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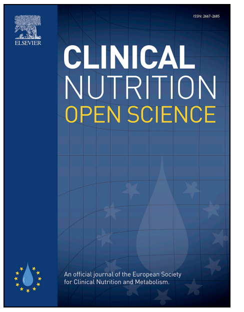

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Screening for malnutrition in people living with cancer and overweight or obesity: a scoping review.

Short title: Malnutrition in people with cancer and overweight/ obesity.

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Key words: malnutrition, cancer, overweight, screening

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Authors' contributions: SC, TM, VI, SW, EW and JT developed the concept and aim of the review, and were involved in all stages of development and review of the manuscript. FT and TM undertook paper review and data charting. NB, LM, AB, LG, DP and YMG contributed valuable expertise to the overall manuscript, and reviewed all versions of the manuscript. SC and TM performed the main writing of the manuscript.

Ethical statement: The was no ethical approval needed for this review.

Title

Screening for malnutrition in people living with cancer and overweight or obesity: a scoping review.

Abstract

Background: Current approaches to malnutrition screening in cancer pathways may not identify malnutrition in people living with overweight or obesity. The review aims to identify current screening techniques and their potential validity in people living overweight or obesity and cancer.

Methods: PubMed, Medline and CINAHL were searched for English-language publications reporting data from malnutrition screening tools in adults with cancer living with overweight or obesity. These included 1) diagnostic accuracy studies with validity analysis against a reference, 2) comparative studies, without validity analysis, and 3) monomethod studies of single malnutrition screening tools. Registered in Open Science Framework. (https://doi.org/10.17605/OSF.IO/ZWFBM).

Results: 3705 records were identified with 16 full-text papers included. Eleven tools and measures were used to screen for malnutrition in people living with overweight or obesity and cancer. These included questionnaires (Malnutrition Universal Screening Tool; Malnutrition Screening Tool; Patient Generated Subjective Global Assessment (original/Short Form); Nutrition Risk Screening-2002; Short Nutritional Assessment Questionnaire and its variations; Mini Nutrition Assessment-Short Form), an algorithm-based tool (Nutrition Risk Index), and handgrip strength measures.

Discussion: There is a lack of consensus on the most appropriate tool, though combining subjective and objective measures may improve malnutrition screening in people with cancer and overweight or obesity.

Highlights

1. Sixteen studies were included, identifying 11 tools and measures.

2. A combination of subjective and objective measures (but not body mass index) may improve screening approaches in people who are living with overweight or obesity and have cancer.

3. Validated approaches to screening for malnutrition, specifically in people with cancer and overweight or obesity, are limited, and further studies are required.

Background

The prevalence of cancer-related malnutrition varies from 30-80% across cancer types, with strong evidence indicating that malnutrition has a detrimental impact on both patients and healthcare systems[1, 2]. Malnutrition in people with cancer is linked to poorer outcomes such as increased chemotherapy toxicities[3, 4], risk of treatment interruption or delay[4], lower quality of life[5], extended hospital stays, increased hospital costs[6,7] and higher mortality rates[3,4]. Identifying and managing cancer-related malnutrition remains a challenge, with current clinical guidance recommending that all people with cancer be screened for malnutrition risk using a validated malnutrition screening tool[8]. Multiple validated malnutrition screening tools exist, but the extent to which these tools correctly classify people living with overweight or obesity is uncertain in this population[9]. Currently, 40-60% of people with a new cancer diagnosis are estimated to be living with overweight or obesity[10], with 30-80% thought to be at risk of being malnourished[11, 12, 13].

Screening tools for malnutrition risk is intended to be quick and easy to administer[16]. If a risk is identified, the patient should then be referred for a complete nutritional assessment (structured process/ assessment tool) by a registered nutrition professional (e.g. a dietitian). Various reviews have sought to identify suitable malnutrition screening tools in oncological settings[14,15], yet none provide a focus on individuals living with cancer, and overweight or obesity.

Given the absence of published reviews focused on malnutrition screening tools specific to this population alone, we adopted a broader scope to capture a more complete understanding of the evidence base. Specifically, in addition to screening tools designed for routine clinical practice to identify individuals at risk of malnutrition (screening), we included both nutritional assessment tools that incorporate a screening component and standalone malnutrition measures. For the purposes of this review, the term malnutrition screening tool encompasses both screening tools and relevant assessment instruments with a screening function that have been used to report malnutrition risk.

The aim of this scoping review was to identify and evaluate published evidence to inform improvements in malnutrition screening for people with cancer living with overweight or obesity. Specifically, to determine which malnutrition screening tools and/or clinical measures, used alone or in combination, may be effective in identifying malnutrition risk in people living with cancer with overweight or obesity. A secondary aim was to consider the reported strengths and limitations of the screening tools and measures identified.

Method

This review was reported following the Preferred Reporting Items of Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist. It was registered in the Open Science Framework (https://doi.org/10.17605/OSF.IO/ZWFBM).

Study selection and eligibility criteria

Inclusion criteria: Studies involving adult participants (aged 18 years or older) that investigated malnutrition screening instruments or standalone clinical measures in individuals living with overweight or obesity and a cancer diagnosis. The search included quantitative, qualitative, or mixed-method designs and was limited to publications in English. Studies focused on dietary interventions, supplement interventions, definition papers, conference proceedings, and letters to editors were excluded. The population/ concept/ context framework for inclusion of studies was applied as follows:

Population: Adults with a cancer diagnosis living with overweight or obesity

Concept: A structured malnutrition screening approach. This can include, a validated malnutrition screening tool, screening component of a validated malnutrition assessment measure, or functional or physical measures used to indicate malnutrition risk e.g. handgrip strength.

Context: Any setting and any country

Information sources

A search strategy for PubMed, Medline and CINAHL databases was developed with a health specialist librarian. Searches were conducted between 01/12/21 and 21/01/22, and updated on 01/06/2024.

Search strategy

A preliminary search on PubMed, Medline, and CINAHL databases identified commonly used indexing terms, which were then combined iteratively in a second search using MeSH terms and keywords related to cancer, malnutrition, and nutrition screening. Key terms included combinations of "cancer," "malnutrition," "nutrition screening tools," "nutrition biomarkers," and "body composition." The full search strategy and term combinations used for each database are provided in Supplementary file 1.The same search strategy was applied in Medline and CINAHL.

Selection of evidence

Identified sources were stored on the EndNote 20 reference management system. Following duplicate removal, two independent reviewers (TM and FT) screened paper titles and abstracts for eligibility. Studies meeting the initial criteria then underwent full-text review to confirm inclusion. In the event of reviewer disagreement, a third independent reviewer (SC) was consulted.

Data charting process and data items and synthesis of results

A data extraction form was developed using the Joanna Briggs Institute methodology for scoping reviews[17]. The form was then tested, and TM conducted the final data extraction. Data collected included the author, country of origin, year of publication, study design, sample size, cancer type, weight status, malnutrition risk tool, other tools used, malnutrition risk results, other results, and authors' conclusion (Table 1). Given the nature of scoping reviews, the quality of data was not critically appraised. Conflicts regarding study eligibility during data extraction were resolved through discussion among the two reviewers and a third reviewer.

A narrative synthesis of the results was conducted with extracted data organised based on the reported method to screen for or assess malnutrition. Where applicable, data on the reported comparator/reference screening or assessment method and the associated statistical approaches were also recorded (i.e., agreement with the reference method or sensitivity/specificity in predicting malnutrition risk) (Table 2). The mean values were reported, along with the sensitivity and specificity of the tool of interest, across different malnutrition risk classifications (e.g., moderate risk and high risk).

Papers were further separated into three categories:

1) Diagnostic accuracy studies that examined how accurately a malnutrition screening tool or measure identified malnutrition risk or estimated malnutrition prevalence, by conducting a concurrent validity analysis against a standard reference.

2) Comparative studies similar to the diagnostic accuracy studies, but without conducting validity analysis.

3) Monomethod studies of a single malnutrition screening method.

In addition to studies involving individuals with a cancer diagnosis, we undertook a review of literature on malnutrition screening in people living with overweight or obesity and other non-communicable diseases (NCDs), using the same search strategy and terms but excluding cancer-related keywords. This was to support the interpretation of findings in light of the limited cancer-specific evidence and the shared nutrition risk profiles and malnutrition-influenced clinical outcomes observed between NCDs and cancer[18]. Relevant data from these studies, along with the full search strategy and combinations of search terms, are provided in Supplementary File 1 and 2 and are drawn upon in the discussion to contextualise the main findings.

Results

The database search yielded 3705 references after removing duplicates (Figure 1). Of those, 3089 did not meet the eligibility criteria and were excluded. Ninety-seven studies underwent full-text screening against inclusion criteria, with 70 excluded. Thus, 27 full-text papers were eligible for inclusion. After deciding to exclude the non cancer studies, 16 studies were included in the final review. Table 1 reports included study characteristics.

Insert Figure 1 (flow chart) here

Seven cross-sectional, eight prospective cohorts and one retrospective cohort study were included. Two studies measured performance against a validated reference (comparator) with defined diagnostic criteria, see Table 2.

Eleven different screening tools and measures were used to identify malnutrition risk. Five screening tools included a questionnaire. The tools included Malnutrition Universal Screening Tool, MUST[19, 22, 23, 24, 26]; Malnutrition Screening Tool, MST[19, 23]; Patient Generated-Subjective Global Assessment, PG-SGA (and Short Form versions; SF)[11, 13, 23, 27]; Nutrition Risk Screening-2002, NRS-2002[29, 30, 31, 32]; Short Nutritional Assessment Questionnaire and the adapted form for residential care (SNAQ; and SNAQ-rc)[33]. One study combined a questionnaire and anthropometric measure(s) (Mini Nutrition Assessment-Short Form, MNA-SF[12]). One screening tool used an algorithm format (Nutrition Risk Index, NRI)[19, 39, 40]. Handgrip strength (HGS) was the only functional measure of malnutrition status reported[27].

Malnutrition Universal Screening Tool

There were five studies[19, 22, 23, 24, 26] using MUST to measure malnutrition risk in people living with cancer and overweight or obesity. Incidence of malnutrition in this population varied between 34-70% in studies (19,22,23, 24,26). When compared against standards [22, 24], MUST appeared to underestimate malnutrition risk in two studies, PG-SGA (34% vs 40%) [22] and percentage fat free mass and fat mass combined (64% vs 80%) [24]. While a similar prevalence was shown between MUST and PG-SGA-SF, 49%vs 47% respectively [23]. Finally, MUST showed a 32.5% sensitivity and 99.6% specificity when compared to computerised tomography (CT), which was performed to diagnose cancer cachexia, sarcopenia, and myosteatosis according to consensus criteria. However, it is noted that this was for the whole population, of which 57% were living with overweight and obesity [19].

Malnutrition Screening Tool

The MST was used in two studies[19, 23]. One study, in which 57% of participants were overweight or obese, validated MST[19] against CT, with 48.3% sensitivity and 74.6% specificity. In the second study, authors reported using the MST, but no results were presented[23].

Nutrition Risk Screening-2002

NRS-2002 was used in four studies[29, 30, 31, 32]. In two comparative studies, incidence of malnutrition was reported as a proportion of the whole population and no subgroup analysis by BMI category were conducted. The prevalence of overweight or obesity, and malnutrition within these study populations ranged between 100%[29] and 33.3%[30]. Of this, 23.5%[29] and 46.7%[30] of these populations were at risk of malnutrition, respectively.. Two monomethod studies[31, 32] found that 12% and 59.2% of the populations were overweight or obese respectively, 46.1% of which were at risk of malnutrition.

Short Nutritional Assessment Questionnaire

The SNAQ was evaluated in two studies[21, 33]. In a Dutch rehabilitation study in which 48% were living with overweight or obesity [21], the diagnostic accuracy of the SNAQ and two of its iterations, SNAQ-rc and SNAQ-65+, were assessed. The study showed that SNAQ-65+ had high diagnostic accuracy (sensitivity 96%, specificity 77%) in the whole sample, compared to measures of nutritional status (weight loss at one, three and six months and BMI). In one monomethod study [33] of 75 people with cancer (44% living with overweight or obesity), 48% of the overall sample (all BMI categories), were identified as at risk of malnutrition. No validation methods were conducted against a comparator.

Nutrition Risk Index

The NRI was reported in three studies[19, 39, 40]. Firstly, in a validation study[19] on 725 people, NRI showed 22.4% sensitivity and 92.1% specificity compared to CT (cancer cachexia, sarcopenia, and myosteatosis according to consensus criteria). Data for the validation included all participants, of which 57% were living with overweight or obesity. The two other studies reported incidence of malnutrition risk, but no performance measures were conducted. In one study with 90 participants, the NRI was used as the standard reference[39] identifying 54% of participants as at risk of malnutrition, including those with a mean BMI 24.6 kg/m2 (16.1- 43.6 kg/m2). In a monomethod study[40] involving 144 participants, 58% of whom were overweight or obese, malnutrition risk was identified in 29% and 67%, respectively.

Mini Nutrition Assessment-Short Form

The MNA-SF were examined in a monomethod study[12], showing 49.5% of the cancer population experiencing overweight or obesity were also malnourished[12].

Patient Generated-Subjective Global Assessment

The PG-SGA was reported in three studies[11, 13, 27]. The PG-SGA, an assessment tool with screening constituents (PG-SGA-short form), showed variable rates of malnutrition in three comparative studies. In a population where 54.4% were living with overweight or obesity, PG-SGA identified more people as at risk for malnutrition than hand grip strength (HGS) alone (40.9% vs 21.0%) [27]. In another study, 1157 participants, all of whom were living with overweight or obesity, compared CT-derived measures of sarcopenia and myosteatosis using published cutoffs, against the PG-SGA. 64% of the sample were found to be at risk of malnutrition[13]. A monomethod[11] study in 450 people, 63% of whom were living with overweight or obesity and cancer, found 29% of the population were malnourished.

Hand grip strength

HGS**,** a measure of muscle strength, is used as a clinical indicator of malnutrition risk or muscle mass. Identified studies used two diagnostic criteria for nutritional risk: HGS <27kg in men and <16kg in women[28] or a score of <2 standard deviations from the mean[41]. A comparative study[27] of 232 females living with cancer (54.4% living with overweight or obesity) compared HGS with the PG-SGA-SF. In the overall sample, 21% had dynapenia (as determined by HGS) while 40.9% were at malnutrition risk (as assessed by PG-SGA-SF).

Discussion

This review aimed to explore whether current malnutrition screening tools might be suitable for assessing the risk of malnutrition in people living with overweight or obesity and cancer. Sixteen studies describing 11 tools and measures were identified.

MUST

Based on the studies included in this review, MUST was not able to accurately identify malnutrition in those living with cancer and overweight or obesity [19] when compared to validated methods. This contrasts with people with normal/ underweight (BMI 18.5-24.9kg/m^2) and cancer, where it displays good sensitivity and specificity[42, 43, 45]. One limitation of MUST is that people with a BMI greater than 20 kg/m^2 will receive zero in one of the three scoring elements, reducing the likelihood of being identified as at risk of malnutrition. In comparative studies focusing on people living with cancer, MUST scoring was similar to more subjective approaches such as the PG-SGA. However, in a non-cancer population of hospitalised patients, Van Vliet and colleagues[25] demonstrated that in people with both a BMI of <25kg/m^2 and >25kg/m^2, MUST underreported malnutrition risk compared with the PG-

SGA, therefore providing some insight into the extremes of weight categories, including the overweight/ living with obesity population.

MST

The MST identifies malnutrition risk via two items: absolute weight loss in the past six months and reduced appetite (Table 2). Similar to MUST, the MST diagnostic performance[19] was low. In a population where 57% were living with overweight or obesity MST showed very low sensitivity and high specificity compared to CT-derived body phenotypes (cancer cachexia and pre-cachexia, myosteatosis and sarcopenia)[19]. The use of reduced appetite instead of weight or BMI within MST may in some part explain the high specificity, but clinical utility should be considered with caution due to its low sensitivity. This reflects the different criteria used across studies for malnutrition in the overweight/ obese population, therefore possibly affecting interpretation and reporting.

NRS-2002

In a comparative study focusing on people living with overweight or obesity and cancer[29] the NRS-2002 identified 23.5% as at risk of malnutrition, of which 10.7% were confirmed as being malnourished by the Global Leadership Initiative on Malnutrition (GLIM) criteria, which is a standardized approach for diagnosing malnutrition, requiring at least one phenotypic criterion (weight loss, low BMI, or reduced muscle mass) and at least one etiologic criterion (reduced food intake/assimilation or inflammation/disease burden) to be met [29]. When using the NRS-2002, the user does not have to rely solely on BMI; instead the tool considers weight loss, general condition and current food intake. In studies by Tangvik et al [31] and Swalarz et al [32] in people living with cancer, the NRS-2002 identified 29% and 51.2% as at risk of malnutrition, respectively. However, BMI alone classed just 1.6 and 6.9% with underweight, respectively. As such, BMI alone may underestimate the risk of malnutrition.

MNA, MNA-SF and modified MNA-SF

Although initially developed as an assessment tool, many studies use the first step of the MNA known as the screening step to report malnutrition risk. The MNA-SF was developed in 2001 by Rubenstein and colleagues[44] as a shortened version of the full MNA to screen for malnutrition risk in the older population. Gioulbasanis et al.[12] who utilised the MNA found the majority of their sample that was identified at risk were ultimately malnourished.

PG-SGA

The first part of the PG-SGA (also known as PG-SGA-SF) can be completed independently by the patient and constitutes a screening of weight change, symptoms and dietary intake. The second part includes a physical examination, and is recommended to be conducted by a trained healthcare professional. Therefore, the first four questions (PG-SGA-SF) are often seen as the 'screening tool' component and the complete tool is defined as a nutritional assessment. Both in this review and elsewhere[45] the PG-SGA is typically utilised as the reference for validating other nutrition screening tools, including oncology settings[46]. Despite not being assessed from a diagnostic perspective, in a comparative study that included people with overweight or obesity, the PG-SGA-SF was compared to CT-derived sarcopenia and myosteatosis[13]. In this study, 36% of people with pancreatic cancer with overweight and 44% with obesity, were classified as well nourished based on the PG-SGA-SF, yet showed signs of sarcopenia or myosteatosis. Similarly, in a sample of women with breast cancer, the PG-SGA-SF identified almost twice as many people at malnutrition risk compared to HGS[27]. The PG-SGA-SF also identifies nutritional barriers known as nutrition impact symptoms. The array of nutritional barriers assessed as part of the PG-SGA-SF may be considered a key benefit of the tool in people living with overweight or obesity where objective measures may under diagnose the risk of malnutrition. For instance, in a study where MUST identified 49% as being at risk of malnutrition, the PG-SGA-SF found that over 70-90% of the group had at least 1-2 nutrition impact symptoms[23]. This is important, as in the same study both greater weight loss and lower food intake were associated with two or more nutrition impact symptoms. This would suggest that unintentional weight loss and symptom burden may be important predictors of malnutrition in people living with overweight and obesity, even if the person's BMI may not be suggestive of malnutrition risk.

NRI and blood biomarkers

The NRI showed low diagnostic performance in Bhuachalla et al.'s study[19] with 57% of the sample living with overweight or obesity. In a subsequent study of older adults, the NRI served as the standard reference where CT-derived estimates of muscle mass index were found to moderately identify malnutrition. NRI may not be regarded as a valid reference method, due to the inclusion of serum albumin which has been deemed an unreliable marker of malnutrition risk[48, 49]. Saroul et al.[39] and Magnano et al.[40] emphasised this by reporting serum albumin along with total NRI. Low serum albumin was not associated with total malnutrition risk via NRI, indicating promise for those living with overweight or obesity.

HGS and anthropometric measures

HGS is a measure of muscle function, and a low HGS is an indicator of increased postoperative complications, length of hospitalisation and decreased physical status[47]. However, a lack of consensus on HGS measurement protocols, alongside the application of different cut-off values across studies makes it difficult to interpret the findings.

Synthesis of findings

Studies were often difficult to compare due to the heterogeneity of the standard reference approaches applied, and also the lack of studies in people living with overweight or obesity and a cancer diagnosis. The diagnostic accuracy studies presented two different reference methods, including: Muscle area by CT [19] and NRI[39]. This variability is expected given the numerous existing validated approaches to identify malnutrition. This causes challenges in drawing definitive conclusions from pooled data and in some instances also raises questions regarding the best choice of reference method. For example, Bhuachalla et al.[19] focused on those who were all living with overweight or obesity, and utilised CT (cancer cachexia and precachexia, sarcopenia and myosteatosis) as the gold standard method of body composition analysis and diagnosis of abnormal body composition phenotypes, indicating NRI as having a higher diagnostic performance. Conversely, Saroul et al.[39] focused on participants living with cancer using the NRI as the standard reference which was analysed against CT-derived muscle mass index. This was also described by Bhuachalla et al.[19] who found that MUST and their formula for CT-derived cancer cachexia had similar parameters. However, the authors highlight that 38% of cancer cachexia prevalence was not identified using BMI or weight loss elements of the diagnostic criteria. This suggests they may not be sensitive markers for identifying malnutrition risk in those living with overweight or obesity. Concerns have been shown in other subgroups including older people with cancer, in which sarcopenia, malnutrition, and cancer cachexia are highly prevalent and can overlap or occur separately [50]. The standard reference method must therefore be appropriate to its comparators when conducting a malnutrition risk screening validation study, inclusive of people living with overweight or obesity, and therefore factors such as understanding the same/ similar fields in different instruments, the impact on specificity and sensitivity and therefore predicted significance versus understanding which fields may give greater prognostic significance needs to be understood. This is not straightforward as many malnutrition screening tools are typically heavily influenced by weight-related components such as BMI and percentage weight loss. Martin et al.[51] propose a more robust grading system for malnutrition risk considering percentage weight loss and BMI as independent yet significant predictors of malnutrition, for those with overweight or obesity.

There is also evidence of more advanced cancer among people living with overweight or obesity compared to those with underweight, and lower overall survival in women with obesity[11]. This could be in part due to undetected and untreated malnutrition and delays on referral for assessment of malnutrition in those with a higher BMI. Indeed, data show that living with obesity can result in a lower likelihood of being referred to a dietitian for support when in hospital[52].

Lack of malnutrition screening may be indicative of weight stigma and lack of awareness of the nutritional needs of people living with overweight or obesity and cancer, resulting in potential discrimination[53]. This important consideration needs to be addressed not just in cancer treatment but society as a whole. Therefore clinicians should be aware of their own biases when screening people living with overweight or obesity. Anthropometric measurements as well as functional assessments such as HGS and gait speed may be feasible for use among those living with overweight or obesity as indirect measures of malnutrition. However, clinical judgement and time constraints need to be considered.

The value of self-completed or qualitative malnutrition identification must not be discounted. Screening tools, including qualitative components of malnutrition appear to provide greater identification of nutrition risk in people living with overweight or obesity. For example, discrepancies appeared in several studies that applied tools such as the PG-SGA or MNA/MNA-SF compared to quantitative malnutrition component-based screening tools. However, these subjective parameters may not accurately reflect current nutritional status and do not allow for a definitive diagnosis of malnutrition. This emphasises the importance of harmonising both quantitative and qualitative components especially in those living with overweight or obesity. It should also be noted that the average BMI of 27 kg/m2 within the included studies is similar to the population average and to that found in comparable studies of cancer populations[9, 54].

Although no individual or combination of screening tools have been shown to be effective in this population, this review highlights areas of strength and weaknesses around current tools used for the broad population of people with cancer. A uniform approach is unlikely to meet the needs of those living with overweight or obesity and cancer.

Strengths and limitations

There was an element of subjectivity when interpreting the included studies. In a few studies 'screening' and 'assessment' terminology were used interchangeably, limiting our capacity to differentiate between malnutrition screening and assessment studies. Those who were living with overweight or obesity were grouped, preventing the exploration of effective tools in the two populations. The metabolic distinction between overweight and obesity should be discussed in future reviews.

The review identified physical biomarkers that when combined with current screening tools could enhance malnutrition screening in individuals living with overweight or obesity. However, training, accuracy and time to screen patients could limit their use. The definition of malnutrition varied across studies, further limiting our ability to compare findings between studies and reach a conclusion on the most appropriate approaches for this population. While comparison studies were conducted,the reference tools had often not been validated or evaluated for use in malnutrition risk screening in people living with overweight or obesity. Therefore, the review highlights the critical need for clear and consistent definitions of malnutrition, and nutrition screening. Alongside the need to identify the most appropriate reference standards for this specific population..Most participants were from European caucasian backgrounds, therefore the malnutrition screening criteria e.g. BMI can differ by ethnicity and age.

Conclusion

Our findings highlight the lack of consensus regarding the suitability of using current malnutrition screening tools in people living with overweight or obesity and cancer. NRI was identified as a potentially suitable tool for this population[19], but is based on a single study and would benefit from further research. Despite comparative and monomethod design studies, without pooled validation studies, it is challenging to draw clear conclusions.It is however clear that many of the available tools fail to identify malnutrition risk adequately in this population. A combination of subjective and objective measures other than BMI may improve screening approaches in people who are living with cancer and overweight or obesity.

This would require the key questions that are used in the PGSGA-SF, such as changes in oral intake, unintentional weight loss and loss of appetite, in order to gain better clarity of the risk. Further malnutrition risk screening validation and development studies in people living with overweight or obesity and cancer, are needed. This review could not suggest an optimal tool or combinations of tools to use for those with overweight or obesity due to the sparse evidence available in this population. The findings provide a starting point for researchers, and for healthcare professionals to begin to acknowledge limitations of commonly used tools in those with overweight or obesity. This will pave the way for more research into this important and overlooked area, and also help health care professionals to consider appropriate screening, and the significant effect of inadequate referrals.

Data Statement: As this was a Scoping Review there are no data to share.

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Figure legends

Figure 1. PRISMA-SCr flow chart summarising search results.

Table 1. Included study characteristics

Diagnostic accuracy studies						
Author	**Study design**	**Population characteristics**	**Methods used**	**Malnutrition risk prevalence (%)**	**Standard reference (S.R)**	**Malnutrition risk prevalence by S.R (%)**
Saroul et al. 2017	Prospective	Sample: 90 head & neck cancer			NRI	54%
	France	Gender: 86% male	Percent (%) weight loss	38% 28%		
		Age (years, mean ± SD): 61 ± 11	CT-L3 muscle mass index	58%		
		BMI (mean ± SD): 24.6kg/m² (5.4kg/m²)	Muscle mass index (Jansen formula)	44%		
		Setting: inpatients	SPPB	18%		
			GLIM-gait speed	15%		
			MUAC	28%		
			Low prealbumin	8%		
			Low albumin	31%		
Bhuachalle t al. 2017	Prospective	Sample: 725 cancer patients			CT - Cancer cachexia	41.5%
	Ireland	Gender: 60% male			CT - pre-cachexia	6%
		Age (years, mean ± SD): 65 ± 7.2			CT - sarcopenia	41%
		BMI (mean ± SD): 25.8kg/m² (4.6kg/m²)			CT - myosteatosis	45.5%
		Setting: outpatients	MUST	Moderate: 18% High risk: 23%		
			MST	42%		
			NRI	Mild: 11% Moderate: 61% Severe: 18.5%		

Comparative studies

Author	Study Design	Population Characteristics	Methods	Prevalence using screening tool of interest (%)	Prevalence compared to other screening tools/ measures
Fang et al. 2021	Prospective	Sample: 409	NRS-2002	47%	
	gastric cancer	Gender: 76% Male	BMI		2%
	China	Age (years, mean ± SD): 57 ± 10	CT - low skeletal muscle mass		65%
		BMI (mean ± SD): Group 1 23.45kg/m² (2.56 kg/m²) Group 2 25.09kg/m² (3.00 kg/m²)	CT - myosteatosis		14%
		Setting: outpatient	BMI		2%
			albumin, g/l (mean ± SD)		41 (4)
			haemoglobin, g/l (mean ± SD)		132 (22)
Ferreira 2012	Cross-sectional	Sample: 50	MUST	low risk: 46% high risk: 34%	
	surgical for cancer & GI	Gender: 54% male	SGA		moderate/severe: 40%
	Portugal	Age (years, mean ± SD): 53.6 ± 17.5			
		BMI: with 58% overweight or obesity			
		Setting: inpatient	BMI <18.5kg/m²		6%
Huang et al. 2021	Cross-sectional	Sample: 587	GLIM		12%
	gastric cancer	Gender: 74% male			
	China	Age (years, mean ± SD): 65 ± 13	NRS-2002	23.5%	

		BMI (mean ± SD): 24.8kg/m² (2.39kg/m²)	GLIM-HGS		15%
		Setting: inpatient	GLIM-gait speed		15%
			albumin, g/l (mean ± SD)		39.5 (5)
			haemoglobin, g/l (mean ± SD)		131 (29)
Keaver 2021	Prospective	Sample: 232	PG-SGA	41%	
	breast cancer	Gender: 61% female	HGS (dynapenia)	21%	
	Ireland	Age (years, mean ± SD): 64 ± 11	Recent weight loss	37%	
		BMI (mean ± SD): 26.6kg/m² (6.2kg/m²)	Living alone		22%
		Setting: mixed patient	Reduced dietary intake		24%
Lorton et al. 2019	Prospective	Sample: 200	MUST	49%	
	cancer	Gender: 60% male	MST	Not reported	
	Germany	Age (years, mean): 65	BMI		12%
		BMI : 40% >24.9kg/m²	Weight loss 5-9.9%		30%
		Setting: mixed patient	Weight loss ≥ 10%		36%
			PG-SGA loss of appetite		47%
			PG-SGA nausea		34%
			PG-SGA early satiety		27%
Martin et al. 2020	Prospective	Sample: 1157	CT - sarcopenia		Female: 37% Male: 45%
	head & neck, lung and gastrointestinal cancer	Gender: 64% male	CT - myosteatosis		Female: 45% Male: 65%
	Canada	Age (years, mean ± SD): 63.6 ± 11.4	PG-SGA >9		36%
		BMI (mean ± SD): 29.6kg/m² (4.3kg/m²)	PG-SGA-SF 4-8		28%

		Setting: outpatient	PG-SGA - no appetite PG-SGA - dry mouth PG-SGA - feel full quickly		26% 25% 21%
Tsaoutsi et al. 2016	Prospective colorectal cancer Greece	Sample: 90 Gender: 51% female Age (years, mean ± SD): 71.3 ± 6.5 BMI (mean ± SD): Female 27.9kg/m² (4.7kg/m²) Male 25.6kg/m² (4.1kg/m²) Setting: inpatient	MUST BIA - low FFMI & high FMI	64% 80%	
Monomethod studies					
Author	**Study design**	**Population characteristics**	**Methods**	**Prevalence using screening tool of interest (%)**	**Prevalence compared to other screening tools/ measures**
Chaves et al. 2010	Cross-sectional cancer Portugal	Sample: 450 Gender: 60% male Age (years, mean ± SD): 62 ± 13 BMI: 63% > 24.9kg/m² Setting: outpatient	PG-SGA BMI	29% 4%	
Gioulbasanis et al. 2015	Cross-sectional cancer Greece	Sample: 594 Gender: 73% Age (years): >18 BMI (mean ± SD): 28.6kg/m² (3.3kg/m²) Setting: inpatient	MNA Weight loss >5%	49.%	13% 43%
Loh et al. 2012	Cross-sectional	Sample: 104	MUST	75%	

	cancer Malaysia	Gender: 61% female Age (years, mean ± SD): 65 ± 11 BMI (mean ± SD): 26.2kg/m² (5.6 kg/m²) Setting: inpatient	BMI <20 kg/m² Unintentional weight loss		5% High risk: 84 Low risk: 16%
Magnano et al. 2015	Retrospective HN cancer Italy	Sample: 144 Gender: 85% male Age (years, mean ± SD): 66 ± 13.3 BMI (mean ± SD): 25.7kg/m² Setting: inpatient	BMI NRI low albumin low transferrin	29% moderate 67% severe	36% 87%: severely malnourished 12%: moderately malnourished 88%: severely malnourished 28%: moderately malnourished
Simon et al. 2021	Cross-sectional HN cancer Netherlands	Sample: 75 Gender: 77% male Age (years, mean ± SD): 65.9 ± 10 BMI (mean ± SD): 25kg/m² (5.7kg/m²) Setting: outpatient	SNAQ BMI <18.5kg/m²	48%	12%
Swalarz 2018	Prospective bladder cancer Poland	Sample: 125 Gender: 86% male Age (years, mean): 65.2 BMI: 54% with overweight or obesity Setting: inpatient	NRS-2002 BMI <18.5kg/m²	51%	2%

Tangvik 2014	Cross-sectional	Sample: 3962	NRS-2002	29%	
	cancer & pulmonary disease	Gender: 50% female	BMI <20.5kg/m² *		17%
	Norway	Age (years, mean ± SD): 63.4 ± 18.1			
		BMI (mean ± SD): 25.3kg/m² (5.4kg/m²)			
		Setting: inpatient			

CC, calf circumference; FMI, fat mass index; FFMI, fat free mass index; GLIM, Global Leadership Initiative on Nutrition; HGS, hand-grip strength; MAMC, mid arm muscle circumference; MNA, Mini Nutritional Assessment; MNA-SF, Mini-Nutritional Assessment Short Form; MUAC, mid upper arm circumference; MUST, Malnutrition Universal Screening Tool; NRI, Nutrition Risk Index; NRS, Nutritional Risk Screening; PG-SGA, Patient Generated Subjective Global Assessment; SD, standard deviation; SNAQ, Simplified Nutritional Appetite Questionnaire; SPPB, Short Physical Performance Battery; TSF, tricep skinfold.

Table 2. Summary of malnutrition screening methods and performance measures against reported reference standards for included diagnostic accuracy studies

Author, yr (No. participants, diagnosis, country)	Standardised Reference (Comparator)		Malnutrition Screening Measure/approach		Performance measures for malnutrition screening measure vs comparator				
	Method	Diagnostic criteria (Incidence)	Method	Diagnostic criteria (incidence)	Sensitivity (%)	Specificity (%)	CohensKappa	Positive predictive Value (PPV) %	Negative predictive value (NPV) %
Bhuachalla et al. 2017 (N=725, All cancers, Ireland) 55.6% with overweight /obesity	**CT (L3)**	**Cancer Cachexia (41.5%)** defined by International consensus definition **Precachexia (5.8%)** defined by ESCNM definition **Sarcopenia (41%) & myosteatosis (45.5%)** defined by cancer specific criteria[$]	**MUST**	Low risk: 0 Medium risk: 1 High risk: 2+	≥1 + sarcopenia: 45.3 ≥2 + sarcopenia: 26.6 ≥1 + myosteatosis: 45.3 ≥2 + myosteatosis: 26.6 ≥1 + precachexia: 45.8 ≥2 + precachexia: 20.8 ≥1 + cachexia: 72.8 ≥2 + cachexia: 81.8	≥1 + sarcopenia: 45.3 ≥2 + sarcopenia: 26.6 ≥1 + myosteatosis: 45.3 ≥2 + myosteatosis: 26.6 ≥1 + precachexia: 45.8 ≥2 + precachexia: 20.8 ≥1 + cachexia: 72.8 ≥2 + cachexia: 81.8		Sarcopenia: 18.6 Cachexia: 30.2 **(+MUST>=1)**	Sarcopenia: 55 Myosteatosis: 52 Precachexia: 57 Cachexia: 27 **(+MUST 0)**
			MST	Low risk: 0/1 at risk: ≥2	≥2 + sarcopenia: 39.4 ≥2 + myosteatosis: 49.8 ≥2 + precachexia: 75.0 ≥2 + cachexia: 63.5	≥2 + sarcopenia: 56.6 ≥2 + myosteatosis: 65.9 ≥2 + precachexia: 59.6 ≥2 + cachexia: 74.5		Sarcopenia: 16.2 Cachexia: 26.3 **(+MST >=2)**	Sarcopenia: 61 Myosteatosis: 50 Precachexia: 23 Cachexia: 35 **(+MST 0/1)**
			NRI	Low risk: >100 Mild: 97.5–100 Moderate: 83.5–97.5 Severe: <83.5	<97.5 +sarcopenia: 85.8 <97.5 + myosteaosis: 88.6 <97.5 + precachexia: 95.0 <97.5 + cachexia: 92.9	<97.5 +sarcopenia: 25.1 <97.5 + myosteaosis: 27.5 <97.5 + precachexia: 21.1 <97.5 + cachexia: 32.1		Sarcopenia: 36.7 Cachexia: 42.1 **(+NRI<97.5)**	Sarcopenia:14 Myosteatosis:11 Precachexia:3 Cachexia:7 **(+NRI >100)**
Saroul et al. 2017 (N=90, Head & Neck cancer, France)	**NRI**	1.519 x albumin + (current weight / usual weight) x 100	**CT-L3 Muscle Mass Index (L3MMI)**	(n=78) ≤17 for male ≤15 for female	66	67		73	59
			Muscle Mass index (Janssen formula)	(n=88) ≤10.76 for male ≤6.76 for female	62	52		51	63
			BMI	(n=90) Current weight / height2	25	98		92	53
			SPPB	≤8	35	100		100	57

This table provides a summary of the methodology and malnutrition diagnostic thresholds used for different nutritional screening measures and instruments alongside their specificity, sensitivity against the chosen comparator measures. Where appropriate PPV and NVP are reported as 0.9–1.0 excellent; 0.8–0.9 good; 0.7–0.8 fair; 0.6–0.7 poor; and 0.5–0 fail. Where Cohen's kappa was used to assess the agreement between the two tests, with $\kappa = 1$ for perfect agreement and $\kappa = 0$ for randomness

Abbreviations: CC, calf circumference; FMI, fat mass index; FFMI, fat free mass index; GLIM, Global Leadership Initiative on Nutrition; HGS, hand-grip strength; MAMC, mid arm muscle circumference; MNA, Mini Nutritional Assessment; MNA-SF, Mini-Nutritional Assessment Short Form; MUAC, mid upper arm circumference; MUST, Malnutrition Universal Screening Tool; NRI, Nutrition Risk Index; NRS, Nutritional Risk Screening; PG-SGA, Patient Generated Subjective Global Assessment; SD, standard deviation; SNAQ, Simplified Nutritional Appetite Questionnaire; SPPB, Short Physical Performance Battery; TSF, tricep skinfold. ESCNM - European Society of Clinical Nutrition
and Metabolism Special Interest Group for 'cachexia–anorexia in chronic wasting diseases. GLIM – Global Leaders In Malnutrition, consensus group definition of malnutrition.

[$] Martin L et al. *J Clin Oncol* 2013;**31**:1539–1547.
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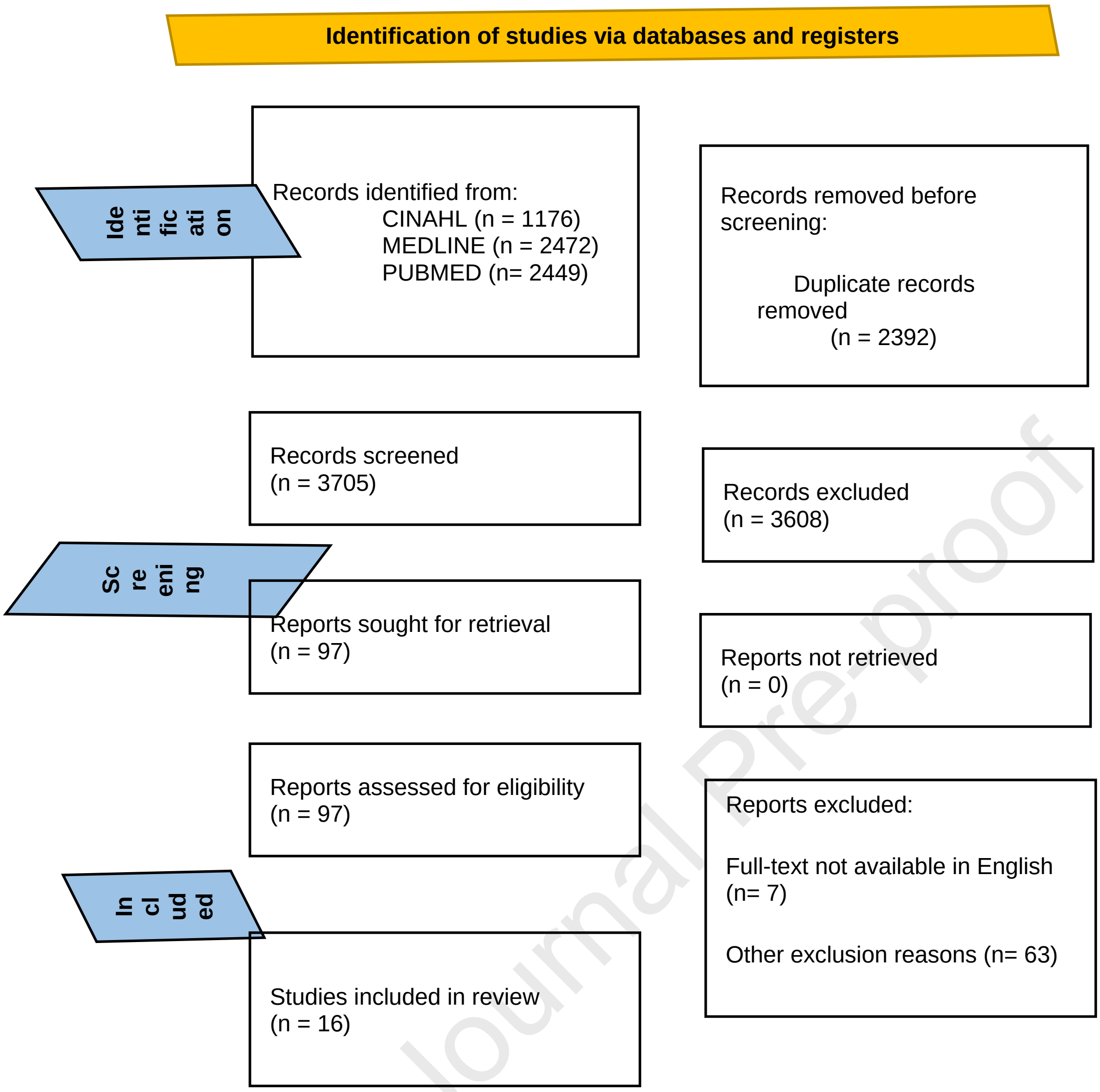
Figure 1. PRISMA-SCr flow chart summarising search results.



Declaration of Interest Statement

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The author is an Editorial Board Member/Editor-in-Chief/Associate Editor/Guest Editor for this journal and was not involved in the editorial review or the decision to publish this article.

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