BMC Cancer

SYSTEMATIC REVIEW

Open Access

Diagnostic performance of GLIM and PG-SGA for malnutrition assessment in adult cancer patients: a systematic review and meta-analysis

Jielin Zhou[1†], Shoumei Yang[1†], Ting Liu[2†], Yubei Sun[1*] and Suyi Li[1*]

Abstract

Objective Consistency between malnutrition defined by Global Leadership Initiative on Malnutrition (GLIM) and Patient-Generated Subjective Global Assessment (PG-SGA) has not been thoroughly elucidated in patients with cancer. The study aimed to compare their consistency, and summarize the impact of malnutrition defined by GLIM on adverse outcomes.

Method PubMed, Embase, Cochrane library and Web of Science databases were searched from inception to May 1, 2024. Initially, the amalgamated sensitivity, specificity and area under curve (AUC) with 95% confidence intervals (CIs) were calculated. Subsequently, hazard ratios (HR) or odd ratios (OR) and 95% CIs for overall survival (OS), all-cause mortality, postoperative complications, disease-free survival (DFS) and recurrence-free survival (RFS) were pooled.

Result Fifty-six studies (55,767 participants) were included. Compared with PG-SGA criteria, the overall sensitivity, specificity and area under curve (AUC) for GLIM was 0.71 (95% CI: 0.63–0.78), 0.80 (95% CI: 0.65–0.90) and 0.79 (95% CI: 0.75–0.83). Subgroup analysis revealed that the diagnostic value in Asian or among patients aged under 60 years were higher than non-Asian or those aged over 60 years. Moreover, GLIM-defined malnutrition was significantly associated with overall survival (OS) [hazard ratios (HR) = 1.57, 95% CI: 1.46–1.67], all-cause mortality (HR = 1.43, 95% CI: 1.29–1.57), postoperative complications [odd ratios (OR) = 1.57, 95% CI: 1.40–1.73], disease-free survival (DFS) (OR = 1.52, 95% CI: 1.36–1.68) and recurrence-free survival (RFS) (OR = 1.41, 95% CI: 1.10–1.72).

Conclusion GLIM criteria exhibit moderate diagnostic accuracy for identifying malnutrition among patients with cancer, when compared to the PG-SGA. This accuracy is pronounced in the Asian and patients under the age of 60. Furthermore, GLIM-defined malnutrition was significantly associated with OS, DFS, RFS, all-cause mortality and postoperative complication risks in patients with cancer.

Keywords GLIM, PG-SGA, Cancer-related malnutrition, Systematic review, Meta-analysis

[†]Jielin Zhou, Shoumei Yang and Ting Liu contributed equally to this work.

*Correspondence:
Yubei Sun
sunyubei@gmail.com
Suyi Li
njlisuyi@sina.com
Full list of author information is available at the end of the article

Introduction

Cancer is a major global public health problem with over 19.3 million new cases being reported and nearly one in six people died from cancer in 2020 [1, 2]. Owning to the anorexia/appetite loss, physical inactivity, metabolic disorders and systemic inflammation induced by the tumor itself and/or side effects of anticancer therapies [3, 4], patients with cancer are at a particularly high risk of developing malnutrition. This risk is especially pronounced in patients with head and neck (H&N), esophagogastric region, pancreas, and the entire upper gastrointestinal (GI) tract, with a prevalence that ranges from 25 to 85% [5, 6]. These cancers often lead to difficulties in eating, swallowing, and nutrient absorption due to the anatomical location and the nature of the disease. For instance, head and neck cancers can impair oral intake and swallowing function, while esophagogastric and pancreatic cancers can cause early satiety, nausea, and malabsorption. As a result, patients with these cancers are more likely to experience significant weight loss and nutritional deficiencies, which can further complicate their treatment and recovery.

Cancer-associated malnutrition could also increase risk of morbidity and mortality, reduce health-related quality of life, and generate a significant economic burden for health services [7]. Furthermore, published report suggested that 1 of 3 patients admitted to hospitals with cancer are either suffering from malnutrition or are at significant risk of developing it [8]. Additionally, estimates suggest that a significant proportion, ranging from 10 to 20 percent, of cancer-related deaths are attributable to the adverse effects of malnutrition, rather than the malignancy itself [9]. Therefore, accurate identification of nutritional status through effective nutritional assessment is crucial for improving survival outcomes.

The Patient-generated Subjective Global Assessment (PG-SGA), endorsed by both the European Society for Clinical Nutrition and Metabolism (ESPEN) and the American Dietetic Association, has become a widely recognized benchmark for subjective nutrition assessment among oncology patients [10, 11]. However, due to the fact that the assessment consists of seven distinct components, the result derived from the PG-SGA is relatively time-consuming [12]. Subsequently, ESPEN introduced diagnostic criteria for malnutrition in 2015 [13], focusing on easily applicable parameters such as body mass index (BMI), weight loss and/or fat-free mass index, all of which have undergone validation across various clinical settings [14]. However, compelling evidence indicated that disease-associated inflammation also plays a vital role in malnutrition [15]. In 2019, the Global Leadership Initiative on Malnutrition (GLIM) criteria as a consensus report, were officially proposed with the goal of normalizing the clinical diagnosis of malnutrition, which have incorporated disease burden/inflammation [16]. The Global Leadership Initiative on Malnutrition (GLIM) framework encompasses a synergistic set of phenotypic indicators—such as percentage weight loss, low body mass index, and diminished muscle mass—as well as etiologic factors, including diminished food intake or assimilation and the presence of acute or chronic inflammation, to diagnose malnutrition [17]. The GLIM offers a straightforward process that minimizes the time and workload demands on healthcare professionals.

A series of studies have reported the diagnostic consistent between PG-SGA and GLIM in patients with cancer [18–20]. However, the true accuracy of diagnostic performance of GLIM and PG-SGA for malnutrition assessment in adult patients with cancer remains controversial, such as consistency, sensitivity and specificity of diagnostic criteria. The primary purpose of this study was to accurately assess the diagnostic efficacy of the GLIM criteria for malnutrition through an extensive meta-analysis of existing literature published up to May 1, 2024. The secondary aims were to pool the association of malnutrition defined by the GLIM criteria with overall survival (OS), all-cause mortality, postoperative complications, disease-free survival (DFS), and recurrence-free survival (RFS).

Materials and methods

This study adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-2020) (Table S1) [21]. This systematic review and meta-analysis was registered at the International Prospective Register of Systematic Reviews (PROSPERO) (number CRD42024580584).

Databases and search

The literature search, study selection, and data extraction processes were performed by two authors (J.Z. and S.Y.) independently. Any discrepancies between the two authors were addressed through collaborative discussion, culminating in a consensus. The databases of PubMed, EMBASE, Cochrane Library and Web of Sciences were scanned until May 1, 2024. Additionally, reference lists of studies were also searched. The following keywords: "Patient-Generated Subjective Global Assessment" OR "PG-SGA" AND "Global Leadership Initiative on Malnutrition" OR "GLIM" AND "cancer" OR "tumor" OR "malignancy" OR "carcinoma" OR "neoplasms" were independently searched by Two authors (Table S2).

Inclusion and exclusion criteria

A study was deemed eligible based on the following criteria: (1) Eligible participants were pathologically

diagnosed with adult cancer, with no restrictions on tumor type, stage, or treatment history; (2) A comparative evaluation of the diagnostic accuracy of the GLIM criteria against the established PG-SGA standard; (3) The study focused on outcomes of interest, including OS, postoperative complications, all-cause mortality, DFS, and RFS; (4) enough data were available to perform the analyses (2×2 contingency table for diagnostic test was considered, raw binary data or pre-calculated odds ratio (OR), risk ratio (RR), hazard ratio (HR) for outcomes of interest was available).

Publications were excluded if they met any of the following conditions: (1) reports were reviews, letter or conference summaries; (2) research was not linked with malnutrition; (3) studies that were duplicates by the same author or research group; (4) no available data or no adequate data.

Quality assessment

The quality assessment was conducted independently by two authors (J.Z. and S.Y.) adopting Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) checklist for diagnostic accuracy studies [22] or using the Newcastle–Ottawa scale (NOS) for non-diagnostic studies [23]. QUADAS-2 checklist includes patient selection, index test, reference standard, flow and timing, corresponding to 3 kinds of result, "yes, unclear, no", "low risk, unclear risk, high risk" or "low concern, unclear concern, high concern". The quality of each characteristic for NOS was assessed and scored as 'low risk' or 'high risk' according to predefined criteria [2].

Data extraction

The following information was extracted from the included studies; (1) first author, (2) year of publication, (3) sample size, (4) continent (country), (5) mean/median age (range), (6) sex, (7) cancer stage, (8) type of patients with cancer, (9) study type, (10) information required to reconstruct a 2×2 contingency table (True Positives (TP), False Positives (FP), True Negatives (TN), False Negatives (FN)), (11) outcomes of interest (OS or postoperative complications or all-cause mortality, DFS or RFS).

Statistical analysis

Originally, a diagnostic meta-analysis of the GLIM and PG-SGA in adult patients with cancer was performed. The PG-SGA was used as the reference method. The pooled outcomes were derived by transforming the results of the screening tools into binary variables for analysis. The true positive, false positive, true negative and false negative were calculated. The amalgamated measures of diagnostic performance, including sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), diagnostic odds ratio (DOR), and the area under the receiver operating characteristic curve (AUC) with their respective 95% confidence intervals (95% CI), were pooled. The I^2 statistic was utilized to evaluate the degree of heterogeneity observed among the studies. The combined effect size and its corresponding 95% confidence interval were calculated using a fixed-effects model when the heterogeneity index I^2 was below 50%, and a random-effects model was employed when I^2 was above 50%. A subgroup analysis was performed to distinguish the potential sources of heterogeneity. Moreover, Fagan's nomogram was employed to explore the post-test probabilities, assuming a pre-test probability of malnutrition at 40%.

Subsequently, a meta-analysis of the relationship of GLIM-defined malnutrition with adverse outcomes in patients with cancer was reviewed. HR and 95% confidence intervals (CIs) for OS and all-cause mortality, and OR and 95% CIs for postoperative complications, DFS and RFS were pooled. All statistical analyses were performed using STATA version 15.1 (STATA Corp, College Station, Texas, USA).

Results

Literature screening and characteristics of the included studies

Following the initial search through PubMed, EMBASE, the Cochrane Library, and the Web of Science databases, a total of 134 unique studies were identified. The detailed selection process is summarized in Fig. 1. Originally, due to the duplication, 20 records were excluded. After screening the titles and abstracts, 114 studies were reviewed for further assessment, among which 24 records including editorials, letters and reviews, 21 records were not relevant to the current study. Subsequently, 13 papers were excluded by reviewing the full text, of which 5 studies with wrong population, 8 studies were unable to extract data. Eventually, 56 articles were included in the current meta-analysis. Of these, 18 studies were available for comparing the consistency between PG-SGA and GLIM in diagnostic cancer malnutrition, and 45 studies assessed the association between GLIM-malnutrition and OS, mortality, postoperative complications, DFS and RFS.

The main characteristics of the included studies are presented in Table 1. In this meta-analysis, we identified 56 published papers with 55,767 patients with cancer, including 7 cross-sectional and 49 cohort studies. These studies were published from 2019 to 2024 and conducted in China, Australia, Brazil, Norway, Finland, Turkey, Spain, Greece, Poland, Japan, Netherlands, UK, Germany and South Korea. Apart from 4 studies with unknown average age of patients, the average age of

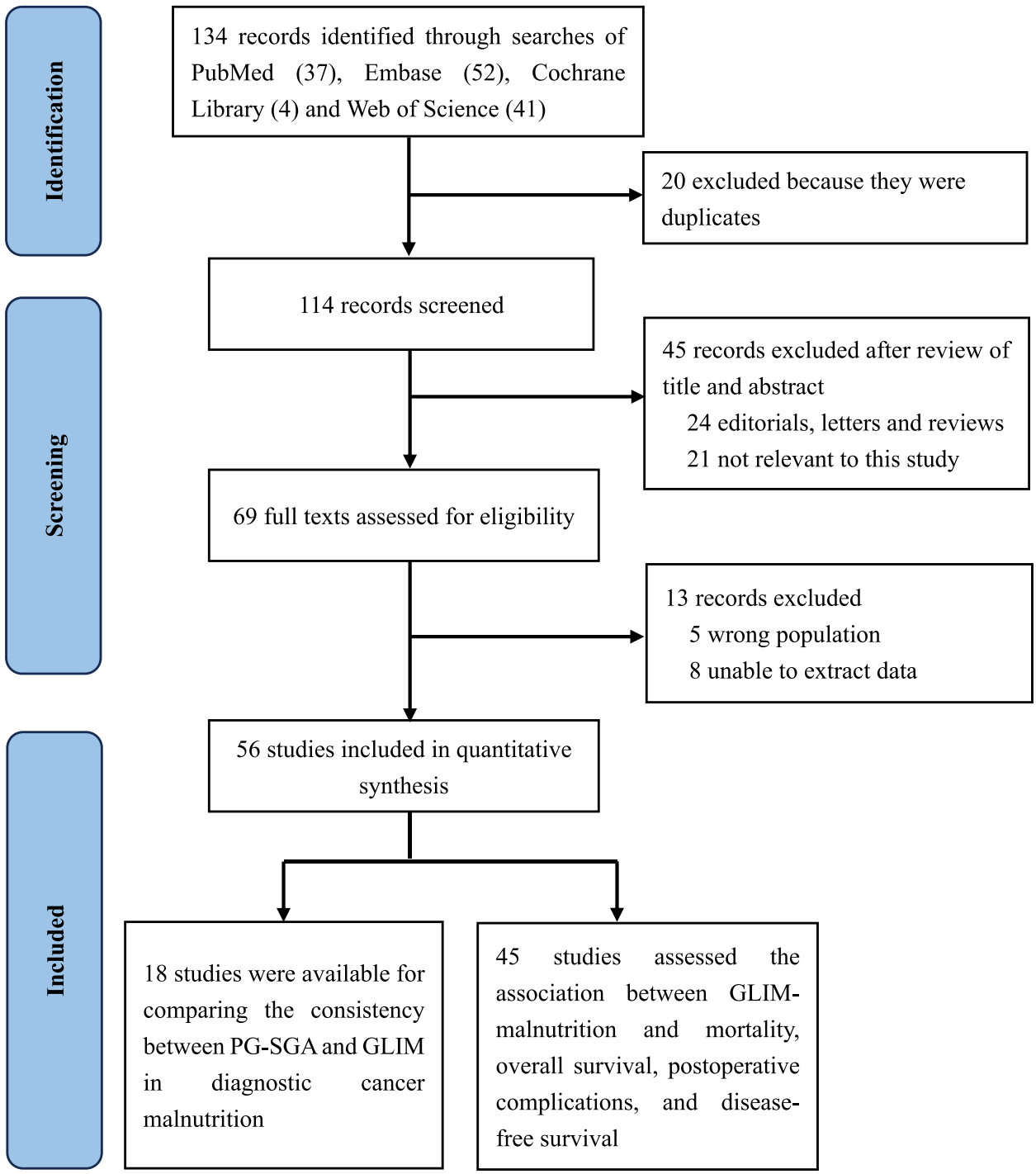

Fig. 1 Flowchart of search strategy and study selection

patients in other studies is over 50 years old. Seventeen articles enrolled patients with all types of cancer, 27 articles enrolled the gastrointestinal cancer, 3 articles enrolled the lung cancer, and the others enrolled the head and neck cancer, hepatocellular carcinoma, non-Hodgkin's lymphoma, breast cancer, cervical cancer and neuroendocrine tumours. The proportion of male patients ranged from 0% to 84.0% across the studies.

Table 1 Characteristics of included in the meta-analysis

Author	Year	N	Continent	Mean age	Sex	Stage	Cancer type	Tool	Study type	Outcome	Confounding factor
Zhang Z et al. [18]	2021	637	Asia (China)	18–92 (57)	Men (60.1%)	All	All	PG-SGA and GLIM	Cross-sectional	NA	NA
De Groot LM et al. [19]	2020	246	Oceania (Australia)	49–75 (62)	Men (26%)	All	All	PG-SGA and GLIM	Cohort	1-year mortality	NA
Huo Z et al. [20]	2023	6697	Asia (China)	53–66 (60)	Men (66.5%)	All	Lung cancer	PG-SGA and GLIM	Cohort	Overall survival	NA
Crestani MS et al. [24]	2023	183	South America (Brazil)	48–75 (61)	Men (54%)	All	All	PG-SGA and GLIM	Cohort	NA	NA
Henriksen C et al. [25]	2022	426	European (Norway)	58–74 (66)	Men (54.2%)	All	Colorectal cancer	PG-SGA and GLIM	Cross-sectional	NA	NA
Liu Y et al. [26]	2023	182	Asia (China)	18–80 (NA)	Men (79.7%)	All	Esophageal squamous carcinoma	PG-SGA and GLIM	Cohort	NA	NA
Yin L et al. [27]	2021	360	Asia (China)	56–73 (64)	Men (80.8%)	All	Esophageal Cancer	PG-SGA and GLIM	Cohort	Postoperative complications	NA
Rosnes KS et al. [28]	2021	144	European (Norway)	45–72 (58)	Men (53%)	All	All	PG-SGA and GLIM	Cross-sectional	NA	NA
Orell HK et al. [29]	2022	65	European (Finland)	33–77 (61)	Men (76.9%)	All	Head and neck cancer	PG-SGA and GLIM	Cohort	Overall survival, disease-free survival	NA
Balcı C et al. [30]	2023	267	Asia (Turkey)	45–71 (58)	Men (57.3%)	All	All	PG-SGA and GLIM	Cohort	NA	NA
Tan S et al. [31]	2024	207	Asia (China)	45–68 (57)	Men (82.1%)	All	Hepatocellular carcinoma	PG-SGA and GLIM	Cross-sectional	NA	NA
da Silva Couto A et al. [32]	2023	191	South America (Brazil)	48–74 (61)	Men (57.6%)	All	Colorectal cancer	PG-SGA and GLIM	Cohort	NA	NA
Zhang KP et al. [33]	2021	3777	Asia (China)	43–71 (56)	Men (58.1%)	All	All	PG-SGA and GLIM	Cohort	1-year mortality	NA
Wang Y et al. [34]	2024	562	Asia (China)	52–65 (59)	Men (70.3%)	All	All	PG-SGA and GLIM	Cross-sectional	NA	NA
Xu LB et al. [35]	2022	895	Asia (China)	57–76 (66)	Men (74%)	I–II	Gastric cancer	PG-SGA and GLIM	Cohort	Overall survival, postoperative complications	NA
Yin L et al. 1 [36]	2021	3998	Asia (China)	46–68 (57)	Men (47.2%)	All	All	PG-SGA and GLIM	Cohort	Overall survival	NA
Qin L et al. [37]	2021	217	Asia (China)	48–68 (60)	Men (57.1%)	All	Gastric cancer	PG-SGA and GLIM	Cross-sectional	NA	NA
Solon LA et al. [38]	2023	82	South America (Brazil)	45–73 (59)	Men (52.4%)	All	All	PG-SGA and GLIM	Cross-sectional	NA	NA
Contreras-Bolívar V et al. 1 [39]	2019	282	European (Spain)	58–73 (60)	Men (55.7%)	All	All	GLIM-malnutrition	Cohort	6-month mortality	Adjustment
Zou Y et al. [40]	2022	963	Asia (China)	32–83 (54)	Men (60.1%)	All	Non-Hodgkin's lymphoma	GLIM-malnutrition	Cohort	1-year mortality	Adjustment
Zhang Q et al. [41]	2021	3457	Asia (China)	45–73 (59)	Men (56.1%)	All	Colorectal, gastric, lung and breast cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment

Table 1 (continued)

Author	Year	N	Continent	Mean age	Sex	Stage	Cancer type	Tool	Study type	Outcome	Confounding factor
Yin L et al. 2 [42]	2021	3998	Asia (China)	46–68 (57)	Men (47.2%)	All	All	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Shen N et al. [43]	2023	385	Asia (China)	62–84 (73)	Men (60.0%)	I–III	Colorectal cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Yin L et al. 3 [44]	2022	2376	Asia (China)	51–65 (59)	Men (45.2%)	All	All	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Huang DD et al. [45]	2021	587	Asia (China)	52–78 (65)	Men (73.6%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, postoperative complications	Adjustment
Huang DD et al. 1 [46]	2022	597	Asia (China)	64–80 (72)	Men (77.5%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, disease-free survival	Adjustment
Chen XY et al. [47]	2022	636	Asia (China)	48–82 (65)	Men (60.5%)	I–III	Rectal cancer	GLIM-malnutrition	Cohort	Overall survival, postoperative complications	Adjustment
Wu T et al. [48]	2022	3612	Asia (China)	52–77 (64)	Men (60.2%)	All	Colorectal cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Harimoto N et al. [49]	2023	174	Asia (Japan)	60–81 (70)	Men (82.4%)	All	Hepatocellular carcinoma	GLIM-malnutrition	Cohort	Overall Survival, postoperative complications, recurrence-free survival	Adjustment
Song HN et al. [50]	2022	918	Asia (China)	49–83 (66)	Men (60.5%)	I–III	Colorectal cancer	GLIM-malnutrition	Cohort	Overall survival, postoperative complications, disease-free survival	Adjustment
Yin L et al. 4 [4]	2021	1219	Asia (China)	49–69 (59)	Men (67.3%)	All	Lung cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Li Q et al. [51]	2021	877	Asia (China)	47–73 (59)	Men (70.4%)	All	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Ruan X et al. [52]	2022	1358	Asia (China)	52–67 (60)	Men (59.7%)	All	Colorectal cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Li ZZ et al. [53]	2024	356	Asia (China)	52–80 (66)	Men (65.7%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, disease-free survival, postoperative complications	Adjustment
Matsui R et al. 1 [54]	2023	457	Asia (Japan)	57–79 (68)	Men (65.9%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, recurrence-free survival	Adjustment
Omiya S et al. 1 [55]	2023	293	Asia (Japan)	21–93 (70)	Men (84.0%)	All	Hepatocellular carcinoma	GLIM-malnutrition	Cohort	Overall survival, recurrence-free survival	Adjustment
Laan J et al. [56]	2023	294	European (Netherlands)	40–64 (52)	NA	All	Cervical cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment

Table 1 (continued)

Author	Year	N	Continent	Mean age	Sex	Stage	Cancer type	Tool	Study type	Outcome	Confounding factor
Clement DSVM et al. [57]	2023	118	European (UK)	57–75 (67)	Men (47.0%)	II-IV	Neuroendocrine tumours	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Song GJ et al. [58]	2024	302	Asia (Korea)	31–91 (60)	Men (72.5%)	All	Gastric cancer	GLIM-malnutrition	Cohort	Recurrence-free survival	Adjustment
Sánchez-Torralvo FJ et al. [59]	2021	208	European (Spain)	48–73 (61)	Men (55.3%)	All	All	GLIM-malnutrition	Cohort	6-month mortality	Adjustment
Poulter S et al. [60]	2021	2794	Oceania (Australia)	48–77 (63)	Men (50.0%)	All	All	GLIM-malnutrition	Cohort	Mortality at 30 days	Adjustment
Shi J et al. [61]	2023	776	Asia (China)	45–61 (52)	Men (0.0%)	All	Breast cancer	GLIM-malnutrition	Cohort	All-cause mortality	Adjustment
Kakavas S et al. [62]	2020	218	European (Greece)	57–83 (70)	Men (49.0%)	All	Gastrointestinal cancer	GLIM-malnutrition	Cohort	90-day all-cause mortality	Adjustment
Zheng X et al. [63]	2023	1308	Asia (China)	52–68 (60)	Men (71.3%)	All	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Przekop Z et al. [64]	2022	157	European (Poland)	52–75 (64)	Men (74.5%)	All	Head and Neck Cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Chen WZ et al. [65]	2022	742	Asia (China)	65–91 (72)	Men (77.1%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, total complications	Adjustment
Zhang X et al. 1 [66]	2021	1192	Asia (China)	aged 65 years or older	Men (68.4%)	All	All	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Matsui R et al. [67]	2022	512	Asia (Japan)	55–82 (68)	NA	II-III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Zhang Y et al. [68]	2022	182	Asia (China)	47–77 (62)	Men (74.2%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival, disease-free survival	Adjustment
Asakawa A et al. [69]	2023	198	Asia (Japan)	24–87 (72)	Men (70.2%)	I–III	Lung cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Cai W et al. [70]	2022	1007	Asia (China)	NA	Men (73.5%)	I–III	Gastric cancer	GLIM-malnutrition	Cohort	Overall survival	Adjustment
Chen W et al. 1 [71]	2024	850	Asia (China)	50–78 (64)	Men (65.6%)	All	Colorectal cancer	GLIM-malnutrition	Cohort	Overall survival, disease-free survival, postoperative complications	Adjustment
Wobith M et al. [72]	2022	260	European (Germany)	NA	Men (56.5%)	All	All	GLIM-malnutrition	Cohort	Overall complication	Adjustment
Liu C et al. [73]	2021	2388	Asia (China)	NA	Men (63.8%)	All	All	GLIM-malnutrition	Cohort	Complications	Adjustment
Sun S et al. [74]	2023	220	Asia (China)	53–71 (62)	Men (75.5%)	All	Gastric cancer	GLIM-malnutrition	Cohort	Postoperative complications	Adjustment
Yin L et al. 5 [27]	2021	360	Asia (China)	56–73 (64)	Men (80.8%)	All	Esophageal Cancer	GLIM-malnutrition	Cohort	Postoperative complications	Adjustment

NA not applicable, *PG-SGA* Patient-Generated Subjective Global Assessment, *GLIM* Global Leadership Initiative on Malnutrition

Quality of selected literature

For diagnostic meta-analysis, the results of the quality evaluation of all included articles based on the QUADAS-2 tool are shown (see Fig. S1 in the Supporting Information online). The overall quality was generally acceptable [18–20, 24–38]. For non-diagnostic meta-analysis, 21 studies were judged at a low risk of bias [4, 39–58], and 17 at high risk [27, 59–74] (see Table S3 in the Supporting Information online).

Diagnostic accuracy of the GLIM and PG-SGA criteria for detecting malnutrition

Eighteen studies [21–38] with 20 datasets investigated the diagnostic accuracy of the PG-SGA and GLIM criteria for malnutrition. Forest plots for the sensitivity and specificity of the GLIM criteria in diagnosing malnutrition are displayed in Fig. 2. Compared with the PG-SGA (used as the reference method), the pooled sensitivity, specificity, PLR, NLR and DOR of the GLIM for detecting malnutrition was 0.71 (95%CI: 0.63–0.78), 0.80 (95%CI: 0.65–0.90), 3.5 (95% CI: 1.9–6.5), 0.36 (95% CI: 0.28–0.46), 10 (95% CI: 5–21), respectively. According to the bivariate boxplot (Fig. 3), there were four sets of data outside the double circles, suggesting that there was significant heterogeneity across the articles.

As a result, a subgroup analysis based on year of publication (before 2021 or after 2021), study type (cohort or cross-sectional study), sample size (less than 500 or more than 500), participant from continent (Asian or non-Asian) and mean age of patients (less than 60 or more than 60) was performed for the diagnostic accuracy of the GLIM and PG-SGA criteria in assessment malnutrition (Table 2). It also appeared to have better diagnostic value in the Asian population (sensitivity, 0.71; specificity, 0.86; PLR, 5.2; NLR, 0.34; DOR, 15; AUC, 0.83) than in the non-Asian population. Furthermore, the GLIM criteria seemed to have better diagnostic value in those mean age less than 60 participant (sensitivity, 0.73; specificity, 0.87; PLR, 5.5, NLR, 0.32; DOR, 16; AUC, 0.82).

SROC curve and publication bias

The SROC curve for the GLIM and PG-SGA criteria in assessment malnutrition was situated in Fig. 4A, and the AUC value was 0.79 (95%CI: 0.75–0.83), implying that the GLIM criteria was moderate in differentiating malnutrition when comparing with PG-SGA. Moreover, a Deeks' funnel plot was generated to evaluate the bias in these included studies (Fig. 4B). The plot showed no apparent asymmetry for comparing the GLIM and PG-SGA criteria ($P=0.56$), indicating a low risk of bias (the P value > 0.10).

Clinical efficacy of the GLIM criteria in predicting malnutrition

Fagan's nomogram was applied to estimate the post-test probability of malnutrition in patients (see Fig. S2 in the Supporting Information online). According to the previous research, the pre-test possibility was set at 40% [75] Fagan's nomogram showed that the post-test probability of malnutrition based on positive GLIM test was 70%, and the post-test probability of malnutrition in negative GLIM test was 19%.

The association of GLIM-defined malnutrition with adverse outcome

Thirty studies with 48 datasets investigated the association of malnutrition defined by the GLIM with OS (Fig. 5A). The GLIM-defined malnutrition was related with a poor OS (HR = 1.57, 95%CI: 1.46–1.67), as calculated by the fixed effect model. And further stratified analysis suggested that moderate (HR = 1.23, 95% CI: 1.15–1.31) and severe (HR = 1.48, 95% CI: 1.38–1.57) malnutrition defined by the GLIM was associated with a poor OS.

Eight studies with 17 datasets assessed the association of malnutrition defined by the GLIM with mortality (Fig. 5B). The GLIM-defined malnutrition was markedly related with an elevated risk of mortality (HR = 1.43, 95%CI: 1.29–1.57), as used by the fixed effect model. Moreover, GLIM defined moderate (HR = 1.61, 95% CI: 1.08–2.15) and severe (HR = 2.02, 95% CI: 1.36–2.67) malnutrition was linked with an increased risk of mortality.

Thirteen studies with 21 datasets evaluated the association of malnutrition defined by the GLIM with postoperative complications (Fig. 5C). The malnutrition defined by the GLIM was obviously associated with an enhanced risk of postoperative complications (HR = 1.57, 95%CI: 1.40–1.73), as adopted by the fixed effect model. In addition, moderate (HR = 1.37, 95% CI: 1.03–1.7) and severe (HR = 2.17, 95% CI: 1.5–2.83) malnutrition defined by the GLIM was related with an increased risk of postoperative complication.

Twelve studies with 16 datasets investigated the relationship of malnutrition defined by the GLIM with disease-free survival or recurrence-free survival (Fig. 5D). A fixed-effect model meta-analysis showed that malnutrition defined by the GLIM was associated with a reduced disease-free survival (HR = 1.52, 95%CI: 1.36–1.68) and recurrence-free survival (HR = 1.41, 95%CI: 1.10–1.72).

Discussion

The study is a comprehensive systematic review and meta-analysis of the GLIM and PG-SGA criterion validity of nutrition assessment tools in the patients

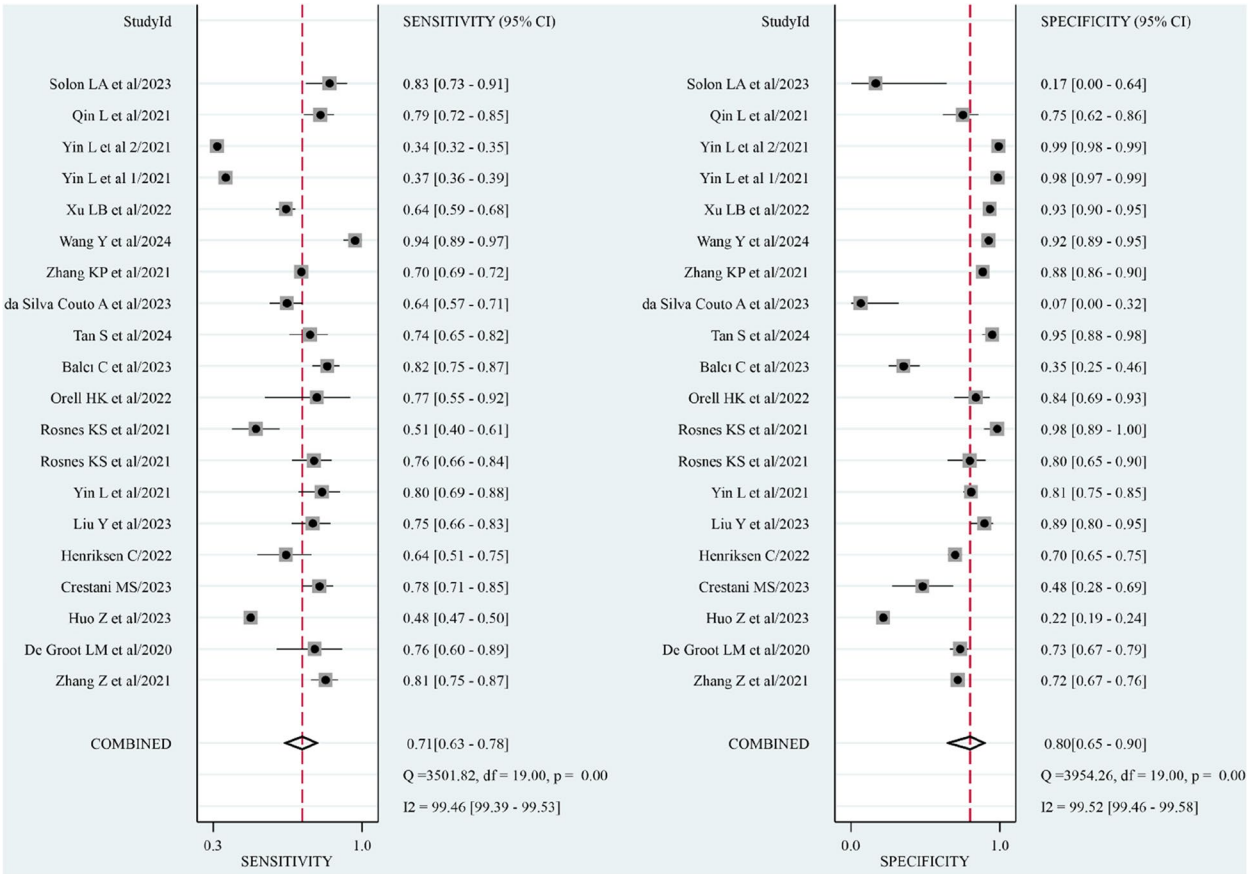

Fig. 2 Forest plots of the pooled sensitivity and specificity for comparing GLIM and PG-SGA criteria in diagnosing malnutrition

with cancer for the diagnosis of malnutrition, and the association of GLIM-defined malnutrition with adverse outcome. According to our current pooled results, when the PG-SGA was used as the reference standard, the GLIM criteria exhibited moderate diagnostic value,

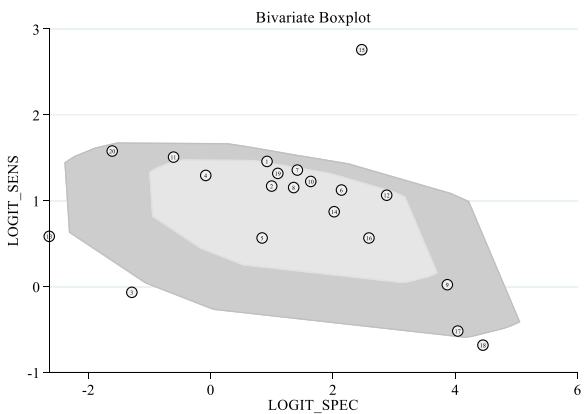

Fig. 3 Bivariate boxplot assessment the heterogeneity of the included studies

specifically for the Asian population or for individuals under the age of 60. More importantly, our pooled analysis revealed that GLIM-defined malnutrition was associated with OS, mortality, postoperative complications, DFS and RFS. Assessment of malnutrition by the GLIM criteria in patients with cancer can provide pivotal prognostic value to target nutritional intervention and management strategies. Therefore, these findings indicated that GLIM-defined malnutrition may be considered into a component of multidisciplinary cancer care.

Currently, the PG-SGA is recognized as a gold standard and is extensively utilized in clinical practice for evaluating the nutritional status of patients with cancer [10, 11]. However, its disadvantage could need to take a lot of time to finish. At first, our diagnostic meta-analysis showed that sensitivity, specificity, PLR, NLR, DOR and AUC in GLIM were 0.71, 0.80, 3.5, 0.36, 10 and 0.79 compared to PG-SGA. Generally, a high level of accuracy is indicated when the area under the ROC curve exceeds 0.90, a moderate level is suggested by values between 0.70 and 0.90, and a low level is denoted by scores ranging from 0.50

Table 2 The results of the subgroup analysis for the diagnosis of malnutrition

Subgroup	No of studies	Sensitivity (95% CI)	Specificity (95% CI)	Positive likelihood ratio (LR +)	Negative likelihood ratio (LR-)	Diagnostic odds ratio (DOR)	AUC
Publication year							
Before 2021	9	0.67 (0.54, 0.78)	0.90 (0.79, 0.96)	6.8 (3.7, 12.4)	0.36 (0.27, 0.49)	19.0 (13.0, 16.0)	0.85 (0.82, 0.88)
After 2021	11	0.75 (0.66, 0.82)	0.66 (0.40, 0.85)	2.2 (1.1, 4.6)	0.38 (0.22, 0.66)	6.0 (2.0, 20.0)	0.77 (0.73, 0.81)
Study type							
Cohort	12	0.66 (0.56, 0.75)	0.78 (0.54, 0.92)	3.0 (1.3, 6.9)	0.43 (0.33, 0.58)	7.0 (3.0, 19.0)	0.74 (0.70, 0.78)
Cross-sectional	8	0.77 (0.67, 0.85)	0.83 (0.65, 0.92)	4.4 (2.1, 9.4)	0.27 (0.19, 0.40)	16.0 (6.0, 42.0)	0.86 (0.82, 0.88)
Sample size							
Less than 500	13	0.74 (0.69, 0.79)	0.72 (0.53, 0.86)	2.7 (1.5, 4.9)	0.36 (0.28, 0.46)	8.0 (3.0, 17.0)	0.78 (0.74, 0.81)
More than 500	7	0.65 (0.45, 0.80)	0.90 (0.70, 0.97)	6.3 (2.0, 20.5)	0.39 (0.24, 0.66)	16.0 (4.0, 65.0)	0.83 (0.79, 0.86)
Continent							
Asia	12	0.71 (0.59, 0.80)	0.86 (0.72, 0.94)	5.2 (2.4, 11.2)	0.34 (0.24, 0.48)	15.0 (6.0, 38.0)	0.83 (0.80, 0.86)
Non-Asia	8	0.71 (0.63, 0.78)	0.65 (0.35, 0.87)	2.1 (0.9, 4.5)	0.44 (0.30, 0.66)	5.0 (1.0, 15.0)	0.73 (0.69, 0.77)
Mean age							
NA	1	-	-	-	-	-	-
Less than 60	10	0.73 (0.65, 0.80)	0.87 (0.75, 0.96)	5.5 (2.3, 12.4)	0.32 (0.22, 0.44)	16.0 (7.0, 40.0)	0.82 (0.79, 0.88)
More than 60	9	0.70 (0.62, 0.77)	0.65 (0.43, 0.82)	2.0 (1.1, 3.8)	0.46 (0.29, 0.74)	4.0 (1.0, 13.0)	0.73 (0.69, 0.76)

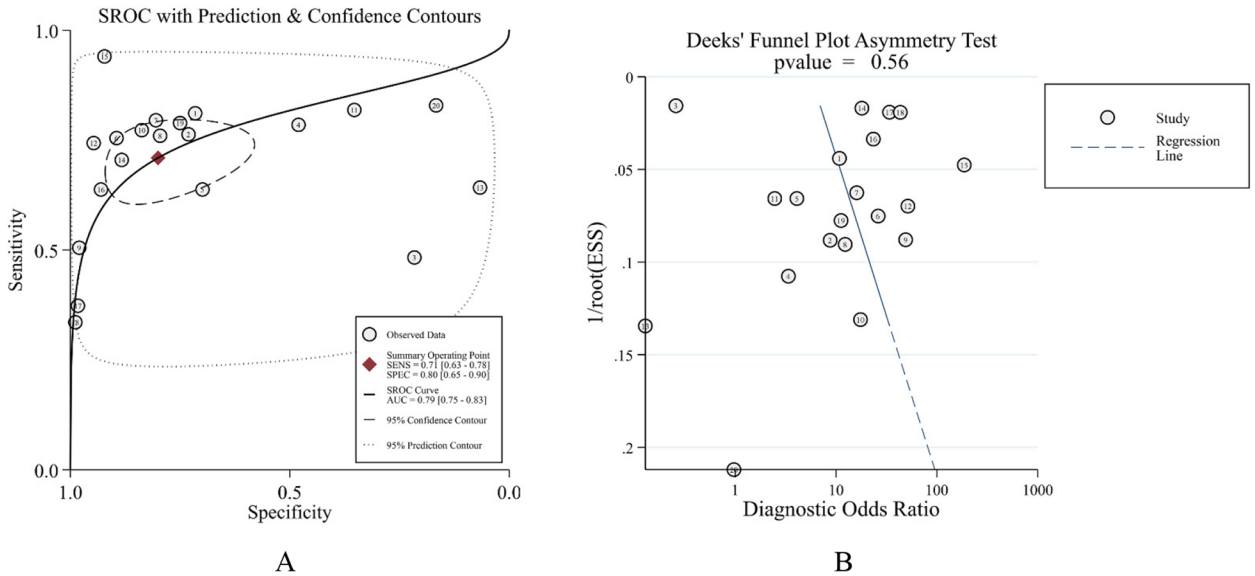

Fig. 4 SROC curve (**A**) and Deeks' funnel plot asymmetry test (**B**) for comparing GLIM and PG-SGA criteria

to 0.69 [58]. Our diagnostic meta-analysis demonstrated that the accuracy between the PG-SGA and GLIM methods was moderate. However, across the 18 included studies, there was substantial heterogeneity ($I^2 = 99.46\%$ for sensitivity, and $I^2 = 99.52\%$ for specificity). Bivariate boxplot displayed that 4 studies (Study ID: 3, 13, 15, 18) fell outside the circles, indicating heterogeneity across the studies. In addition, a subgroup analysis was further employed to explore the source of heterogeneity. Interestingly, compare with PG-SGA methods, GLIM exhibited better diagnostic accuracy in the Asian population than in the non-Asian population. The GLIM for Asian population in BMI is relatively low, making it easier to identify cases of malnutrition [76]. Furthermore, the number of included studies could provide a plausible explanation. By subgroup analysis of mean age of participant, the GLIM

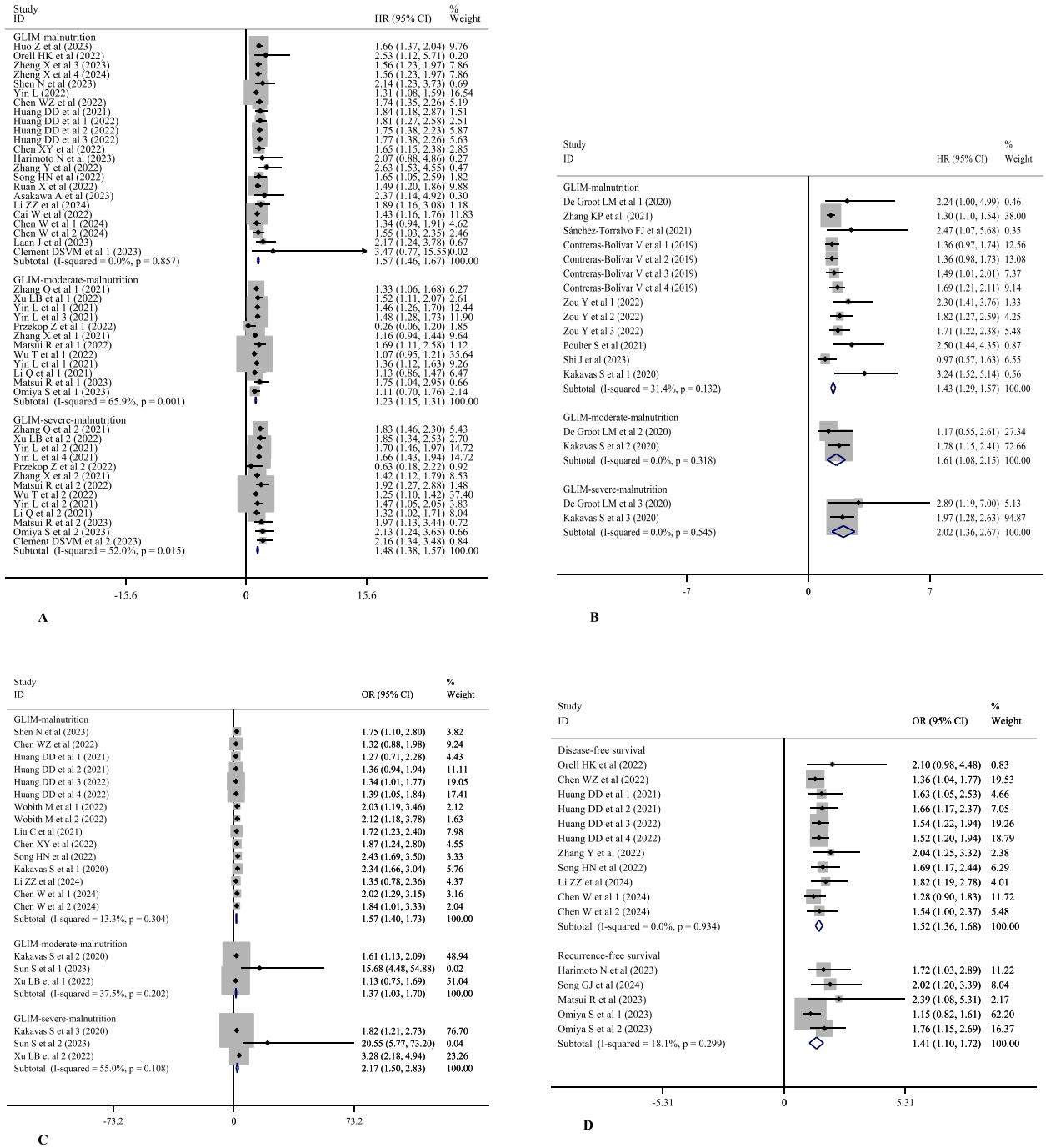

Fig. 5 **A** The forest plot of the association between GLIM-defined malnutrition and overall survival (OS) in cancer patients. **B** The forest plot of the association between GLIM-defined malnutrition and mortality rate in cancer patients. **C** The forest plot of the association between GLIM-defined malnutrition and postoperative complication in cancer patients.**D** The forest plot of the association between GLIM-defined malnutrition and disease-free survival or recurrence-free survival in cancer patients

criteria seemed to have better diagnostic value in those mean age less than 60 participant. Advanced age is a critical risk factor for malnutrition among older adults with cancer [77]. The scoring of age in PG-SGA and GLIM criteria appears to be inconsistent. Specifically, individuals over the age of 65 can receive an additional score in the PG-SGA criteria [78], whereas age is not a factor in the GLIM assessment. Thus, compared with PG-SGA,

the GLIM may mitigate the effect of age on malnutrition. Fagan's nomogram was employed to illustrate the likelihood of malnutrition. The pre-test probability was established at 40% referred to previous study. If the GLIM test result is positive, it indicates a 70% likelihood of malnutrition among participants. Conversely, a negative GLIM test result suggests a 19% chance of malnutrition.

Next, the relationship of GLIM-defined malnutrition with adverse outcome was meta-analyzed. We discovered that GLIM-defined malnutrition (both moderate and severe) is associated with a shorter OS and a higher all-cause mortality. The malnutrition defined by GLIM may be an unfavorable prognostic factor for OS and mortality in patients with cancer, as reported in other studies [79, 80]. Moreover, we observed that GLIM-defined malnutrition (both moderate and severe) increases the risk of postoperative complications. The phenotypic criteria of GLIM-defined malnutrition encompass low body mass index (BMI), weight loss, and diminished muscle mass, all of which have been demonstrated to have a strong correlation with postoperative complications [80]. Previous studies have exhibited that malnutrition may contribute to abnormal function of macrophages, neutrophils, and lymphocytes, thereby suppressing immune responses and increasing the incidence of postoperative complications [81, 82]. In addition, malnutrition defined by GLIM was related with poor DFS and RFS in patients with cancer. The reasons for poor DFS and RFS include increased postoperative complications and poor compliance with post operative chemotherapy due to reduced muscle mass and body weight loss. Evidence indicated that reduced muscle mass and body weight loss exacerbate DFS and RFS [83, 84]. Thus, GLIM-defined malnutrition was demonstrated to have good discriminatory ability for predicting the adverse outcome in patients with cancer.

The major merit of this study is the inclusion 56 published article with over 55,000 cancer patients. The current study has an increasing credibility and precision compared with previous and original individual studies. Moreover, subgroup analyses based on year of publication, study type, sample size, participant from continent and mean age of patients were performed to appraise the source of heterogeneity. Additionally, Deeks' funnel plot was used, and detected almost no publication bias among the included studies, suggesting that our results are accurate, reliable and convincing.

Nonetheless, this current systemic review and meta-analysis is also subject to some unavoidable limitations. Foremost, the reported articles exhibited inconsistencies in cancer staging and types. The inability to adjust for these factors in calculating the pooled effect was constrained by the limited available data. Next, the adjusted confounders in the included studies were inconsistent when investigated the association between GLIM-defined malnutrition and adverse outcome, which might have reduced the compatibility of the studies.

Future perspectives and implications for clinical practice

The integration of the GLIM criteria into clinical practice holds significant potential for improving the management of malnutrition in cancer patients, particularly those at high risk, such as those with pancreatic, lung, gastric, and head and neck cancers. The ease of application and comprehensive nature of the GLIM criteria make them a valuable tool for multidisciplinary teams to identify and address nutritional deficiencies early in the care continuum, as demonstrated in various clinical studies [69, 85–87]. Future efforts should focus on optimizing the implementation of GLIM criteria, and enhancing its accessibility and utility in clinical settings.

Conclusion

In summary, the results of this meta-analysis imply that the GLIM criteria have moderate diagnostic accuracy for identifying cancer patients with malnutrition, compared to the PG-SGA, specifically for Asian population or for individuals who are less than 60 years old. Moreover, GLIM-defined malnutrition was associated with the exacerbated OS, DFS and RFS, and increased risks of all-cause mortality and postoperative complications in patients with cancer. These findings may endorse the implementation of the GLIM criteria in clinical practice for patients with cancer.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-13809-6.

Supplementary Material 1: Table S1 PRISMA 2020 checklist. Table S2 Search strategy. Table S3 Evaluation of the quality for non-diagnostic study. Figure S1 Risk of bias assessment using QUADA-2. Figure S2 Fagan's nomogram of the GLIM criteria for the diagnosis of malnutrition.

Authors' contributions

J.Z. and T.L. designed and conducted the research. S.Y. and S.L. performed or assisted in performing the statistical analysis of the data. J.Z. and Y.S. wrote the manuscript draft. J.Z. and S.L. had primary responsibility for the final content. All authors approved and reviewed the final manuscript.

Funding

This work was supported by the National Natural Science Foundation of China (NSFC: 82404241 to J.Z).

Data availability

The datasets used during the current study are available from the corresponding author.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Oncology, Anhui Provincial Cancer Hospital, the First Affiliated Hospital, University of Science and Technology of China, Hefei, Anhui 230031, China. [2]Department of Pharmaceutics, School of Pharmaceutical Sciences, Anhui Medical College, Hefei, Anhui 230601, China.

Received: 11 January 2025 Accepted: 25 February 2025
Published online: 23 April 2025

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