%	46%	NR
Boulhosa, 2020 (28)	NR	NR	NR	NR	NR	75.6%	NR
Brito, 2021 (29)	30.1%	57.0%	31.6%	29.7%	83.4%	41.7%	26.3% moderate/ 15.3% severe
Burgel, 2021 (30)	NR	57.0%	CC: 25.3% APMT: 12.9%	NR	NR	41.7%	26.3% moderate/ 15.3% severe
Cruz, 2022 (31)	23.8%	50.8%	44.8%	NR	NR	42.4%	NR
Araújo, 2022 (32)	NR	NR	NR	NR	NR	47.4%	20.8% moderate/ 26.6% severe
Shimizu, 2022 (33)	NR	NR	NA	NR	NR	55.3%	NA
El Chaar, 2022 (34)	NR	NA	NA	NR	NR	23.0%	NA
Fierini, 2020 (35)	NR	NR	NR	NR	NR	23.0%	9.9% moderate/ 8.9% severe
Martín, 2020 (36)	7.6%	NR	NA	NR	NR	18.9%	6.7% moderate/ 8.7% severe
Guan Ke, 2020 (37)	NR	NR	NA	NR	NA	15.5%	NA
Haines, 2021 (38)	NR	NR	NA	NR	NR	1.7%	NA
H-Ketabforoush, 2021 (39)	0.9%	NR	NA	NR	NR	63.0%	NA
Hao, 2019 (40)	22.9%	44.7%	NR	NR	NR	0.96%	NA
Henrique, 2020 (41)	NR	NR	NR	NA	100%	10.7% to 41.3%	NA
Hirose, 2021 (42)	NR	NR	NR	NA	100%	42.4%	NA
Huang, 2021 (43)	14.1%	17.9%	24.6%	NA	100%	11.9%	NA
Huang, 2021 (44)	56.1%	23.3%	45.2%	71.2%	100%	34.5%	28.7% moderate/ 30.1% severe
Huang, 2022 (45)	NR	NR	NR	NR	NR	58.9%	NA

IJmker-Hemink, 2022 (46)	NR	NR	NR	NR	NR	27.9%	NR
Kakavas, 2020 (47)	16.5%	56.0%	NR	54.0%	NR	33.0%	17.4% moderate/ 13.6% severe
K-Szymanowska, 2022 (48)	NR	NR	23.4%	NA	100%	38.7%	NR
Kootaka, 2021 (49)	NR	NR	NR	NR	NR	18.9%	NR
Lauwers, 2021 (50)	3.0%	14%	11.0%	32.0%	100%	24.0%	8.0% moderate/ 15.0% severe
Li, 2021(51)	NR	NR	47.1%	NR	100%	52.9%	25.9% moderate / 27.0% severe
Liu, 2021 (52)	13.3%	27.8%	11.9%	NA	100%	38.9%	27.0 moderate 11.9% severe
Song, 2022 (53)	12.1%	17.4%	10.1%	NA	100%	23.6%	NA
López-Valverde, 2021 (54)	NR	NR	NR	NR	NR	71.4%	NA
Xu, 2020 (55)	NR	NR	NR	NR	NR	35%	NA
Martín-Martínez, 2021 (56)	NR	NR	NA	NR	NR	45.5%	NA
Matsumoto, 2020 (57)	42.0%	18%	51.0%	21.0%	37.0%	33.0%	15.0% moderate / 18.0% severe
Mitani, 2021 (58)	NR	NR	NR	NR	58.2%	87.6%	14.7% moderate / 72.9% severe
Fernandez, 2021 (59)	38.1%	61.9%	51.6%	94.1%	74.6%	50.3%	21.2% moderate/29.1% severe
Nishioka, 2021 (60)	25.5%	28.8%	39.3%	27.8%	5.8%	29%	NA
Nozoe, 2021 (61)	NR	NR	NR	NR	NR	28.7%	NA
Oguri, 2022 (62)	25.2%	8.9%	MAC: 31.3% ASMI: 24.5%	NA	100%	24.2%	NA
Ohta, 2022 (63)	6.7%	36.6%	NR	NR	48%	46%	18.0% moderate / 28.0% severe
Ucar, 2021 (64)	6.8%	47.5%	MAC: 7.6 CC: 35.6% SMI: 12.4% RF CSA: 42% RF MT: 36.2% HGS: 75%	54.2%	83.9%	GLIM-MAC: 47.5% GLIM-CC: 55.9% GLIM-SMI: 46.7% GLIM- RF MT: 57.6% GLIM-RF CSA: 59.3% GLIM-HGS: 75%	NA
Pereira, 2021 (65)	NR	NA	NA	NA	NR	21.1%	10.0% moderate / 11.1% severe

Pérez, 2021 (66)	37%	NA	38%	NA	NR	18.75%	NA
Pironi, 2021 (67)	NR	52%	NA	38.8%	78%	CRP>0.5mg/dL: 49.7% CRP>5mg/dL: 29.8%	NA
Pourhassam, 2020 (68)	NR	NR	NA	NR	NR	17%	NA
Probert, 2020 (69)	26%	NA	39.5	NA	100%	48%	NA
Qin, 2021 (70)	NR	NR	NR	NA	NR	65%	NA
Rives-Lange, 2021 (71)	NR	NR	NA	NA	NR	18% (at admission)	13% moderate/ 5% severe
Rodrigues, 2021 (72)	NR	NA	NR	NR	NR	GLIM BMI+INF: 28.3% GLIM AMC+INF: 15% GLIM CC + INF: 68.3%	GLIM BMI + INF 8.3% moderate / 20% severe
Rouget, 2021 (73)	NR	NR	NA	46.2%	NR	37.5%	26.3% severe
Sánchez-Torralvo, 2022 (74)	20.6%	NR	37.9%	NR	NR	80%	NA
Sánchez-Torralvo, 2021 (75)	20.2%	70.9%	59.6%	NR	95.7%	87.9%	NA
Sanz-Paris, 2021 (76)	17.0%	30.7%	31.7%	NA	100%	43.8%	NA
Li, 2022 (77)	NR	NR	NR	NR	NR	70.3%	NA
Sanz-París, 2020 (78)	14.6%	54.6%	50%	57.9%	23.4%	52.9%	35.8% moderate/ 16.4% severe
Shahbazi, 2021 (79)	6.4%	44%	24.8%	80.7%	100%	61.5%	NA
Shimizu, 2020 (80)	49.6%	63.3%	47.8%	50.1%	28.6%	64.7%	NA
Shimizu, 2019 (81)	NR	NR	NR	NR	NR	64.8%	NA
Shimizu, 2021 (82)	46.8%	NR	NR	NR	100%	48.8%	17.2 moderate/ 20.9% severe
Skeie, 2020 (83)	NR	27.3%	-	100%	-	35.4%	NA
Sobestiansky, 2021 (84)	NR	NR	CC: 20.4% FFMI: 46.4%	NR	NR	GLIM -FFMI: 64% GLIM CC: 60%	NA
Tan, 2022 (85)	NR	NR	NR	NR	NR	35.9%	NR for all patients
Theilla, 2021 (86)	NR	NR	NR	-	100%	40.5%	NA
Thomas, 2022 (87)	NR	NR	NR	NR	NR	28.6%	NA
Verstraeten, 2021 (88)	NR	NR	NR	NR	NR	51.0%	NA
Wang, 2021 (89)	NR	NR	NR	NR	NR	75.7%	45% moderate/ 30.7% severe
Wang, 2021 (90)	NR	NR	NR	NR	NR	GLIM-NRS-2002: 24.5% GLIM-MNA-SF: 23.3%	GLIM-NRS-2002: 8.6% moderate/ 15.8% severe

							GLIM-MNA-SF: 8.6% moderate/ 14.6% severe
Xie, 2022 (91)	NR	NR	NR	NR	NR	67.1%	NA
Xu, 2020 (92)	NR	NR	-	NR	NR	21.4%	NA
Xu, 2022 (93)	NR	NR	NR	NR	NR	38.3%	21.7% moderate/ 16.6% severe
Yilmaz, 2020 (94)	NR	NR	NR	NR	NR	25.8%	10% moderate/ 15.8% severe
Yin, 2021 (95)	NR	NR	NR	NR	100%	33.3%	NA
Yin, 2022 (96)	NR	NR	NR	-	100%	30.2%	16.7% moderate/ 13.6% severe
Yin, 2021 (97)	NR	NR	NR	NR	NR	24%	19.5% moderate/ 4.4% severe
Yin, 2021 (98)	NR	NR	NR	38.3%	NR	28%	14.7% moderate/ 13.3% severe
Yin, 2021 (99)	NR	NR	NR	38.3%	100%	GLIM-CC: 28% GLIM-CC+HGS: 26.5%	NR
Yin, 2022 (100)	NR	NR	NR	38.3%	NR	28.1%	NR
Yin, 2021 (101)	NR	NR	NR	38.1%	100%	30.4%	NR
Yin, 2022 (102)	20.2%	34.3%	30.1%	35.2%	100%	38.3%	NA
Yin, 2021 (103)	NR	NR	NR	38%	NR	24%	20% moderate/ 4% severe
Yoshida, 2022 (104)	NR	NR	NR	NR	NR	NR	NR
Yu, 2021 (105)	NR	NR	NR	NR	NR	17.9%	NR
Zhang, 2021 (106)	NR	NR	NR	NR	NR	49.1%	NA
Zhang, 2021 (107)	NR	NR	NR	NR	100%	27.6%	NA
Zhang, 2021 (108)	NR	NR	NR	NR	-	70.3%	41.3% moderate/ 29.1% severe
Zhang, 2021 (109)	NR	NR	NR	NR	NR	28.3%	NA
Zhou, 2021 (110)	NR	NR	NR	NA	100%	GLIM-SMI: 27.3% GLIM-HGS: 26.8%	NA
Zhuang, 2020 (111)	11.4%	68.1%	NA	NA	73.3%	69.0%	NA
Zugasti-Murillo, 2021 (112)	NR	NR	NA	NA	100%	29.7%	17.2% moderate/ 12.5% severe
Ballesteros-Pomar, 2021 (113)	25.5%	67.9	CC: 64.2% HGS: 74.5% ASM/H^2: 100%	NA	100%	27.5%	11.5% moderate/ 16% severe
Contreras-Bolivar, 2019 (114)	20.6%	NR	AMC: 9.1% MAC: 14.8%	NR	95.4%	MAC: 72.2% AMC: 71.8% FFMI: 77.6% HGS: 8.0%	NA

			HGS: 37.9% FFMI: 42.2%				
Zhang, 2021 (115)	31%	39%	31.2%	NR	100%	59%	Moderate: 33.5% Severe: 25.4%
Maeda, 2020 (116)	48.1%	15.6%	42%	48.3%	50.8%	18%	Moderate: 9% Severe: 9%
Formisano, 2021 (117)	Non-ICU: 21.2% ICU: NR	Non-ICU: 95.7% ICU: 100%	NA	Non-ICU: 62.8% ICU: 100%	Non-ICU: 100% ICU: 100%	NR	NA

Abbreviations: APMT = adductor pollicis muscle; ASM/H² = skeletal muscle mass/height²; ASMI: appendicular skeletal muscle mass index; BMI = body mass index; CC = calf circumference; CRP = C reactive protein; EI = energy intake; FFMI = fat free mass index; HGS = handgrip strength; INF = inflammation; MAC = muscle arm circumference; MAN-SF = Mini Nutritional Assessment - Short Form; MM = muscle mass; NR = not reported; NA = not applicable (criterion not evaluated); NRS-2002 = nutritional risk screening 2002; RF-CSA = rectus femoris cross-sectional area; RF-MT = rectus femoris muscle thickness; SMI = skeletal muscle index; WL = weight loss

Table 3. Adherence to the guidance on validation of GLIM criteria for malnutrition diagnosis among studies involving hospitalized patients.

First Author, year (ref)	Validation Aim	Data collection	Guidance validation	Nº of criteria	Etiological criteria	MM measures	Agreement	Concurrent validity		Predictive validity	
								Semi-gold standard	Statistic test	Outcome	Statistic test
Allard, 2020 (22)	√	Retrospective	Before	√	NA	NA	Ø	√	√	Ø	Ø
Allepaerts, 2020 (23)	√	Retrospective	Before	√	√	*X*	Ø	Ø	Ø	√	√
Balci, 2021 (24)	√	Retrospective	Before	√	NA	NA	√	√	√	√	√
Bedock, 2021 (25)	X	Prospective	After / Not cited	*X*	*X*	*X*	Ø	Ø	Ø	Ø	Ø
Bedock, 2020 (26)	√	Prospective	Before	*X*	*X*	Ø	Ø	Ø	Ø	√	√
Bellanti, 2020 (27)	√	Prospective	Before	√	*X*	√	Ø	Ø	Ø	Ø	√
Boulhosa, 2020 (28)	X	Prospective	Before	√	*X*	*X*	*X*	Ø	Ø	Ø	Ø
Brito, 2021 (29)	√	Prospective	After/ Cited	√	√	√	√	√	√	√	√
Burgel, 2021 (30)	X	Prospective	Before	√	√	√	Ø	√	√	Ø	Ø
Cruz, 2022 (31)	√	Prospective	After / Not cited	√	*X*	*X*	Ø	Ø	Ø	√	√
Araújo, 2022 (32)	√	Prospective	After / Cited	√	√	*X*	√	√	√	√	√
Shimizu, 2022 (33)	X	Prospective	After / Not cited	√	*X*	*X*	Ø	Ø	Ø	Ø	Ø
El Chaar, 2022 (34)	√	Prospective	After / Not cited	*X*	*X*	*X*	*X*	*X*	√	Ø	Ø
Fierini, 2020 (35)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	Ø	Ø

Martín, 2020 (36)	√	Prospective	Before	*X*	√	*X*	Ø	Ø	Ø	√	√
Guan Ke, 2020 (37)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	Ø	Ø
Haines, 2021 (38)	√	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
H-Ketabforoush, 2021 (39)	*X*	Prospective	After / Not cited	*X*	*X*	Ø	Ø	Ø	Ø	√	Ø
Hao, 2019 (40)	*X*	Prospective	Before	*X*	*X*	Ø	Ø	Ø	Ø	Ø	Ø
Henrique, 2020 (41)	√	Prospective	Before	√	√	√	Ø	√	√	√	Ø
Hirose, 2021 (42)	√	Retrospective	After / Not cited	√	NA	NA	*X*	*X*	Ø	√	√
Huang, 2021 (43)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Huang, 2021 (44)	√	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Huang, 2022 (45)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	Ø	Ø
IJmker-Hemink, 2022 (46)	√	Retrospective	After / Not cited	√	NA	NA	√	√	√	√	√
Kakavas, 2020 (47)	√	Prospective	After / Not cited	√	*X*	*X*	Ø	Ø	Ø	√	√
K-Szymanowska, 2022 (48)	*X*	Prospective	After / Not cited	*X*	Ø	X	Ø	Ø	Ø	Ø	Ø
Kootaka, 2021 (49)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Lauwers, 2021 (50)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Li, 2021(51)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√

Liu, 2021 (52)	*X*	Retrospective	After / Not cited	√	NA	NA	√	√	√	√	√
Song, 2022 (53)	*X*	Retrospective	After / Not cited	√	Ø	NA	Ø	Ø	Ø	√	√
López-Valverde, 2021 (54)	*X*	Prospective	After / Not cited	?	X	?	Ø	Ø	Ø	√	√
Xu, 2020 (55)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Martín-Martínez, 2021 (56)	*X*	Prospective	After / Not cited	*X*	X	Ø	Ø	Ø	Ø	√	Ø
Matsumoto, 2020 (57)	*X*	Prospective	Before	√	X	X	Ø	*X*	√	Ø	Ø
Mitani, 2021 (58)	*X*	Retrospective	After / Not cited	√	NA	NA	√	√	√	√	Ø
Fernandez, 2021 (59)	√	Prospective	After	√	√	√	√	√	√	√	√
Nishioka, 2021 (60)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	Ø	√
Nozoe, 2021 (61)	*X*	Prospective	After / Not cited	√	√	X	Ø	Ø	Ø	Ø	√
Oguri, 2022 (62)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Ohta, 2022 (63)	*X*	Prospective	After / Not cited	√	X	√	Ø	Ø	Ø	Ø	Ø
Ucar, 2021 (64)	*X*	Prospective	After / Not cited	√	X	√	√	Ø	Ø	Ø	Ø
Pereira, 2021 (65)	*X*	?	Before	?	?	?					
Pérez, 2021 (66)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	Ø	Ø
Pironi, 2021 (67)	*X*	Prospective	Before	*X*	√	Ø	Ø	Ø	Ø	Ø	Ø
Pourhassam, 2020 (68)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	Ø	Ø

Probert, 2020 (69)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Qin, 2021 (70)	*X*	Prospective	After / Not cited	*X*	Ø	X	√	Ø	Ø	Ø	Ø
Rives-Lange, 2021 (71)	*X*	Prospective	After / Not cited	*X*	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Rodrigues, 2021 (72)	*X*	Prospective	After / Not cited	*X*	Ø	√	Ø	Ø	Ø	√	Ø
Rouget, 2021 (73)	*X*	Prospective	Before	*X*	X	Ø	Ø	Ø	Ø	Ø	Ø
Sánchez-Torralvo, 2022 (74)	*X*	?	After / Not cited	√	?	?	Ø	Ø	Ø	Ø	Ø
Sánchez-Torralvo, 2021 (75)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Sanz-Paris, 2021 (76)	*X*	Prospective	After / Not cited	*X*	Ø	X	Ø	Ø	Ø	Ø	Ø
Li, 2022 (77)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	Ø	Ø
Sanz-París, 2020 (78)	√	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Shahbazi, 2021 (79)	√	Prospective	After / Not cited	√	*X*	√	√	*X*	√	√	√
Shimizu, 2020 (80)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	Ø	√
Shimizu, 2019 (81)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	Ø	√
Shimizu, 2021 (82)	√	Retrospective	Before	√	NA	Ø	Ø	Ø	Ø	√	√
Skeie, 2020 (83)	*X*	Retrospective	Before	√	NA	Ø	Ø	Ø	Ø	√	√
Sobestiansky, 2021 (84)	*X*	Retrospective	After /Cited	√	NA	NA	Ø	Ø	Ø	√	√
Tan, 2022 (85)	√	Prospective	After /Cited	√	*X*	Ø	√	*X*	√	√	Ø

Theilla, 2021 (86)	√	Retrospective	After / Not cited	√	NA	NA	Ø	√	√	Ø	Ø
Thomas, 2022 (87)	*X*	Retrospective	After / Cited	√	NA	NA	√	√	√	Ø	Ø
Verstraeten, 2021 (88)	*X*	Retrospective	After / Not cited	√	NA	Ø	Ø	Ø	Ø	√	√
Wang, 2021 (89)	*X*	Prospective	After / Not cited	√	Ø	Ø	√	*X*	Ø	√	√
Wang, 2021 (90)	*X*	Retrospective	After / Not cited	√	NA	NA	√	Ø	Ø	Ø	Ø
Xie, 2022 (91)	*X*	Retrospective	After / Not cited	*X*	NA	Ø	Ø	Ø	Ø	Ø	√
Xu, 2020 (92)	√	?	Before	*?*	*?*	?	Ø	Ø	Ø	√	√
Xu, 2022 (93)	√	Retrospective	After / Not cited	√	NA	Ø	√	√	√	√	√
Yilmaz, 2020 (94)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Yin, 2021 (95)	*X*	Retrospective	After / Not cited	√	NA	NA	√	Ø	√	√	√
Yin, 2022 (96)	*X*	Retrospective	After / Cited	√	NA	NA	Ø	Ø	Ø	√	√
Yin, 2021 (97)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Yin, 2021 (98)	*X*	Retrospective	After / Cited	√	NA	NA	Ø	Ø	Ø	√	√
Yin, 2021 (99)	*X*	Retrospective	After / Cited	√	NA	NA	√	Ø	Ø	√	√
Yin, 2022 (100)	*X*	Retrospective	After / Not cited	√	NA	NA	√	Ø	Ø	Ø	√
Yin, 2021 (101)	*X*	Retrospective	After / Not cited	√	NA	NA	√	Ø	Ø	Ø	√
Yin, 2022 (102)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Yin, 2021 (103)	√	Prospective	Before	√	*X*	*X*	Ø	Ø	Ø	Ø	Ø

Yoshida, 2022 (104)	*X*	Prospective	After / Not cited	?	*X*	*X*	Ø	Ø	Ø	Ø	Ø
Yu, 2021 (105)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Zhang, 2021 (106)	√	Retrospective	After / Not cited	√	NA	NA	√	√	√	√	√
Zhang, 2021 (107)	*X*	Retrospective	After / Not cited	√	NA	NA	Ø	Ø	Ø	√	√
Zhang, 2021 (108)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Zhang, 2021 (109)	*X*	Retrospective	Before	√	NA	NA	√	*X*	√	Ø	√
Zhou, 2021 (110)	*X*	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	Ø	Ø
Zhuang, 2020 (111)	*X*	Prospective	Before	*X*	√	Ø	Ø	Ø	Ø	Ø	Ø
Zugasti-Murillo, 2021 (112)	*X*	Prospective	After / Not cited	*X*	√	Ø	√	*X*	√	√	√
Ballesteros-Pomar, 2021 (113)	*X*	Prospective	After / Not cited	*X*	*X*	√	Ø	Ø	Ø	√	√
Contreras-Bolivar, 2019 (114)	√	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Zhang, 2021 (115)	√	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	√
Maeda, 2020 (116)	Ø	Retrospective	Before	√	NA	NA	Ø	Ø	Ø	√	Ø
Formisano, 2021 (117)	Ø	?	Before	?	?	Ø	Ø	Ø	Ø	Ø	Ø

Abbreviations: MM = muscle mass; NA = not applicable (criterion not evaluated)

Legend: *X* = not fulfilled the criterion; √ = fulfilled the criterion; Ø = not assessed the criterion; - = criterion not required; ? = Unclear.

A scoping review on the GLIM criteria for malnutrition diagnosis: understanding how and for which purpose it has been applied in studies on hospital settings

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Supplementary Material

Supplementary Box 1: Literature Search Strategy applied in all database

Supplementary Table 1: References and reasons for exclusion of articles during the full-text reading phase of eligibility confirmation

Supplementary Table 2: General features of studies using GLIM criteria for malnutrition diagnosis of hospitalised patients

Supplementary Table 3: Definition of phenotypic and etiological criteria among studies using the GLIM criteria for malnutrition diagnosis of hospitalised patients

Supplementary Figure 1: GLIM framework for malnutrition diagnosis

Supplementary Figure 2: Outcomes evaluated by studies on GLIM criteria application in hospitalised patients.

Supplementary *Box 1: Literature search strategy applied in all database (04/16/2022)*

PubMed (via National Library of Medicine)   "GLIM"[Title/Abstract] OR "GLIM criteria"[Title/Abstract] OR "GLIM"[Title/Abstract] OR "GLIM criteria"[Title/Abstract] OR "global leadership initiative on malnutrition"[Title/Abstract] OR "global leadership initiative on malnutrition"[Title/Abstract] OR "Scored-GLIM"[Title/Abstract] Filters: from 2018/8/1 - 2022/4/16
Embase (via Elsevier)   ('global leadership initiative on malnutrition':ab,ti OR glim:ab,ti OR 'glim criteria':ab,ti OR 'scored-glim':ab,ti) AND [01-08-2018]/sd NOT [16-04-2022]/sd
Web of Science   ((AB=(GLIM)) OR AB=("Scored-GLIM")) OR AB=("Global Leadership Initiative on Malnutrition") OR AB=("GLIM criteria") and Timespan: 2018-08-01 to 2022-04-16 (Publication Date)
Scopus   (TITLE-ABS-KEY (glim) OR TITLE-ABS-KEY ("GLIM criteria") OR TITLE-ABS-KEY ("Scored-GLIM") OR TITLE-ABS-KEY ("Global Leadership Initiative on Malnutrition")) AND PUBYEAR > 2017

Supplementary table 1. References and reasons for exclusion of articles during the full-text reading phase of eligibility confirmation (n = 44)

Reference	Reason for exclusion
1. Abdel-Lah O. Incidence and Grade of Malnutrition on Patients with Gastric Cancer. Clinical Nutrition. 2019	Abstract publication.
2. Abdel-Lah O. Descriptive Study of Nutritional Status in Patients with Esophageal Cancer. According to the New GLIM Criteria. Clinical Nutrition. 2019	Abstract publication.
3. Akazawa N. Using GLIM criteria, cutoff value for low BMI in Asian populations discriminates high or low muscle mass: A cross-sectional study. Nutrition. 2021 Mar;81:110928.	Did not assess GLIM criteria.
4. Almeida MFL. Use of glim as a nutritional assessment tool and the caloric adequation of critical patients in enteral nutritional therapy in a public hospital of Macaé, Rio De Janeiro, Brazil. Clinical Nutrition. 2020	Abstract publication.
5. Avesani CM. A Comparative Analysis of Nutritional Assessment Using Global Leadership Initiative on Malnutrition Versus Subjective Global Assessment and Malnutrition Inflammation Score in Maintenance Hemodialysis Patients. Journal of Renal Nutrition. 2021 Jul 27;S1051-2276(21)00172-2	Did not assess hospitalized patients.
6. Azman M. Mid-Upper Arm Circumference vs. Quadriceps Muscle Layer Thickness as a Surrogate Measure of Fat Free Mass Index for GLIM Criteria Assessment among Head and Neck Cancer Patients. International Journal of Gerontology 15 (2021) 266271	Did not assess hospitalized patients.
7. Boslooper-Meulenbelt K. Malnutrition according to GLIM criteria in stable renal transplant recipients: Reduced muscle mass as predominant phenotypic criterion. Clinical Nutrition. 2021 May 40(5):3522-3530.	Did not assess hospitalized patients.
8. Casas Deza D. Mini Nutritional Assessment - Short Form Is a Useful Malnutrition Screening Tool in Patients with Liver Cirrhosis, Using the Global Leadership Initiative for Malnutrition Criteria as the Gold Standard. Nutrition in Clinical Practice. 2021 Oct 36(5):1003-1010. doi:10.1002/ncp.10640	Did not assess hospitalized patients.

9.Cereda E, Pedrazzoli P, Lobascio F, et al. The prognostic impact of BIA-derived fat-free mass index in patients with cancer. Clinical Nutrition. 2021 Jun 40(6):3901-3907. doi:10.1016/j.clnu.2021.04.024	Did not assess GLIM criteria.
10. Chen X. Preliminary investigation on the prevalence of nutritional risk and malnutrition in cancer patients using NRS 2002 and malnutrition diagnosis (GLIM) criteria in a tertiary (A) teaching hospital in Chongqing. Chinese Journal of Clinical Nutrition. 2020	Full text not available to authors
11.Chien SC. Associations of obesity and malnutrition with cardiac remodeling and cardiovascular outcomes in Asian adults: A cohort study. PLoS Medicine. 2021 Jun;18(6):e1003661. 2021 Jun 1.	Did not assess hospitalized patients.
12. Cohen-Cesla T. Usual nutritional scores have acceptable sensitivity and specificity for diagnosing malnutrition compared to GLIM criteria in hemodialysis patients. Nutrition Research. 2021 Aug;92:129-138.	Did not assess hospitalized patients.
13. Ehrsson YT. Mapping Health-Related Quality of Life, Anxiety, and Depression in Patients with Head and Neck Cancer Diagnosed with Malnutrition Defined by GLIM. Nutrients. 2021 Apr;13(4):1167.	Did not assess hospitalized patients.
14. Einarsson S. Mapping the frequency of malnutrition in patients with head and neck cancer using the GLIM Criteria for the Diagnosis of Malnutrition. Clinical Nutrition ESPEN. 2020 Jun;37:100-106.	Did not assess hospitalized patients.
15. Elgeidie A. Protein Energy Malnutrition After One-Anastomosis Gastric Bypass with a Biliopancreatic Limb ≤200 cm: A Case Series. Journal of Laparoendoscopic & Advanced Surgical Techniques. 2020 Dec;30(12):1320-1328.	Did not assess GLIM criteria.
16. Eyre S. Using Bioimpedance Spectroscopy for Diagnosis of Malnutrition in Chronic Kidney Disease Stage 5-Is It Useful?. Journal of Renal Nutrition. 2022 Mar;32(2):170-177.	Did not assess hospitalized patients.
17. Fiorindi C. GLIM Criteria for Malnutrition in Surgical IBD Patients: A Pilot Study. Nutrients. 2020 Jul 25;12(8):2222	Did not assess hospitalized patients.
18. Gobbi M. Nutritional status in post SARS-Cov2 rehabilitation patients. Clinical Nutrition. 2021 Apr 20;S0261-5614(21)00205-3	Did not assess hospitalized patients.

19. Henriksen C. Agreement between GLIM and PG-SGA for diagnosis of malnutrition depends on the screening tool used in GLIM. Clinical Nutrition. 2022 Feb;41(2):329-336	Did not assess hospitalized patients.
20. Hettiarachchi J, Reijnierse EM, Soh CH, et al. Malnutrition is associated with poor trajectories of activities of daily living in geriatric rehabilitation inpatients: RESORT. Mechanisms of Ageing and Development. 2021 Jul;197:111500.	Did not assess hospitalized patients.
21. Jiang, Z. Three steps of Global Leadership (nutritional field) Initiative on Malnutrition (GLIM) and fill the diseases name (Chinese version ICD-10 listed) "nutritional risk " and "malnutrition " on front page of discharge medical record for letting big-data to find it to design the DRG contents for China. Chinese Journal of Clinical Nutrition	Full-text was not found.
22. Kaluźniak-Szymanowska A. Malnutrition, Sarcopenia, and Malnutrition-Sarcopenia Syndrome in Older Adults with COPD. Nutrients. 2021 Dec 23;14(1):44	Did not assess hospitalized patients.
23. Karavetian M. Malnutrition-Inflammation Score VS Phase Angle in the Era of GLIM Criteria: A Cross-Sectional Study among Hemodialysis Patients in UAE. Nutrients. 2019 Nov 14;11(11):2771.	Did not assess hospitalized patients.
24. Kaźmierczak-Siedlecka K. Influence of malnutrition stage according to GLIM 2019 criteria and SGA on the quality of life of patients with advanced cancer. Influencia del grado de desnutrición según los criterios GLIM 2019 y el método SGA sobre la calidad de vida de los pacientes con cáncer avanzado. Nutricion hospitalaria.2020 Dec 16;37(6):1179-1185.	Did not assess hospitalized patients.
25. Li, Y. A cross-sectional survey of malnutrition prevalence as per GLIM criteria in patients with gastrointestinal malignancies at different stages. Chinese Journal of Clinical Nutrition	Full-text was not found.
26. Liu H. Application of the GLIM criteria in patients with intestinal insufficiency and intestinal failure at nutritional risk on admission. European Journal of Clinical Nutrition. 2022 Jan 24.	Did not assess hospitalized patients.
27. López-Gómez JJ. Malnutrition at diagnosis in amyotrophic lateral sclerosis (als) and its influence on survival: Using glim criteria. Clinical Nutrition. 2021 Jan;40(1):237-244.	Did not assess hospitalized patients.

28. Mueller TC. Measurement of body mass by bioelectrical impedance analysis and computed tomography in cancer patients with malnutrition - a cross-sectional observational study. Medicine (Baltimore). 2020 Dec 11;99(50):e23642	Did not assess hospitalized patients.
29. Nishio K, Arai Y, Abe Y, et al. Relation between number of teeth, malnutrition, and 3-year mortality in elderly individuals ≥85 years. Oral Diseases. 2021 Sep 14.	Did not assess hospitalized patients.
30. Olsen MN, Tangvik RJ, Halse AK. Evaluation of Nutritional Status and Methods to Identify Nutritional Risk in Rheumatoid Arthritis and Spondyloarthritis. Nutrients. 2020 Nov 21;12(11):3571	Did not assess hospitalized patients.
31. Petermann-Rocha F. Frailty, sarcopenia, cachexia and malnutrition as comorbid conditions and their associations with mortality: a prospective study from UK Biobank. Public Health (Oxf). 2021 Jan 11;fdaa226.	Did not assess hospitalized patients.
32. Polončič P, Novak P, Puzić Ravnjak N, Majdič N. The associations between nutritional and functional status during recovery from Guillain-Barré syndrome: a retrospective study. International Journal of Rehabilitation Research. 2021 Mar 1;44(1):57-64.	Did not assess GLIM criteria.
33. Pourhassan M. Inflammation as a diagnostic criterion in the GLIM definition of malnutrition-what CRP-threshold relates to reduced food intake in older patients with acute disease?. European Journal of Clinical Nutrition. 2022 Mar;76(3):397-400	Did not assess GLIM criteria.
34. Rosato E. Assessing Malnutrition in Systemic Sclerosis With Global Leadership Initiative on Malnutrition and European Society of Clinical Nutrition and Metabolism Criteria. Journal of Parenteral and Enteral Nutrition. 2021 Mar;45(3):618-624	Did not assess hospitalized patients.
35.Sanchez-Rodriguez D. Prediction of 5-year mortality risk by malnutrition according to the GLIM format using seven pragmatic approaches to define the criterion of loss of muscle mass. Clinical Nutrition. 2021 Apr;40(4):2188-2199	Did not assess hospitalized patients.
36. Sanchez-Rodriguez D. Mortality in malnourished older adults diagnosed by ESPEN and GLIM criteria in the SarcoPhAge study. Journal of Cachexia, Sarcopenia and Muscle. 2020 Oct;11(5):1200-1211	Did not assess hospitalized patients.

37. Sobrini P. MNA-SF as a screening tool for malnutrition diagnosed with the glim criteria in older persons with cancer. European Geriatric Medicine. 2021 Jun;12(3):653-656	Did not assess hospitalized patients.
38. Steer B. Malnutrition Prevalence according to the GLIM Criteria in Head and Neck Cancer Patients Undergoing Cancer Treatment. Nutrients. 2020 Nov 13;12(11):3493.	Did not assess exclusively hospitalized patients.
39. Wojteczek A. Prevalence of malnutrition in systemic sclerosis patients assessed by different diagnostic tools. Clinical Rheumatology. 2020 Jan;39(1):227-232	Did not assess hospitalized patients.
40.Xie, H. Investigation on nutritional risk and malnutrition prevalence of elderly patients with pressure ulcer using NRS 2002 and GLIN criteria a tertiary (A) hospital in Ningbo. Chinese Journal of Clinical Nutrition	Full text not available to authors.
41. Zhang, X. Nutritional risk screening and GLIM steps 2 and 3 for the diagnosis of malnutrition and severity of malnutrition(Consensus 2020). Chinese Journal of Clinical Nutrition	Full-text was not found.
42. Borda MG. Muscle Volume and Intramuscular Fat of the Tongue Evaluated With MRI Predict Malnutrition in People Living With Dementia: A 5-Year Follow-up Study. J Gerontol A Biol Sci Med Sci. 2022 Feb 3;77(2):228-234.	Did not assess hospitalized patients.
43. Korwel KW. Prevalence of malnutrition, risk of malnutrition and quality of life among patients with Inflammatory Bowel Disease. Journal of Crohn's and Colitis	Abstract publication.
44. Osuna-Padilla IA. Phase angle as predictor of malnutrition in people living with HIV/AIDS. Nutrition in Clinical Practice. 2022 Feb;37(1):146-152.	Did not assess hospitalized patients.

Supplementary Table 2. General features of studies using GLIM criteria for malnutrition diagnosis of hospitalised patients

First Author, year (ref)	Language	Study aims	Design Local	Sample	Data collection	Outcomes of interest	NST	Malnutrition diagnosis
Allard, 2020 (22)	English	Determine the sensitivity and specificity of GLIM criteria for diagnosing malnutrition and its severity compared to SGA	Multicentric secondary analysis of a prospective study Canada	784 general patients Gender NR Age NR	07/10 to 02/13 Assessor NR Moment NR	None	Canadian Nutrition Screening Tool	GLIM criteria SGA
Allepaerts, 2020 (23)	English	Associate malnutrition by GLIM criteria to clinical outcomes and describe the malnutrition prevalence by GLIM criteria	Unicentric Cross-sectional Belgium	79 geriatric patients 22.8% males 84.9 ± 5.3 years	09/15 to 10/16 Assessor NR After clinical stabilisation	Mortality after discharge, LOS, institutionalisation	MAN	GLIM criteria
Balci, 2021 (24)	English	Compare the malnutrition prevalence by GLIM criteria, SGA, and NRS-2002; explore the agreement between these tools, and their association with survival during 5-year	Unicentric Secondary analysis of a prospective study Turkey	231 general patients 43.7% males 62.2 ±18.2 years	12/13 to 03/14 Assessor NR First 48 h	Mortality after discharge	NRS-2002	GLIM criteria SGA
Bedock, 2021 (25)	English	Assess the effects of early nutritional management, compare the prevalence and severity of malnutrition before and 30 days after hospital discharge, and identify its predictive factors	Unicentric Prospective cohort France	91 COVID-19 patients 60.4% males 57.7±15.6 years	03/20 to 04/20 Assessor NR Moment NR	None	NR	GLIM criteria
Bedock, 2020 (26)	English	Assess the prevalence and severity of malnutrition, and its association with disease severity at admission, transfer to ICU, or death	Unicentric Prospective cohort France	114 COVID-19 patients 60.5% males 59.9 ±15.9 years	03/20 to 04/20 Assessor NR Moment NR	In-hospital mortality, transfer to ICU	NR	GLIM criteria

Bellanti, 2020 (27)	English	Compare sensibility and specificity of MUST, SGA, and NRS-2002 to GLIM criteria, and evaluate the association between nutritional status alteration and sarcopenia	Unicentric Cross-sectional Italy	152 elderly patients 57% males 78.2 ±7.6 years	03/19 to 02/20 Trained research First 24 h	Sarcopenia	MUST NRS-2002 SGA	GLIM criteria
Boulhosa, 2020 (28)	English	Assess malnutrition risk in liver disease patients using NRS2002 and RFH-NPT	Unicentric Cross-sectional Brazil	86 advanced chronic liver disease patients Gender NR Age NR	04/18 to 07/19 Assessor NR First 48 h	None	NRS-2002 RFH-NPT	GLIM criteria
Brito, 2021 (29)	English	Evaluate the concurrent and predictive validity of GLIM criteria for malnutrition diagnosis in hospitalized patients.	Unicentric Prospective cohort Brazil	601 general patients 51.3% males 55.7 ± 14.8 years	09/18 to 02/20 Trained researchers First 48h	LOS, ICU transfer in-hospital death, hospital readmission and death six months after discharge	NR	GLIM criteria SGA
Burgel, 2021 (30)	English	Compare the accuracy of AND-ASPEN, ESPEN, and GLIM criteria in diagnosing malnutrition	Unicentric Cross-sectional Brazil	600 general patients 51.3% males 55.7±14.8 years	09/18 to 07/19 Registered dietitian First 48 h	None	NR	GLIM criteria SGA ESPEN AND-ASPEN
Cruz, 2022 (31)	English	Identify clinical, sociodemographic, and nutritional predictors of hospital readmission within 30 days after discharge	Unicentric Prospective cohort Brazil	252 general patients 61.4% males 57±15.8 years	01/18 to 01/20 Assessor NR Moment NR	Hospital readmission	NRS-2002	GLIM criteria
Araújo, 2022 (32)	English	Evaluate the prevalence of malnutrition and assess the concurrent and predictive validity of emergent tools for diagnosing malnutrition	Unicentric Prospective cohort Brazil	241 AECOPD patients 46.5% males 68.3±10.2 years	03/19 to 03/20 Registered dietitian First 72 h	In-hospital mortality, LOS	NR	GLIM criteria SGA ESPEN AND-ASPEN

Shimizu, 2022 (33)	English	Investigate the association of food texture post-stroke with malnutrition and sarcopenia	Multicentric Cross-section study Japan	443 post-stroke rehabilitation patients 55.1% males 77.5±7.7 years	01/19 to 01/20 Assessor NR First 72 h	Sarcopenia	MNA-SF	GLIM criteria
El Chaar, 2022 (34)	English	Determine the concurrent validity and reliability of different combinations of three diagnostic tools in comparison to validated NST	Unicentric Cohort Prospective Lebanon	578 general patients 48.3% males 65.0±16.9 years	03/19 to10/19 Registered dietitian First 72h	None	MNA-SF NRS- 2002	GLIM criteria AND-ASPEN ESPEN
Fierini, 2020 (35)	English	Compare the malnutrition prevalence in three sites of an Academic Health Sciences and explore possible reasons for poor intake	Multicentric Cross-sectional Canadian	264 general patients 49.0% males 62.8±1.8 years	2011 Assessor NR Moment NR	None	Canadian Nutrition Screening Tool	GLIM criteria
Martín, 2020 (36)	English	Assess the GLIM criteria performance to identify risk for adverse clinical outcomes	Unicentric Cohort Prospective Mexico	1,015 general patients 45.6% males 51 years (37-69)	06/19 to 07/19 Registered dietitian Moment NR	Hospital mortality Unplanned transfer to critical care areas	NRS- 2002	GLIM criteria
Guan Ke, 2020 (37)	Chinese	Investigate nutritional risk and malnutrition among patients admitted to a tertiary hospital	Unicentric Cross-sectional China	5,802 general patients 54.8% males 58.3±13.3 years	11/16 to 12/17 Registered dietitian Moment NR	None	NRS- 2002	GLIM criteria
Haines, 2021 (38)	English	Assess the effects of malnutrition at admission on outcomes	Multicentric Cohort Retrospective USA	31,029 gastrointestinal surgery patients 46.5% males 61.3±16.1 years	2011 to 2016 Assessor NR Moment NR	Hospital mortality, LOS, major complications	NR	GLIM criteria
H-Ketabforoush, 2021 (39)	English	Assess protein and energy intake and investigate their association with in hospital mortality	Unicentric Cohort Prospective Iran	126 critically ill patients with COVID 39% males 60.2±13.7 years	08/20 to 03/21 Assessor NR At admission	Hospital mortality	NR	GLIM criteria

Hao, 2019 (40)	Chinese	Investigate the nutritional risk and prevalence of malnutrition and their implications for nutritional intervention	Unicentric Cross – sectional China	1,036 neurological disease patients 74.4% males 56.8±12.7 years	01/18 to 01/19 Registered dietitian Moment NR	None	NRS -2002	GLIM criteria
Henrique, 2020 (41)	English	Evaluate the applicability and validity of the GLIM compared to SGA and provide the best malnutrition-related variables to predict complications.	Unicentric Cohort Prospective Brazil	206 surgical patients 46.6% males 58.5 (IQR: 46-66) years	07/18 to 11/19 Trained research First 24h	Postoperative complications	NR	GLIM criteria SGA
Hirose, 2021 (42)	English	Determine the prevalence and prognostic implication of malnutrition by GLIM criteria in comparison to GNRI	Multicentric Secondary analysis of a prospective Japan	890 cardiac diseases patients 58.5% males 80.5 (IQR: 72-87) years	11/16 to 03/18 Assessor NR Moment NR	Mortality after discharge	MUST	GLIM criteria GNRI
Huang, 2021 (43)	English	Investigate the prognostic value of GLIM and to explore whether the addition of muscle quality, strength and gait speed could improve its predictive value for postoperative complications and survival	Unicentric Secondary analysis of a prospective China	587 surgery cancer patients 73.6% males 65 (IQR 13) years	08/14 to 06/19 Assessor NR Moment NR	Hospital mortality, mortality after discharge, major complications, LOS, hospital readmission	NRS- 2002	GLIM criteria
Huang, 2021 (44)	English	Determine the correlations between GLIM-defined malnutrition and body composition and functional parameters and its predictive value for postoperative complications and long-term survival	Unicentric Secondary analysis of a prospective China	597 cancer patients 77.5% males 72 (IQR 8) years	08/14 to 06/19 Assessor NR Moment NR	Hospital mortality, mortality after discharge, major complications, disease-free survival	NRS -2002	GLIM criteria

Huang, 2022 (45)	English	Assess malnutrition incidence by GLIM criteria and to explore its phenotypic and etiological criteria.	Unicentric Cohort prospective China	73 GI diseases patients 71.2% males 37.8±13.5 years	06/16 to 10/19 Registered dietitian Moment NR	None	NRS- 2002	GLIM criteria
IJmker-Hemink, 2022 (46)	English	Assess the concurrent and predictive validity of GLIM criteria, and compare the association of malnutrition according to GLIM criteria and PG-SGA and outcomes	Unicentric Secondary analysis of a prospective Netherlands	574 general patients 48.4% males 59.6±16.3 years	07/15 to 05/16 Registered dietitian At admission	Hospital mortality, mortality after discharge	MUST	GLIM criteria PG-SGA
Kakavas, 2020 (47)	English	Evaluate the prognostic ability of GLIM criteria to predict PPCs and 90-day all-cause mortality rate.	Unicentric prospective cohort Greece	218 GI surgical cancer patients 41.3% males 70.1±13.1 years	10/18 to 12/19 Registered dietitian First 24h	PPCs and 90-day all-cause mortality rate	NR	GLIM criteria
K-Szymanowska, 2022 (48)	English	Evaluate the diagnostic performance of three screening tools used in the GLIM algorithm.	Unicentric Cross-sectional Poland	124 COPD patients 59.7% males 69.4±6.1years	09/19 to 11/20 Registered dietitian Moment NR	None	MNA-SF MUST NRS-2002	GLIM criteria
Kootaka, 2021 (49)	English	Compare the prognostic predictive value of GLIM and ESPEN criteria for malnutrition.	Unicentric Secondary analysis of a prospective study Japan	921 CVD patients 68.5% males 67.8±13.4 years	12/11 to 04/16 Assessor NR Before hospital discharge	Mortality after discharge, physical function	GNRI	GLIM criteria ESPEN
Lauwers, 2021 (50)	English	Assess the prevalence of malnutrition by GLIM in subjects admitted for a DFU and its association with DFU severity.	Unicentric Cohort prospective Belgium	110 DFU patients 80% males 68.0±12.0 years	07/16 to 09/19 Assessor NR First 48h	Mortality after discharge, major complications	NRS-2002	GLIM criteria MNA
Li, 2021(51)	English	Determine the optimal combination of different indicators of MM; investigate the GLIM value to predict survival.	Multicentric Secondary analysis of a prospective study China	877 Gastric cancer patients 70.4% males 59.2±11.8 years	10/12 to 07/19 Registered dietitian Moment NR	Mortality after discharge	NRS-2002	GLIM criteria
Liu, 2021 (52)	English	Assess the prevalence of malnutrition in patients	Multicentric	2388 cancer patients	07/14 to 09/14 Assessor NR	In hospital mortality, major	NRS-2002	GLIM criteria

		with cancer using GLIM, the association between GLIM and clinical outcomes, and compare GLIM to SGA.	Secondary analysis of a prospective study China	63.8% males Age NR	First 24h	complications, LOS and ICU stay, health costs		SGA
Song, 2022 (53)	English	Evaluate the application of GLIM and explore the effect of GLIM-defined malnutrition on both short-term and long-term postoperative clinical outcomes.	Unicentric Cohort retrospective China	918 colorretal cancer patients 60.5% males 66 (IQR 17) years	07/14 to 10/19 Assessor NR Moment NR	Mortality after discharge, major complications	NRS-2002	GLIM criteria
López-Valverde, 2021 (54)	English	Test the hypothesis that patients with malnutrition and impaired muscle function will have adverse outcomes.	Unicentric Cohort prospective Spain	77 patients with ischemic DFU 74% males 69.6 years (DP NR)	12/19 to 11/20 Assessor NR First 48h	Mortality after discharge, major complications, hospital readmission	None	GLIM criteria
Xu, 2020 (55)	English	Determine the optimal reference values of CC, investigate the prevalence of GLIM-defined malnutrition based on different NST and assess its relationship with outcomes	Multicentric Cross-sectional China	6519 elderly patients 60.8% males 78 ± 5.7 years	03/12 to 05/12 Assessor NR First 24 hours	In hospital death, LOS, major complications, health costs, neutrophil/lymphocyte ratio, infections	NRS-2002 MUST MAN-SF	GLIM criteria
Martín-Martínez, 2021 (56)	English	Assess the prevalence, risk factors, and clinical outcomes of oral dysphagia and malnutrition, and follow-up 3- and 6-month clinical outcomes.	Unicentric Cohort prospective Spain	205 COVID-19 non-critically patients 52.2% females 69.3±17.5 years	04/20 to 07/20 Registered dietitian First 24h	In hospital mortality, symptoms of disease, oral pharyngeal dysphagia	NRS-2002	GLIM criteria
Matsumoto, 2020 (57)	English	Evaluate the prevalence of malnutrition by GLIM, and the association between MNA-SF score,	Unicentric Cross-sectional Japan	490 general patients 45% females 69.5±16.0 years	06/19 to 07/19 Registered dietitian At admission	None	MNA-SF	GLIM criteria

		GS, and GLIM criteria and the type of hospitalization.						
Mitani, 2021 (58)	English	Compare GLIM, CONUT score, and SGA, and evaluate the usefulness of them for predicting clinical outcomes.	Unicentric Cohort prospective Japan	177 general patients 54.8% males 65.6 ± 12.9 years	01/16 to 12/18 Doctor After the nutritional intervention	In hospital mortality, hospital transfer for further chronic care	None	GLIM criteria SGA
Fernandez, 2021 (59)	English	Evaluate the applicability and validity of GLIM to identify malnutrition, and determine which screening tool and combination of criteria better capture the state of malnutrition.	Unicentric Secondary analysis of a prospective study Brazil	165 acutely ill older adults admitted to EW 60% males 73 (IQR: 65 - 102) years	09/19 to 03/20 First 24h	In hospital mortality, LOS	MST SNAQ MAN-SF	GLIM criteria MNA- FF
Nishioka, 2021 (60)	English	Evaluate the prevalence of malnutrition and sarcopenia and its possible associated factors.	Unicentric Secondary analysis of a retrospective study Japan	601 older hospitalized patients 40.9% males 80 (IQR: 72-86) years	11/18 to 10/20 Registered dietitian Moment NR	None	MUST	GLIM criteria
Nozoe, 2021 (61)	English	Assess the prevalence of malnutrition by GLIM and ESPEN criteria and its association with outcomes.	Unicentric Cross-sectional Japan	115 patients with acute stroke 66% males 72 (13) years	06/20 to 02/21 Nurse, other Before hospital discharge	ADL and home discharge	MNA-SF	GLIM criteria ESPEN
Oguri, 2022 (62)	English	Examine the combined prognostic value of malnutrition and renal function.	Unicentric Cohort retrospective Japan	314 heart failure older patients 54.1% males 82 (IQR: 73-86) years	08/19 to 10/20 Doctor, nurse Moment NR	90-day all-cause mortality	SGA	GLIM criteria
Ohta, 2022 (63)	English	Evaluate the association between poor oral functional and nutritional status.	Unicentric Cross-sectional Switzerland	60 older patients 36.7% males 82.5±7.0 years	10/19 to 07/20 Registered dietitian Moment NR	Oral function	NRS-2002 MNA-SF	GLIM criteria
Ucar, 2021 (64)	English	Identify cut-off values for low MM and assess the	Unicentric Cross-sectional	118 general patients	01/19 to 02/20 Doctor	None	NRS-2002 MNA-SF	GLIM criteria

		prevalence of malnutrition using different phenotypic criteria.	Turkey	44.1% males 64 (IQR: 18-93) years	First 48h			
Pereira, 2021 (65)	English	Associate malnutrition and hospital mortality.	Unicentric Cohort retrospective Brazil	90 general patients with PNT 61.1% males 63 (IQR: 46-74) years	Period NR Assessor NR Moment NR	In hospital mortality	None	GLIM criteria
Pérez, 2021 (66)	Spanish	Evaluate the prevalence of malnutrition at admission and its association with LOS and health costs.	Unicentric Cross-sectional Spain	203 general patients 47.3% males 62.4±20.3 years	06/18 to 12/18 Registered dietitian First 24h	LOS, health costs	NRS-2002	GLIM criteria
Pironi, 2021 (67)	English	Assess the prevalence of malnutrition and the provided nutritional therapy in patients with COVID-19.	Unicentric Cross-sectional Italy	268 COVID-19 critically and non-critically patients 54.9% males 74 (IQR: 63 -84) years	04/2020 Doctor, nurse Moment NR	None	NRS-2002	GLIM criteria
Pourhassam, 2020 (68)	English	Investigate the association between malnutrition and changes of thigh MM and muscle strength.	Unicentric Secondary analysis of a prospective study Germany	41 frail older patients 27% males 82.4±6.6 years	09/17 to 11/18 Assessors NR First 24h	Physical function, thigh MM, and muscle strength	MNA-SF	GLIM criteria
Probert, 2020 (69)	English	Investigate possible differences in morbidity, malnutrition, sarcopenia, and specific drug use in patients with hip fracture, ten years apart.	Unicentric Cohort prospective Sweden	154 patients with hip fracture 37.5% males 80.5±11.5 years	5 months in 2008 and 5 months in 2018 Assessor NR Moment NR	Mortality after discharge, physical function, sarcopenia, drug use	None	GLIM criteria
Qin, 2021 (70)	English	Determine the validity of GLIM criteria using PG-SGA as a comparator and explore the association between nutrition status and quality of life.	Unicentric Cross-sectional China	217 gastric cancer patients 57.1% males 60 (IQR: 50-67) years	01/19 to 05/19 Assessor NR Moment NR	Quality of life	None	GLIM criteria PG-SGA

Rives-Lange, 2021 (71)	English	Assess the nutritional status of severe COVID-19 patients at acute phase, 1 and 3 months after ICU discharge.	Unicentric Cohort prospective France	38 COVID-19 critically-ill patients 76% males 66 (IQR: 59-72) years	03/20 to 05/20 Registered dietitian Moment NR	None	None	GLIM criteria
Rodrigues, 2021 (72)	English	Evaluate the use of US to assess the quadriceps muscle, comparing to other nutritional tools, including GLIM, and the patients' clinical outcomes.	Unicentric Cohort prospective Brazil	60 critically ill patients 53.3% males 57.5±14.8 years	09/18 to 03/19 Registered dietitian First 48h at ICU	In hospital and ICU mortality, mortality after discharge, LOS and ICU stay, duration of MV	None	GLIM criteria SGA
Rouget, 2021 (73)	English	Evaluate the prevalence of malnutrition.	Unicentric Cohort prospective France	80 COVID-19 critically and non-critically patients 75% males 59.5 (IQR: 19-87) years	03/20 to 04/20 Doctor At admission	None	NRS-2002	GLIM criteria
Sánchez-Torralvo, 2022 (74)	English	Assess the relationship between malnutrition and the level of anxiety and depression.	Unicentric Cohort prospective Spain	282 cancer patients 55.7% males 60.4±12.6 years	Period NR Assessor NR First 24h	Anxiety and depression	None	GLIM criteria
Sánchez-Torralvo, 2021 (75)	English	Evaluate the clinical applicability of L3-CT-determined sarcopenia in malnourished patients and establish its association with 6-month mortality.	Unicentric Cohort prospective Spain	208 cancer patients 55.3% males 60.5 ±12.9 years	10/17 to 04/18 Assessor NR First 24h	Mortality after discharge	None	GLIM criteria
Sanz-Paris, 2021 (76)	English	Assess whether the muscle thickness and echogenicity were associated with dysphagia, malnutrition, sarcopenia, and functional capacity in acute hospital	Unicentric Cross-sectional Spain	101 patients with hip fracture 70.3% females 86±9 years	01/20 to 03/20 Assessor NR First 24h	None	MNA-SF	GLIM criteria

		admission for a hip fracture.						
Li, 2022 (77)	English	Explore the related factors to malnutrition and explore whether GLIM-positive patients who did not meet the NRS-2002 would benefit from nutritional treatment	Unicentric Cohort retrospective China	108 adults with Crohn's disease 69.4% males 31.0 (IQR: 19.0-38.3)	03/20 to 03/21 Registered dietitian First 48h	None	NRS-2002	GLIM criteria
Sanz-París, 2020 (78)	English	Determine whether GLIM nutrition status at admission is associated with long-term survival and identify which GLIM criteria are indicator of early or late death	Multicentric Cohort retrospective Spain	159 elderly patients with type 2 diabetes mellitus 47.8% males 78.1 years	05/07 to 05/08 Assessor NR First 24h -72h	Mortality after discharge	MAN-SF	GLIM criteria
Shahbazi, 2021 (79)	English	Investigate the nutritional status of critically ill patients and validate the GLIM criteria in comparison to SGA	Unicentric Cohort prospective Iran	109 COVID-19 critically ill patients 53% males 60.9±13.7 years	06/20 to 01/21 Assessor NR	Duration of ICU stay and in-ICU death	None	GLIM criteria SGA
Shimizu, 2020 (80)	English	Determine the prevalence and characteristics of malnutrition in older adults assessed by GLIM and ESPEN criteria	Unicentric Cross-sectional Japan	335 older patients 54% males 80 ± 7.5 years	04/18 to 11/18 Assessor NR Moment NR	None	MAN-SF	GLIM criteria ESPEN
Shimizu, 2019 (81)	English	Clarify the association between malnutrition and improvement of swallowing ability during rehabilitation of stroke	Unicentric Cohort retrospective Japan	188 older patients 63.3% males 78.9 ± 7.7 years	03/16 to 05/18 Assessor NR First 72 h	Swallowing ability	MAN-SF	GLIM criteria
Shimizu, 2021 (82)	English	Investigate the predictive validity of the previously reported BMI cut-off values of the GLIM criteria	Multicentric Cohort retrospective Japan	26,098 older patients with pneumonia 58.4% males Age NR	04/14 to 12/18 Assessor NR Moment NR	In hospital mortality, LOS, and hospital readmission	None	GLIM criteria

Skeie, 2020 (83)	English	Investigate the prevalence of malnutrition according to weight loss and BMI criteria in GLIM's second step and their association with severe postoperative complications	Multicentric Cohort retrospective Norway	6,110 patients undergoing gastrointestinal resections 53.9% males 68 years	05/15 to 05/18 Assessor NR Moment NR	Postoperative complications and death within 30 days following surgery	None	GLIM criteria
Sobestiansky, 2021 (84)	English	Investigate prevalence of malnutrition and sarcopenia and their association with mortality	Unicentric Cohort prospective Sweden	56 geriatric patients 68% males 84 ± 7.3 years	11/09 to 11/10 Assessor NR Moment NR	Mortality after discharge	MAN-SF	GLIM criteria
Tan, 2022 (85)	English	Validate GLIM and investigate its role in predicting short-term surgical outcomes	Unicentric Cohort prospective China	1,115 patients with digestive cancer 66.8% males 62.2±10.8 years	01/20 to 12/20 Trained researchers Moment NR	Major complications, LOS, 30-days death and readmission	NRS-2002 MUST MAN-SF	GLIM criteria SGA
Theilla, 2021 (86)	English	Compare and validate the GLIM malnutrition criteria, with SGA, Phase Angle, FFMI, and PANDORA	Unicentric Cohort retrospective Israel	84 critically ill patients 69% males 50 ± 20 years	11/17 to 06/18 Assessor NR First 24 hours	None	MUST	GLIM criteria SGA
Thomas, 2022 (87)	English	Determine the validity of the GLIM in identifying protein-energy malnutrition	Unicentric Cohort retrospective Australia	224 vascular surgical patients 70.1% males 67.3±14.4 years	10/14 to 08/16 Registered dietitian First 72 hours	None	None	GLIM criteria PG-SGA
Verstraeten, 2021 (88)	English	Assess the prevalence, the coexistence, and the association between malnutrition and sarcopenia	Unicentric Cohort prospective Australia	506 in geriatric rehabilitation patients 42% males 83.4 (IQR: 77.5-87.9) years	10/17 to 08/18 Nurse First 48 hours	LOS	None	GLIM criteria
Wang, 2021 (89)	English	Investigate the performance of GLIM criteria for malnutrition assessment	Unicentric Cohort prospective China	189 patients with oesophageal cancer 68.7% males 64.9 ± 6.7 years	08/18 to 08/19 Assessor NR Moment NR	Mortality after discharge, major complications, LOS, intraoperative	NRS-2002 MUST MAN-SF PNI GNRI	GLIM criteria

						parameters, and ICU readmission		
Wang, 2021 (90)	English	Explore suitable BMI cut-off values using the GLIM criteria and investigate the prevalence of malnutrition	Multicentric Secondary analysis of a prospective study China	8,725 elderly patients 60.5% males 74 (IQR: 68–79) years	2013 to 2015 Assessor NR Moment NR	None	NRS-2002 MAN-SF	GLIM criteria
Xie, 2022 (91)	English	Explore the associations of GLIM-defined malnutrition with muscle mass, muscle quality, and muscle strength	Unicentric Cross-sectional China	1,135 elderly patients 44% males 80 (IQR: 73-85) years	03/17 to 03/18 Registered dietitian After 48 hours	Muscle quantity, muscle quality, and muscle strength	MAN-SF	GLIM criteria
Xu, 2020 (92)	English	Validate the GLIM criteria, determine the number of NRS2002 positive patients who do not meet the GLIM, and examine whether these patients would benefit from nutritional support therapy	Multicentric Secondary analysis of a prospective study China	1,831 elderly patients Gender NR Age NR	Period NR Assessor NR Moment NR	Major, total, and infectious complications	NRS-2002	GLIM criteria
Xu, 2022 (93)	English	Validate the effectiveness of the GLIM criteria compared with PG-SGA and assess the impact of malnutrition on clinical outcomes	Unicentric Secondary analysis of a prospective study China	895 patients with gastric cancer 73.9% males 67 years	07/14 to 03/18 Assessor NR Moment NR	In hospital death, LOS, health costs, hospital readmission, postoperative complications	MUST	GLIM criteria PG-SGA
Yilmaz, 2020 (94)	English	Assess the association between malnutrition status and 1-year mortality	Unicentric Cohort retrospective Turkey	120 patients with hematologic malignancy 65.8% males 53.6 ±14.1 years	04/16 to 04/17 Registered dietitian Moment NR	One-year survival	NRS-2002	GLIM criteria
Yin, 2021 (95)	English	Evaluate whether malnutrition, as defined by	Unicentric	360 oesophageal cancer patients	12/12 to 11/19	In hospital death, LOS, major	NRS-2002	GLIM criteria

		PG-SGA, ESPEN consensus and GLIM, can be used to predict complications	Secondary analysis of a prospective study China	after esophagectomy 80.8% males 64 ±7.7 years	Registered dietitian First 24 h	complications, health costs, ICU stay, emergency treatment, discharge status, revision surgery		PG-SGA ESPEN
Yin, 2022 (96)	English	Evaluated whether fat mass assessment using the triceps skinfold thickness provides additional prognostic value to the GLIM framework	Multicentric Secondary analysis of a prospective study China	2,672 patients with lung cancer 66.3% males 59±9.8 years	11/12 to 12/18 Assessor NR Moment NR	Mortality after discharge, quality of life	NRS-2002	GLIM criteria
Yin, 2021 (97)	English	Assess the efficacy and clinical utility of the GLIM criteria in identifying survival-related malnutrition	Multicentric Secondary analysis of a prospective study China	1,219 patients with lung cancer 67.2% males 58.8 ± 9.9 years	07/13 to 10/18 Registered dietitian First 48 h	Mortality after discharge	NRS-2002	GLIM criteria
Yin, 2021 (98)	English	Establish a decision tool based on the GLIM criteria that can be conveniently referred upon patient admission to accelerate the diagnosis of malnutrition	Multicentric Secondary analysis of a prospective study China	3,998 patients with cancer 47.2% males 56.9 ±11.3 years	07/13 to 10/18 Registered dietitian First 48 h	Mortality after discharge, quality of life, physical function, LOS, health costs, and ICU stay	NRS-2002	GLIM criteria
Yin, 2021 (99)	English	Evaluate whether including the hand grip strength is helpful for diagnosing malnutrition	Multicentric Secondary analysis of a prospective study China	3,998 patients with cancer 47.2% males 56.9 ±11.3 years	07/13 to 10/18 Registered dietitian First 48 h	Mortality after discharge, LOS, health costs, and treatment in ICU	NRS-2002	GLIM criteria PG-SGA
Yin, 2022 (100)	English	Develop and utilize a tool to optimize the early identification of malnutrition	Multicentric Secondary analysis of a prospective study China	3,998 patients with cancer 47.2% males 56.9± 11.3 years	07/13 to 10/18 Registered dietitian First 48 h	None	NRS-2002	GLIM criteria PG-SGA
Yin, 2021 (101)	English	Establish a machine learning-based, individualized decision	Multicentric Secondary analysis of a prospective study	14,134 patients with cancer 52.8% males	11/11 to 04/19	None	NRS-2002	GLIM criteria PG-SGA

		system to identify and grade malnutrition	China	56.8± 11.8 years	Trained researchers Moment NR			
Yin, 2022 (102)	English	Derive the sex-specific FMI cut-offs and analyse the associations of a low FMI, handgrip weakness, and the GLIM-defined malnutrition with cancer survival.	Multicentric Cohort retrospective China	2,376 patients with cancer 54.8% males 59 (IQR: 51 -65) years	07/13 to 04/19 Trained researchers First 48 h	Mortality after discharge	NRS-2002	GLIM criteria PG-SGA
Yin, 2021 (103)	English	Establish and validate a rapid and simple-to-use decision pathway for diagnosing and grading malnutrition on the basis of the GLIM criteria.	Multicentric Cohort prospective China	1,219 patients with lung cancer 67.3% males 58.8 ± 9.9 years	07/13 to 10/18 Registered dietitian First 48 h	None	NRS-2002	GLIM criteria
Yoshida, 2022 (104)	English	To clarify whether the eGFR ratio is appropriate for evaluating muscle mass and investigate the accuracy and usefulness of the eGFR ratio in the diagnosis of sarcopenia and malnutrition.	Unicentric Cross-sectional Japan	151 general patients 56.9% males 78 ± 11.3 years	01/20 to 07/21 Assessor NR Moment NR	None	None	GLIM criteria
Yu, 2021 (105)	English	Investigate the association of malnutrition with LOS	Unicentric Cohort retrospective China	139 patients with COVID-19 51.8% males 61.4±14.7 years	02/20 to 04/20 Doctor Moment NR	LOS	NRS-2002	GLIM criteria
Zhang, 2021 (106)	English	Evaluate and validate the use of the GLIM criteria	Multicentric Secondary analysis of a prospective study China	3,777 patients with cancer 58.1% males 56.4±11.9 years	05/2011 to 10/2018 Assessor NR Moment NR	One-year survival	NRS-2002	GLIM criteria PG-SGA
Zhang, 2021 (107)	English	Report the prevalence and clinical associations of malnutrition with clinical	Multicentric Secondary analysis of a retrospective study China	2,724 patients with cancer 65.2% males 71 ±5.3 years	2013 to 2020 Assessor NR First 48 h	Mortality after discharge, quality of life	None	GLIM criteria PG-SGA

		outcomes using PG-SGA SF, PG-SGA, and GLIM						
Zhang, 2021 (108)	English	Weigh the GLIM criteria and develop a scored-GLIM system, and then validate as well as evaluate its application in nutritional assessment and survival prediction	Multicentric Secondary analysis of a retrospective study China	3,547 patients with cancer 56.1% males 59.1 ±12.8 years	07/13 to 12/18 Registered dietitian Moment NR	Mortality after discharge	NRS-2002	GLIM criteria PG-SGA
Zhang, 2021 (109)	English	Evaluate the diagnostic capacity of NRS2002, and PG-SGA in light of the GLIM criteria	Multicentric Secondary analysis of a prospective study China	637 patients with cancer 60.1% males 57 (IQR: 18- 92) years	09/18 to 03/19 Nurse First 72 h	None	NRS-2002, MUST	GLIM criteria PG-SGA
Zhou, 2021 (110)	English	Determine the feasibility of substituting HGS for MM as one of the constituents in the GLIM to diagnose malnutrition	Multicentric Secondary analysis of a prospective study China	2,209 patients with GI cancer 67.2% males 64.7±11.3 years	01/16 to 12/19 Assessor NR Moment NR	None	NRS-2002	GLIM criteria
Zhuang, 2020 (111)	Chinese	Characterize the malnutrition status, nutrition impact symptoms, and quality of life at the end of radiotherapy and explore the association between nutritional status with nutrition impact symptoms and quality of life	Unicentric Cross-sectional China	210 patients with head and neck cancer 61.4% males 53.2±13.0 years	12/18 to 01/20 Assessor NR Moment NR	Quality of life, and nutrition impact symptoms	NRS-2002	GLIM criteria BMI < 18.5 kg/m^2 with poor general condition NRS-2002
Zugasti-Murillo, 2021 (112)	English	Assess the prevalence of hospital malnutrition upon admission ten years later.	Multicentric Cross-sectional Spain	2,185 general patients 54.8% males 67.1±17.0 years	02/2019 Assessor NR First 48 h	In hospital mortality, LOS	MUST	GLIM Criteria
Ballesteros-Pomar, 2021 (113)	English	Determine the impact of low MM and strength, disease-related	Unicentric Cohort prospective Spain	200 general patients 50% males	04/19 to 09/19 Registered dietitian	LOS, death, readmissions at	MUST	GLIM Criteria

		malnutrition and sarcopenia on clinical outcomes		75.4 ±22.5 years	First 48 h	three months, and quality of life		
Contreras-Bolivar V, 2019 (114)	English	Determine the prevalence of malnutrition using different diagnostic classifications, and its association with clinical outcomes.	Unicentric Cohort prospective Spain	282 patients with cancer 57.6% males 60.4 ±12.6 years	10/17 to 04/18 Assessor NR First 24h	in hospital mortality, mortality after discharge, LOS	MUST	GLIM criteria SGA
Zhang, 2021 (115)	English	Investigate the application of the GLIM criteria in nutrition assessment and survival prediction	Multicentric cohort retrospective China	1492 elderly cancer patients 68% of males Age NR	Period NR Assessor NR Moment NR	Overall survival	NRS-2002	GLIM criteria
Maeda, 2020 (116)	English	Investigate the optimal reference values of BMI for discriminating severe malnutrition according to the GLIM criteria, as well as the prevalence of malnutrition	Unicentric Cross-sectional Japan	4796 general patients 53% males 67.3 ± 13.2 years	05/218 to 08/18 Assessor NR Moment NR	In-hospital mortality	MUST MNA-SF	GLIM Criteria
Formisano, 2021 (117)	English	Provide an approach to reduce the risk of malnutrition and improve the clinical outcomes	Unicentric Design NR Italy	143 COVID-19 patients (94 non-ICU and 49 ICU patients) Gender NR 71.5 ± 15.2 years	Period NR Assessor NR Moment NR	None	NRS-2002 adapted	GLIM Criteria

Abbreviations: AND-ASPEN = Academic of Nutrition and Dietetics - American Society of Parenteral and Enteral Nutrition; AECOPD = acute exacerbated chronic obstructive pulmonary disease; ADL = activities daily life; BMI = body mass index; CC = calf circumference; CONUT = Controlling Nutrition Status Score; COPD = chronic obstructive pulmonary disease; COVID-19 = Corona Virus Disease-2019; CVD = cardiovascular disease; DFU = diabetic foot ulcer; DP = standard deviation; ESPEN = European Society of Nutrition and Metabolism; EW = emergency ward; FFMI = fat free mass index; FMI = fat mass index; GI = gastrointestinal; GFR = glomerular filtration rate; GNRI = geriatric nutritional risk index; GLIM = Global Leadership Malnutrition; GS = grip strength; HGS = handgrip strength; IQR = interquartile range; ; ICU = intensive care unit; L3-CT = third lumbar vertebra-computer tomography determined; LOS = length of hospital stay; MAN = Mini Nutritional Assessment; MAN-SF = Mini Nutritional Assessment - Short Form; MM = muscle mass; MV = mechanical ventilation; MST = malnutrition screening tool; MUST = Malnutrition Universal Screening Tool; NRS-2002 = Nutritional Risk Screening; NST = nutritional screening tool; NR= not reported; PANDORA = Patient- and Nutrition-Derived Outcome Risk Assessment score; PPC = pulmonary postoperative complications; PNI = prognostic nutritional index ; PG-SGA = patient generated subjective global assessment; RFH-NPT = Royal Free Hospital Nutritional

Prioritizing Tool; SGA = subjective global assessment; SNAQ = Short Nutritional Assessment Questionnaire; TPN = total parenteral nutrition; US= ultrasonography; USA = United States.

Supplementary Table 3. Definition of phenotypic and etiological criteria among studies using the GLIM criteria for malnutrition diagnosis of hospitalised patients

First Author, year (ref)	'Phenotypic criteria			Etiological criteria		Severity
	Low BMI	**WL**	**Low MM**	**Reduced EI**	**Inflammation**	
Allard, 2020 (22)	Measured data	Informed and measured data	Not evaluated	Qualitative method	CRP >8 mg/L	BMI and WL
Allepaerts, 2020 (23)	NR as evaluated	NR as evaluated	BIA - ASMI, kg/m^2: <7 for males and <5.7 females	Quantitative method	Disease understanding	NR as evaluated
Balci, 2021 (24)	Unclear	NR as evaluated	BIA - FFMI, kg/m^2: < 17 males and < 15 females	Quantitative method	Disease understanding	BMI, WL, and MM loss
Bedock, 2021 (25)	Informed and measured data	Informed and measured data	Not evaluated	Unclear	Disease understanding	NR as evaluated
Bedock, 2020 (26)	Informed and measured data	Informed and measured data	Not evaluated	NR as evaluated	Disease understanding	BMI and WL
Bellanti, 2020 (27)	Measured data	Unclear	BIA - FFM, SMI, and ASMM (Cut-off NR)	Unclear	NR as evaluated	NR as evaluated
Boulhosa, 2020 (28)	Measured and estimated data	Informed or registered and measured data	AMC <P15	Semi-quantitative method	NR as evaluated	NR as evaluated
Brito, 2021 (29)	Measured data	Informed and measured data	CC, cm: ≤34 males, ≤33 females AMPT ≤P5 for age and gender	Semi-quantitative method	CRP > 5 mg/L	BMI, WL, and MM loss
Burgel, 2021 (30)	Measured data	Informed and measured data	CC, cm: ≤34 males, ≤33 females AMPT ≤P5 for age and gender	Semi-quantitative method	CRP > 5 mg/L	BMI, WL, and MM loss
Cruz, 2022 (31)	Measured and estimated data	Informed and measured data	CC, cm: ≤34 males, ≤33 females	NR as evaluated	NR as evaluated	NR as evaluated

Araújo, 2022 (32)	Measured data	Informed and measured data	BIA- FFMI, kg/m^2: < 17 males and < 15 females	Semi-quantitative method	CRP > 5 mg/L	NR as evaluated
Shimizu, 2022 (33)	NR as evaluated	NR as evaluated	BIA- SMI, kg/m^2: < 7.0 males and <5.70 females	NR as evaluated	Unclear	BMI, WL, and MM loss
El Chaar, 2022 (34)	Measured data	Calculated with usual weight informed by patients	Not evaluated	Semi-quantitative method	Not evaluated	Not evaluated
Fierini, 2020 (35)	Unclear	Not evaluated	Not evaluated	Semi-quantitative method	Not evaluated	Not evaluated
Martín, 2020 (36)	Measured and informed data	Informed by patients	Physical examination	Semi-quantitative method	Disease understanding CCI	NR as evaluated
Guan Ke, 2020 (37)	Measured data	NR as evaluated	Not evaluated	NR as evaluated	NR as evaluated	BMI, WL
Haines, 2021 (38)	NR as evaluated	NR as evaluated	Not evaluated	Not evaluated	Albumin <3.5g/dL	Not evaluated
H-Ketabforoush, 2021 (39)	Informed data	NR as evaluated	Not evaluated	NR as evaluated	NR as evaluated	Not evaluated
Hao, 2019 (40)	NR as evaluated	NR as evaluated	Not evaluated	NR as evaluated	NR as evaluated	Not evaluated
Henrique, 2020 (41)	Measured and informed data	Informed by patients	BIA- FFMI, kg/m^2: < 17 males and < 15 females CC, cm: < 34 males and < 33 females MAMA, cm^2: < P15	Semi-quantitative method	Disease understanding	BMI, WL, MAMA
Hirose, 2021 (42)	NR as evaluated	Informed by patients	BIA - ASMI, kg/m^2: < 7.0 males and <5.70 females	Not evaluated	Disease understanding	Not evaluated
Huang, 2021 (43)	NR as evaluated	NR as evaluated	CT - SMI, cm^2/m^2: < 40.8 males and < 34.9 females	Not evaluated	Disease understanding	Not evaluated
Huang, 2021 (44)	NR as evaluated	NR as evaluated	CT - SMI, cm^2/m^2: < 40.8 males and < 34.9 females	NR as evaluated	Disease understanding	Not evaluated
Huang, 2022 (45)	Measured data	Unclear	BIA - ASMI, kg/m^2: < 7.0 males and <5.70 females	NR as evaluated	CRP >8mg/L	NR as evaluated

IJmker-Hemink, 2022 (46)	Measured data	Unclear	BIA- FFMI, kg/m^2: < 17 males and < 15 females	Qualitative method	Disease understanding	Not evaluated
Kakavas, 2020 (47)	Measured data	Informed by patients	CC, cm: < 31	NR as evaluated	CRP > 5 mg/dL	BMI, WL, CC
K-Szymanowska, 2022 (48)	NR as evaluated	NR as evaluated	BIA- ALM, kg/m^2: < 5.6 females and <7.4 males	Not evaluated	Disease understanding	Not evaluated
Kootaka, 2021 (49)	Measured data	NR as evaluated	Calculated ASMI, kg/m^2: < 7.0 males and < 5.4 females	Semi-quantitative method	Disease understanding	Not evaluated
Lauwers, 2021 (50)	Measured data (Cut-off NR)	Informed by patients (Cut-off NR)	BIA- ASMM (Cut-off NR)	Unclear	Disease understanding	Not evaluated
Li, 2021(51)	Unclear (Cut-off NR)	Unclear (Cut-off NR)	CC, MAC, HGS (Cut-off NR)	Unclear	Disease understanding	BMI, WL, MM
Liu, 2021 (52)	Measured data	NR as evaluated	CC, cm: <33 females and <34 males HGS, Kg: <18 females and <28 males	Not evaluated	Disease understanding	BMI, WL
Song, 2022 (53)	Unclear	Informed by patients	HGS < p10	Not evaluated	Disease understanding	Not evaluated
López-Valverde, 2021 (54)	Measured and estimated data	Calculated with usual weight registered in medical records	NR as evaluated	Unclear	Unclear	Not evaluated
Xu, 2020 (55)	Measured data	NR as evaluated	CC, cm: ≤29.6 males and ≤27.5 females	Unclear	Disease understanding	Not evaluated
Martín-Martínez, 2021 (56)	NR as evaluated (Cut-off NR)	NR as evaluated (Cut-off NR)	Not evaluated	Unclear	CRP ≥ 0.5 mg/dL and disease understanding	Not evaluated
Matsumoto, 2020 (57)	Measured data	Unclear (Cut-off NR)	CC, cm: < 34 males and < 33 females	Unclear	Unclear	CC

Mitani, 2021 (58)	NR as evaluated	NR as evaluated	BIA - SMI, kg/m²: <7.0 males and < 5.7 females	NR as evaluated	CRP ≥ 0.5 mg/dL and disease understanding	BMI, WL, MM
Fernandez, 2021 (59)	NR as evaluated	Informed by patients	CC, cm: < 31 AMA: <15th percentile	Semi-quantitative method	CRP ≥ 5.0 mg/dL and disease understanding	BMI, WL, MM
Nishioka, 2021 (60)	Measured data	Unclear	BIA- SMI, kg/m²: <7.0 males and < 5.7 females	Not evaluated	CRP (Cut-off NR) and disease understanding	BMI, WL, MM
Nozoe, 2021 (61)	NR as evaluated	NR as evaluated	BIA- SMI, kg/m²: <7.0 males and < 5.7 females	Semi-quantitative method	CRP ≥ 0.5 mg/dL and disease understanding	Not evaluated
Oguri, 2022 (62)	NR as evaluated	NR as evaluated	MAC, cm: ≤ 21 BIA- SMI, kg/m²: <7.0 males and < 5.7 females	Not evaluated	Disease understanding	Not evaluated
Ohta, 2022 (63)	Unclear	NR as evaluated	BIA- FFMI, kg/m²: <17 males and <15 females	Unclear	CRP > 10 mg/dL	NR as evaluated
Ucar, 2021 (64)	Measured data	NR as evaluated	BIA - SMI, kg/m²: <9.2 males and < 7.4 females US (Cut-off NR) CC, cm: <33 and MAC, cm: <21	NR as evaluated	CRP > 5 mg/dL and disease understanding	Not evaluated
Pereira, 2021 (65)	NR as evaluated	Not evaluated	Not evaluated	Not evaluated	CRP ≥1.0 mg/dL and disease understanding	BMI

Pérez, 2021 (66)	Measured and estimated data (< 22 kg/m² if MAC <23.5 cm)	Not evaluated	HGS (cut-off stratified by sex and age according to the dynamometer manufacturer)	Not evaluated	Disease understanding	Not evaluated
Pironi, 2021 (67)	Measured and estimated data	Calculated with informed usual weight Cut-off: ≥ 5% in one month	Not evaluated	Quantitative method	CRP > 0.5 mg/dL	Not evaluated
Pourhassam, 2020 (68)	NR as evaluated	NR as evaluated	Not evaluated	Unclear (According to MNA-SF)	CRP > 2mg/dL	Not evaluated
Probert, 2020 (69)	Unclear	Not evaluated	CC, cm: < 33	Not evaluated	Disease understanding	Not evaluated
Qin, 2021 (70)	Measured and informed data	NR as evaluated	BIA- FFMI, kg/m²: < 15 females and <17 males	Not evaluated	Disease understanding	Not evaluated
Rives-Lange, 2021 (71)	Unclear (Cut-off NR)	NR as evaluated (Cut-off NR)	Not evaluated	Not evaluated	Disease understanding	BMI, WL
Rodrigues, 2021 (72)	Unclear	Not evaluated	CC, cm: ≤ 34 males and ≤ 33 females MAC < 15p	Not evaluated	Disease understanding	BMI
Rouget, 2021 (73)	Measured and informed data (Cut-off NR)	Unclear (Cut-off NR)	Not evaluated	Semi-quantitative method	Unclear	BMI, WL, albuminaemia, NRS-2002
Sánchez-Torralvo, 2022 (74)	Measured data	NR as evaluated	HGS < 5p	Semi-quantitative method	Glasgow prognostic score (Cut-off NR)	Not evaluated
Sánchez-Torralvo, 2021 (75)	Measured data	NR as evaluated	CT - SMI, cm^2/m^2: < 43 males if BMI < 25 kg/m^2 and < 53 if BMI > 25 kg/m^2	NR as evaluated	Glasgow prognostic score (Cut-off NR)	Not evaluated
Sanz-Paris, 2021 (76)	Unclear	NR as evaluated	BIA- SMI, kg/m²: < 7 males and <5.5 females	Not evaluated	Disease understanding	Not evaluated

Li, 2022 (77)	Measured data	Unclear	BIA - FFMI, kg/m²: <17 males and <15 females	NR as evaluated	Unclear	Not evaluated
Sanz-París, 2020 (78)	Measured, estimated, and informed data	NR as evaluated	CC, cm: < 31 MAMC, cm: < 21	Unclear	Albumin < lowest quartile	BMI, WL, MM
Shahbazi, 2021 (79)	Informed data	Informed by patients	MAMC < fifth percentile for age and gender	NR	Disease understanding	Not evaluated
Shimizu, 2020 (80)	Unclear	Unclear	CC, cm: ≤30 males and ≤ 29 females	Semi-quantitative method	Unclear	Not evaluated
Shimizu, 2019 (81)	Measured data	NR as evaluated	calculated SMI, kg/m²: <6.70 males and <4.75 females	Semi-quantitative method	NR as evaluated	Not evaluated
Shimizu, 2021 (82)	NR as evaluated	Not evaluated	Not evaluated	Not evaluated	Disease understanding	BMI
Skeie, 2020 (83)	Unclear	Calculated with usual weight registered in medical records	Not evaluated	Impaired food assimilation or absorption	Not evaluated	BMI, WL
Sobestiansky, 2021 (84)	Measured data	Informed by patients	DXA- FFMI, kg/m^2: <15 males <17 females CC, cm: < 31	Qualitative method	CRP (cut-off NR) and disease understanding	Not evaluated
Tan, 2022 (85)	Measured data	Unclear	CT - SMI cm^2/m^2: < 43.13 male and < 37.81 females	Semi-quantitative method	CRP (cut-off NR) and disease understanding	BMI, WL, MM
Theilla, 2021 (86)	Measured data	Informed by patients	BIA- FFMI, kg/m^2: <15 males <17 females	Not evaluated	Disease understanding	Not evaluated
Thomas, 2022 (87)	Measured and estimated data	Calculated with informed usual weight	DXA - ASMI, kg/m^2: <7.26 males and <5.25 females	NR as evaluated	CRP > 0.8 mg/L and disease understanding	Not evaluated

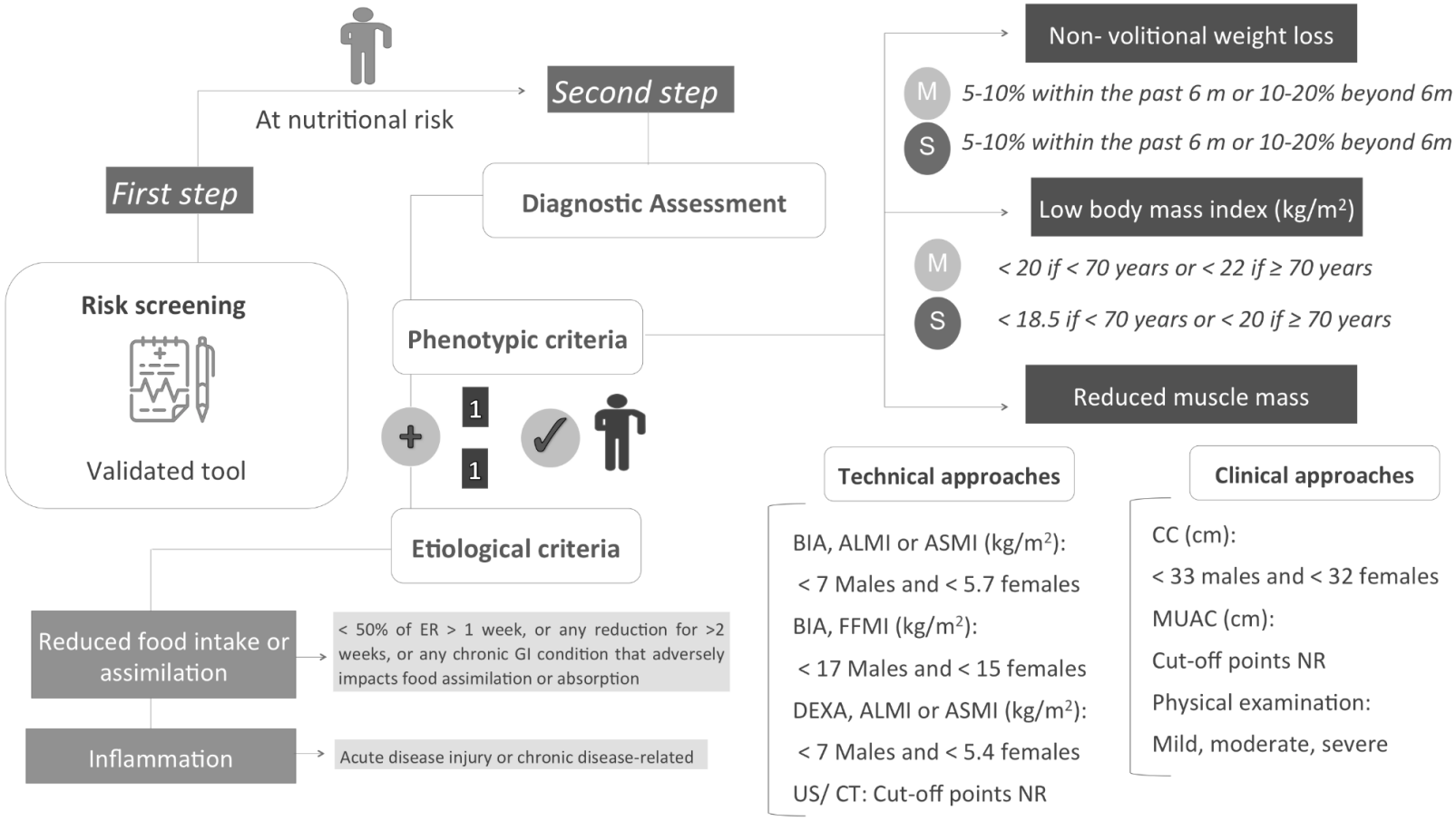
Verstraeten, 2021 (88)	Measured data	NR as evaluated	BIA- SMI, kg/m^2: ≤ 10.75 males and ≤ 6.75 females	Qualitative method	Disease understanding, and Cumulative Illness Rating Scale	Not evaluated
Wang, 2021 (89)	NR as evaluated	Unclear	BIA - SMI, kg/m^2: < 9.87 males and < 7.15 kg/m^2 females	NR as evaluated	Unclear	MM
Wang, 2021 (90)	Measured data	NR as evaluated	NR as evaluated	NR as evaluated	Disease understanding	WL, BMI and MM
Xie, 2022 (91)	Unclear	Unclear	Not evaluated	NR as evaluated	NR as evaluated	Not evaluated
Xu, 2020 (92)	NR as evaluated	NR as evaluated	Not evaluated	Semi-quantitative method	Disease understanding	Not evaluated
Xu, 2022 (93)	NR as evaluated	NR as evaluated	CT images - SMI, cm^2/m^2: ≤ 40.8 males and < 34.9 cm^2/m^2 females	Unclear	NLR (>2.70) and MLR (>0.27)	WL, BMI and MM
Yilmaz, 2020 (94)	Measured data	NR as evaluated	Unclear	Unclear	Unclear	Unclear
Yin, 2021 (95)	Measured data	Informed by patients	CC, cm: < 30 males and < 29 females	Not evaluated	Disease understanding	Not evaluated
Yin, 2022 (96)	Measured data	Calculated with informed usual weight	CC, cm: < 30.5 males and < 29 female	Not evaluated	Disease understanding	BMI and MM
Yin, 2021 (97)	NR as evaluated	NR as evaluated	MAMC, CC and HGS/W < 15^{th} percentile for each gender	NR as evaluated	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM

Yin, 2021 (98)	Unclear	Ccalculated with informed usual weight	CC, cm: < 30.5 males and < 29 female	Unclear	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM
Yin, 2021 (99)	Measured data	Calculated with informed usual weight	CC, cm: < 30.5 males and < 29 female HGS, kg: < 20.1 males and < 12.7 females	NR as evaluated	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM
Yin, 2022 (100)	Unclear	NR as evaluated	CC, cm: < 30.5 males and < 29 female	Unclear	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM
Yin, 2021 (101)	Measured data	Calculated with informed usual weight	CC, cm: < 30.5 males and < 29 females	Not evaluated	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM
Yin, 2022 (102)	Measured data	Calculated with informed usual weight	BIA- FFMI, kg/m^2: <15 males and <17 females	Not evaluated	By disease understanding	Not evaluated
Yin, 2021 (103)	Measured data	Calculated with informed usual weight	CC, cm: < 30 males < 29.5 females HGS/W: < 0.34 males and < 0.22 females	NR as evaluated	CRP > 10 mg/L, WBC > $10*10^9$/L, NLR > 3, and disease understanding	WL, BMI and MM
Yoshida, 2022 (104)	NR as evaluated	NR as evaluated	NR as evaluated	NR as evaluated	NR	NR as evaluated
Yu, 2021 (105)	NR as evaluated	NR as evaluated	CC, cm: < 30 males and < 29 females	NR as evaluated	Disease understanding	NR as evaluated

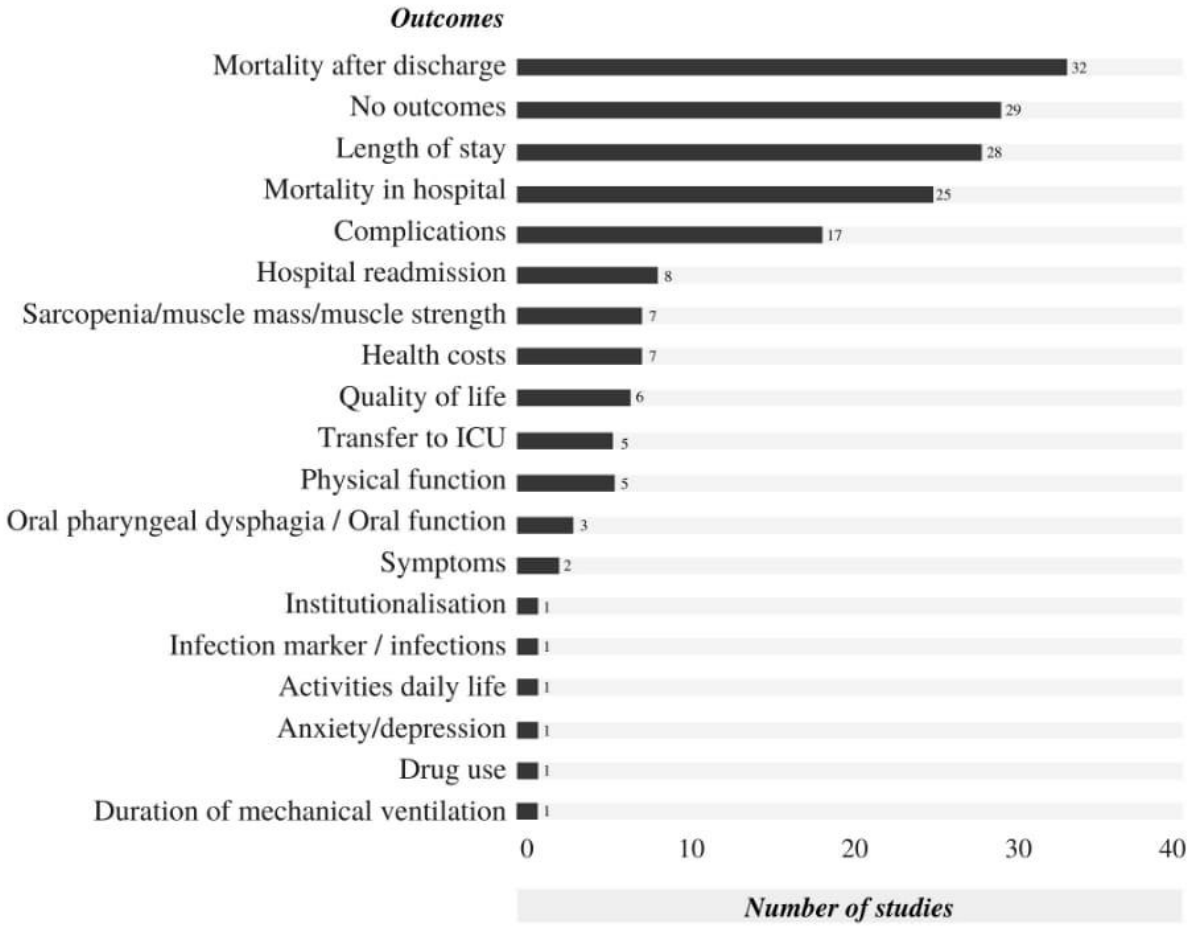
Zhang, 2021 (106)	NR as evaluated	NR as evaluated	CC, cm: < 30 males and < 29 females MAMC, cm: < 18.6 males and < 17.0 females HGS, kg: < 28 males and < 18 females	Not evaluated	Disease understanding	Not evaluated
Zhang, 2021 (107)	NR as evaluated	NR as evaluated	NR as evaluated	Not evaluated	Disease understanding	Not evaluated
Zhang, 2021 (108)	Measured data	Calculated with informed usual weight and measured/ estimated actual body weight	CC, cm: < 30 males and < 29 females MAMC, cm: < 18.6 males and < 17.0 females HGS/W: < 0.34 males and < 0.22 females	Unclear	Not evaluated	WL and MM
Zhang, 2021 (109)	Measured data	Calculated with informed usual weight	Physical examination (calf and mid-arm circumference points)	Not evaluated	NR as evaluated	Not evaluated
Zhou, 2021 (110)	NR as evaluated	NR as evaluated	CT images - SMI, cm^2: < 40.8 males and 34.9 females HGS, kg: < 26 kg males and < 18 females	Not evaluated	Disease understanding	Not evaluated
Zhuang, 2020 (111)	NR as evaluated	NR as evaluated	Not evaluated	Not evaluated	Disease understanding	Not evaluated
Zugasti-Murillo, 2021 (112)	Measured and estimated data	Calculated with usual weight registered in medical records	Not evaluated	Not evaluated	Disease understanding	WL, and BMI
Ballesteros-Pomar, 2021 (113)	NR as evaluated	NR as evaluated	BIA - ASM/$height^2$, kg/m^2: < 7 males and < 5.5 females CC, cm: < 30 males and < 29 females HGS, kg: < 27 males and < 16 females	Not evaluated	Disease understanding	NR as evaluated

Contreras-Bolivar V, 2019 (114)	Measured data	NR	AMC and MAC <p5 BIA - FFMI, kg/m^2: <15 females and < 17 males	Semi-quantitative method	Glasgow prognostic score	Not evaluated
Zhang, 2021 (115)	Unclear	Informed by patients	CC, cm: ≤30 males and ≤29 females	Qualitative method	Disease understanding All patients with this criteria	BMI, MM
Maeda, 2020 (116)	NR	Informed by patients	CC, cm: ≤ 30 males and ≤ 29 females	Qualitative method	Unclear	BMI, WL, MM
Formisano, 2021 (117)	Estimated or informed	Unclear	Not evaluated	Unclear	Unclear	Not evaluated

Abbreviations: ALM = appendicular lean mass; AMC = arm muscle circumference; APMT = adductor pollicis muscle; ASMI: appendicular skeletal muscle mass index; ASMM = Appendicular Skeletal Muscle Mass; BIA = bioelectrical impedance; BMI = body mass index; CC = calf circumference; CCI = Charlson Comorbidity Index; CRP = C reactive protein; CT = computer tomography; DXA = Dual X-ray Absorptiometry; FMI = fat mass index; FFM = fat free mass; FFMI = fat free mass index; EI = energy intake; HGS = handgrip strength; HGS/W = handgrip strength/weight; MAC = muscle arm circumference; MAMA = midarm muscle area; MAMC = mid arm muscle circumference; MM = muscle mass; NLR = neutrophil/lymphocyte ratio; NRS-2002 = Nutritional Risk Screening; NST = nutritional screening tool; NR= not reported; SMI = skeletal muscle index; US = ultrasound; WL = weight loss



Supplementary Figure 1: GLIM framework for malnutrition diagnosis.
Abbreviations: ALMI = appendicular lean muscle index; ASMI = appendicular skeletal muscle index; BIA = Impedance bioelectric analysis; CC = calf circumference; CT = computerised tomography; DXA = densitometry; FFMI = fat free mass index; MUAC = mid-arm muscle circumference; M = moderate; NR = not reported; S = severe; US = ultrasonography.



Supplementary Figure 2: Outcomes evaluated by studies on GLIM criteria application in hospitalized patients.

ARTIGO CIENTÍFICO II

Feasibility and criterion validity of the GLIM criteria for the diagnosis of malnutrition in critically ill patients: a longitudinal study

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ABSTRACT

Background & aims: The Global Leadership Initiative on Malnutrition (GLIM) proposed a framework for malnutrition diagnosis that requires validation in the intensive care unit (ICU) setting. This study aimed to evaluate the feasibility and validity of the GLIM criteria in the ICU.

Methods: A cohort study involving critically ill patients. Data regarding the diagnosis of malnutrition by the Subjective Global Assessment (SGA) and GLIM criteria within 24 h after ICU admission were prospectively collected. Patients were followed up until hospital discharge to assess the hospital/ICU length of stay (LOS), mechanical ventilation duration, ICU readmission, and hospital/ICU mortality. Three months after discharge, the patients were contacted to record outcomes (readmission and death). Agreement, accuracy tests and regression analyses were performed.

Results: Among the 450 patients (64 [54–71] years, 52.2% men), the GLIM criteria could be applied to 83.7% of them. Malnutrition prevalence was 47.8% by SGA and 65.5% by GLIM criteria. The GLIM criteria presented an AUC equal to 0.835 (95%CI, 0.790–0.880), sensitivity of 96.6%, and specificity of 70.3%. Malnutrition by GLIM criteria increased the odds of prolonged ICU-LOS by 1.75 times (95%CI, 1.08–2.82) and ICU readmission 2.66 times (95%CI, 1.15–6.14).

Conclusion: The GLIM criteria were feasible in more than 80% of the patients and presented sensitivity >90%, specificity >70%, and substantial agreement with the SGA in critically ill patients. It was an independent predictor of prolonged ICU LOS and ICU readmission.

Keywords: malnutrition, critical care, critically ill patients, criterion validity.

INTRODUCTION

Critical illness is characterized by a metabolic response mediated by proinflammatory cytokines and counterregulatory hormones. This metabolic response leads to hypermetabolism and hypercatabolism, which are associated with negative energy and protein balance. Critical illness results in a significant loss of subcutaneous fat and muscle mass (MM), contributing to the impairment of nutritional status and, consequently, malnutrition[1]. It is well recognized that malnutrition is associated with worse outcomes, such as prolonged hospital and intensive care unit (ICU) length of stay (LOS), more days on mechanical ventilation (MV), increased infection rate, mortality, and higher hospital costs[2,3]. The prevalence of malnutrition in ICU settings ranges from 5 to 82%, and this wide variation can be explained by the lack of standards in the diagnosis of malnutrition worldwide and the complexity of critically ill patients[3].

Assessment of nutritional status in the ICU is a major challenge because traditional methods have limited applicability in this population due to sensory impairment and the use of sedation This challenge precludes the collection of patients' nutritional history because interactions with the examiner are limited. Body fluid disturbances are common in critically ill patients and can cause the overestimation of the measured weight and mid-arm (MAC) and calf (CC) circumferences. In addition, biochemical tests for albumin are unreliable in the presence of inflammation, severe disease, and/or trauma[4] and cannot be used for nutritional assessment[5]. The Subjective Global Assessment (SGA) is the reference method for malnutrition diagnosis through the identification of changes in body composition, reduced food intake, and functional changes to subjectively diagnose patients as well-nourished, moderately malnourished, or severely malnourished[6]. Studies have suggested that malnourished patients according to the SGA have a high rate of ICU readmissions and mortality[7-10]. However, the SGA is not universally accepted for malnutrition diagnosis because of the challenges related to its applicability, which is dependent on the examiner's expertise.

During the conference of the American Society of Parenteral and Enteral Nutrition in January 2016, the need to reach a global consensus on the diagnosis of malnutrition in clinical settings was considered. Subsequently, a committee comprising representatives of the main global societies of clinical nutrition developed the Global Leadership Initiative on Malnutrition (GLIM) criteria. It is a consensus-based framework composed of three phenotypic (reduced body mass index [BMI], unintentional weight loss [UWL], and reduced MM) and two etiologic (reduced food intake/impaired nutrient assimilation and inflammation) criteria; malnutrition is

diagnosed when patients present with at least one of each criteria set. The phenotypic criteria are used to define malnutrition severity[11]. The GLIM Steering Committee reinforced the need for validation studies on this approach in different settings[12].

To the best of our knowledge, only a few validation studies of the GLIM criteria involving critically ill patients have been published until now[13-17]. Two of these studies assessed only concurrent validity[14,16], one of them evaluated only predictive validity[17], and the other two studies reported data on both concurrent and predictive validity[13,15]. The sensitivity and specificity of the studies ranged from 65 to 92% and from 72 to 93%, respectively. Malnutrition diagnosed using the GLIM criteria increased the odds of hospital mortality by 4.0 times in one study[15], while it was not associated with clinical outcomes in the other studies[13,17].

Considering the scarcity of studies on the validity of the GLIM criteria for malnutrition diagnosis in ICU settings and their heterogeneous results, this study aimed to evaluate the concurrent and predictive validity and the feasibility of this criteria for diagnosing malnutrition in critically ill patients. We hypothesized that the GLIM criteria compared with the SGA present satisfactory accuracy metrics and prognostic value in identifying worse clinical outcomes, such as ICU and hospital LOS and death, duration of MV, and ICU readmission. We assumed that the GLIM criteria has a high feasibility rate.

METHODS

Study design and sample

A cohort study of patients from six ICUs of a hospital complex in southern Brazil was conducted, and data was prospectively collected between July 2019 and March 2020 and between May 2021 and April 2022. The suspended data collection was due to the coronavirus disease 2019 (COVID-19) pandemic. The hospital's ethics committee approved this study (no. 4,735,356), and data collection started after obtaining informed consent from the patients or relatives of the patients.

The population comprised all adult/elderly patients admitted to the ICUs 24h before data collection, and the sample was selected using the convenience sampling method. The inclusion criteria were individuals of both sexes aged ≥ 18 years, with available blood gas analysis and blood count results, and patients for whom it was possible to obtain a simplified nutritional anamnesis (from the patients or their relatives). Pregnant women, patients who were

transferred from another ICU, and those who were readmitted to the ICU were excluded from the study.

The sample size calculation was based on the following two approaches that considers the predictive and concurrent validity of the GLIM criteria: a) considering the difference in mortality in malnourished (66%) and well-nourished (46%) patients, as evidenced in the study conducted by Shahbazi et al.[15], a power of 80%, a significance level of 5%, and an additional 20% for potential losses and adjustments in multivariate analysis, the estimated sample size was 254 patients and b) based on the sensitivity of 80% recommended by the GLIM criteria validation guide[12] and on the mean prevalence of malnutrition of 58% reported in a systematic review conducted by Lew et al[3], a power of 80%, a significance level of 5%, and additional 20% for potential losses to follow-up and adjustments in a multivariate model, the estimated sample size was 472 patients. These calculations were performed using the online calculator http://www.openepi.com/Menu/OE_Menu.htm, which was considered the highest estimated sample size for the present study (n = 472).

Data collection

Using a standardized data collection form, a team of trained researchers composed of three dietitians and three nutrition undergraduate students collected the data within the first 24 h of ICU admission. Clinical and sociodemographic data including age, sex, previous medical history, reason for hospital admission, days of pre-ICU hospitalization, previous ICU admission unit, reason for ICU admission, MV and hemodialysis (HD) use at admission, and laboratory results (arterial blood gas analysis, potassium, sodium, blood count, creatinine, and, when available, C-reactive protein [CRP] levels]) were collected from the electronic records of patients. The Sequential Organ Failure Assessment (SOFA)[18] score was used to classify clinical severity. For nutritional assessment, simplified anamnesis, anthropometry, and physical examination were performed as detailed below.

- *Nutritional anamnesis*: The patients or their relatives provided anamnesis information. This information included usual body weight (in the last six months), current body weight, and height. Body mass index (BMI) and UWL were calculated as follows: BMI = [body weight/height ²], expressed in kg/m², and UWL = [(usual body weight – current body weight) x 100/usual body weight], expressed in %. Assessment of food consumption was semi-quantitative based on self-reported intake (100%, 75%, 50%,

25%, or 0%) compared with the usual intake. We also asked about changes in food consistency, the presence of gastrointestinal symptoms (anorexia, nausea, vomiting, and diarrhea) in the last two weeks, and changes in functional capacity.

- *Anthropometry*: CC was measured on the largest circumference in the plane perpendicular to the longitudinal line of the calf [19], and the adductor pollicis muscle thickness (APMT) was measured using a LANGE® adipometer, pinching the vertex of the imaginary triangle formed by the extension of the thumb and forefinger (the measurement was performed three times, and the mean was calculated for classification)[20]. To avoid overestimation of the measurements, CC was not measured in patients with lower limb edema or venous return boots, and APMT was not measured in patients with hand edema[21].
- *Physical examination*: It included inspection of specific anatomical points to assess the MM (temporal, pectoral, deltoid-supraclavicular, and infraclavicular areas; quadriceps; and gastrocnemius) and subcutaneous fat (orbital, triceps, and overlying rib areas) depletions, which were classified as mild, moderate, or severe. Generalized and local fluid accumulation in the extremities (assessed by the presence of depression on the skin after applying pressure for 5s using the right thumb) and ascites were also assessed and classified as absent, mild, moderate, or severe[1].

Nutritional assessment tools

The SGA was applied, as proposed by Detsky et al., for the diagnosis of malnutrition, considering the information obtained from the nutritional anamnesis and physical examination. When data on UWL could not be reported by patients or their relatives, the SGA was not applied because this component is mandatory for the diagnosis of malnutrition. Patients were subjectively classified as well-nourished, moderately or suspiciously malnourished, or severely malnourished [6].

Malnutrition was diagnosed using the GLIM criteria based on the evaluation of the five proposed criteria[11]. Unintentional WL and BMI were calculated using informed data. Reduced MM was considered when the patient presented with at least one of the evaluated criteria (moderate to severe muscle loss according to the physical examination and/or reduced CC and/or reduced APMT). Inflammation was considered present when the patient had a CRP level $\geq$ 5 mg/dL. Reduced energy intake was evaluated as described above. To assess the reduction

in nutrient assimilation, the presence of gastrointestinal symptoms (vomiting or diarrhea) or clinical diagnosis (e.g., pancreatitis or major abdominal surgery) registered in the electronic medical records of patients was considered. Patients were classified as malnourished when they presented with at least one etiologic criterion and one phenotypic criterion, with the severity of malnutrition determined using the BMI and UWL criteria according to the cut-off points detailed in **Table 1** (GLIM-1). Furthermore, the feasibility of applying the GLIM criteria and of the classification of malnutrition severity was evaluated, considering the number of patients for whom each criterion could be evaluated. Malnutrition diagnosis was also diagnosed considering the etiologic criterion filled in all the patients due to their critically ill disease state, which was named GLIM-2.

Outcomes

The primary outcomes were ICU mortality, duration of MV, and ICU LOS. The secondary outcomes were hospital LOS, ICU readmission, hospital mortality, and hospital readmission and mortality 3 months after hospital discharge.

Information on in-hospital outcomes were obtained from the patients' electronic records at the time of hospital discharge, while information on outcomes within 3 months after hospital discharge was obtained by telephone contact from patients or relatives.

Statistical analyses

Descriptive statistics were summarized as follows: categorical variables, absolute (n) and relative (%) frequency and continuous variables, mean and standard deviation (parametric variables) or median and interquartile range (nonparametric variables). The normality of the continuous variables was assessed using the Kolmogorov-Smirnov test.

For analysis, malnutrition diagnosis based on the GLIM criteria and the SGA was considered as a bicategorical variable, with the categories moderate and severe malnutrition. The agreement of the GLIM criteria with the SGA, which was considered as the reference method, for malnutrition diagnosis was tested by calculating the kappa coefficient, and the values were classified as follows: <0.20, poor; 0.21 to 0.40, fair; 0 .41 to 0.60, moderate; 0.61 to 0.80, substantial; 0.81 to 0.99, almost perfect; and 1.00, perfect [22]. The concurrent validity of the GLIM criteria for diagnosing malnutrition, considering the SGA as the reference method, was investigated by constructing the receiver operating characteristic (ROC) curve and

calculating the area under the curve (AUC) with its respective 95% confidence interval (CI). Furthermore, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. According to the GLIM criteria validation guide, a sensitivity and specificity > 80% and kappa > 0.80 are indicative of satisfactory concurrent validity[12]. We assessed the association between each criterion of the GLIM and malnutrition diagnosis by the SGA using crude logistic regression models.

To assess the predictive validity of the GLIM criteria for diagnosing malnutrition, a comparison of clinical and nutritional characteristics and outcomes of interest between patients with and without malnutrition was performed using bivariate analyses: Student's t-test for parametric variables, Mann-Whitney U test for nonparametric variables, and Chi-square test for categorical variables. Subsequently, multivariate Cox and logistic regression analyses were performed considering the outcomes of interest as the dependent variables. Cox regression analysis was used to evaluate the association between malnutrition and hospital and ICU mortality, and logistic regression analysis was used to evaluate the association between malnutrition and other outcomes of interest (prolonged hospital stay, prolonged ICU stay, MV duration, readmission to ICU, and hospital readmission and mortality within 90 days after discharge). Prolonged hospital and ICU stays were categorized based on the median hospital LOS ($\geq$ 20 days) and ICU LOS ($\geq$ 5 days), respectively. This approach was adopted because no universal criteria for defining these variables were identified in the literature. MV was categorized as higher or lower than 2 days considering the median MV duration of our sample and the prognostic value of this cutoff [23]. Crude and adjusted models were constructed, and the covariates included in the adjusted model were defined by a p value < 0.20 in the bivariate analyses, considering its clinical relevance.

Statistical analysis was performed using SPSS version 21.0 (IBM Corporation, INC., Chicago, IL, USA), and p values < 0.05 were considered significant.

RESULTS

General characteristics of the sample

A total of 472 patients were included in the present study, but there were 22 deaths within 24 h before obtaining anamnesis from the relatives. Thus, they could not be included due to the lack of data and the final sample comprised 450 patients, among whom 52.2% were

male, with a median age of 64 (54–71) years. The patient's selection flow is illustrated on **Supplementary Figure 1**.

More than half of the patients (53.3%) received MV at ICU admission, 8% underwent HD, and 22.2% had sepsis, with 64.7% of the patients having undergone a surgical procedure prior to ICU admission. Approximately one-third of the patients (29.3%) were admitted directly to the ICU; among those who had been admitted to another unit before ICU admission, 49.9% were in the ward and 22.7% were in the emergency room. The median number of days in the hospital before admission to the ICU was 1 (0–7) day. The main reasons for ICU admission were respiratory or lung (29.3%), oncological (28.8%), gastrointestinal and/or hepatic (16.2%), infectious (10.4%), or cardiac (7.8%) disorders. Other clinical features, as well as the nutritional characteristics and the outcomes of all patients are presented in the **Supplementary Table 1**.

Regarding the outcomes, the hospital and ICU LOS was equal to 20 (11 - 35) and 5 (3-9), respectively. More than 10% of patients had ICU readmission (11.8%), 20% died in the ICU while 28.9% died during the hospitalization. Among the 320 survivors, we got call contact with 243 patients (75.9%) 3 months after discharge. Among them, 24.7% were readmitted to the hospital and 4.5% died in this period.

Considering that we had two periods of data collection due to the COVID-19 pandemic, we compared the general characteristics, malnutrition prevalence, and outcome incidence between patients included in the first and second periods, and no difference was observed (data not shown).

Viability and feasibility of the GLIM criteria in the ICU

Nutritional anamnesis was obtained from the patients in 51.6% of sample, while in 47.6% of patients it was obtained from their relatives, and in the remaining (0.9%) it was collected from the electronic records. Malnutrition could not be determined in 16.2% of the patients. **Table 2** presents the frequency of inviability for each phenotypic and etiologic criterion in all the patients (n=450); inflammation identification was the criterion that was the most frequently unavailable because of a lack of CRP results (28.7%).

In patients for whom the diagnosis of malnutrition could not be made (n= 73), the phenotypic criteria could not be defined in 31 of them, mainly due to a lack of information on reduced MM (27 patients), with the use of the normal BMI and UWL criteria, while in 50

patients, the etiologic criteria could not be defined, mainly due to the lack of inflammation data for all patients, with the confirmation of normal energy intake criteria. For seven and five patients, data on UWL and BMI, respectively, were not available, whereas two patients did not have data related to reduced energy intake.

Among the 377 patients for whom the diagnosis of malnutrition was made based on the GLIM criteria, data on any of the phenotypic criteria were not available for less than 5% of patients, while 21% of them did not have data on inflammation. The severity of malnutrition could not be determined in 52 (21%) patients who were diagnosed as malnourished. Considering all patients with inflammation (GLIM-2), malnutrition could not be diagnosed in 32 (7.1%) of them.

Prevalence of malnutrition

Among the 377 patients diagnosed with malnutrition based on the GLIM criteria, the prevalence of malnutrition assessed using the SGA was 47.8%; of these, 21.0% were classified as moderately malnourished and 26.8% as severely malnourished, and the SGA could not be applied to 5.8% of them due to the lack of UWL information.

According to the GLIM-1 criteria, the prevalence of malnutrition was 65.5% (n= 247); 21.8% had moderate malnutrition, 22.5% had severe malnutrition, and in 21.2% of the patients, malnutrition severity could not be classified. Considering the etiologic criteria for the presence of inflammation in all the patients (GLIM-2), the prevalence of malnutrition was 68.9% (n= 288).

Table 2 shows the frequency of each etiologic and phenotypic criterion, with reduced MM being the most frequent phenotypic criterion (55.7%) and inflammation being the most frequent etiologic criterion (74.0%). All criteria, except inflammation, were significantly associated with malnutrition diagnosed based on the SGA, as shown in **Figure 1**.

Concurrent validity of the GLIM criteria

The accuracy metrics of the GLIM-1 criteria for identifying malnutrition in critically ill patients included an AUC-ROC of 0.835 (95% CI 0.790–0.880), sensitivity and NPV >90% and specificity and PPV >70%, as shown in **Table 3**. The agreement between the GLIM-1 criteria and SGA was substantial. When we considered all patients with the inflammation

criterion (GLIM-2 criteria), the AUC-ROC was 0.789 (0.743–0.835), sensitivity was 96.9%, specificity was 60.9%, and agreement between the GLIM-2 and SGA criteria was moderate.

Predictive validity of the GLIM criteria

Table 4 presents a comparison of the clinical and nutritional features and outcomes of patients grouped according to the presence or absence of malnutrition determined using the GLIM criteria (GLIM-1). Patients with malnutrition were older, had higher SOFA score, and had longer hospital LOS before admission to the ICU. In addition, they had a higher frequency of sepsis and surgical procedures than those observed in patients without malnutrition. The frequencies of MV use and HD on admission did not differ between the groups. Patients with malnutrition had lower usual and current body weights, higher %WL, and lower BMI, CC, and APMT than those observed in patients without malnutrition. Malnourished patients had a higher frequency of prolonged hospital and ICU LOS, ICU readmission, and hospital and ICU deaths, and no difference in the frequency of readmission and death within three months after discharge was observed between the groups.

As shown in **Table 5**, malnutrition identified using the GLIM-1 criteria increased the odds of prolonged ICU LOS by 1.74 times and of ICU readmission by 2.66 times after adjusting for confounders in the multivariate analysis. Malnutrition was not an independent predictor of prolonged hospital LOS, MV days, in-hospital and ICU deaths, readmission, or death within 3 months after discharge. When GLIM-2 was considered for the diagnosis of malnutrition, malnutrition was independently associated only with IUC readmission, increasing the odds for this outcome by 2.27 times.

DISCUSSION

This study aimed to evaluate the concurrent and predictive validity and the feasibility of the GLIM criteria for diagnosing malnutrition in critically ill patients. Among the 450 patients included in this study, the diagnosis of malnutrition was feasible in 83.8% of them, with a malnutrition prevalence of 65.5%. The sensitivity and NPV of the GLIM criteria compared with the SGA were greater than 90%, while the specificity and PPV were greater than 70%, indicating substantial agreement between the tools. Malnourished patients according to the GLIM criteria were more likely to have an ICU LOS $\geq$ 5 days and be readmitted to the ICU compared with patients without malnutrition.

The prevalence of malnutrition in the ICU ranged from 5 to 82% according to a systematic review that included 20 observational studies[3], which can be explained by the heterogeneity of patients and the different methods applied for malnutrition diagnosis. The literature on the prevalence of malnutrition according to the GLIM criteria in the ICU is still scarce, ranging from 18% to 68% [13-17,24,25]. A prevalence of less than 20% was reported in three studies with some particularities: a study involving overweight patients with COVID-19 (mean BMI, 27.8 kg/m²) that did not assess reduced MM (18%)[24], a Brazilian study involving critical trauma victims (18.2%) that did not report the criteria used for the malnutrition diagnosis,[16] and another Brazilian study that defined malnutrition only by reduced MAC, as they considered inflammation for all the patients (15%)[17]. In the present study, the prevalence of malnutrition was 65.5%, with 21.8% of the patients classified as moderately malnourished, 22.5% as severely malnourished, and 21.2% without indicators for classifying the severity of malnutrition. None of the studies that evaluated malnutrition according to the GLIM criteria in the ICU reported the feasibility and severity of malnutrition. The different clinical features of critically ill patients, their age, and the lack of uniformity in the application of the GLIM criteria are important determinants of the wide range of prevalence found among the studies.

The application of the GLIM criteria involves the evaluation of three phenotypic and two etiologic criteria, which was not followed by all studies involving critically ill patients[13-17,24,25]. Most studies considered all patients to have the etiologic criterion of inflammation based on the organic response observed in critically ill patients [14,15,17,25], while others did not report this information[13,16,24]. In our study, GLIM criteria for malnutrition diagnosis when inflammation criterion was considered for all patients presented lower specificity and was not an independent predictor of prolonged ICU LOS, suggesting that a more objective evaluation of inflammation (such as CRP evaluation) can be necessary. Regarding the phenotypic criteria, the greatest challenge is related to the evaluation of reduced MM, which was not performed in some studies involving critically ill patients[24,25] or was assessed using methods with limited accuracy and clinical applicability, such as the MAMC (due to the difficulty in measuring the tricipital skinfold thickness in the ICU)[15] and bioelectrical impedance analysis (because overestimation of lean body mass due to fluid retention is commonly observed in critically ill patients)[13,14]. In our study, the evaluation of this phenotypic criterion was feasible in 92.2% of the patients as we used three indicators (CC, APMT, and physical examination) as recommended by the Steering Committee of GLIM[12].

According to the GLIM criteria validation guide, concurrent validity must be assessed by calculating the sensitivity and specificity and comparing them with a standard semi-gold tool such as the SGA, with values greater than 80% considered as satisfactory. It is still recommended to evaluate the agreement between the methods, with a kappa coefficient greater than 0.80 considered as satisfactory[12]. In our study, the sensitivity was satisfactory; however, the specificity and kappa values did not reach the recommended cut-off values. We identified four studies that evaluated the concurrent validity of the GLIM criteria compared with the SGA. One study involving 109 critically ill patients with COVID-19 reported the study results in accordance with the recommendations of the validation guide (sensitivity and specificity greater than 90% and kappa greater than 0.80). However, reduced MM was evaluated using a single and questionable applicability indicator (MAMC), and inflammation was considered present in all the patients[15]. A retrospective study involving 84 critically ill patients also found satisfactory accuracy (sensitivity =80% and specificity=79%), but the authors also used a unique indicator to assess MM (fat free mass index using bioelectrical impedance analysis) and considered all patients as having inflammation[14]. Another retrospective cohort study of 120 patients found a sensitivity <70% and kappa <0.70, but the authors considered only patients with severe malnutrition[13]. Finally, a Brazilian study that involved 407 trauma victims demonstrated a sensitivity and specificity of 82.9% and 72.4%, respectively[16].

It is important to distinguish the particularities of accuracy metrics and their clinical implications: false negatives and false positives will have a different impact on clinical practice. Incorrect classification of malnourished patients as well-nourished (false negative) can lead to non-treatment, whereas an incorrect diagnosis of well-nourished patients as malnourished (false positive) can lead to overfeeding and has iatrogenic potential. Therefore, sensitivity and NPV of a diagnosis tool should be emphasized as they are related to true positive cases (malnourished individuals correctly identified by the test method), while specificity and PPV are related to true negative cases (well-nourished individuals correctly identified by the test method) [26]. A malnutrition diagnostic tool with low specificity in ICU settings should not be considered a major problem since nutritional therapy is not guided by nutritional status but rather guided by the stage of critical illness [27,28].

In our study, malnutrition identified using the GLIM criteria was an independent predictor of prolonged ICU LOS and ICU readmission and was not associated with the other evaluated outcomes. A few studies have evaluated the predictive validity of the GLIM criteria

in the ICU setting, and only Shahbazi et al. reported an association between malnutrition and in-hospital mortality, increasing its risk by more than four times (OR=4.01; 95% CI 1.44–11.12). However, the authors did not include severity scores in the multivariate analysis, and their study sample included patients with a reduced APACHE II score (mean=14.87), which may not represent all critically ill patients[15]. Two studies that evaluated predictive validity found no association between malnutrition and the outcomes of interest (LOS, MV duration, hospital mortality, and 60- and 90-day mortality after discharge) after adjusting for confounders, which can be explained by the small sample size (120[13] and 60[17]) and consequent lack of power for this assessment. According to the GLIM criteria validation guide, meaningful health outcomes, such as in-hospital mortality, major complications, 30-day mortality after discharge, 30- and 60-day readmission rate after discharge, and hospital LOS should be used to assess the predictive validity of the criteria. However, no specifications related to meaningful health outcomes in ICU settings have been provided[12]. Although in the current study malnutrition according to the GLIM criteria was not an independent predictor of any meaningful health outcome outlined in the validation guide, the duration of ICU stay and ICU readmission were identified as indicators of prognosis and were related to increased health costs in this setting; therefore, them should be considered as meaningful health outcomes[29,30].

Some limitations of our study must be pointed out in the interpretation of our results. First, we considered low APMT as an indicator of reduced MM; however, it is not one of the alternatives proposed by the GLIM Steering Committee[31]. Despite this limitation, some studies have already reported the prognostic value of low APMT in critically ill patients[32,33], and using this indicator, only 3.18% of the patients in our study were considered as having reduced MM using. We believe that the identification of reduced MM using physical examination could have overestimated the frequency of this criterion since more than 62.9% of our study participants were older than 60 years. In addition, we did not adjust the CC measure for adiposity, which could have underestimated the frequency of reduced MM using this criterion. Although a recent study proposed an adjustment of CC for BMI[34], its validity in hospital settings has not yet been investigated. We used self-reported weight and height data for estimating the BMI and UWL instead of using measured data. However, this study is a pragmatic study because measuring these anthropometric parameters in clinical practice is not feasible. In contrast, the strengths of this study should be highlighted. First, we included a large sample size of critically ill patients from six ICUs, providing sufficient power for our study. We also evaluated the five GLIM

criteria and followed a validation guide to test the predictive and concurrent validities of the criteria. Since all the criteria, except inflammation, were associated with malnutrition, our results suggest that it is important to fully apply this approach and consider all patients as having the etiologic criterion of inflammation when an objective parameter (such as CRP) is not available. Finally, we described the feasibility of each GLIM criterion and the feasibility of the criteria for malnutrition diagnosis, which has not been reported in previous studies and is essential for defining the applicability of the criteria in clinical practice.

Our results add evidence to the validity of the GLIM criteria in the ICU setting, since the results demonstrated high sensitivity and substantial agreement between this approach and the SGA. Furthermore, the results demonstrated the prognostic value of the GLIM criteria in predicting prolonged ICU LOS and ICU readmission. Future studies are necessary to evaluate the validity of the GLIM criteria in predicting patients who might respond to nutritional therapy[35]. In addition, it is necessary to test the validity of the GLIM criteria by considering the two straightforward steps that comprise this approach, with nutritional risk screening as the first step. In this study, the first step was not performed because there is no gold standard screening tool, and the application of different tools can influence the prevalence of malnutrition and the validity of the GLIM criteria, as previously demonstrated in our research that involved non-critically ill patients [36].

Conclusion

The GLIM criteria presented a sensitivity higher than 90%, specificity higher than 70%, and substantial agreement with the SGA for malnutrition diagnosis in critically ill patients. Malnourished patients diagnosed based on the GLIM criteria had a 1.7 and 2.6 times increase in the odds of ICU stay $\geq$5 days and ICU readmission, respectively. The application of the GLIM criteria was feasible in 83.7% of the study participants and was dependent on the anamnesis reported by patients' relatives in 47.6% of the patients.

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Conflict of interest

The authors declare no conflicts of interest.

Authorship

FMS contributed to the conception of the study. DSJM, ELR, JL, and FMS contributed to data acquisition. FMS and DSJM analyzed the data. FMS, DSJM JL, and ELR contributed to the interpretation of data. FMS and DSJM drafted the manuscript. All authors critically revised the manuscript, provided their final approval, and agreed to be accountable for all aspects of the work ensuring its integrity and accuracy.

Data sharing

All data can be shared if required with the corresponding author.

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Table 1 - Malnutrition diagnosis according to the GLIM criteria (GLIM -1)

Phenotypic Criteria	
Weight loss (%)	5 - 10% within past 6 months or 10 - 20% beyond 6 months - moderate >10% within past 6 months or >20% beyond 6 months - severe
Reduced BMI (Kg/m²)	BMI ≤ 20Kg/m² if <70 years, or BMI ≤ 22Kg/m² if >70 years - moderate BMI ≤18.5 kg/m² if age <70 years, or BMI ≤20 kg/m² if age ≥70 - severe
Reduced MM	Reduced adductor pollicis muscle thickness (< P5, according to age and sex - ref) and/or calf circumference (classified by the cut-off points ≤34cm for males and ≤33cm for females - ref), and physical examination (if presence of moderate or severe muscle mass loss) This criterion was not applied to classification of the severity since there is no established cut-off point for none indicator considered.
Etiologic Criteria	
Reduced food intake or assimilation	- Semi-quantitative evaluation based on patients´ self-reported percent of actual intake (100%, 75%, 50%, 25%, or 0%) compared to their usual intake, in the last two weeks. - Chronic GI conditions that adversely impact food assimilation or absorption (nausea, vomiting, gastric cancer, pancreatic syndrome, short bowel disease).
*Inflammation**	CRP (≥5 mg/dL)

Abbreviations: BMI = body mass index; CRP= C-reactive protein; GI = gastrointestinal; GLIM = Global Leadership Initiative on Malnutrition; MM= muscle mass. Adapted from Cederholm T et al. [11]
* GLIM-2 - this criterion was considered present for all patients due to the inflammatory response observed in critically ill patients.

Table 2 - Feasibility and Factibility of Malnutrition Diagnosis by the GLIM Criteria: Phenotypic and Etiological Criteria

	Total Sample (n=450)		**Feasible GLIM Sample (n=377)**	
	Impossibility	Checked Criterion	Impossibility	Checked Criterion
Phenotypic criteria n (%)				
UWL	25 (5.6%)	156 (34,7%)	18 (4.8%)	144 (38.2%)
Reduced BMI	17 (3.8%)	62 (13.8%)	12 (3.2%)	56 (14.9%)
Reduced MM	35 (7.8%)	241 (53.6%)	8 (2.1%)	210 (55.7%)
Etiological criteria n (%)				
Reduced energy Intake/ nutrients assimilation	5 (1.1%)	195 (43.3%)	3 (0.8%)	177 (46.9%)
Inflammation	129 (28.7%)	301 (66.9%)	79 (21%)	279 (74%)
Malnutrition diagnoses n (%)	73 (16.2%)	377 (83.7%)	-	247 (65.5%)
Malnutrition severity n (%)	-	-	80 (21.2%)	167 (44.2%)

Abbreviations: BMI = body mass index; GLIM = Global Leadership Initiative on Malnutrition; MM= muscle mass; UWL= unintentional weight loss.

Table 3 - Concurrent validity of GLIM criteria for malnutrition diagnosis considering Subjective Global Assessment as reference method

Accuracy metrics	**GLIM - 1 (n=377)**	**GLIM - 2 (n= 418)**
AUC-ROC (CI 95%)	0.835 (0.790 – 0.880)	0.789 (0.743 - 0.835)
Sensibility	96.6%	96.9%
Specificity	70.3%	60.9%
PPV	76.9%	70.2%
NPV	95.3%	95.3%
Kappa	0.671 (p <0.001)	0.572 (p <0.001)

Abbreviations: AUC = area under the curve; ROC = receiver operating characteristics; CI = confidence interval; GLIM = Global Leadership Initiative on Malnutrition; PPV= positive predictive value; NPV= negative predictive value. GLIM 1 = inflammation defined by CRP values; GLIM 2 = inflammation defined by the burden of the critical disease as present in all patients.

Table 4 - Features of critically ill patients grouped according to the presence of malnutrition diagnosed by GLIM Criteria.

Variables	Well-nourished patients *(n= 130)*	Malnourished patients *(n= 247)*	P - value
Clinical Features			
Age (years)	60.5 (46.7- 68.0)	65.0 (57.0 - 73.0)	< 0.001 [a]
SOFA score	5.0 (3.0 - 9.0)	7.0 (3.5 - 11.0)	0.023 [a]
Pre ICU days	1.0 (0 - 3.2)	3.0 (0 - 11.0)	< 0.001 [a]
Sepse diagnosis	15 (11.5%)	72 (29.1%)	< 0.001 [b]
Surgical procedures	103 (79.2%)	136 (55.1%)	< 0.001 [b]
MV at admission	61 (46.9%)	135 (54.7%)	0.187 [b]
HD at admission	9 (6.9%)	23 (9.3%)	0.551 [b]
Nutritional Features			
Current Weight (Kg)	81.6 ± 14.9	66.6 ± 14.9	< 0.001 [c]
Usual Weight (Kg)	80.0 (72.0 - 91.2)	71.0 (60.0 - 82.0)	< 0.001 [a]
UWL (%) (n= 209)	3.33 (2.4 - 4.3)	9.82 (6.3 - 16.0)	< 0.001 [a]
BMI (kg/m²)	28.19 (25.6 - 31.6)	23.4 (20.7 - 26.5)	< 0.001 [a]
CC (cm) (n= 346)	37.3 (35.5 - 40.0)	31.9 (29.9 - 35.0)	< 0.001 [a]
APMT (mm) (n= 335)	25.0 (23.0 - 28.0)	20.3 (17.3 - 23.6)	< 0.001 [a]
Nº Phenotypic criteria	0 (0-0)	2 (1-2)	< 0.001 [a]
Nº Etiological criteria	1 (0 - 1)	2 (1-2)	< 0.001 [a]
Outcomes			
MV days	2.0 (1.0 - 10.5)	2.0 (1.0 - 8.0)	0.777 [a]
Prolonged ICU LOS (>5 days)	52 (40.0%)	144 (58.5%)	0.001 [b]
Prolonged Hospital LOS (>20 days)	53 (40.8%)	141 (57.3%)	0.003 [b]

ICU readmission	8 (6.2%)	36 (14.6%)	0.024 [b]
Hospital death	19 (14.6%)	94 (38.1%)	< 0.001 [b]
ICU death	15 (11.5%)	65 (26.3%)	0.001 [b]
3m after discharge readmission *	15 (16.5%)	33 (28.7%)	0.058 [b]
3m after discharge death *	2 (2.2%)	8 (6.9%)	0.191 [d]

Abbreviations: APMT = aductor pollicis; BMI = body mass index; CC= calf circumference; GLIM = Global Leadership Initiative on Malnutrition; HD= hemodialysis; ICU= intensive care unit; LOS= length of stay; MV= mechanical ventilation; UWL= unintentional weight loss.

[a] *Mann Whitney test.* [b] *Chi-Square test* [c] *Test T Student* [d] *Fisher Test.*

* 3 m after discharge (n =243): well-nourished patients (n = 91) and malnourished patients (n = 152)

Table 5 - Predictive validity of GLIM criteria for malnutrition diagnosis: multivariate analysis

	GLIM - 1		GLIM - 2	
Dependent variables	**OR [a]/HR [b] (IC 95%)**	**p-value**	**OR [a]/HR [b] (IC 95%)**	**p-value**
Prolonged ICU LOS (5≥ days) [a]				
Crude	2.103 (1.364 - 3.243)	0.001	1.775 (1.165 - 2.705)	0.008
Adjusted	**1.749 (1.084 - 2.821)**	**0.022**	1.520 (0.961 - 2.405)	0.073
Prolonged Hospital LOS (≥20 days) [a]				
Crude	1.937 (1.258 - 2.983)	0.030	1.648 (1.083 - 2.508)	0.020
Adjusted	1.194 (0.726 - 1.964)	0.486	1.061 (0.657 - 1.712)	0.809
MV duration (≥ 2 days) [a]				
Crude	1.167 (0.674 - 2.020)	0.581	1.039 (0.608 - 1.776)	0.888
Adjusted	0.990 (0.543 - 1.806)	0.973	0.880 (0.495 - 1.564)	0.663
ICU readmission [a]				
Crude	2.614 (1.177 - 5.806)	0.018	2.327 (1.054 - 5.141)	0.037
Adjusted	**2.660 (1.153 - 6.137)**	**0.022**	**2.270 (1.004 - 5.144)**	**0.050**
ICU Death [b]				
Crude	1.719 (0.979 - 3.020)	0.059	1.574 (0.896 - 2.764)	0.115
Adjusted	1.579 (0.889 - 2.804)	0.119	1.442 (0.813 - 2.558)	0.210
Hospital Death [b]				
Crude	1.701 (1.033 - 2.800)	0.037	1.553 (0.944 - 2.553)	0.083
Adjusted	1.562	0.086	1.400	0.192

	(0.939 - 2.601)		(0.844 - 2.323)	
3M after discharge readmission [a]				
Crude	2.039 (1.027 - 4.047)	0.042	1.882 (0.968 - 3.658)	0.062
Adjusted	1.704 (0.811 - 3.577)	0.159	1.718 (0.855 - 3.449)	0.128
3M after discharge Death [a]				
Crude	3.259 (0.675 - 15.742)	0.141	2.569 (0.533 - 12.380)	0.240
Adjusted	1.443 (0.264 - 7.870)	0.672	1.220 (0.227 - 6.543)	0.817

Abreviations: GLIM = Global Leadership Initiative on Malnutrition; HD= hemodialysis; ICU= intensive care unit; LOS= length of stay; MV= mechanical ventilation.

Model adjusted for age, SOFA, pre-UCI days, and e surgical

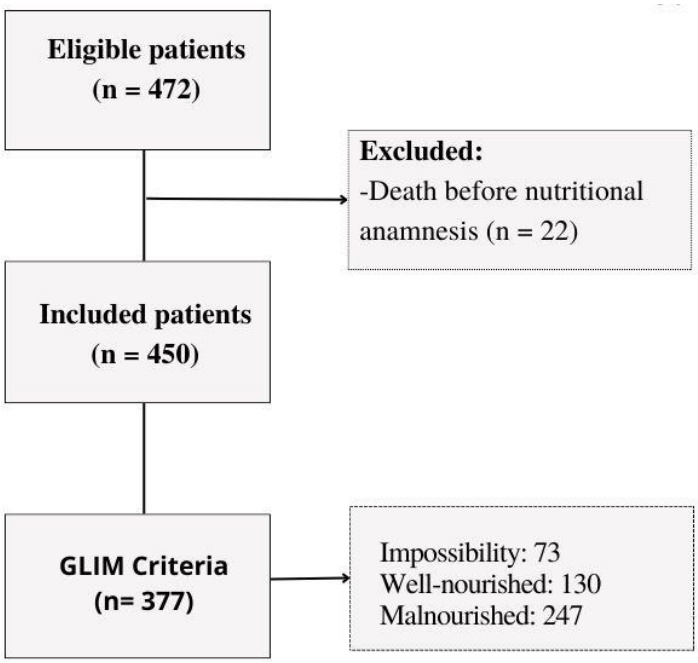
[a] *Logistic regression* [b] *Cox regression*

Feasibility and criterion validity of the GLIM criteria for the diagnosis of malnutrition in critically ill patients: a longitudinal study

Danielle Silla Jobim Milanez[1], Elisa Loch Razzera[1], Júlia Lima[1], Flávia Moraes Silva [2]

Supplementary Material

Supplementary Figure 1 - Flow chart of patients selection



Supplementary Table 1 - Clinical features, nutritional characteristics and outcomes of all sample

Variables	Total sample *(n= 450)*
Clinical Features	
Age (years)	64.0 (54.0 - 71.0)
SOFA score	6.0 (3.0 - 10.0)
Pre ICU days	1.0 (0.0 - 7.0)
Sepse diagnosis	100 (22.2%)
Surgical procedures	291 (64.7%)
MV at admission	240 (53.3%)
HD at admission	36 (8.0%)
Nutritional Features	
Current Weight (Kg)	72.2 $\pm$ 17.1
Usual Weight (Kg)	75.0 (63.2 - 85.0)
UWL (%) (n= 209)	8.6 (5.2 - 14.2)
BMI (kg/m²)	25.2 (22.3 - 29.1)
CC (cm) (n= 346)	34.5 (31.0 - 37.4)
APMT (mm) (n= 335)	22.3 (18.6 - 25.0)
Nº Phenotypic criteria	1 (0-1)
Nº Etiological criteria	1 (1 - 2)
Outcomes	
MV days	2.0 (1.0 - 8.0)
Prolonged ICU LOS (>5 days)	229 (50.9%)
Prolonged Hospital LOS (>20 days)	225 (50.1%)
ICU readmission	53 (11.8%)

Hospital death	130 (28.9%)
ICU death	90 (20.0%)
3m after discharge readmission *	60 (24.7%)
3m after discharge death *	11 (4.5%)

Abbreviations: BMI = body mass index; MV= mechanical ventilation; HD= hemodialysis; UWL= unintentional weight loss; CC= calf circumference; APMT = aductor pollicis LOS= length of stay; ICU= intensive care unit; GLIM = Global Leadership Initiative on Malnutrition.

* 3 m after discharge (n =243): well-nourished patients (n = 91) and malnourished patients (n = 152)

CONSIDERAÇÕES FINAIS

A desnutrição no ambiente hospitalar ainda é uma condição muito frequente e está associada a piores desfechos. Dentre os pacientes hospitalizados, o paciente crítico apresenta uma resposta metabólica mediada por citocinas pró-inflamatórias e hormônios contrarreguladores, que contribuem para o comprometimento do estado nutricional, sendo o diagnóstico de desnutrição um desafio no ambiente de UTI. Conforme já abordado anteriormente, a ASG é um método considerado como referência, contudo apresenta limitações e não é universalmente aceita para o diagnóstico de desnutrição devido aos desafios relacionados à sua aplicabilidade. Com intuito de padronizar o método para diagnóstico em desnutrição ao redor do mundo, comitês internacionais de nutrição clínica propuseram os critérios do GLIM para diagnóstico de desnutrição.

O presente trabalho teve como objetivo avaliar o estado da arte acerca da aplicação dos critérios do GLIM em pacientes hospitalizados, explorando sua metodologia de aplicação e a adesão dos mesmos às orientações sobre validação dos critérios do GLIM. Além disso, investigar a validade de critério dessa proposta, bem como a factibilidade da aplicação dos critérios do GLIM para o diagnóstico de desnutrição em pacientes críticos adultos e idosos. Para responder a estes objetivos foram conduzidos uma revisão de escopo e um estudo original, com os seguintes achados: 1) os critérios do GLIM têm sido aplicados de forma heterogênea e as recomendações das orientações sobre validação raramente foram aderidas; 2) os critérios do GLIM foram factíveis em mais de 80% dos pacientes críticos, apresentaram sensibilidade >90%, especificidade >70% e concordância substancial com a ASG em pacientes críticos, além de ser preditor independente de permanência prolongada na UTI e readmissão na UTI.

Os resultados mapeados na revisão de escopo reforçam a necessidade de estudos com melhor detalhamento acerca dos métodos de aplicação de cada critério proposto pelo GLIM, bem como de maior adesão às recomendações do guia de validação publicado pelo Comitê do GLIM. Por outro lado, no que diz respeito à validade concorrente e preditiva dos critérios do GLIM em paciente crítico, apesar dos nossos achados não terem atendido a todos os pré requisitos elencados pelo guia de validação, (haja vista que a especificidade foi inferior à 80% e a concordância, embora substancial, não atingiu o kappa=0,8), os resultados são promissores. Isso pois, em termos de aplicabilidade na prática clínica a alta sensibilidade é necessária já que identificar equivocadamente um paciente desnutrido como sem desnutricao no ambiente de

UTI pode levar a uma negligência acerca do manejo de pacientes com risco de síndrome de realimentaçaão, condicao associada a piores desfechos e que tem a desnutricao como um fator de risco. Ainda, uma menor especificidade irá implicar em maior frequência de falsos positivos, ou seja, pacientes sem desnutrição diagnosticados como desnutridos. Identificar um paciente de forma equivocada como desnutrido no ambiente de UTI não deve ser considerado um grande problema, uma vez que a terapia nutricional não é guiada pelo estado nutricional, mas sim pelo estágio da doença crítica. Porém, apesar de válidos, os critérios do GLIM puderam ser aplicados em 80% da amostra e o diagnóstico foi dependente da anamnese com familiar em cerca de metade dos casos. Mas a sua objetividade torna a proposta interessante, já que depender de anamnese é uma limitação intrínsica de todos os métodos que conhecemos para diagnóstico de desnutrição.

Como perspectivas futuras, ainda é necessário avaliar se há algum indicador de massa muscular reduzida mais apropriado para definição desse critério fenotípico que compõe o diagnóstico de desnutrição proposto pelo GLIM. Além disso, é importante avaliar se há alguma e qual a combinação de critérios está associada a pior prognóstico, para que no futuro, essa informaçaão possa ser considerada em um algoritmo norteador da tomada de decisão acerca da intervenção nutricional mais apropriada para cada paciente. Ainda, pesquisas futuras devem ser realizadas para investigar se o diagnóstico de desnutrição realizado através dos critérios do GLIM pode predizer o impacto da terapia nutricional na incidência dos desfechos clínicos. Esta avaliação pode, idealmente, ser investigada através de um ensaio clínico randomizado, comparando pacientes com e sem desnutrição alocados em grupos com intervenção nutricional mais agressiva e menos agressiva.

ANEXO - Termo de Consentimento Livre e Esclarecido

Termo de Consentimento Livre e Esclarecido - Familiar

Seu familiar, _____, está sendo convidado para participar do projeto de pesquisa "**Validade de ferramentas para identificação de risco nutricional e desnutrição em pacientes críticos: estudo de coorte prospectivo**". Esse estudo tem por objetivo avaliar o estado nutricional de pacientes hospitalizados em unidade de terapia intensiva (UTI) a partir de diferentes ferramentas que definem se o paciente apresenta risco nutricional ou desnutrição, a fim de identificar o quanto essas ferramentas acertam nesse diagnóstico e qual a ferramenta mais acurada para triagem nutricional e diagnóstico nutricional, duas etapas importantes no cuidado nutricional desses pacientes.

Isso é importante pois já sabemos que pacientes críticos com risco nutricional ou que já apresentem desnutrição tem uma pior condição clínica e menor chance de melhora, mas ainda existem poucas formas confiáveis para identificar quais pacientes apresentam risco nutricional e desnutrição. Por isso, esse estudo está sendo proposto e você está sendo convidado a participar.

Esse projeto de pesquisa será realizado nas UTIs do Complexo Hospitalar Santa Casa. Caso você concorde com a participação do seu familiar neste estudo, será convidado a responder algumas perguntas sobre a história nutricional, o consumo alimentar e o peso corporal dele. Faremos a estimativa do peso e da altura dele a partir da medida da circunferência do braço e da medida da altura do joelho. Faremos também a medida da circunferência da sua panturrilha e da espessura do músculo adutor do polegar (um músculo que fica entre o seu dedo indicador e polegar) para verificar se há perda de massa muscular. Nós entraremos em contato com o seu familiar após três e seis meses da sua alta hospitalar para sabermos como ele está e se ele precisou reinternar neste período e por qual motivo - para isso precisaremos que você nos informe um contato telefônico. Nós acessaremos o prontuário médico do seu familiar para acompanhar a evolução clínica até que ele receba alta hospitalar.

Esse estudo poderá contribuir com a validação de novos métodos de triagem de risco nutricional e de diagnóstico de desnutrição na UTI. Você não é obrigado a concordar com a participação do seu familiar no estudo e pode retirar o seu consentimento em qualquer momento caso desista da participação. Se você não quiser participar do estudo, o atendimento do seu familiar no hospital não terá nenhuma alteração. O risco associado à participação nesse estudo é mínimo, já que as perguntas relacionadas ao risco nutricional já são feitas pela nutricionista na rotina assistencial, assim como as medidas antropométricas. Caso você não queira responder a qualquer uma das perguntas ou não queira que alguma medida antropométrica seja realizada em seu familiar, o pesquisador não a realizará.

Eu,....., fui informado dos objetivos especificados acima e da justificativa desta pesquisa de forma clara e detalhada. Recebi informações específicas sobre cada procedimento no qual o participante estará envolvido, dos desconfortos ou riscos previstos tanto quanto dos benefícios esperados. Todas as minhas dúvidas foram respondidas com clareza e sei que poderei solicitar novos esclarecimentos a qualquer momento. Além disso, sei que novas informações obtidas durante o estudo me serão fornecidas e que terei liberdade de retirar meu consentimento de participação na pesquisa face a estas informações.

O profissional Dr/Dra. ..... certificou-me de que as informações coletadas terão caráter confidencial. Fui informado que não haverá nenhum gasto com a participação nesta pesquisa. Potenciais prejuízos decorrentes diretamente da pesquisa

serão ressarcidos pelos pesquisadores. Os dados coletados serão utilizados apenas para a realização deste estudo e o nome dos participantes não será divulgado em nenhum momento.
Os dados obtidos serão utilizados somente para este estudo, sendo os mesmos armazenados pela pesquisadora principal durante 5 (cinco) anos e após totalmente destruídos (conforme preconiza a Resolução 466/12). Todos os documentos relacionados ao estudo e o processamento computadorizado dos dados (informações e resultados) serão tratados de forma confidencial e somente números e iniciais identificarão seu familiar, garantindo o sigilo dos dados.
EU_____, recebi as informações sobre os objetivos e a importância desta pesquisa de forma clara e concordo em participar do estudo. Declaro que também fui informado:

- Da garantia de receber resposta a qualquer pergunta ou esclarecimento acerca dos assuntos relacionados a esta pesquisa.
- De que minha participação é voluntária e terei a liberdade de retirar o meu consentimento, a qualquer momento e deixar de participar do estudo, sem que isto traga prejuízo para a vida pessoal e nem para o atendimento prestado ao meu familiar.
- Da garantia que meu familiar não será identificado quando da divulgação dos resultados e que as informações serão utilizadas somente para fins científicos do presente projeto de pesquisa.
- Sobre o projeto de pesquisa e a forma como será conduzido e que em caso de dúvida ou novas perguntas poderei entrar em contato com a pesquisadora responsável pela pesquisa: Flávia Moraes Silva, pelo telefone 995752778 ou pelo e-mail flaviams@ufcspa.edu.br, ou na Universidade - Rua Sarmento Leite, 245, prédio III, sala 507.
- Também que, se houverem dúvidas quanto a questões éticas, poderei entrar em contato com Comitê de Ética em Pesquisa da Irmandade Santa Casa de Misericórdia de Porto Alegre – telefone 3214.8571 , Endereço: Av. Independência, 155 – 6º andar- Hospital Dom Vicente Scherer - POA/RS, caso esteja internado em algum dos hospitais do Complexo Hospitalar Santa Casa durante a participação no estudo.
- Atesto que recebi uma via deste termo de consentimento.

Assinatura do paciente: .....
Assinatura do investigador: .....

Pesquisador responsável: Flávia Moraes Silva

Termo de Consentimento Livre e Esclarecido - Paciente

Você está sendo convidado para participar do projeto de pesquisa "**Validade de ferramentas para identificação de risco nutricional e desnutrição em pacientes críticos: estudo de coorte prospectivo**". Esse estudo tem por objetivo avaliar o estado nutricional de pacientes hospitalizados em unidade de terapia intensiva (UTI) a partir de diferentes ferramentas que definem se o paciente apresenta risco nutricional ou desnutrição, a fim de identificar o quanto essas ferramentas acertam nesse diagnóstico e qual a ferramenta mais acurada para triagem nutricional e diagnóstico nutricional, duas etapas importantes no cuidado nutricional desses pacientes.

Isso é importante pois já sabemos que pacientes críticos com risco nutricional ou que já apresentem desnutrição tem uma pior condição clínica e menor chance de melhora, mas ainda existem poucas formas confiáveis para identificar quais pacientes apresentam risco nutricional e desnutrição. Por isso, esse estudo está sendo proposto e você está sendo convidado a participar.

Esse projeto de pesquisa será realizado nas UTIs do Complexo Hospitalar Santa Casa. Caso você concorde em participar do estudo, será convidado a responder algumas perguntas sobre sua história nutricional, seu consumo alimentar e peso corporal. Faremos a estimativa do seu peso e da sua altura a partir da medida da circunferência do seu braço e da medida da altura do seu joelho. Faremos também a medida da circunferência da sua panturrilha e da espessura do músculo adutor do polegar (um músculo que fica entre o seu dedo indicador e polegar). Nós entraremos em contato com você após três e seis meses da sua alta hospitalar para sabermos como está a sua saúde e se você precisou reinternar neste período e por qual motivo - para isso precisaremos que você nos informe um contato telefônico. Nós acessaremos o seu prontuário médico para acompanhar a sua evolução clínica até a sua alta hospitalar.

Esse estudo poderá contribuir com a validação de novos métodos de triagem de risco nutricional e de diagnóstico de desnutrição na UTI. Você não é obrigado a concordar em participar do estudo e pode retirar o seu consentimento em qualquer momento caso desista da participação. Se você não quiser participar do estudo, o seu atendimento no hospital não terá nenhuma alteração. O risco associado à participação nesse estudo é mínimo, já que as perguntas relacionadas ao risco nutricional já são feitas pela nutricionista na rotina assistencial, assim como as medidas antropométricas. Caso você não queira responder a qualquer uma das perguntas ou não queira que alguma medida antropométrica seja realizada, o pesquisador não a realizará.

Eu,....., fui informado dos objetivos especificados acima e da justificativa desta pesquisa de forma clara e detalhada. Recebi informações específicas sobre cada procedimento no qual o participante estará envolvido, dos desconfortos ou riscos previstos tanto quanto dos benefícios esperados. Todas as minhas dúvidas foram respondidas com clareza e sei que poderei solicitar novos esclarecimentos a qualquer momento. Além disso, sei que novas informações obtidas durante o estudo me serão fornecidas e que terei liberdade de retirar meu consentimento de participação na pesquisa face a estas informações.

O profissional Dr/Dra. ..... certificou-me de que as informações coletadas terão caráter confidencial. Fui informado que não haverá nenhum gasto com a participação nesta pesquisa. Potenciais prejuízos decorrentes diretamente da pesquisa serão ressarcidos pelos pesquisadores. Os dados coletados serão utilizados apenas para a realização deste estudo e o nome dos participantes não será divulgado em nenhum momento.

Os dados obtidos serão utilizados somente para este estudo, sendo os mesmos armazenados pela pesquisadora principal durante 5 (cinco) anos e após totalmente destruídos (conforme preconiza a Resolução 466/12). Todos os documentos relacionados ao estudo e o processamento computadorizado dos dados (informações e resultados) serão tratados de forma confidencial e somente números e iniciais identificarão você, garantindo o sigilo dos dados.
EU_____, recebi as informações sobre os objetivos e a importância desta pesquisa de forma clara e concordo em participar do estudo. Declaro que também fui informado:

- Da garantia de receber resposta a qualquer pergunta ou esclarecimento acerca dos assuntos relacionados a esta pesquisa.
- De que minha participação é voluntária e terei a liberdade de retirar o meu consentimento, a qualquer momento e deixar de participar do estudo, sem que isto traga prejuízo para a minha vida pessoal e nem para o atendimento prestado a mim.
- Da garantia de que não serei identificado quando da divulgação dos resultados e que as informações serão utilizadas somente para fins científicos do presente projeto de pesquisa.
- Sobre o projeto de pesquisa e a forma como será conduzido e que em caso de dúvida ou novas perguntas poderei entrar em contato com a pesquisadora responsável pela pesquisa: Flávia Moraes Silva, pelo telefone 995752778 ou pelo e-mail flaviams@ufcspa.edu.br, ou na Universidade - Rua Sarmento Leite, 245, prédio III, sala 507.
- Também que, se houverem dúvidas quanto a questões éticas, poderei entrar em contato com Comitê de Ética em Pesquisa da Irmandade Santa Casa de Misericórdia de Porto Alegre – telefone 3214.8571 , Endereço: Av. Independência, 155 – 6º andar- Hospital Dom Vicente Scherer - POA/RS, caso esteja internado em algum dos hospitais do Complexo Hospitalar Santa Casa durante a participação no estudo.
- Atesto que recebi uma cópia deste termo de consentimento.

Assinatura do paciente: .....
Assinatura do investigador: .....

Pesquisador responsável: Flávia Moraes Silva