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Narrative Review

Utilization and validation of the Global Leadership Initiative on Malnutrition (GLIM): A scoping review

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SUMMARY

Background & aims: The diagnosis of malnutrition remains a significant challenge despite various published diagnostic criteria. In 2018, the Global Leadership Initiative on Malnutrition (GLIM) published a set of evidence-based criteria as a framework for malnutrition diagnosis in adults. A scoping review was conducted to understand how the GLIM criteria have been used in published literature and compare the reported validation methods to published validation guidance.

Methods: Dialog and Dimensions databases were searched by publication date (January 1, 2019, through January 29, 2021). Data were extracted and mapped to the research objectives.

Results: Seventy-nine studies were reviewed; 32% were in patients at least 65 years of age; 67% occurred in hospitals. The majority were cohort studies (61%). Fifty-seven percent employed all 5 GLIM criteria. Regarding phenotypic criteria, 92% used low BMI, and 45% applied anthropometry as a marker for muscle mass, of which 54% used calf circumference. Regarding etiologic criteria, 72% used reduced food intake/assimilation, and 85% applied inflammation/disease burden. Validation of GLIM criteria was described in 77% of publications.

Conclusions: The GLIM criteria have been studied extensively since their publication. Low BMI was the phenotypic criterion used most often, whereas both reduced food intake/assimilation and inflammation/disease burden were frequently employed as the etiologic criteria. However, how the criteria were combined and how validation was conducted were not clear in most studies. Adequately powered, methodologically sound validation studies using the complete GLIM criteria are needed in various patient populations and disease settings to assess validity for the diagnosis of malnutrition.

1. Introduction

Malnutrition is a global problem across the continuum of care. Evidence consistently shows this condition results in poorer outcomes for patients and healthcare systems and is associated with adverse outcomes, including an elevated risk of complications, longer lengths of stay (LOS), more frequent readmissions, higher mortality rates, and increased healthcare costs [1–4]. Yet, diagnosing malnutrition remains a significant challenge throughout healthcare settings, particularly for non-nutrition experts.

One potential challenge in diagnosing and treating malnutrition is its evolving diagnostic criteria. Historically, malnutrition was identified using a parameter such as food intake, body weight changes, and laboratory measures (eg, albumin). However,

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drawbacks of these variables indicate they should not be used by themselves to diagnose malnutrition [5–7]. In an effort to unify terminology and criteria, the Academy of Nutrition and Dietetics (AND) and the American Society for Enteral and Parenteral Nutrition (ASPEN) published a joint consensus statement in 2012 on the characteristics for diagnosing adult malnutrition [5]. In 2015, the European Society for Clinical Nutrition and Metabolism (ESPEN) issued its consensus statement on the diagnostic criteria for malnutrition applicable to all clinical settings. The ESPEN consensus differs from the AND-ASPEN consensus with its inclusion of body mass index (BMI) as a diagnostic criterion (Fig. 1) [8].

Evolving criteria and lack of agreement between nutrition societies highlight the need for a global set of diagnostic criteria suitable for use in any healthcare setting and patient population. In late 2018, the Global Leadership Initiative on Malnutrition (GLIM) published a consensus on malnutrition diagnosis, representing experts from several international clinical nutrition societies including ESPEN, ASPEN, Parenteral and Enteral Nutrition Society of Asia (PENSA) and Federación Latinoamericana de Terapia Nutricional, Nutrición Clínica y Metabolismo (FELANPE) [9]. The GLIM consensus proposed a two-step model: 1) screening to identify "at-risk" status using any validated screening tool, and 2) assessing to diagnose and grade the severity of malnutrition (Fig. 1 and Table 1) [9]. This consensus includes a minimal set of clinically relevant diagnostic criteria that can be applied in a variety of settings and patient populations [10]. Since its publication, the GLIM criteria have been included in numerous studies. However, an understanding of their application in clinical practice and validation in research is needed, as the practice of sound science is foundational to providing evidence-based nutrition care for human health and as a human right [11].

The criteria are a proposed framework based on expert opinion; however, its validity to diagnose malnutrition needs to be established. Recently, Keller et al., and de van der Schueren et al., published a validation process for the GLIM criteria, providing best-practice guidance on conducting retrospective and prospective studies to evaluate criterion and construct validity and reliability of the framework [12,13].

This scoping review was conducted to understand how the GLIM criteria have been used in published literature in adult (age >18 years) patient populations and compare the reported validation methods to published validation guidance (Table 2).

To understand how GLIM is being utilized, two research questions guided this scoping review:

1. How have the GLIM criteria been evaluated in the literature?
2. How do the validation methods reported in the literature compare to the published guidance on validation of operational criteria for diagnosing malnutrition [12,13]?

2. Materials and methods

The protocol was drafted according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis Extension for Scoping Reviews (PRISMA-ScR) guidelines and checklist before the literature search and data extraction were conducted [14].

The search strategy was developed by a health science librarian (BH) and all study authors. Multiple searches were conducted using Dialog databases (Allied & Complementary Medicine™, BIOSIS Previews®, Embase®, EMCare®, FSTA®, International Pharmaceutical Abstracts, MEDLINE®, ToxFile®) and Dimensions database, using database-specific strategies and following the PRISMA-ScR guidelines. The Dialog strategy search included abstracts with either the terms "Global Leadership Initiative on Malnutrition" or "GLIM" and publication dates after 2018 (ie, ((Global n/2 Leadership n/2 Initiative n/2 Malnutrition)) or (GLIM n/3 criter*)) AND pd (>2018)). The Dimensions search strategy included full-text publications between 2019 and 2021 with the keywords "Global

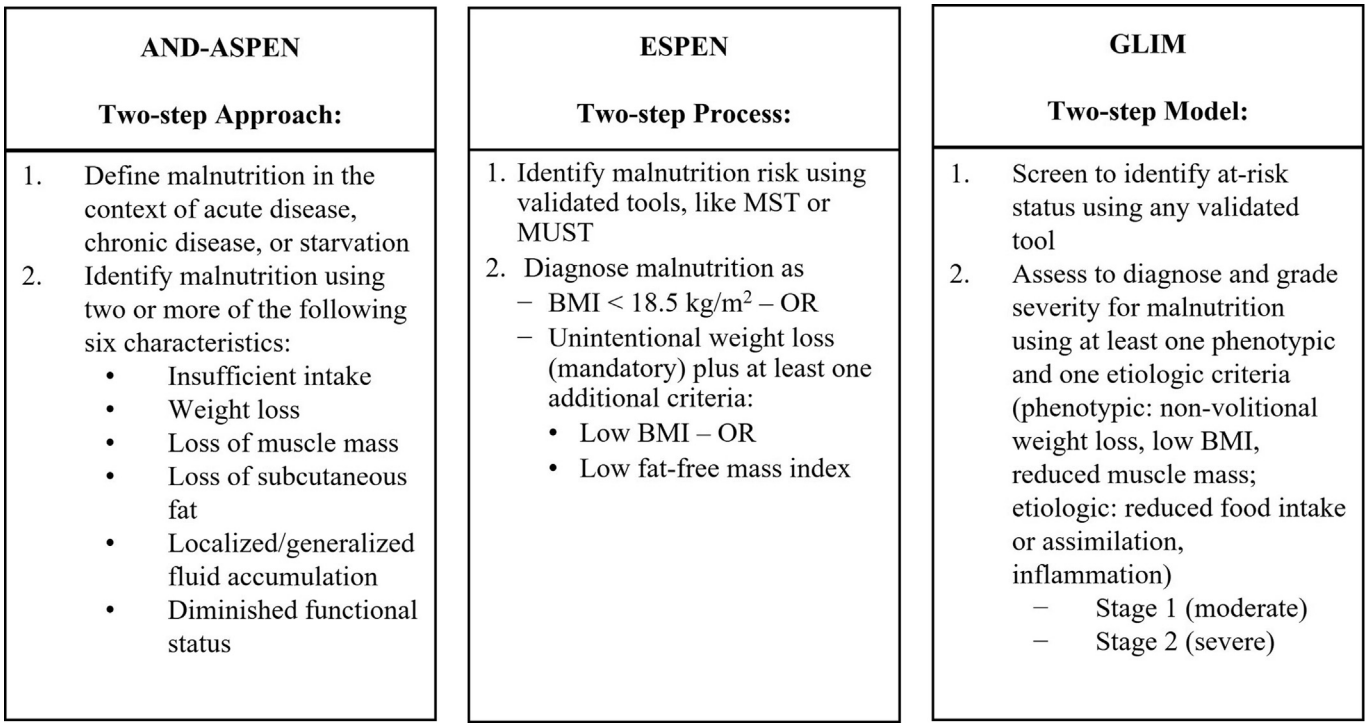

Fig. 1. A summary of diagnostic criteria/characteristics for identifying malnutrition in adults from the Academy of Nutrition and Dietetics (AND) and the American Society for Parenteral Enteral and Nutrition (ASPEN) (left) [5], the European Society for Clinical Nutrition and Metabolism (ESPEN) (middle) [8], and the Global Leadership Initiative on Malnutrition (GLIM) (right) [9].

Table 1
Global Leadership Initiative on Malnutrition (GLIM) criteria and thresholds for the diagnosis of malnutrition [9].

Phenotypic criteria			Etiologic criteria	
Non-volitional weight loss (%)	Low BMI (kg/m^2)	Reduced muscle mass	Reduced food intake or assimilation	Inflammation
>5% within past 6 months, or > 10% beyond 6 months	<20 if < 70 years or <22 if > 70 years Asia: < 18.5 is < 70 years or <20 if > 70 years	Reduced by validated body composition measuring techniques [FFMI, kg/m^2 by DXA or corresponding standards using other body composition methods like BIA, CT or MRI]	<50% of energy requirements >1 week, or any reduction for >2 weeks, or GI symptoms or chronic GI condition that adversely impacts food intake/ absorption/assimilation	Acute disease/injury or chronic disease-related; C-reactive protein may be used as a supportive measure

*Requires at least one phenotypic criterion and one etiologic criterion for the diagnosis of malnutrition. BMI = body mass index; FFMI = fat free mass index; DXA = dual-energy X-ray absorptiometry; BIA = bioelectrical impedance analysis; CT = computerized tomography; MRI = magnetic resonance imaging; GI = gastrointestinal.

Table 2
Inclusion criteria.

Population	Human patient populations Age ≥18 years Any condition or disease-state Any healthcare setting
Concept	GLIM publications between January 1, 2019, through January 29, 2021
Context	Full-text, peer-reviewed publications Utilization of the GLIM criteria Written in English

Leadership Initiative Malnutrition" and the requirement that all keywords be within five terms of one another. A secondary search was conducted using proximity filters to identify results where "GLIM" was associated with the terms "nutrition" or "criteria". The search was conducted in January 2021; results were limited by publication date (January 1, 2019, through January 29, 2021). The authors reviewed the search results to determine their relevance to the research questions.

Two reviewers (AS and SB) independently reviewed titles and abstracts for inclusion. Articles were considered for full-text review when inclusion criteria were met: 1) full-text, peer-reviewed publication, 2) used GLIM criteria, 3) written in English, and 4) conducted in adult patient populations 18 years of age and older. Abstracts, narrative reviews, editorials, commentaries, book chapters, and manuscripts submitted for publication but not yet peer-reviewed were excluded. Selected articles for full-text review were then independently reviewed by the two reviewers (AS and SB).

2.1. Charting the results

Search results were compiled, and duplicate citations were removed. Extracted information included: author(s); publication year; country of origin; objective(s); study population; study design; malnutrition screening tools used (eg, Malnutrition Screening Tool [MST]), nutritional assessment tools used (eg, Subjective Global Assessment [SGA]); comparator(s) to GLIM; sample size estimation; intervention; type of validity (concurrent, predictive, and construct as defined by Keller et al., and de van der Schueren et al., [12,13]); reliability; outcome(s); malnutrition prevalence and severity (Stage 1/moderate; Stage 2/severe); and GLIM criteria. These extracted data were entered into an Excel spreadsheet (Table 1 – Supplementary Material). Each citation was screened using the inclusion and exclusion criteria. Two reviewers (AS and SB) independently collected data for the first ten publications to refine the template and ensure data charting consistently reflected our research questions. Disagreements to include or exclude publications or address differences in charting were resolved by consensus with additional reviewers (KT and MITDC).

2.2. Analysis and summary of results

Extracted data for each variable were collated and analyzed. Heat maps were generated from the extracted data to visualize the frequency of publications for a particular variable. Descriptive statistics as frequencies and percentages were used to analyze the data and map them to the research questions. In addition, validity data were evaluated using the published guidance for validating operational criteria for malnutrition [12,13].

3. Results

3.1. Search results

The database search identified 595 publications (Fig. 2). No additional publications were found through other sources. After duplicates (n = 3) and other non-eligible publications were removed (eg, book chapters, conference abstracts, guidelines, theses, and reviews, n = 118), 474 articles were reviewed for eligibility. Of these, 395 were excluded for the following reasons: published in a non-peer-reviewed journal (n = 5), not a full-text research publication (n = 116), GLIM criteria not used (n = 122), non-adult study population (n = 4), language (n = 54), and publication type (n = 94). The final review included 79 published studies (Table 1 – Supplementary Material).

3.2. Study characteristics

Table 3 describes the study characteristics for all 79 publications. Of these, 25 (32%) were conducted in patients at least 65 years of age [15–39]. In addition, the majority were conducted in acute care/hospital settings (n = 53; 67%) [15,16,18,19,23–25,31–34], [36,37,40–79], followed by community and outpatient settings (n = 20, 26%) [17,20,26–29,35,38,80–91] and home care and nursing homes (n = 4; 5%) [21,22,30,92]; and 2 (3%) studies did not specify the setting [39,93]. Cancer was the most frequently reported diagnosis (n = 20; 26%) [36,39,45–48,55,56,64, 69,73–75,78,79,83,85,87,91,92]; other diagnoses included COVID-19 (n = 5; 6%) [42,52,63,67,77], gastrointestinal (GI) (n = 5; 6%) [51,53,54,58,82], renal (n = 4; 5%) [43,84,86,90], and cardiovascular diseases (CVD) (n = 3; 4%) [23,32,57]. Several studies were categorized as "other" because their patient populations were described by specific care settings rather than diagnoses, such as acute care/hospital setting or primary care, (n = 31; 39%) [15–19,21,22,24,26–28,30,35,37,38,40,41,44,49,59–62,66,68,71,76, 80,81,89,93]. Most studies were conducted in multiple countries throughout Europe (n = 39; 49%) [16–18,20–22,24–31,36, 42,43,45–48,51,52,55,56,59,60,63,66–68,71,80,81,87–89,92,93] and Asia (n = 31; 39%) [15,19,23,32–35,37–39,41,57,58,61,62, 64,69,70,72–79,83,84,86,90,91]; 4 studies (5%) were conducted in

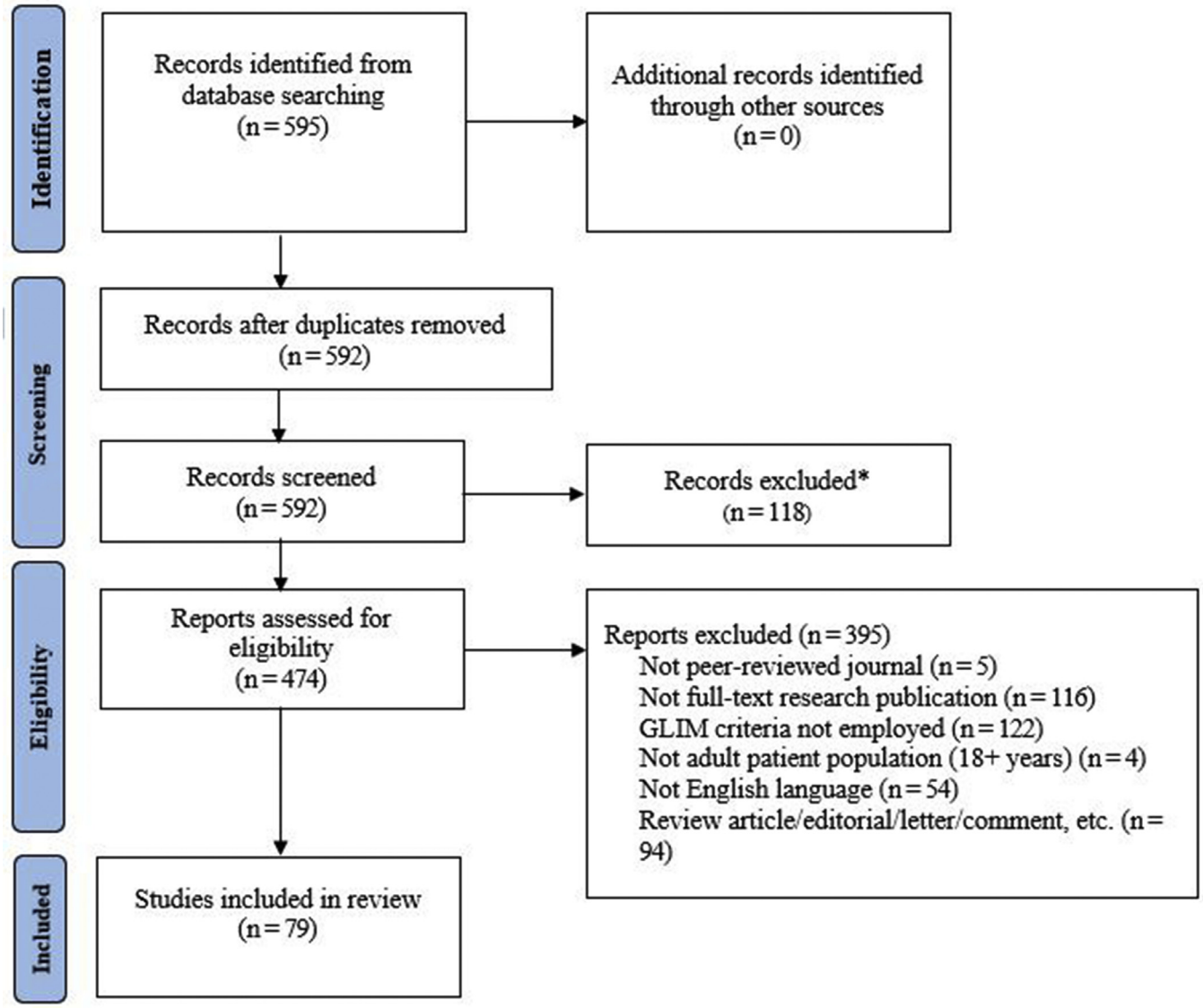

Fig. 2. Flow chart of search results. *: Due to record type (eg, book chapters, conference abstracts, editorials, reviews, guidelines, letters/comments, theses).

North America [40,50,53,85] and 4 (5%) in South America [44,54,65,82].

Regarding study design, the majority were cohorts (n = 48; 61%) [16,17,19,20,22–30,32,34,38–42], [44–49,52–55,57,60,65–68], [72–77,80,84,85,88,89,91], followed by cross-sectional (n = 30; 38%) [15,18,21,33,35–37,43,50,51,56,58,61–64,69–71,78,79,81–83,86–88,90,93] and double-blind, randomized, placebo-controlled studies (n = 1; 1%) [92]. Within the cohort studies, 63% (n = 30) were prospective [17,19,22–25,28–30,38,42,44,45,47,52,54,55,60,65–67,72–76,80,85,89,91], and 37% (n = 18) were retrospective [16,20,26,27,31,32,34,39–41,46,48,49,53,57,68,77,84].

3.3. Evaluation of GLIM criteria reported in the literature

3.3.1. Malnutrition risk screening and nutritional assessment

The majority of publications reported the prevalence of malnutrition (n = 70; 89%) (Fig. 1 – Supplementary Material) [16–21,23–33,35–48,50,51], [53–69,71–73,75–84,86–91,93]. Forty-nine publications (62%) reported malnutrition screening using validated tools [15–19,21,23–27,29–33,35–37,39–41] [45,50–52,57,61–63,66,67,69–79], [82,83,88,90–92]. The most frequently used screening tools were the Mini-Nutritional Assessment (MNA) (n = 15; 31%) [16,17,21,24–27,29–33,35,36,62] and the Nutrition Risk Screening-2002 (NRS-2002) (n = 15; 31%) [39,41,52,63,67,72–77,79,88,91,92] (Fig. 2 – Supplementary Material). Furthermore, 30 publications (38%) reported Stage 1 malnutrition severity [19,21,31,34,39,41,42,44,47,51,54–56,59–62,65,66,68·69,71,73,74,76,77,80,85,86,91] and 34 (43%) reported Stage 2 malnutrition severity [19,21,31,34,39–42,44,47,51,54–56,59–62,65–69,71,73,74,76,77,80,85,86,91–93] (Fig. 3 - Supplementary Material). In addition, 27% of studies (n = 21) reported using validated nutritional assessment tools concurrently with GLIM: SGA (n = 12; 57%) [18,40,41,44,45,54,56,59,60,65,70,71], the Patient-Generated-Subjective Global Assessment (PG-SGA) (n = 8; 38%) [26,43,64,75,78,83,85,93], and the long MNA version (n = 1; 5%) [22] (Fig. 4 – Supplementary Material).

3.3.2. Outcomes

Many publications (n = 50; 63%) reported outcomes [16–18,22–32,34,35,37–39,41,42,44,45,53–57,59–62],

		Diagnosis														
GLIM Criteria	Criterion Used?	Arthritis	Cancer	COVID-19	Critical illness	CVD	Diabetes	Frailty	GI diseases	Healthy	Mixed	Orthopedic	Other*	Pneumonia	Renal	Total
Non-volitional weight loss	Yes	1	20	5	1	3	1	1	5	1	2	1	26		4	71
	No				1						1		3	1		6
	Not specified												2			2
Weight loss total		1	20	5	2	3	1	1	5	1	3	1	31	1	4	79
Low BMI	Yes	1	17	5	2	3	1	1	5	1	3	1	28	1	4	73
	No		2										1			3
	Not specified		1										2			3
Low BMI total		1	20	5	2	3	1	1	5	1	3	1	31	1	4	79
Reduced muscle mass	Yes	1	17	2	2	3	1		3	1	1	1	22		3	57
	No		2	3				1	2		2		7	1	1	19
	Not specified		1										2			3
Reduced muscle mass total		1	20	5	2	3	1	1	5	1	3	1	31	1	4	79
Reduced food intake/ assimilation	Yes		14	5		2	1		3	1	3		25		3	57
	No		5		2	1		1	2			1	4	1	1	18
	Not specified	1	1										2			4
Reduced food intake total		1	20	5	2	3	1	1	5	1	3	1	31	1	4	79
Disease burden/ inflammation	Yes		17	5	2	3	1		5	1	2	1	26	1	3	67
	No		2					1			1		3		1	8
	Not specified	1	1										2			4
Inflammation total		1	20	5	2	3	1	1	5	1	3	1	31	1	4	79

Fig. 3. Heat map summarizing the frequency of GLIM phenotypic criteria (non-volitional weight loss, low BMI, and reduced muscle mass) and etiologic criteria (reduced food intake/assimilation and disease burden/inflammation) reported in the literature by diagnoses. Green shading indicates a greater number of publications; yellow shading indicates fewer publications. GLIM = Global Leadership Initiative on Malnutrition; BMI = body mass index; CVD = cardiovascular disease; GI = gastrointestinal; Other* may include dementia, acute illness, or liver disease, or diagnosis was not described. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article).

[64–69,72–75,77,80,83–85,89,91,93], which we categorized as healthcare system-related and patient-related (Fig. 5 – Supplementary Material). More healthcare system outcomes (n = 65; 52%) [16,22,23,25–31,34,37–39,41,42,44,45,53–55,57,60–62,65,67–69,72–75,77,80,83–85,89,91] than patient outcomes (n = 22; 18%) [17,18,24,26,29,30,36,38,56,57,64,74,75,80,93] were reported. Within healthcare system outcomes, mortality was reported most frequently (n = 33; 27%) [16,22,23,25,26,28–31,34,37–42,44,45,53,55,57,60,61,65,67,68,73–75,80,83,85,89]. Other outcomes were hospitalization/readmissions/costs (n = 11; 9%) [27,29,34,38,44,62,67,69,83,85,91], hospital and/or intensive care unit LOS (n = 10; 8%) [27,34,44,53,65,67,77,83,91], complications (n = 7; 6%) [53–55,68,72,85], critical care admission (n = 2; 2%) [42,67], and institutionalization (n = 2; 2%) [16,29]. Patient outcomes included sarcopenia (n = 6; 5%) [17,18,24,35,38,93], physical function (n = 5; 4%) [38,57,75,80,93], quality of life (n = 5; 4%) [56,59,64,74,75], falls/fractures (n = 3; 2%) [29,38], frailty (n = 2; 2%) [26,38], and cognitive function (n = 1; 1%) [80].

3.3.3. Use of GLIM phenotypic and etiologic criteria

The types and frequencies of GLIM criteria applied to diagnose malnutrition varied throughout the literature (Fig. 3). Overall, 57% of the studies (n = 45) employed all 5 GLIM criteria [16–19,21,26–33,35–37,39,41,43–45,47,48,51,54], [55,57,61,62,64,66,67,69,71,73–78,82,83,86,90,91]. Out of 79 studies, 68% (n = 54) studies applied all 3 phenotypic criteria [16–19,21,23,25–33,35–37,39,41,43–45,47,48,51,54–57], [59,61,62,64,66,67,69–71,73–79,82,83,86,88,90–93]. Non-volitional weight loss was reported in 71 studies (90%) [16–33,35–37,39–48] [51–64,66–79,81–88,90–93]; within this subset, 58% (n = 41) applied the GLIM thresholds previously described in Table 1 [16,20,24,26,27,30–33,37,39,40,42–47,51,53,55–58,63,64,66,67,69,70,72,73,77–79,81,83,84,86,90,92]. Several studies (n = 27; 38%) used other criteria (eg, weight loss greater than 4.5 kg in the past year) [17,19,22,23,25,28,29,35,41,48,52,54,59–62,68,71,74–76,82,84,85,87,88,93], and 4 studies (6%) did not specify criteria [18,21,36,91] (Fig. 6 – Supplementary Material).

Table 3
Study characteristics.

	Study participant age		
	≥18 years [n]	≥65 years [n]	Total [n (%)] (total n = 79)
Clinical setting			
Hospital	40	13	53 (67%)
Community	2	8	10 (13%)
Outpatient	10	0	10 (13%)
Nursing home	0	3	3 (4%)
Home care	1	0	1 (1%)
Not specified	1	1	2 (3%)
Diagnosis			
Cancer	18	2	20 (26%)
COVID-19	5	0	5 (6%)
GI diseases	5	0	5 (6%)
Renal	4	0	4 (5%)
Mixed	2	1	3 (4%)
CVD	1	2	3 (4%)
Arthritis	1	0	1 (1%)
Frailty	0	1	1 (1%)
Diabetes	0	1	1 (1%)
Critical illness	2	0	2 (3%)
Heathy	0	1	1 (1%)
Orthopedic	0	1	1 (1%)
Pneumonia	0	1	1 (1%)
Other*	16	15	31 (39%)
Region			
Europe			39 (49%)
Asia			31 (39%)
North America			4 (5%)
South America			4 (5%)
Africa			1 (1%)
Study design			
Cross-sectional			30 (38%)
Prospective cohort			30 (38%)
Retrospective cohort			18 (23%)
Double-blind, randomized, placebo-controlled			1 (1%)

CVD – cardiovascular disease; GI – gastrointestinal; Other* may include dementia, acute illness, or liver disease, or diagnosis was not described.

Low BMI was used more frequently than either non-volitional weight loss or reduced muscle mass (n = 73; 92%) (Fig. 3) [15–21,23–45,47,48] [50–84,86,88,90–93]. The majority of studies (n = 64; 88%) applied the GLIM thresholds for low BMI (Table 1 and Fig. 7 – Supplementary Material) [15–17,19–21,23–35,37–40, 42–45,47], [48,50–58,62–74,76–81,83,84,86,88,90–92].

Reduced muscle mass was applied as a phenotypic criterion in 72% of studies (n = 57) and was assessed using a variety of methods (Fig. 3) [15–19,21,23,25–33,35–39,41,43–45,47,48], [51,54–57,59, 61,62,64–67,69–71,73–79,82,83,86,88,90–93] Several anthropometric methods for assessing low muscle mass were reported throughout the literature (n = 39; 45%) [25,28,30,31,33,35, 37,39,44,45,54,55,59,61,62,65,71,73–78,82,91]; within this subset, 54% (n = 21) used calf circumference [25,28,30,31,33,35,37, 39,44,54,55,61,62,65,73–78,91]. Additional body composition methods included bioelectrical impedance analysis (BIA) (n = 16; 18%) [16,19,21,23,30,41,47,51,54,64,66,70,73,86,90,93], handgrip strength (n = 13; 15%) [26–28,30,45,62,71,73,76,79,82,83,91], dual-energy X-ray absorptiometry (n = 8; 9%) [17,28,29,38,43,59,88,93], computed tomography scans (n = 2; 2%) [67,79], ultrasound scans (n = 1; 1%) [15], and equations to estimate skeletal muscle index (n = 2; 2%) [32,57] (Fig. 8 – Supplementary Material).

Regarding the etiologic criteria, reduced food intake/assimilation was described in the majority of the literature (n = 5 7; 72%) [15–19,21,24,26–33,35–37,39–45,47,48], [50–52,54,55,57,60–64, 66–69,71–78,81–83,86,90,91,93]. Among these, 26 (46%) used the GLIM thresholds from Table 1 (Fig. 9 – Supplementary Material) [16,31–33,35,37,39–42,44,51,54,55,57,64,67,68,73,74,76,77,82,83, 90,91]. Inflammation was applied in 67 studies (85%) (Fig. 3) [15–19,21,23–48,51–55], [57–67,69–83,86,87,90,91]. Within this subset, 67% (n = 45) reported inflammation using disease burden/diagnosis [15,16,19,23,25–27,30,32–35,37,38,41–45], [51–55,57, 61,62,64–66,69,70], [72–74,76–83,87,90], 25% (n = 17) used inflammation biomarkers as criteria, such as C-reactive protein [17,24,28,29,31,39,40,46–48,58,59,63,67,71,75,91], and 5 (7%) did

			Validity Type					
GLIM Validation Study? Y/N	**Study Type**	**GLIM Comparators**	**Concurrent**	**Concurrent, construct**	**Concurrent, predictive**	**Predictive**	**Predictive, construct**	**Total**
Y	Prospective cohort	ESPEN malnutrition criteria*	1	1	1	1		4
		PG-SGA			2			2
		Screening tool(s)			1			1
		SGA			4	1		5
		Not specified				15		15
	Prospective cohort total		**1**	**1**	**8**	**17**		**27**
	Retrospective cohort	ESPEN malnutrition criteria*			1			1
		SGA	1		1			2
		Not specified				10	1	11
	Retrospective cohort total		**1**		**2**	**10**	**1**	**14**
	Cross-sectional	Body composition, handgrip strength	1					1
		ESPEN malnutrition criteria*	3					3
		PG-SGA	1		3			4
		Screening tool(s)	2		1			3
		SGA			1			1
		SGA, screening tools			1			1
		SGA, body composition, other	1					1
		Other	1					1
		Not specified				5		5
	Cross-sectional total		**9**		**6**	**5**		**20**
Total			**11**	**1**	**16**	**32**	**1**	**61**

Fig. 4. Heat map showing the frequency of publications reporting on the validation of GLIM criteria as concurrent, predictive, and construct validity by study design (prospective and retrospective cohorts and cross-sectional) and choice of comparators. Green shading indicates a greater number of publications; yellow shading indicates fewer publications. GLIM = Global Leadership Initiative on Malnutrition; ESPEN = European Society for Clinical Nutrition and Metabolism; PG-SGA = Patient-Generated Subjective Global Assessment; SGA = Subjective Global Assessment. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article).

not specify how inflammation was assessed [18,21,36,60,86] (Fig. 10 – Supplementary Material).

3.4. Validation of GLIM criteria

A total of 61 publications (77%) reported criterion validity as concurrent and/or predictive validity [16–19,22–42,44,45,51,53–57], [59–62,64–75,77,78], [80,82–86,88,89,91,93]. Within these, 2 studies (3%) also reported on construct validity [32,66] (Fig. 4 and Figure 11 – Supplementary Material). Most studies were prospective cohorts (n = 27; 44%). Among these, the types of validity reported were concurrent (n = 1; 4%) [19], concurrent, construct (n = 1; 4%) [66], concurrent, predictive (n = 8; 30%) [23,29,44,54,60,65,75,91], and predictive (n = 17; 63%) [17,22,24,25,28,30,38,42,45,55,67,72–74,80,85,89]. Five (18%) prospective cohorts used the SGA as the semi-gold standard comparator for concurrent and/or predictive validity [44,45,54,60,65], 4 (15%) used the ESPEN malnutrition criteria [17,19,29,66], and 2 (7%) used the PG-SGA [75,91]. In addition, 1 publication (4%) reported using screening tool(s) as comparator(s) [23]. Meaningful health outcomes for predictive validity were not specified for 15 (56%) of the prospective studies [22,24,25,28,30,38,42,55,67,72–74,80,85,89].

Fourteen (23%) studies were retrospective; of these, the types of validity reported were concurrent (n = 1; 7%) [40], concurrent, predictive (n = 2; 14%) [41,57], predictive (n = 10; 71%) [16,26,27,31,34,39,53,68,77,84], and predictive, construct (n = 1; 7%) [32]. Two (14%) studies applied SGA as the semi-gold standard for validation [40,41], and 1 (7%) applied the ESPEN criteria [57]. Also, 11 (79%) of the retrospective studies did not specify meaningful health outcomes for predictive validity testing [16,26,27,31,32,34,39,53,68,77,84].

Of these 61 studies, 2 (3%) reported reliability results [51,69]. In addition, 15 studies (25%) reported sample size estimation [24,30–32,41,44,54,55,65,69,70,72,82,85,93] (Figs. 12 and 13 – Supplementary Material).

4. Discussion

GLIM has been proposed as a common global framework that contains a minimal set of indicators typically used in clinical practice to standardize how adult malnutrition is characterized in any care setting. It is a simple framework to be used concurrently with validated nutritional assessment tools, such as the SGA [9]. Since the framework is consensus-based, research is needed to assess its validity and reliability in diverse clinical settings and patient populations [9,12,13]. This scoping review was conducted to describe how the GLIM criteria have been evaluated and compare the reported validation methods to the published guidance on validation of operational criteria for diagnosing malnutrition to ultimately inform the foundation for future research.

Consistencies and inconsistencies were identified in how GLIM was utilized relative to the consensus and validation guidance. Firstly, only one-fourth of studies used validated nutritional assessment tools; however, all reported using validated tools concurrently with GLIM as recommended by the consensus and validation guidance [9,12,13]. The criteria are not intended to replace validated tools or be the sole means of diagnosing malnutrition [12,13]. In addition, only 11% of studies (n = 9) provided information on the combinations of phenotypic and etiologic criteria [30,40,43,47,54,66,74,75,91]; however, the guidance states all possible combinations of indicators need to be evaluated to determine those most sensitive to identify malnutrition [12,13]. This is a key finding, as different combinations of indicators could yield different prevalence rates and outcomes.

Secondly, a high percentage of studies used low BMI as a diagnostic criterion. While it is an accepted screening tool for identifying excess adiposity at the population level, its application as a proxy for body composition in clinical settings is limited. Therefore, using low BMI as the only phenotypic criterion for diagnosing malnutrition is not recommended [94]. Patients with acute or chronic conditions and high BMIs are at increased risk for low muscle mass (ie, sarcopenic obesity, which is a malnutrition-related condition associated with poor outcomes) [95–98]. Body mass index lacks the sensitivity other measures have, such as body composition, and will under-diagnose malnutrition in patients with high BMIs. As a result, it may not be the optimal phenotypic criterion to use [90,94]. This is an important area of future validation research.

Thirdly, while anthropometry is an accessible and inexpensive means to estimate muscle mass and adiposity in clinical settings, its accuracy is limited as it does not directly assess body composition. Furthermore, inconsistent measurement techniques can be problematic when assessors are not sufficiently trained, or the appropriate adjustments are not made to account for patient-specific conditions, such as excess adiposity or edema. Anthropometry constituted almost half of the tools to assess low muscle mass in the GLIM literature, with calf circumference being the primary measurement. While beyond the scope of this review, we do not know how many studies adjusted calf circumference cut-offs for edema or excess adiposity. Recent studies have identified practical adjustments that clinicians should include when using calf circumference as a marker of low muscle mass [99,100].

The quality of study design varied throughout the literature. For instance, the majority of prospective and retrospective cohort investigations reported concurrent criterion validation results; however, fewer than 20% used validated tools like SGA as semi-gold comparators. According to the validation guidance, concurrent criterion validity is considered the best form of validation and is determined by comparing the criteria to semi-gold comparators [12,13]. The SGA and PG-SGA are well-validated tools and recommended to be used as comparators when validating GLIM criteria. Investigators designing validation studies need to consider selecting appropriate comparators and applying at least one phenotypic and one etiologic criterion for retrospective cohort studies and all five criteria in prospective cohort studies [12,13].

Determining sample size is a critical aspect of study design but was described in only 25% of publications. Sample size estimations are needed to ensure studies are adequately powered for results to be statistically conclusive [12,13]. The absence of sample size estimation can often lead to incorrect conclusions, thus potentially impacting clinical practice and nutrition care. This is an ongoing issue that needs to be addressed, as it has been noted that “most current published research findings are false” because sample size estimations are either faulty or missing [101].

Reliability assesses the degree to which the results obtained by application of criteria can be replicated, either by the same assessor or among assessors, yet just 3% of papers reported reliability results. For GLIM to be used globally in different settings and populations, evaluating reliability needs to be part of validation efforts [12,13].

It must be acknowledged that if health is a human rights issue and conversely, human rights are a health issue, then well-designed clinical studies are at the core of assuring patients’ right to evidenced-based nutrition care [11]. Therefore, following the scientific method in clinical research is paramount to remedying the gaps in research related to the GLIM framework and its validation: 1) Generate the research hypothesis and study objective(s); 2) Select the patient population, randomize to avoid selection bias, and stratify to minimize the effects of confounding variables; 3)

Determine the required sample size to assure adequate power to detect statistical significance; 4) Analyze the data using appropriate statistical methods to prevent collinearity; and 5) Interpret the findings and draw conclusions based on the correct study design method [102].

The limitations of this scoping review merit comment. Firstly, it was limited to GLIM literature published between January 1, 2019, and January 29, 2021; many studies have been published after January 29, 2021, and are not reflected in our scoping review results. Secondly, the scoping review was not designed to compare studies published before and after publication of the validation guidance in 2020. Since the guidance is now available, all investigators should follow its recommendations when designing prospective and/or retrospective validation studies [12,13]. Thirdly, while several studies reported meaningful health outcomes for predictive validity, analyzing these outcomes was outside of this scoping review, thus limiting any conclusions regarding the predictive validity of GLIM. Lastly, our search was limited to English language publications, which excluded some studies and may have biased the findings.

In conclusion, the GLIM consensus has been extensively studied in a variety of settings and patient populations around the globe since its publication, demonstrating its relevance to nutrition care. With the exception of a limited number of studies, we found consistent gaps in systematic and methodological approaches for validation; therefore, the validity of the criteria across the continuum of care remains largely unknown [18,29,40,68,73,83]. Adequately powered, methodologically sound validation studies using the complete GLIM criteria are needed among various patient populations and disease settings to assess validity for malnutrition diagnosis. The GLIM consensus is a significant advancement for the diagnosis of adult malnutrition with four international nutrition societies working together to address this important global public health issue. However, until GLIM is validated for use in diverse clinical settings and patient populations through well-designed studies, including those that incorporate machine learning techniques, we highly recommend the concurrent use of validated assessment tools like SGA to diagnose malnutrition and validate the GLIM criteria. An important research need is validation of the GLIM criteria across adult patient settings to establish global criteria for malnutrition, inform the diagnostic classification of malnutrition, and guide clinical practice.

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Statement of authorship

Maria Isabel Toulson Davisson Correia: Conceptualization, Methodology, Formal Analysis, Investigation, Writing – Original Draft, Writing – Review & Editing.

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Carla Prado: Conceptualization, Methodology, Formal Analysis, Writing – Review & Editing.

David Evans: Conceptualization, Methodology, Writing – Review & Editing.

Abby Sauer: Conceptualization, Methodology, Data Curation, Investigation, Formal Analysis, Writing – Original Draft, Writing – Review & Editing, Project Administration.

Refaat Hegazi: Conceptualization, Writing – Review & Editing.

Leah Gramlich: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing.

Data availability statement

Additional information about the original contributions beyond that provided in this manuscript are included in Supplementary Material. Further inquiries can be directed to the corresponding author.

Conflict of Interest

Maria Isabel Toulson Davisson Correia: Consulting and/or honoraria for Abbott Nutrition, Baxter, Danone, Fresenius, Nestle and Takeda.

Kelly A. Tappenden: Honoraria from Abbott Nutrition.

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Abby C. Sauer: Employee of Abbott Nutrition.

Refaat Hegazi: Employee of Abbott Nutrition.

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Appendix A. Supplementary data

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