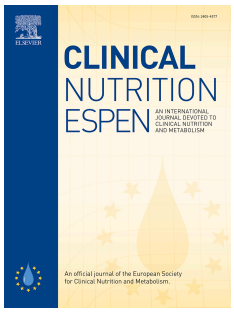

Routine Assessment of Nutritional, Functional and Inflammatory Criteria in Patients with Cancer: A systematic review

Chattarin Pumtako, Ross D. Dolan, Josh McGovern, Donald C. McMillan

PII: S2405-4577(24)00198-0

DOI: https://doi.org/10.1016/j.clnesp.2024.06.052

Reference: CLNESP 2155

To appear in: *Clinical Nutrition ESPEN*

Received Date: 12 March 2024

Revised Date: 19 June 2024

Accepted Date: 27 June 2024

Please cite this article as: Pumtako C, Dolan RD, McGovern J, McMillan DC, Routine Assessment of Nutritional, Functional and Inflammatory Criteria in Patients with Cancer: A systematic review, *Clinical Nutrition ESPEN*, https://doi.org/10.1016/j.clnesp.2024.06.052.

Routine Assessment of Nutritional, Functional and Inflammatory Criteria in Patients with Cancer: A systematic review

Chattarin Pumtako[1], Ross D Dolan[1], Josh McGovern[1], Donald C McMillan [1]

1. Academic Unit of Surgery, School of Medicine, University of Glasgow, New Lister Building, Royal Infirmary, Glasgow, G31 2ER, UK

Corresponding author:
Chattarin Pumtako
Academic Unit of Surgery
University of Glasgow
Room 2.51, Level 2, New Lister Building, Glasgow Royal Infirmary, Glasgow, United Kingdom, G31 2ER
E-mail: C.Pumtako.1@research.gla.ac.uk

Abstract

Background: The review discusses the significant impact of cancer on patients, particularly focusing on cachexia - a condition marked by weight and lean tissue loss. This condition critically affects the nutritional status, quality of life, and treatment outcomes of cancer patients.

Research Question: The review seeks to understand the effectiveness and necessity of routine clinical monitoring of cancer cachexia, and how it can aid in better therapeutic interventions.

Methods: The systematic review followed a pre-defined protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)statement. A systematic search using specific keywords was conducted in PubMed and EMBASE databases on October 24, 2023, supplemented by citations from the original papers. The selection process involved screening titles and abstracts for relevance.

Results: The review finds varying levels of effectiveness in the different measurement criteria used for monitoring cachexia. It highlights the potential of the Global Leadership Initiative on Malnutrition (GLIM) framework in defining and managing cancer cachexia, though noting some challenges in standardisation and implementation of measurements.

Conclusion: The present systematic review highlights the variability and lack of standardization in the application of GLIM criteria for monitoring cachexia in cancer patients. Despite these challenges, it will be important to determine the most efficacious clinically routine nutritional and inflammation assessments in the routine application of GLIM criteria assessment.

Keywords

Cancer, Cachexia, Routine assessment, Malnutrition, Systematic inflammatory, Weight loss

Introduction

Of all of the effects of cancer on the host the most obvious is cachexia, characterized by progressive involuntary loss of weight and lean tissue. This is a prevalent syndrome as the cancer progresses and, in addition to nutritional status, impacts on functional status, quality of life and treatment outcomes. This complex condition transcends the simple perception that this is a nutritional problem since nutritional interventions have not been successful (1, 2). The syndrome's complex pathophysiology involves negative energy and protein balance (3) and systemic inflammation (2, 4). In particular, systemic inflammation, however measured, has been considered as tip of the tumour/ host iceberg alerting to changes in host metabolism, catabolism and quality of life (5). Patients with aggressive cancer, such as lung and pancreatic cancer, often exhibit systemic inflammation at diagnosis, complicating their prognosis and potential benefit from conventional nutritional interventions (1, 6).

Therefore, there is a need to clinically monitor the syndrome of cancer cachexia (similar to that of tumour progression) on a routine basis to provide longitudinal knowledge of the condition and landmarks for therapeutic intervention. The aim of the present review was to examine which measurements best captured this syndrome for routine clinical monitoring of the host.

Nutritional status

The importance of nutritional status in the definition of cancer cachexia is emphasised in the Fearon definition (3) which proposed a diagnosis of cachexia if any one of these conditions regarding weight loss was met: a minimum of 5% weight loss in the past six months, excluding straightforward starvation causes; or at least a 2% weight loss in the those patients with a BMI <20

kg/m2 or the presence of sarcopenia. Indeed, these criteria have formed the cornerstones of clinical research in cancer cachexia in the past 3 decades. From this definition a Body Mass Index (BMI) -adjusted weight loss grading system has been shown to have prognostic value (7, 8) and was found to be associated with quality of life in patients with advanced cancer (8, 9). However, there have been long established malnutrition screening tools such as Malnutrition Universal Screening Tool (MUST), Malnutrition Screening Tool (MST) and Nutritional Risk Screening 2002 (NRS-2002) and of these MUST would appear most closely aligned with the Fearon definition (10). This is perhaps not surprising since weight loss and BMI are integral to the MUST score. The Fearon definition also included the presence of sarcopenia as an indicator of cachexia in patients with cancer. In the past decade of so with the advent of Computed Tomography (CT)-derived body composition and a reliable assessment of low muscle mass, the relationship between a low muscle mass and global quality of life (11) and its prognostic importance has been confirmed (12-14).

Functional status

In addition to being defined as part of the syndrome of cancer cachexia, sarcopenia has, in turn, been defined as a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength that is associated with physical disability, poor quality of life and death. From the above it is clear that muscle mass can be routinely measured by CT-derived body composition analysis. In contrast, muscle strength and its relationship with the ability to carry out daily living activities is less well defined. In oncology, such Eastern Cooperative Oncology Group Performance Status (ECOG-PS) has been recognised to be associated with quality of life (15) and survival (16). Similarly, a direct method of muscle strength, hand grip strength has been shown to be associated with quality of life (17) and survival (18).

Systemic inflammation

Although not included in the Fearon criteria for diagnosis of cancer cachexia, inflammation plays a pivotal role in cancer growth and progression and is considered a hallmark of cancer (19). Indeed, the prognostic importance of systemic inflammation had led to its inclusion in a number of consensus frameworks for defining cancer cachexia (2). The main systemic inflammation based prognostic scores used in this context are the Glasgow Prognostic Score (GPS) (20) and the neutrophil lymphocyte ratio (21, 22). Furthermore, the systemic inflammatory response (SIR), as evidenced by the modified Glasgow Prognostic Score (mGPS), has been shown to be associated with quality of life (15, 23, 24).

Proposed combinations of criteria

Over the past two decades attempts to clinically identify the syndrome of cancer cachexia have evolved. Presently, initiatives like the Global Leadership Initiative on malnutrition (GLIM) criteria consider cancer cachexia to be “disease related malnutrition with inflammation” (2) and consider both phenotypic criteria (weight loss, BMI and low muscle mass) and aetiologic criteria (low food intake/assimilation and disease burden/inflammation). However, the measurements to be used for criteria of low muscle mass, low food intake and inflammation remain to be defined and linked to routine clinical practice.

Patton and coworkers introduced the Routine EValuatiOn of people LivIng with cancer protocol (REVOLUTION) (25), designed to provide continuous assessment of patients with advanced cancer. For body composition evaluation bioelectrical impedance measurement and CT scans were proposed. For physical function Karnofsky Performance Status (KPS) and the use of

an eight-day continuous physical activity monitoring were proposed. For appraising the SIR full white cell count, urea and electrolytes, albumin, and lactate dehydrogenase were proposed tests. Lastly, for quality of life European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire (EORTC-QLQ-C30), Edmonton Symptom Assessment System (ESAS), the Functional Assessment of Anorexia/ Cachexia Therapy Scale (FAACT), Patient-Generated Subjective Global Assessment (PGSGA), the Hospital Anxiety and Depression Scale (HADS), and the Eating Assessment Tool–10 (EAT-10) were proposed (25). Upon closely examining the details of REVOLUTION certain concerns arise. Although Revolution study covers all aspects of the cancer cachexia patients, it does not clearly define the best method or sequence in which to conduct these assessments.

Vigano and colleagues (26) outlined routinely available clinical, nutritional, and functional criteria for staging cachexia in advanced cancer patients. Beginning with the four-stage classification system proposed for cachexia namely non-cachexia (NCa), pre-cachexia (PCa), cachexia (Ca) and refractory cachexia (RCa), patients were assigned to these cachexia stages according to five classification criteria available in clinical practice: 1) biochemistry (high C-reactive protein or leukocytes, or hypoalbuminemia, or anemia), 2) food intake (normal/decreased), weight loss: 3) moderate (≤5%) or 4) significant (>5%/past six months) and 5) ECOG-PS ≥ 3. They then determined if symptom severity, body composition changes, functional levels, hospitalizations and survival rates varied significantly across cachexia stages. There were significant differences across the cachexia stages for most of the outcome measures including symptoms, body composition, hand-grip strength, clinical outcomes and survival. They concluded that the above 5 clinical criteria can be used to stage cachexia in cancer patients and predict important clinical, nutritional and functional outcomes.

Methods

- **Search strategy**

The current systematic review of the published literature was conducted following a pre-defined protocol as articulated in the PRISMA statement. A systematic search was conducted using keywords "(Cancer) AND (The Global Leadership Initiative on Malnutrition)" Two databases, PubMed and EMBASE, were extensively explored to retrieve relevant articles on 24th October 2023. Moreover, citations from the original assessment paper were followed to ensure comprehensive inclusion of relevant studies. Titles and abstracts of these articles were screened to determine their relevance for full-text review.

- **Data Extraction:**

For papers shortlisted for full-text review, key data points were extracted and tabulated. This included the study objective, population demographics, study design, results, and conclusions.

- **Analysis:**

After close consideration of details from the Revolution and Vigano framework papers, specific concerns related to methodology and outcomes were noted. Based on these observations, the primary focus of this review was directed towards the GLIM framework. The analysis of the framework and its implications in clinical practice formed the crux of our analysis.

Results

The systematic literature search found 2,801 studies (**Figure 1**). A total of 993 studies were excluded before the title and abstract screening and 1,681 studies were excluded after the title and abstract screening. Additionally, 33 studies measured outcomes using GLIM criteria to assess the efficacy of treatment or its impact without specifying which particular GLIM assessment model was implemented were excluded after full text articles were assessed for eligibility. Reasons for exclusion are shown in **Figure 1**. Analysis of 94 pertinent studies revealed a consistent application of GLIM assessment, The summary of characteristics of the 94 studies was shown in **Table 1**.

Phenotypic Criteria

It was consistently observed that all studies recorded weight loss, patients' weight and height (BMI). The lower muscle mass criterion was absent from 11 studies (27-37). Twenty-eight studies used CT scans at the L3 vertebral level, with this method being the sole assessment tool in 21 studies (38-58). Only a minority of six studies used this method in conjunction with muscle strength assessments (59-64), and one study used Bioelectrical Impedance Analysis (BIA) (65). Anthropometry was the most common assessment method, implemented in 38 studies, measuring parameters such as mid-arm muscle circumference (MAMC), mid-upper arm circumference (MUAC), muscle arm circumference (MAC), arm muscle circumference (AMC), appendicular skeletal muscle index (ASMI), calf circumference (CC), and triceps skin fold (TSF) thickness. Fifteen studies exclusively relied on anthropometry (66-80), while 21 studies integrated it with muscle strength assessments (81-101), 1 study combined anthropometry with BIA (102), and 1 study combined both BIA and muscle strength assessments (103). The utilization of BIA devices, despite being the simplest and quickest method, was the least frequent, appearing in only 15

studies. Of these, BIA was the sole assessment tool in 9 studies (104-112), was combined with muscle strength assessments in 3 studies (113-115), with CT scans in 1 study, with anthropometry in 1 study, and with both anthropometry and muscle strength assessments in 1 study. Nearly all of the 36 studies assessing muscle strength utilized Handgrip Strength (HGS). This method was the sole assessment tool in 5 studies (116-120).

Etiologic criteria

The reduced food intake or assimilation component, there was notable variability, with 15 studies (30, 31, 37, 38, 42, 43, 48, 65, 70, 77, 79, 100, 107, 115, 119) omitting this aspect altogether. Thirty-three studies utilized patient-reported assessments. A diverse range of tools was used across 46 studies for the final assessment approach, including NRS-2002 in 22 studies (29, 32, 39, 45, 46, 51, 56, 57, 60-62, 64, 69, 72, 78, 85, 90, 95, 98, 108, 111, 117), MUST in 7 studies (28, 36, 49, 55, 58, 71, 88), PG-SGA in 5 studies (40, 44, 53, 101, 113), and MST in 2 studies (59, 66). Several studies combined assessment tools, with NRS-2002 and PG-SGA used in 5 studies (33, 82-84, 86), MUST and Mini Nutritional Assessment (MNA) in 2 studies (68, 73), MST and PG-SGA in 1 study (63), and the MD Anderson Symptom Inventory Gastrointestinal (MDASI-GI) with Cancer Appetite and Symptom Questionnaire (CASCO) in 1 study (35). Moreover, there was one study that compared three tools MUST, NRS-2002 and PG-SGA in GLIM (74).

In the context of assessing disease burden and inflammatory conditions, 20 studies did not include this evaluation (32, 36, 50, 51, 54, 56, 60, 63, 68, 73-76, 78, 82, 87, 88, 95, 98, 102) and there were 30 studies predicated their assessments on the assumption that the study population consisted solely of cancer patients. There were 44 studies based on laboratory values, within the laboratory value-based studies, the most measured markers were C-Reactive Protein (CRP),

recorded in 14 studies (28, 31, 34, 35, 40, 53, 71, 80, 93, 105, 109, 111, 112, 116), and Albumin levels, noted in 4 studies (57, 59, 62, 85). Eleven studies conducted a broader analysis incorporating more than one laboratory value, commonly CRP in conjunction with Albumin levels (33, 58, 90, 92, 103, 113). Fifteen studies used this assessment tool to analyses the laboratory results, the most frequently utilized predefined models were mGPS and GPS, implemented in 5 studies (55, 91, 110, 118, 119). The Neutrophil-to-Lymphocyte Ratio (NLR) appearing alone in 3 study (84, 89, 101). One study use both of mGPS and NLR (43). Additionally, 5 studies employed a composite approach, integrating mGPS/GPS or NLR with other indicators, including the Albumin-Lymphocyte Index (ALI) (29), the Systemic Immune-Inflammation Index (SII) (29, 115), the inflammatory burden index (IBI) (52), the Monocyte-to-Lymphocyte Ratio (MLR) (49), the Prognostic Nutritional Index (PNI) (30), the Controlling Nutritional Status (CONUT) (30), and the Lymphocyte-to-Monocyte Ratio (LMR) (115). Moreover, a study used unique markers namely the fat-age-inflammation (FAIN) index (86).

Discussion

The results of the present systematic review show that the comprehensive assessment of nutritional, functional and inflammatory criteria to date are most commonly reported within the GLIM framework (n=94). Within this framework phenotypic criteria are most commonly reported, especially weight loss and BMI and there is agreement on how they should be measured. In contrast, etiologic criteria are less commonly reported and there is little agreement on the individual criteria and how they should be measured. The current ESMO guidelines (121) recommend that cachexia is defined "as disease-related malnutrition with inflammation" as per the GLIM definition of malnutrition. This proposes that phenotypic nutritional criteria (including weight loss) should take precedent over etiologic criteria (including inflammation). This may be because the measures of the phenotypic criteria are well defined by the GLIM group. However, the GLIM group have recently defined the measure of inflammation as a raised CRP (122). Therefore, as previously proposed (2) it may be that cachexia should be defined as disease related inflammation with malnutrition with consequent implications for the reversal of the order of measurements (etiological criteria first followed by phenotypic criteria).

The phenotypic criteria, which encompasses unintentional weight loss and low BMI, are largely pre-defined by the GLIM criteria. These stipulate a weight loss exceeding 5% within three months, or beyond 10% over six months, and delineate a Low BMI as under 20 kg/m² for patients younger than 70 years, or less than 22 kg/m² for those aged 70 and above (123). Demonstrating precision in determining the reduced muscle mass criterion, CT scans at the L3 vertebral level were used in the majority of studies. Nevertheless, HGS and anthropometry could also be utilised, as they have been employed to ascertain lower muscle mass criterion in numerous studies. Moreover, HGS can be used to assess muscle strength, the dominant diagnostic feature of

sarcopenia (124) and a critical aspect of concern in cancer patients suffering from cachexia (25). Recently, in a systematic review of randomised clinical trials in cancer cachexia MacDonald and coworkers (17) concluded that among the objective measures of physical function hand grip strength (HGS) was the most commonly used physical function endpoint. However, heterogeneity in study design, populations, intervention and endpoint selection made it difficult to recommend the optimal physical function endpoint and how to measure this.

In evaluating the etiological criterion, most studies did not reliably report on this aspect. Although there are various tools that have been used to determine the reduced food Intake component (125), the assimilation component is less well defined. Also, as an etiologic factor, disease burden and inflammation are both considered as one criteria where it has not been established whether they have the same effect on outcome. Furthermore, if the sensitivity of the current GLIM framework is dependent on whether disease burden/inflammation is utilized as a diagnostic criterion, given their differential association between SIR and low skeletal muscle mass (14, 126), then it is crucial to distinguish between these factors. Given that the GLIM framework requires just one phenotypic and one etiological criterion; many studies have only considered disease burden and not inflammation in patients with cancer. However, systemic inflammation is increasingly recognized as central to defining, diagnosing, and treating cancer cachexia (6, 127). The origin of the SIR in cancer patients is not fully understood, but it is believed to be a general reaction to tumor-induced hypoxia/necrosis or local tissue damage (2, 128). With regard to defining cancer associated inflammation both GPS/ mGPS and NLR have extensively validated prognostic value and may be employed to measure this criterion (2).

Our analysis illuminated the considerable variability in GLIM criteria application across clinical cancer research, echoing the urgent call for standardized practices. This variability not

only complicates the interpretation of nutritional assessments but also hampers the comprehensive management of cancer cachexia. The present analysis highlights the considerable variability in the application of GLIM criteria application and thus pressing need for standardisation of criteria to be used. Recently resting energy expenditure has been proposed as useful measurement to characterize cachexia in patients with NSCLC (129, 130). However, the complexity and variability of such measurements may be difficult to incorporate into routine clinical practice (131). Furthermore, the present study, given the variable measurements for phenotypic and aetiologic criteria, was not able to differentiate GLIM effects of different cancer types. With the standardisation of GLIM criteria measurements, it may be able to better understand its clinical utility across different cancer populations.

Conclusion

Therefore, despite increasing consensus in what should be measured to define cancer cachexia, the present systematic review highlights the variability and lack of standardization in the application of GLIM criteria for monitoring cachexia in cancer patients. Despite these challenges, it will be important to determine the most efficacious clinically routine nutritional and inflammation assessments in the routine application of GLIM criteria assessment. Further studies are required to test the relative prognostic value of the various GLIM components.

Funding: No funding

Conflict of interest

We declare that there are no conflicts of interest regarding the publication of this paper. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. No financial or personal relationships with other people or organizations have inappropriately influenced our work.

Author contribution

Chattarin Pumtako initiated and was involved in conceptualization, formal analysis, contributed to specifically in methodology, analysis and interpretation of data, wrote the original and revision of the manuscript for important intellectual content and approved the final version of the manuscript.

Ross D Dolan involved in conceptualization, contributed to specifically in methodology, analysis and interpretation of data, revision of the manuscript for important intellectual content and approved the final version of the manuscript.

Josh McGovern involved in conceptualization, analysis and interpretation of results, revised versions of the manuscript and approved the final version of the manuscript.

Donald C McMillan initiated and was involved in conceptualization, formal analysis, investigation, analysis and interpretation of data, wrote the original and revision of the manuscript for important intellectual content and approved the final version of the manuscript.

Refferences

1. Merker M, Felder M, Gueissaz L, Bolliger R, Tribolet P, Kagi-Braun N, et al. Association of Baseline Inflammation With Effectiveness of Nutritional Support Among Patients With Disease-Related Malnutrition: A Secondary Analysis of a Randomized Clinical Trial. JAMA Netw Open. 2020;3(3):e200663.
2. McGovern J, Dolan RD, Skipworth RJ, Laird BJ, McMillan DC. Cancer cachexia: a nutritional or a systemic inflammatory syndrome? Br J Cancer. 2022;127(3):379-82.
3. Fearon K, Strasser F, Anker SD, Bosaeus I, Bruera E, Fainsinger RL, et al. Definition and classification of cancer cachexia: an international consensus. Lancet Oncol. 2011;12(5):489-95.
4. Johns N, Tan BH, MacMillan M, Solheim TS, Ross JA, Baracos VE, et al. Genetic basis of interindividual susceptibility to cancer cachexia: selection of potential candidate gene polymorphisms for association studies. J Genet. 2014;93(3):893-916.
5. McAllister SS, Weinberg RA. The tumour-induced systemic environment as a critical regulator of cancer progression and metastasis. Nat Cell Biol. 2014;16(8):717-27.
6. Diakos CI, Charles KA, McMillan DC, Clarke SJ. Cancer-related inflammation and treatment effectiveness. Lancet Oncol. 2014;15(11):e493-503.
7. Martin L, Senesse P, Gioulbasanis I, Antoun S, Bozzetti F, Deans C, et al. Diagnostic criteria for the classification of cancer-associated weight loss. J Clin Oncol. 2015;33(1):90-9.
8. Vagnildhaug OM, Blum D, Wilcock A, Fayers P, Strasser F, Baracos VE, et al. The applicability of a weight loss grading system in cancer cachexia: a longitudinal analysis. J Cachexia Sarcopenia Muscle. 2017;8(5):789-97.
9. Daly L, Dolan R, Power D, Ni Bhuachalla E, Sim W, Fallon M, et al. The relationship between the BMI-adjusted weight loss grading system and quality of life in patients with incurable cancer. J Cachexia Sarcopenia Muscle. 2020;11(1):160-8.
10. Ni Bhuachalla EB, Daly LE, Power DG, Cushen SJ, MacEneaney P, Ryan AM. Computed tomography diagnosed cachexia and sarcopenia in 725 oncology patients: is nutritional screening capturing hidden malnutrition? J Cachexia Sarcopenia Muscle. 2018;9(2):295-305.
11. Hanna L, Nguo K, Furness K, Porter J, Huggins CE. Association between skeletal muscle mass and quality of life in adults with cancer: a systematic review and meta-analysis. J Cachexia Sarcopenia Muscle. 2022;13(2):839-57.
12. Shachar SS, Williams GR, Muss HB, Nishijima TF. Prognostic value of sarcopenia in adults with solid tumours: A meta-analysis and systematic review. Eur J Cancer. 2016;57:58-67.
13. Aleixo GFP, Shachar SS, Nyrop KA, Muss HB, Malpica L, Williams GR. Myosteatosis and prognosis in cancer: Systematic review and meta-analysis. Crit Rev Oncol Hematol. 2020;145:102839.
14. McGovern J, Dolan RD, Horgan PG, Laird BJ, McMillan DC. Computed tomography-defined low skeletal muscle index and density in cancer patients: observations from a systematic review. J Cachexia Sarcopenia Muscle. 2021;12(6):1408-17.
15. Laird BJ, Fallon M, Hjermstad MJ, Tuck S, Kaasa S, Klepstad P, et al. Quality of Life in Patients With Advanced Cancer: Differential Association With Performance Status and Systemic Inflammatory Response. J Clin Oncol. 2016;34(23):2769-75.
16. Laird BJ, Kaasa S, McMillan DC, Fallon MT, Hjermstad MJ, Fayers P, et al. Prognostic factors in patients with advanced cancer: a comparison of clinicopathological factors and the

development of an inflammation-based prognostic system. Clin Cancer Res. 2013;19(19):5456-64.
17. McDonald J, Sayers J, Anker SD, Arends J, Balstad TR, Baracos V, et al. Physical function endpoints in cancer cachexia clinical trials: Systematic Review 1 of the cachexia endpoints series. J Cachexia Sarcopenia Muscle. 2023;14(5):1932-48.
18. Lopez-Bueno R, Andersen LL, Koyanagi A, Nunez-Cortes R, Calatayud J, Casana J, et al. Thresholds of handgrip strength for all-cause, cancer, and cardiovascular mortality: A systematic review with dose-response meta-analysis. Ageing Res Rev. 2022;82:101778.
19. Hanahan D, Weinberg RA. Hallmarks of cancer: the next generation. Cell. 2011;144(5):646-74.
20. McMillan DC. The systemic inflammation-based Glasgow Prognostic Score: a decade of experience in patients with cancer. Cancer Treat Rev. 2013;39(5):534-40.
21. Dolan RD, Lim J, McSorley ST, Horgan PG, McMillan DC. The role of the systemic inflammatory response in predicting outcomes in patients with operable cancer: Systematic review and meta-analysis. Sci Rep. 2017;7(1):16717.
22. Dolan RD, McSorley ST, Horgan PG, Laird B, McMillan DC. The role of the systemic inflammatory response in predicting outcomes in patients with advanced inoperable cancer: Systematic review and meta-analysis. Crit Rev Oncol Hematol. 2017;116:134-46.
23. Douglas E, McMillan DC. Towards a simple objective framework for the investigation and treatment of cancer cachexia: the Glasgow Prognostic Score. Cancer Treat Rev. 2014;40(6):685-91.
24. Daly LE, Dolan RD, Power DG, Ni Bhuachalla E, Sim W, Cushen SJ, et al. Determinants of quality of life in patients with incurable cancer. Cancer. 2020;126(12):2872-82.
25. Patton R, Cook J, Haraldsdottir E, Brown D, Dolan RD, McMillan DC, et al. REVOLUTION (Routine EValuatiOn of people LivIng with caNcer)-Protocol for a prospective characterisation study of patients with incurable cancer. PLoS One. 2021;16(12):e0261175.
26. Vigano AAL, Morais JA, Ciutto L, Rosenthall L, di Tomasso J, Khan S, et al. Use of routinely available clinical, nutritional, and functional criteria to classify cachexia in advanced cancer patients. Clin Nutr. 2017;36(5):1378-90.
27. Wongdama S, Lertsiripatarajit P, Wongdama S, Virojanapa K, Chuthapisith S, Siriussawakul A, et al. Performance of a simplified nutrition screening tool for outpatient radiotherapy cancer patients. Medicine (Baltimore). 2023;102(19):e33778.
28. Molfino A, Emerenziani S, Tonini G, Santini D, Gigante A, Guarino MPL, et al. Early impairment of food intake in patients newly diagnosed with cancer. Front Nutr. 2022;9:997813.
29. Zhang KP, Zhang X, Zhang Q, Ruan GT, Song MM, Xie HL, et al. Association between the Lymphocyte-to-C-Reactive Protein Ratio and Survival Outcomes in Cancer Patients with GLIM-Defined Malnutrition: A Multicenter Study. J Nutr Health Aging. 2022;26(9):847-55.
30. Takamizawa Y, Shida D, Boku N, Nakamura Y, Ahiko Y, Yoshida T, et al. Nutritional and inflammatory measures predict survival of patients with stage IV colorectal cancer. BMC Cancer. 2020;20(1):1092.
31. Einarsson S, Karlsson HE, Bjor O, Haylock AK, Tiblom Ehrsson Y. Mapping impact factors leading to the GLIM diagnosis of malnutrition in patients with head and neck cancer. Clin Nutr ESPEN. 2020;40:149-55.
32. Chen WZ, Yu DY, Zhang XZ, Zhang FM, Zhuang CL, Dong QT, et al. Comparison of laparoscopic and open radical gastrectomy for gastric cancer patients with GLIM-defined malnutrition. Eur J Surg Oncol. 2023;49(2):376-83.

33. Ozorio GA, Ribeiro LMK, Santos BC, Bruzaca WFS, Rocha G, Marchi L, et al. Exploring the use of the GLIM criteria to diagnose malnutrition in cancer inpatients. Nutrition. 2023;116:112195.
34. Okada G, Matsumoto Y, Habu D, Matsuda Y, Lee S, Osugi H. Relationship between GLIM criteria and disease-specific symptoms and its impact on 5-year survival of esophageal cancer patients. Clin Nutr. 2021;40(9):5072-8.
35. Tan S, Wang J, Zhou F, Tang M, Xu J, Zhang Y, et al. Validation of GLIM malnutrition criteria in cancer patients undergoing major abdominal surgery: A large-scale prospective study. Clin Nutr. 2022;41(3):599-609.
36. Gascon-Ruiz M, Casas-Deza D, Torres-Ramon I, Zapata-Garcia M, Alonso N, Sesma A, et al. GLIM vs ESPEN criteria for the diagnosis of early malnutrition in oncological outpatients. Clin Nutr. 2021;40(6):3741-7.
37. Przekop Z, Milewska M, Szostak-Wegierek D, Panczyk M, Sobocki J. GLIM-Defined Malnutrition in Patients with Head and Neck Cancer during the Qualification Visit for Home Enteral Nutrition. Nutrients. 2022;14(3).
38. Murnane LC, Forsyth AK, Koukounaras J, Shaw K, King S, Brown WA, et al. Malnutrition defined by GLIM criteria identifies a higher incidence of malnutrition and is associated with pulmonary complications after oesophagogastric cancer surgery, compared to ICD-10-defined malnutrition. J Surg Oncol. 2023;128(5):769-80.
39. Liu Y, Kang J, Qi Z, Yang Y, Bai M, Yi H. Comparison of GLIM and PG-SGA for predicting clinical outcomes of patients with esophageal squamous carcinoma resection. Nutr Hosp. 2023;40(3):574-82.
40. Matsui R, Inaki N, Tsuji T. Impact of malnutrition as defined by the global leadership initiative on malnutrition criteria on the long-term prognosis in older patients with gastric cancer after gastrectomy. Surg Today. 2023;53(5):578-87.
41. Menozzi R, Valoriani F, Ballarin R, Alemanno L, Vinciguerra M, Barbieri R, et al. Impact of Nutritional Status on Postoperative Outcomes in Cancer Patients following Elective Pancreatic Surgery. Nutrients. 2023;15(8).
42. Korczak J, Mardas M, Litwiniuk M, Bogdanski P, Stelmach-Mardas M. Androgen Deprivation Therapy for Prostate Cancer Influences Body Composition Increasing Risk of Sarcopenia. Nutrients. 2023;15(7).
43. McGovern J, Dolan RD, Simmons CPL, Daly LE, Ryan AM, Power DG, et al. Lactate dehydrogenase: relationship with the diagnostic GLIM criterion for cachexia in patients with advanced cancer. Br J Cancer. 2023;128(5):760-5.
44. da Silva Couto A, Gonzalez MC, Martucci RB, Feijo PM, Rodrigues VD, de Pinho NB, et al. Predictive validity of GLIM malnutrition diagnosis in patients with colorectal cancer. JPEN J Parenter Enteral Nutr. 2023;47(3):420-8.
45. Zhang Y, Jiang L, Su P, Yu T, Ma Z, Kang W, et al. Visceral Adipose Tissue Assessment Enhances the Prognostic Value of GLIM Criteria in Patients with Gastric Cancer Undergoing Radical Gastrectomy after Neoadjuvant Treatment. Nutrients. 2022;14(23).
46. Cai W, Yang H, Zheng J, Huang J, Ji W, Lu Y, et al. Global leaders malnutrition initiative-defined malnutrition affects long-term survival of different subgroups of patients with gastric cancer: A propensity score-matched analysis. Front Nutr. 2022;9:995295.
47. Huang Y, Chen Y, Wei L, Hu Y, Huang L. Comparison of three malnutrition risk screening tools in identifying malnutrition according to Global Leadership Initiative on Malnutrition criteria in gastrointestinal cancer. Front Nutr. 2022;9:959038.

48. Xu LB, Mei TT, Cai YQ, Chen WJ, Zheng SX, Wang L, et al. Correlation Between Components of Malnutrition Diagnosed by Global Leadership Initiative on Malnutrition Criteria and the Clinical Outcomes in Gastric Cancer Patients: A Propensity Score Matching Analysis. Front Oncol. 2022;12:851091.
49. Xu LB, Shi MM, Huang ZX, Zhang WT, Zhang HH, Shen X, et al. Impact of malnutrition diagnosed using Global Leadership Initiative on Malnutrition criteria on clinical outcomes of patients with gastric cancer. JPEN J Parenter Enteral Nutr. 2022;46(2):385-94.
50. Findlay M, White K, Brown C, Bauer JD. Nutritional status and skeletal muscle status in patients with head and neck cancer: Impact on outcomes. J Cachexia Sarcopenia Muscle. 2021;12(6):2187-98.
51. Huang DD, Wu GF, Luo X, Song HN, Wang WB, Liu NX, et al. Value of muscle quality, strength and gait speed in supporting the predictive power of GLIM-defined malnutrition for postoperative outcomes in overweight patients with gastric cancer. Clin Nutr. 2021;40(6):4201-8.
52. Xie H, Yuan K, Ruan G, Wei L, Zhang H, Ge Y, et al. Improving the assessment of malnutrition in cancer: Using systemic inflammation markers as a supplement to the inflammation items of the GLIM criteria. Clin Nutr. 2023;42(10):2036-44.
53. Matsui R, Inaki N, Tsuji T. Effect of malnutrition as defined by the Global Leadership Initiative on Malnutrition criteria on compliance of adjuvant chemotherapy and relapse-free survival for advanced gastric cancer. Nutrition. 2023;109:111958.
54. Zhang FM, Chen XL, Wu Q, Dong WX, Dong QT, Shen X, et al. Development and validation of nomograms for the prediction of low muscle mass and radiodensity in gastric cancer patients. Am J Clin Nutr. 2021;113(2):348-58.
55. Abbass T, Dolan RD, MacLeod N, Horgan PG, Laird BJ, McMillan DC. Comparison of the prognostic value of MUST, ECOG-PS, mGPS and CT derived body composition analysis in patients with advanced lung cancer. Clin Nutr ESPEN. 2020;40:349-56.
56. Zhou CJ, Lin Y, Liu JY, Wang ZL, Chen XY, Zheng CG. Malnutrition and visceral obesity predicted adverse short-term and long-term outcomes in patients undergoing proctectomy for rectal cancer. BMC Cancer. 2023;23(1):576.
57. Chen XY, Lin Y, Yin SY, Shen YT, Zhang XC, Chen KK, et al. The geriatric nutritional risk index is an effective tool to detect GLIM-defined malnutrition in rectal cancer patients. Front Nutr. 2022;9:1061944.
58. Almasaudi AS, Dolan RD, Edwards CA, McMillan DC. Hypoalbuminemia Reflects Nutritional Risk, Body Composition and Systemic Inflammation and Is Independently Associated with Survival in Patients with Colorectal Cancer. Cancers (Basel). 2020;12(7).
59. Tolonen A, Kerminen H, Lehtomaki K, Huhtala H, Barlund M, Osterlund P, et al. Association between Computed Tomography-Determined Loss of Muscle Mass and Impaired Three-Month Survival in Frail Older Adults with Cancer. Cancers (Basel). 2023;15(13).
60. Caccialanza R, Cereda E, Agustoni F, Klersy C, Casirati A, Montagna E, et al. Multicentre, randomised, open-label, parallel-group, clinical phase II study to evaluate immunonutrition in improving efficacy of immunotherapy in patients with metastatic non-small cell lung cancer, undergoing systematic nutritional counseling. BMC Cancer. 2022;22(1):1212.
61. Huang DD, Yu DY, Wang WB, Song HN, Luo X, Wu GF, et al. Global leadership initiative in malnutrition (GLIM) criteria using hand-grip strength adequately predicts postoperative complications and long-term survival in patients underwent radical gastrectomy for gastric cancer. Eur J Clin Nutr. 2022;76(9):1323-31.

62. Chen WZ, Zhang XZ, Zhang FM, Yu DY, Chen WH, Lin F, et al. Coexistence of GLIM-defined malnutrition and sarcopenia have negative effect on the clinical outcomes in the elderly gastric cancer patients after radical gastrectomy. Front Nutr. 2022;9:960670.
63. Djordjevic A, Deftereos I, Carter VM, Morris S, Shannon R, Kiss N, et al. Ability of malnutrition screening and assessment tools to identify computed tomography defined low muscle mass in colorectal cancer surgery. Nutr Clin Pract. 2022;37(3):666-76.
64. Zhou LP, Yu DY, Ma BW, Shen ZL, Zou HB, Zhang XZ, et al. Feasibility of substituting handgrip strength for muscle mass as a constituent standard in the Global Leadership Initiative on Malnutrition for diagnosing malnutrition in patients with gastrointestinal cancers. Nutrition. 2021;84:111044.
65. Qin L, Tian Q, Zhu W, Wu B. The Validity of the GLIM Criteria for Malnutrition in Hospitalized Patients with Gastric Cancer. Nutr Cancer. 2021;73(11-12):2732-9.
66. Kiss N, Steer B, de van der Schueren M, Loeliger J, Alizadehsani R, Edbrooke L, et al. Machine learning models to predict outcomes at 30-days using Global Leadership Initiative on Malnutrition combinations with and without muscle mass in people with cancer. J Cachexia Sarcopenia Muscle. 2023;14(4):1815-23.
67. Gounitsioti IS, Poulimeneas D, Grammatikopoulou MG, Kotzamanidis C, Gkiouras K, Nigdelis MP, et al. Objective and Subjective Appetite Assessment in Patients with Gynecological Cancer: A Pre- and Post-Operative Pilot Study. Int J Environ Res Public Health. 2022;19(16).
68. Srinivasaraghavan N, Venketeswaran MV, Balakrishnan K, Ramasamy T, Ramakrishnan A, Agarwal A, et al. Comparison of nutrition screening tools and calf circumference in estimating the preoperative prevalence of malnutrition among patients with aerodigestive tract cancers-a prospective observational cohort study. Support Care Cancer. 2022;30(8):6603-12.
69. Yin L, Fan Y, Lin X, Zhang L, Li N, Liu J, et al. Fat mass assessment using the triceps skinfold thickness enhances the prognostic value of the Global Leadership Initiative on Malnutrition criteria in patients with lung cancer. Br J Nutr. 2022;127(10):1506-16.
70. Yin L, Lin X, Liu J, Li N, He X, Zhang M, et al. Classification Tree-Based Machine Learning to Visualize and Validate a Decision Tool for Identifying Malnutrition in Cancer Patients. JPEN J Parenter Enteral Nutr. 2021;45(8):1736-48.
71. Wang Y, Chen X, Wang Y, Liu Z, Fang Y, Peng Z, et al. Body Composition Measurement Improved Performance of GLIM Criteria in Diagnosing Malnutrition Compared to PG-SGA in Ambulatory Cancer Patients: A Prospective Cross-Sectional Study. Nutrients. 2021;13(8).
72. Yin L, Cheng N, Chen P, Zhang M, Li N, Lin X, et al. Association of Malnutrition, as Defined by the PG-SGA, ESPEN 2015, and GLIM Criteria, With Complications in Esophageal Cancer Patients After Esophagectomy. Front Nutr. 2021;8:632546.
73. Lopez-Gomez JJ, Cerezo-Martin JM, Gomez-Hoyos E, Jimenez-Sahagun R, Torres-Torres B, Ortola-Buigues A, et al. Diagnosis of malnutrition and its relationship with prognosis in hospitalized patients with oncological pathology. Endocrinol Diabetes Nutr (Engl Ed). 2023;70(5):304-12.
74. Zhang Z, Wan Z, Zhu Y, Zhang L, Zhang L, Wan H. Prevalence of malnutrition comparing NRS2002, MUST, and PG-SGA with the GLIM criteria in adults with cancer: A multi-center study. Nutrition. 2021;83:111072.

519 75. Zheng HL, Lin J, Shen LL, Yang HB, Xu BB, Xue Z, et al. The GLIM criteria as an
520 effective tool for survival prediction in gastric cancer patients. Eur J Surg Oncol.
521 2023;49(5):964-73.
522 76. Zhang Z, Wan Z, Zhu Y, Wan H. Predictive validity of the GLIM criteria in treatment
523 outcomes in cancer patients with radiotherapy. Clin Nutr. 2022;41(4):855-61.
524 77. Huo Z, Chong F, Yin L, Li N, Liu J, Zhang M, et al. Comparison of the performance of
525 the GLIM criteria, PG-SGA and mPG-SGA in diagnosing malnutrition and predicting survival
526 among lung cancer patients: A multicenter study. Clin Nutr. 2023;42(6):1048-58.
527 78. Zhang X, Tang M, Zhang Q, Zhang KP, Guo ZQ, Xu HX, et al. The GLIM criteria as an
528 effective tool for nutrition assessment and survival prediction in older adult cancer patients. Clin
529 Nutr. 2021;40(3):1224-32.
530 79. Zhuang CL, Zhang FM, Xu HX, Weng M, Yao Y, Zhou FX, et al. Reference values of
531 low body mass index, mid-upper arm circumference, and calf circumference in cancer patients:
532 A nationwide multicenter observational study. Nutrition. 2022;99-100:111688.
533 80. Cioce M, Botti S, Lohmeyer FM, Galli E, Magini M, Giraldi A, et al. Nutritional status
534 and quality of life in adults undergoing allogeneic hematopoietic stem cell transplantation. Int J
535 Hematol. 2022;116(2):266-75.
536 81. Crestani MS, Stefani GP, Scott LM, Steemburgo T. Accuracy of the GLIM Criteria and
537 SGA Compared to PG-SGA for the Diagnosis of Malnutrition and Its Impact on Prolonged
538 Hospitalization: A Prospective Study in Patients with Cancer. Nutr Cancer. 2023;75(4):1177-88.
539 82. Wu T, Xu H, Zou Y, Cui J, Xu K, Zhou M, et al. Mid-Arm Muscle Circumference or
540 Body Weight-Standardized Hand Grip Strength in the GLIM Superiorly Predicts Survival in
541 Chinese Colorectal Cancer Patients. Nutrients. 2022;14(23).
542 83. Song M, Zhang Q, Liu T, Tang M, Zhang X, Ruan G, et al. Efficacy of Global
543 Leadership Initiative on Malnutrition as potential cachexia screening tool for patients with solid
544 cancer. Nutr J. 2022;21(1):73.
545 84. Wang Y, Wang Y, Li G, Zhang H, Yu H, Xiang J, et al. Associations of intermuscular
546 adipose tissue and total muscle wasting score in PG-SGA with low muscle radiodensity and mass
547 in nonmetastatic colorectal cancer: A two-center cohort study. Front Nutr. 2022;9:967902.
548 85. Liu C, Lu Z, Li Z, Xu J, Cui H, Zhu M. Influence of Malnutrition According to the GLIM
549 Criteria on the Clinical Outcomes of Hospitalized Patients With Cancer. Front Nutr.
550 2021;8:774636.
551 86. Yin L, Song C, Cui J, Lin X, Li N, Fan Y, et al. De novo Creation and Assessment of a
552 Prognostic Fat-Age-Inflammation Index "FAIN" in Patients With Cancer: A Multicenter Cohort
553 Study. Front Nutr. 2022;9:860285.
554 87. Lopez-Gomez JJ, Benito-Sendin Plaar K, Izaola-Jauregui O, Primo-Martin D, Gomez-
555 Hoyos E, Torres-Torres B, et al. Muscular Ultrasonography in Morphofunctional Assessment of
556 Patients with Oncological Pathology at Risk of Malnutrition. Nutrients. 2022;14(8).
557 88. de Sousa IM, Silva FM, de Carvalho ALM, da Rocha IMG, Fayh APT. Accuracy of
558 isolated nutrition indicators in diagnosing malnutrition and their prognostic value to predict death
559 in patients with gastric and colorectal cancer: A prospective study. JPEN J Parenter Enteral Nutr.
560 2022;46(3):508-16.
561 89. Yin L, Liu J, Lin X, Li N, Guo J, Fan Y, et al. Nutritional features-based clustering
562 analysis as a feasible approach for early identification of malnutrition in patients with cancer.
563 Eur J Clin Nutr. 2021;75(8):1291-301.

564 90. Yilmaz M, Atilla FD, Sahin F, Saydam G. The effect of malnutrition on mortality in
565 hospitalized patients with hematologic malignancy. Support Care Cancer. 2020;28(3):1441-8.
566 91. Contreras-Bolivar V, Sanchez-Torralvo FJ, Ruiz-Vico M, Gonzalez-Almendros I, Barrios
567 M, Padin S, et al. GLIM Criteria Using Hand Grip Strength Adequately Predict Six-Month
568 Mortality in Cancer Inpatients. Nutrients. 2019;11(9).
569 92. Ruan X, Wang X, Zhang Q, Nakyeyune R, Shao Y, Shen Y, et al. The performance of
570 three nutritional tools varied in colorectal cancer patients: a retrospective analysis. J Clin
571 Epidemiol. 2022;149:12-22.
572 93. Landgrebe M, Tobberup R, Carus A, Rasmussen HH. GLIM diagnosed malnutrition
573 predicts clinical outcomes and quality of life in patients with non-small cell lung cancer. Clin
574 Nutr. 2023;42(2):190-8.
575 94. Yin L, Lin X, Li N, Zhang M, He X, Liu J, et al. Evaluation of the Global Leadership
576 Initiative on Malnutrition Criteria Using Different Muscle Mass Indices for Diagnosing
577 Malnutrition and Predicting Survival in Lung Cancer Patients. JPEN J Parenter Enteral Nutr.
578 2021;45(3):607-17.
579 95. Yin L, Song C, Cui J, Wang N, Fan Y, Lin X, et al. Low fat mass index outperforms
580 handgrip weakness and GLIM-defined malnutrition in predicting cancer survival: Derivation of
581 cutoff values and joint analysis in an observational cohort. Clin Nutr. 2022;41(1):153-64.
582 96. Li Q, Zhang X, Tang M, Song M, Zhang Q, Zhang K, et al. Different muscle mass
583 indices of the Global Leadership Initiative on Malnutrition in diagnosing malnutrition and
584 predicting survival of patients with gastric cancer. Nutrition. 2021;89:111286.
585 97. Yin L, Liu J, Lin X, Li N, Shi M, Zhang H, et al. Development and validation of a rapid-
586 decision pathway to diagnose malnutrition in patients with lung cancer. Nutrition.
587 2021;84:111102.
588 98. Santos I, Mendes L, Mansinho H, Santos CA. Nutritional status and functional status of
589 the pancreatic cancer patients and the impact of adjacent symptoms. Clin Nutr.
590 2021;40(11):5486-93.
591 99. Zhang Q, Zhang KP, Zhang X, Tang M, Song CH, Cong MH, et al. Scored-GLIM as an
592 effective tool to assess nutrition status and predict survival in patients with cancer. Clin Nutr.
593 2021;40(6):4225-33.
594 100. Zou Y, Xu H, Lyu Q, Weng M, Cui J, Shi H, et al. Malnutrition diagnosed by GLIM
595 criteria better predicts long-term outcomes for patients with non-Hodgkin's lymphoma: A
596 prospective multicenter cohort study. Hematol Oncol. 2023;41(3):371-9.
597 101. Yin L, Lin X, Zhao Z, Li N, He X, Zhang M, et al. Is hand grip strength a necessary
598 supportive index in the phenotypic criteria of the GLIM-based diagnosis of malnutrition in
599 patients with cancer? Support Care Cancer. 2021;29(7):4001-13.
600 102. Artero A, Saez Ramirez T, Muresan BT, Ruiz-Berjaga Y, Jimenez-Portilla A, Sanchez-
601 Juan CJ. The Effect of Fasting on Body Composition Assessment in Hospitalized Cancer
602 Patients. Nutr Cancer. 2023;75(8):1610-8.
603 103. Movahed S, Norouzy A, Ghanbari-Motlagh A, Eslami S, Khadem-Rezaiyan M,
604 Emadzadeh M, et al. Nutritional Status in Patients with Esophageal Cancer Receiving
605 Chemoradiation and Assessing the Efficacy of Usual Care for Nutritional Managements. Asian
606 Pac J Cancer Prev. 2020;21(8):2315-23.
607 104. Wang Y, Zhang L, Zhang T, Jin S, Huang Z, Zhao D, et al. Predictive effect of
608 pretreatment nutritional risk and GLIM-defined malnutrition on the nutrition impact symptom

clusters in patients with head and neck cancer undergoing radiotherapy. Head Neck. 2023;45(2):380-90.
105. Curtis AR, Livingstone KM, Daly RM, Brayner B, Abbott G, Kiss N. Dietary patterns, malnutrition, muscle loss and sarcopenia in cancer survivors: findings from the UK Biobank. J Cancer Surviv. 2023.
106. Gascon-Ruiz M, Casas-Deza D, Marti-Pi M, Torres-Ramon I, Zapata-Garcia M, Sesma A, et al. Diagnosis of Malnutrition According to GLIM Criteria Predicts Complications and 6-Month Survival in Cancer Outpatients. Biomedicines. 2022;10(9).
107. Takimoto M, Yasui-Yamada S, Nasu N, Kagiya N, Aotani N, Kurokawa Y, et al. Development and Validation of Cutoff Value for Reduced Muscle Mass for GLIM Criteria in Patients with Gastrointestinal and Hepatobiliary-Pancreatic Cancers. Nutrients. 2022;14(5).
108. Wan M, Zhang L, Chen C, Zhao D, Zheng B, Xiao S, et al. GLIM Criteria-Defined Malnutrition Informs on Survival of Nasopharyngeal Carcinoma Patients Undergoing Radiotherapy. Nutr Cancer. 2022;74(8):2920-9.
109. Einarsson S, Laurell G, Tiblom Ehrsson Y. Mapping the frequency of malnutrition in patients with head and neck cancer using the GLIM Criteria for the Diagnosis of Malnutrition. Clin Nutr ESPEN. 2020;37:100-6.
110. Amiri Khosroshahi R, Barkhordar M, Talebi S, Imani H, Sadeghi E, Mousavi SA, et al. The impact of malnutrition on mortality and complications of hematopoietic stem cell transplantation in patients with acute leukemia. Clin Nutr. 2023;42(12):2520-7.
111. Guo F, Min L, Chengyuan L, Hong L, Meng W, Chenyi T, et al. The influence of the China GLIM standards on the diagnosis of malnutrition in patients with hematopoietic stem cell transplant. Front Nutr. 2022;9:1077442.
112. Orell HK, Pohju AK, Osterlund P, Schwab US, Ravasco P, Makitie A. GLIM in diagnosing malnutrition and predicting outcome in ambulatory patients with head and neck cancer. Front Nutr. 2022;9:1030619.
113. Balci C, Tufan G, Ozdemir N, Aksoy S, Oksuzoglu OB, Zengin N, et al. GLIM criteria as a valid tool for nutrition assessment and mortality prediction in treatment-naive patients with cancer. Nutr Clin Pract. 2023;38(4):798-806.
114. Muresan BT, Nunez-Abad M, Artero A, Rios Rios J, Cunquero-Tomas AJ, Iranzo V, et al. Relation of Malnutrition and Nosocomical Infections in Cancer Patients in Hospital: An Observational Study. J Nutr Metab. 2022;2022:5232480.
115. Huang CH, Peng TC, Chou YF, Peng YH. Investigating sarcopenia, physical activity, and inflammation biomarkers in newly diagnosed oral cancer patients during curative treatment: A prospective longitudinal study. Asia Pac J Oncol Nurs. 2023;10(8):100261.
116. Harimoto N, Tsukagoshi M, Okuyama T, Hoshino K, Hagiwara K, Kawai S, et al. Significance of malnutrition defined with Global Leadership Initiative on Malnutrition criteria in patients with hepatocellular carcinoma after hepatic resection. Hepatol Res. 2023;53(12):1235-48.
117. Song HN, Wang WB, Luo X, Huang DD, Ruan XJ, Xing CG, et al. Effect of GLIM-defined malnutrition on postoperative clinical outcomes in patients with colorectal cancer. Jpn J Clin Oncol. 2022;52(5):466-74.
118. Sanchez-Torralvo FJ, Contreras-Bolivar V, Ruiz-Vico M, Abuin-Fernandez J, Gonzalez-Almendros I, Barrios M, et al. Relationship between malnutrition and the presence of symptoms of anxiety and depression in hospitalized cancer patients. Support Care Cancer. 2022;30(2):1607-13.

119. Perrier M, Ordan MA, Barbe C, Mazza C, Botsen D, Moreau J, et al. Dynapenia in digestive cancer outpatients: association with markers of functional and nutritional status (the FIGHTDIGO study). Support Care Cancer. 2022;30(1):207-15.
120. Steer B, Loeliger J, Edbrooke L, Deftereos I, Laing E, Kiss N. Malnutrition Prevalence according to the GLIM Criteria in Head and Neck Cancer Patients Undergoing Cancer Treatment. Nutrients. 2020;12(11).
121. Arends J, Strasser F, Gonella S, Solheim TS, Madeddu C, Ravasco P, et al. Cancer cachexia in adult patients: ESMO Clinical Practice Guidelines(☆). ESMO Open. 2021;6(3):100092.
122. Cederholm T, Jensen GL, Ballesteros-Pomar MD, Blaauw R, Correia M, Cuerda C, et al. Guidance for assessment of the inflammation etiologic criterion for the GLIM diagnosis of malnutrition: A modified Delphi approach. Clin Nutr. 2023.
123. Cederholm T, Jensen GL, Correia M, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. J Cachexia Sarcopenia Muscle. 2019;10(1):207-17.
124. Dodds RM, Syddall HE, Cooper R, Benzeval M, Deary IJ, Dennison EM, et al. Grip strength across the life course: normative data from twelve British studies. PLoS One. 2014;9(12):e113637.
125. Martin L, Muscaritoli M, Bourdel-Marchasson I, Kubrak C, Laird B, Gagnon B, et al. Diagnostic criteria for cancer cachexia: reduced food intake and inflammation predict weight loss and survival in an international, multi-cohort analysis. J Cachexia Sarcopenia Muscle. 2021;12(5):1189-202.
126. Abbass T, Dolan RD, Horgan PG, McMillan DC. The relationship between systemic inflammation, body composition and clinical outcomes in patients with operable colorectal cancer at low and medium to high nutritional risk. JCSM Clinical Reports. 2020;5(4):99-107.
127. Arends J, Baracos V, Bertz H, Bozzetti F, Calder PC, Deutz NEP, et al. ESPEN expert group recommendations for action against cancer-related malnutrition. Clin Nutr. 2017;36(5):1187-96.
128. McMillan DC. Systemic inflammation, nutritional status and survival in patients with cancer. Curr Opin Clin Nutr Metab Care. 2009;12(3):223-6.
129. Boudou-Rouquette P, Arrondeau J, Gervais C, Durand JP, Fabre E, De Percin S, et al. Development and validation of a host-dependent, PDL1-independent, biomarker to predict 6-month progression-free survival in metastatic non-small cell lung cancer (mNSCLC) patients treated with anti-PD1 immune checkpoint inhibitors (ICI) in the CERTIM Cohort: The ELY study. EBioMedicine. 2021;73:103630.
130. Jouinot A, Ulmann G, Vazeille C, Durand JP, Boudou-Rouquette P, Arrondeau J, et al. Hypermetabolism is an independent prognostic factor of survival in metastatic non-small cell lung cancer patients. Clin Nutr. 2020;39(6):1893-9.
131. Valter R, Paillaud E, Boudou-Rouquette P, Oubaya N, Aregui A, Lorisson E, et al. Comparison of the prognostic value of eight nutrition-related tools in older patients with cancer: A prospective study. J Nutr Health Aging. 2024;28(4):100188.

Table 1. Key characteristics of eligible studies

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
Wongdama, S., et al. (27)	2023	350	Cross-sectional study	All type without breast or prostate cancer	radiotherapy	quartiles of the previous 7-14 days	Blood test	-	NRS2002, SPENT, PG-SGA
Molfino, A., et al. (28)	2022	102	Prospective study	gastrointestinal or lung cancers	non-interventional	MUST	CRP	-	-
Zhang, K. P., et al. (29)	2022	1431	Cohort study	cancer	non-interventional	NRS2002	ALI/ mGPS/ SII	-	EORTC
Takamizawa, Y., et al. (30)	2020	1030	Cohort study	colorectal cancer	curative resection	-	mGPS/ PNI/ CONUT	-	-
Einarsson, S., et al. (31) -	2020	229	Observational study	head and neck cancer	anti-cancer treatment	-	CRP	-	-
Chen, W. Z., et al. (32)	2023	1359	Retrospective study	gastric cancer	gastrectomy	NRS2002	-	-	-
Ozorio, G. A., et al. (33) +	2023	885	Retrospective study	cancer	chemotherapy, radiotherapy, or surgery	NRS2002, SGA	Albumin CRP	-	-
Okada, G., et al. (34)	2021	117	Randomized controlled trial	esophageal cancer	postoperative	quartiles of the previous 7-14 days	CRP	-	-
Tan, S., et al. (35) +	2022	1115	Observational study	gastric, colorectal, pancreatic, or biliary cancer	cancer treatment	MDASI-GI/ CASCO	CRP	-	-
Gascon-Ruiz, M., et al. (36) +	2021	165	Cross-sectional study	upper gastrointestinal tract, colorectal, and of the head and neck area	active oncological treatment	MUST	-	-	ESPEN
Przekop, Z., et al. (37) +	2022	237	Retrospective study	Head and Neck Cancer		-	Disease*	-	-
Murnane, L. C., et al. (38)	2023	108	Cohort Study	oesophago-Gastric cancer	surgery	-	Disease*, Blood test	CT	-
Liu, Y., et al. (39) +	2023	182	Cohort study	adenocarcinoma and squamous cell carcinoma	surgery	NRS2002	Disease	CT	PG-SGA
Matsui, R., et al. (40)	2023	512	Retrospective cohort study	gastric cancer	gastrectomy	SGA	CRP	CT	-
Menozzi, R., et al. (41)	2023	103	Retrospective study	carcinoma	Surgery	energy requirement	Disease	CT	-
Korczak, J., et al. (42)	2023	64	Observational study	prostate adenocarcinoma	androgen deprivation therapy	-	Disease	CT	NRS2002
McGovern, J., et al. (43)	2023	436	Retrospective cohort study	advanced cancer	anti-cancer therapy with palliative intent	-	NRL/ mGPS	CT	-

Table 1. Key characteristics of eligible studies (continue)

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
da Silva Couto, A., et al. (44) +	2023	191	Retrospective cohort study	colorectal cancer	routine abdominal CT scan	PG-SGA	Disease	CT	-
Zhang, Y., et al. (45)	2022	182	Retrospective cohort study	gastric cancer	radical surgery after neoadjuvant treatment	NRS2002	Disease*	CT	-
Cai, W., et al. (46)	2022	1007	Propensity Score-Matched Analysis	gastric cancer	radical gastrectomy	NRS2002	Disease*	CT	-
Huang, Y., et al. (47)	2022	488	Cohort study	gastrointestinal cancer	non-interventional	quartiles of the previous 7-14 days	Disease	CT	NRS 2002, GNRI, MNA-SF
Xu, L. B., et al. (48)	2022	1188	Retrospective cohort study	gastric cancer	gastrectomy	-	Disease*	CT	-
Xu, L. B., et al. (49) +	2022	1020	Retrospective study	gastric cancer	gastrectomy	MUST	NLR/ MLR	CT	-
Findlay, M., et al. (50)	2021	359	Retrospective cohort study	head and neck cancer	adjuvant	food diary	-	CT	-
Huang, D. D., et al. (51)	2021	587	Observational study	gastric cancer	radical gastrectomy	NRS 2002	-	CT	-
Xie, H., et al. (52)	2023	5700	Prospective study	cancer	noninterventional	self-reported	IBI/CRP/NLR /ALB	CT	ECOG
Matsui, R., et al. (53) +	2023	281	Retrospective cohort study	gastric cancer	adjuvant chemotherapy	BWL, SGA	CRP	CT	-
Zhang, F. M., et al. (54)	2021	1315	Random resampling	gastric cancer	curative surgery	quartiles of the previous 7-14 days	-	CT	-
Abbass, T., et al. (55)	2020	647	Cohort study	lung cancer	radiotherapy	MUST	mGPS	CT	ECOG
Zhou, C. J., et al. (56)	2023	624	Cohort study	rectal cancer	proctectomy	NRS-2002	-	CT	-
Chen, X. Y., et al. (57)	2022	636	Cohort study	rectal cancer patients	proctectomy	NRS-2002	Albumin	CT	-
Almasaudi, A. S., et al. (58)	2020	795	Retrospective cohort study	colorectal Cancer	surgery	MUST	Albumin CRP	CT	-
Tolonen, A., et al. (59)	2023	80	Retrospective-cohort study	upper GI, lower GI, and other cancers	CT scan	MST	Albumin	CT, Handgrip	Sit to Stand
Caccialanza, R., et al. (60)	2022	180	Randomized clinical trial	head and neck cancer	immunonutrition	NRS-2002	-	CT, Handgrip	-
Huang, D. D., et al. (61) +	2022	1359	Cohort study	gastric cancer	gastrectomy	NRS2002	Disease*	CT, Handgrip	-

Table 1. Key characteristics of eligible studies (continue)

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
Chen, W. Z., et al. (62)	2022	742	Observational study	gastric cancer	gastrectomy	NRS2002	Albumin	CT, Handgrip	-
Djordjevic, A., et al. (63)	2022	57	Exploratory study	colorectal cancer	surgery	MST/ PG-SGA	-	CT, Handgrip	-
Zhou, L. P., et al. (64)	2021	2209	Cohort study	gastrointestinal cancers	cancer treatment	NRS2002	Disease*	CT, Handgrip	-
Qin, L., et al. (65) [+]	2021	217	Cross-sectional study	gastric Cancer	cancer treatment	-	Disease*	CT/ BIA	ECOG, KPS, PG-SGA
Kiss, N., et al. (66)[+]	2023	2801	Cohort Study	cancer	radiotherapy, intravenous chemotherapy or immunotherapy	MST	Disease	MMT	PG-SGA
Gounitsioti, I. S., et al. (67)	2022	53	Two-time points study	gynecological Cancer	Surgery	dietary recall	Disease*	Anthropometry	SGA
Srinivasaraghavan, N., et al. (68)	2022	107	Cross-sectional	cancer	noninterventional	MUST/ MNA-SF	-	CC	-
Yin, L., et al. (69)	2022	2672	Cohort study	lung cancer	noninterventional	NRS2002	Disease*	Anthropometry	EORTC
Yin, L., et al. (70)	2021	4025	Cohort study	cancer	cancer treatment	-	Disease	CC	-
Wang, Y., et al. (71)	2021	686	Cross-sectional	cancer	noninterventional	MUST	CRP	CC	PG-SGA
Yin, L., et al. (72) [+]	2021	360	Cohort study	esophageal cancer	Esophagectomy	NRS2002	Disease*	CC	PG-SGA, ESPEN
Lopez-Gomez, J. J., et al. (73)	2023	149	Longitudinal, retrospective study	cancer	cancer treatment	MUST/ MNA	-	ASMI/ CC	-
Zhang, Z., et al. (74)	2021	637	Observational study	cancer	radiation therapy	NRS2002, MUST, PG-SGA	-	MAC/ CC	-
Zheng, H. L., et al. (75) [+]	2023	1121	Retrospective study	gastric adenocarcinoma	radical gastrectomy	quartiles of the previous 7-14 days	-	validated body composition measuring techniques.	-
Zhang, Z., et al. (76) [+]	2022	468	Randomized clinical trial	cancer	radiotherapy	quartiles of the previous 7-14 days	-	CC/ MAC	PG-SGA
Huo, Z., et al. (77) [−]	2023	6697	Rohort study	lung cancer	anticancer therapies	-	Disease*	CC	PG-SGA

Table 1. Key characteristics of eligible studies (continue)

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
Zhang, X., et al. (78) +	2021	1281	Retrospective cohort study	cancers	noninterventional	NRS 2002	-	Anthropometric	-
Zhuang, C. L., et al. (79)	2022	17597	Retrospective study	cancers	noninterventional	-	Disease*	MUAC/ CC	PG-SGA
Cioce, M., et al. (80)	2022	36	Observational study	myeloma, lymphoma, leukemia	allogeneic hematopoietic stem cell transplantation	quartiles of the previous 7-14 days	CRP	PA	NRS-2002
Crestani, M. S., et al. (81)	2023	183	Cohort study	gastrointestinal, head and neck, and lung cancer	cancer therapy	self-reported	Disease*	Handgrip, CC	-
Wu, T., et al. (82) +	2022	10214	Cohort study	colorectal cancer	reduced muscle mass assessment	NRS2002/ PG-SGA	-	Handgrip, MAMC/ CC	-
Song, M., et al. (83) +	2022	8478	Cohort study	16 types of locally or metastatic malignant solid tumors.	cancer therapy	NRS2002/ PG-SGA	Routine blood tests	Handgrip, MAMC/ CC/ TSF	KPS
Wang, Y., et al. (84)	2022	1637	Cohort study	colorectal cancer	surgery	NRS2002/ PG-SGA	NLR	Handgrip, Anthropometry	EORTC
Liu, C., et al. (85) +	2021	2388	Retrospective study	cancer	cancer therapy	NRS2002	Albumin	Handgrip, Anthropometry	-
Yin, L., et al. (86)	2022	14134	Cohort study	cancer	anti-cancer treatment	NRS2002/ PG-SGA	FAIN	Handgrip, Anthropometry	-
Lopez-Gomez, J. J., et al. (87)	2022	43	Cross-sectional study	cancer	noninterventional	food diary	-	Handgrip, Anthropometry	-
de Sousa, I. M., et al. (88)	2022	178	Cohort study	gastric and colorectal cancer	noninterventional	MUST	-	Handgrip, CC	PG-SGA
Yin, L., et al. (89)	2021	4025	Cohort study	cancer	noninterventional	quartiles of the previous 7-14 days	CPR/ NLR	Handgrip, MAC/ TSF/ MAMC/ CC	-
Yilmaz, M., et al. (90)	2020	135	Randomized controlled trials	hematologic malignancy	noninterventional	NRS2002	Albumin CRP	Handgrip, MUAC/ CC	-
Contreras-Bolivar, V., et al. (91) +	2019	351	Observational study	cancer	noninterventional	food diary	GPS	Handgrip, AMC/ CC	MUST, SGA
Ruan, X., et al. (92) -	2022	1,358	Retrospective cohort study	colorectal cancer	cancer treatment	food diary	Albumin CRP	Handgrip, CC/ MAC/ MAMC	-
Landgrebe, M., et al.(93) +	2023	120	Observational study	non-small cell lung cancer	first line anti-neoplastic treatment	percentile	CRP	Handgrip, MMC/ CC	-

Table 1. Key characteristics of eligible studies (continue)

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
Yin, L., et al. (94) +	2021	1238	Cohort study	lung cancer	noninterventional	interview	laboratory indices	Handgrip, CC	-
Yin, L., et al. (95)	2022	2529	Retrospective cohort study	cancer	cancer treatment	NRS2002	-	Handgrip, CC/ MAC/ TSF	-
Li, Q., et al. (96) +	2021	219	Cohort study	gastric cancer	noninterventional	self-reported	Disease*	Handgrip, MAC/ CC	NRS 2002
Yin, L., et al. (97)	2021	1219	Cohort study	lung cancer	noninterventional	Nutrition interview	laboratory indices	Handgrip, CC	-
Santos, I., et al. (98)	2021	41	Cohort study	pancreatic cancer	noninterventional	NRS-2002	-	Handgrip, Anthropometry	-
Zhang, Q., et al. (99) -	2021	3547	Cohort study	cancer	cancer treatment	self-reported	Disease*	Handgrip, AMC/ MAC/ CC	-
Zou, Y., et al. (100) +	2023	963	Cohort study	non-hodgkin's lymphoma	cancer treatment	-	Disease*	Handgrip, MAMC/ MAC/ CC	PG-SGA
Yin, L., et al. (101)	2021	4025	Cohort study	cancers	noninterventional	PGSGA	CRP/ NLR	Handgrip, CC	-
Artero, A., et al. (102)	2023	53	Cross-sectional study	cancer	cancer therapy	the fasting and non-fasting	-	Anthropometry, BIA	-
Movahed, S., et al. (103)	2020	71	Cross-sectional survey study	esophageal Cancer	chemoradiation	24 Hours food recall	Albumin CRP	Handgrip, BIA/ MUAC	-
Wang, Y., et al. (104)	2023	537	Prospective longitudinal study	head and neck cancer	radiotherapy	quartiles of the previous 7-14 days	Disease	BIA	NRS2002
Curtis, A. R., et al. (105)	2023	2415	Cross-sectional study	cancer	non-interventional	dietary recall	CRP	BIA	-
Gascon-Ruiz, M., et al. (106) +	2022	165	Observational prospective study	head and neck, upper digestive tract, and/or colorectal	non-interventional	quartiles of the previous 7-14 days	Disease	BIA	-
Takimoto, M., et al. (107)	2022	660	Retrospective observational study	gastrointestinal and hepatobiliary–pancreatic cancers	digestive surgery and transplantation	-	Disease*	BIA	-
Wan, M., et al. (108) +	2022	113	Retrospective study	nasopharyngeal carcinoma	radiotherapy	NRS2002	Disease*	BIA	-
Einarsson, S., et al. (109) +	2020	210	Observational study	head and neck cancer	nutritional treatment	food diary	CRP	BIA	-
Amiri Khosroshahi, R., et al. (110)	2023	98	Longitudinal study	acute leukemia	hematopoietic stem cell transplantation	dietary recall	mGPS/ CRP	BIA	-

Table 1. Key characteristics of eligible studies (continue)

Author (Reference)	Year	Sample size	Study design	Cancer type	Intervention	Reduce food intake	Inflammatory	Reduce muscle mass	Other tools
Guo, F., et al. (111)	2022	98	Cohort study	leukemias, lymphomas, cancer of plasma cells	hematopoietic stem cell transplant	NRS-2002	CRP	BIA	PG-SGA
Orell, H. K., et al. (112)$^{+}$	2022	65	Randomized controlled study	head and neck cancer	curative	quartiles of the previous 7-14 days	CRP	BIA	PG–SGA
Balci, C., et al. (113)$^{+}$	2023	267	Longitudinal, multicenter observational study	newly diagnosed with different types of cancer	non-interventional study	PG-SGA	Albumin CRP	Handgrip, BIA	
Muresan, B. T., et al. (114)	2022	107	Observational Study	cancer	cancer treatment	quartiles of the previous 7-14 days	Disease	Handgrip, BIA	-
Huang, C. H., et al. (115)	2023	61	Prospective longitudinal study	oral cancer	curative treatment	-	LMR/ NLR/ SII	Handgrip, BIA	5-CST
Harimoto, N., et al. (116)$^{+}$	2023	254	Retrospective cohort study	hepatocellular carcinoma	hepatic resection	quartiles of the previous 7-14 days	CRP	Handgrip	CONUT
Song, H. N., et al. (117)$^{+}$	2022	918	Cohort study	colorectal cancer	surgery	NRS2002	Disease*	Handgrip	-
Sanchez-Torralvo, F. J., et al. (118)	2022	351	Observational prospective study	cancer	cancer treatment	quartiles of the previous 7-14 days	GPS	Handgrip	-
Perrier, M., et al. (119)	2022	879	Cohort study	digestive cancer	chemotherapy or biotherapy	-	mGPS	Handgrip	-
Steer, B., et al. (120)$^{+}$	2020	188	Retrospective study	head and neck cancer	Radiotherapy and chemotherapy	Nutrution interview	Disease	subjective assessment (PG-SGA)	-

Disease* = the study that exclude the etiologic criteria because the disease, $^{+}$ = the study that test the validly or quality of GLIM and the result was positive, and $^{-}$ = result is negative

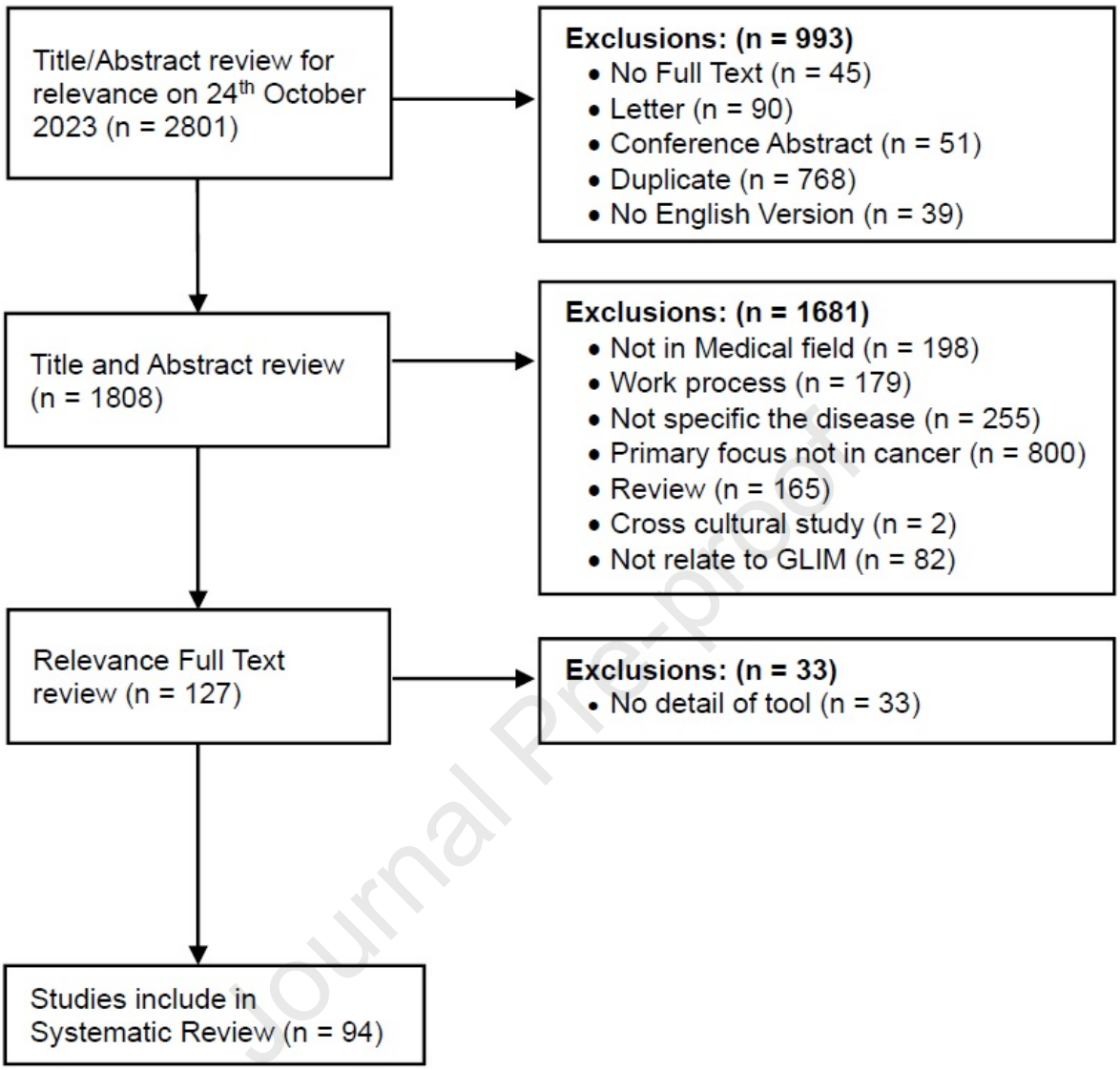

Figure 1 PRISMA flowchart demonstrating study selection.