Journal of Multidisciplinary Healthcare

Dovepress
open access to scientific and medical research

Open Access Full Text Article

REVIEW

Evaluating the Outcomes in Patients with Colorectal Cancer Using the Malnutrition Universal Screening Tool: A Systematic Review

Calin Muntean[1], Andiana Roxana Blidari[2], Alaviana Monique Faur[3], Razvan Ovidiu Curca[4], Catalin Vladut Ionut Feier[5,6]

[1]Medical Informatics and Biostatistics, Department III-Functional Sciences, "Victor Babes" University of Medicine and Pharmacy Timisoara, Timisoara, Romania; [2]Oncology Unit, Department IX-Surgery, "Victor Babes" University of Medicine and Pharmacy Timisoara, Timisoara, Romania; [3]Faculty of Medicine, "Victor Babes" University of Medicine and Pharmacy Timisoara, Timisoara, Romania; [4]Department of Oncology, "Elysee Hospital", Alba Iulia, Romania; [5]First Discipline of Surgery, Department X-Surgery, "Victor Babes" University of Medicine and Pharmacy Timisoara, Timisoara, Romania; [6]First Surgery Clinic, "Pius Brinzeu" Clinical Emergency Hospital, Timisoara, Romania

Correspondence: Andiana Roxana Blidari, Email andiana.blidari@umft.ro

Background: The current systematic review aimed to evaluate the Malnutrition Universal Screening Tool (MUST) for its effectiveness in determining patient outcomes (length of hospital stay, postoperative complications, infection rates, and survival) for colorectal cancer.

Methods: Utilizing a comprehensive search strategy, this review mined literature up to December 2023 from the PubMed, Scopus, and Embase databases. The focus was on identifying studies that scrutinize the prognostic value of MUST in relation to hospital outcomes in colorectal cancer contexts. Adherence to PRISMA guidelines ensured a systematic approach, encompassing various study designs and outcome measures.

Results: Among the seven studies incorporating 1950 patients, a significant correlation emerged between MUST scores and key hospital outcomes. Specifically, patients categorized as high MUST risk faced longer hospital stays, with a mean length of stay for high-risk patients extending up to 26.6 days compared to 14 days for those at lower risk. The prevalence of postoperative complications was substantially higher in the high-risk group, with up to 41.4% of high MUST risk patients experiencing severe complications (Clavien-Dindo 3–5) compared to 8.5% in the low-risk category. Notably, the review found that high MUST scores were strongly predictive of increased postoperative complications and a prolonged hospital stay, underscoring the tool's critical predictive utility for quality of life and use in clinical settings.

Conclusions: Therefore, MUST's capability to predict longer hospital stays and a higher incidence of postoperative complications among high-risk patients highlights its essential function in preoperative evaluations and supports the integration of MUST into routine clinical assessments.

Keywords: cancer, oncology, colorectal cancer, quality of life

Introduction

Colorectal cancer (CRC) stands as the third most common cancer and the second leading cause of cancer death worldwide, with an estimated 1.8 million new cases and 881,000 deaths in 2018.[1–4] The disease's prognosis and treatment outcomes are heavily influenced by the stage at diagnosis, with five-year survival rates ranging from 90% for stage I to around 14% for stage IV.[5] Nutritional status can significantly influence both the progression of cancer and patient resilience to treatment modalities such as surgery, chemotherapy, and radiation therapy.[6–9] Malnutrition, a common comorbidity in CRC, is associated with a higher incidence of treatment complications, increased mortality, and reduced quality of life.[10] The risk of malnutrition in CRC patients increases due to factors such as tumor location, bowel obstruction, and treatment side effects, which can lead to decreased food intake, nutrient malabsorption, and metabolic alterations.[11]

Received: 17 April 2024
Accepted: 30 July 2024
Published: 3 September 2024

Malnutrition is a critical but often under-recognized condition that significantly impacts the associated comorbidities and clinical outcomes in oncology.[12–15] Despite advancements in oncological care, the prevalence of malnutrition among these patients remains high, ranging from 30% to 85%, varying with the stage of cancer, the age of patients, the measurement tools used, and the healthcare setting.[16,17] Malnutrition and cancer cachexia in CRC patients is associated with numerous adverse outcomes, including increased postoperative complications, higher infection rates, longer hospital stays, and, most importantly, decreased survival rates.[18–22] The Malnutrition Universal Screening Tool (MUST), developed by the British Association for Parenteral and Enteral Nutrition, offers a practical approach to identify individuals at risk of malnutrition.[23] It incorporates BMI, unintentional weight loss, and the effect of acute disease on dietary intake to generate an overall risk score.

Malnutrition remains a significant global health challenge, affecting approximately 11% of the global adult population, with higher rates in low-income regions. Among patients with cancer, malnutrition is particularly prevalent and problematic, affecting up to 85% of patients with advanced malignancies such as colorectal cancer.[16,17] This high incidence is due to the combined effects of the disease itself, the metabolic demands of growing tumors, and the side effects of cancer treatments, which can impair nutrient intake and absorption. Clinically, malnutrition in cancer patients is associated with poorer outcomes, including reduced response to therapy, higher complication rates, and decreased survival. Current practices to combat malnutrition in oncology include nutritional screening at diagnosis and throughout treatment, dietary counseling, and the use of enteral or parenteral nutrition when necessary.

The significance of early and accurate nutritional risk identification in colorectal cancer patients cannot be overstated. The MUST, by design, is non-invasive, quick, and requires minimal training to administer, making it an ideal validated screening tool in various healthcare settings.[24] Research has shown that early nutritional interventions in malnourished cancer patients can improve treatment tolerance, enhance quality of life, and potentially improve survival outcomes.[25–27] However, the effectiveness of MUST as a predictor for hospital outcomes in this specific population of patients with CRC is still unclear, underscoring the need for a systematic review of the literature to consolidate current evidence and ascertain the predictive value of MUST in this context.

MUST utilizes three key parameters: body mass index (BMI), unintentional weight loss over a specified time, and the impact of an acute disease process on nutritional intake for more than 5 days. The MUST evaluates nutritional risk based on a patient's BMI, recent weight loss over 3–6 months, and inability to eat due to acute disease for more than 5 days, assigning scores to categorize patients into low (score = 0), moderate (score = 1), or high malnutrition risk (score $\geq$ 2). MUST boasts high sensitivity (96%) and specificity (75%) against the Subjective Global Assessment (SGA) and is praised for its simplicity and quick completion time of 3–5 minutes by healthcare professionals.

Therefore, the primary objective of this systematic review is to evaluate the effectiveness of MUST as assessment tool and predictor for hospital outcomes in patients with colorectal cancer. Specifically, it aims to assess the association between MUST risk categories and clinical outcomes, including but not limited to, length of hospital stay, postoperative complications, infection rates, and survival. Through this review, the clinical utility of these findings is to provide evidence-based recommendations for the use of MUST in the clinical management of colorectal cancer, with the goal of improving patient outcomes and quality of care.

Material and Methods

Protocol and Registration

To ensure an exhaustive and nuanced search of the literature regarding the effectiveness of the Malnutrition Universal Screening Tool (MUST) in predicting hospital outcomes for patients with colorectal cancer, this study employed a refined search strategy across multiple critical electronic databases, including PubMed, Scopus, and Embase. This strategy aimed to include literature published up until December 2023 to incorporate the most current studies on the topic. The focus of the search strategy was to collect relevant literature that evaluates the predictive accuracy of MUST in the context of colorectal cancer, specifically regarding hospital outcomes such as postoperative complications, infection rates, length of stay, and overall survival.

The search strategy was comprehensive, incorporating an extensive array of keywords and phrases closely related to the study's objectives. These included terms related to malnutrition screening, the specific tool in question (MUST), colorectal cancer, and a variety of hospital outcomes. Specific search terms used were: "Malnutrition Universal Screening Tool", "MUST", "colorectal cancer", "colorectal neoplasms", "hospital outcomes", "nutritional screening", "malnutrition assessment", "clinical outcomes", "surgical outcomes", "treatment outcomes", "postoperative complications", "post-operative recovery", "surgical infections", "length of hospital stay", "hospital readmission", "patient survival", "survival analysis", "nutritional status", "nutritional interventions in cancer care", "impact of malnutrition on cancer treatment", and "predictive value of nutritional screening tools".

Boolean operators (AND, OR, NOT) were strategically used to combine these terms in a manner that would refine the search results, ensuring relevance and specificity to the research question. The search query was structured to encompass various combinations and permutations of these terms to capture the broadest possible range of pertinent studies. For example, the search string might look something like this: ("Malnutrition Universal Screening Tool" OR "MUST") AND ("colorectal cancer" OR "colorectal neoplasms") AND ("hospital outcomes" OR "clinical outcomes" OR "surgical outcomes" OR "postoperative complications" OR "length of hospital stay" OR "hospital readmission" OR "patient survival") AND ("nutritional screening" OR "malnutrition assessment" OR "nutritional status") AND ("nutritional interventions in cancer care" OR "impact of malnutrition on cancer treatment" OR "predictive value of nutritional screening tools").

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines,[28] this systematic review protocol was developed to ensure a structured, transparent, and replicable methodology. To promote the openness and accessibility of our research process and findings, the review has been registered with the Open Science Framework (OSF), which provides a platform for sharing our methodology and outcomes with the wider research community. The review's OSF registration code is osf.io/yvn4p. This detailed and expansive search strategy is intended to compile a comprehensive collection of studies, facilitating a thorough understanding of MUST's role in predicting hospital outcomes for colorectal cancer patients, thereby enriching the evidence base for clinical practice and future research.

Eligibility Criteria and Definitions

The eligibility criteria for this systematic review were meticulously established to identify studies that investigate the effectiveness of the MUST questionnaire as a predictor for hospital outcomes in patients with colorectal cancer. Consequently, this review incorporated the following inclusion criteria: (1) Study population: Studies must involve patients diagnosed with colorectal cancer, without restrictions on the stage of cancer or age of patients, to encompass a broad spectrum of clinical scenarios. (2) Focus on MUST and hospital outcomes: Research must specifically explore the use of MUST for nutritional screening and its predictive value for hospital outcomes, including but not limited to length of hospital stay, postoperative complications, infection rates, and survival. This includes studies assessing malnutrition risk, nutritional interventions based on MUST scores, and correlations between MUST scores and clinical outcomes. (3) Types of studies: A wide variety of study designs are eligible, including randomized controlled trials, observational studies, cohort studies, case-control studies, cross-sectional studies, and prospective and retrospective analyses. These studies should provide clear methodologies on the implementation of MUST and the assessment of hospital outcomes. (4) Outcome measures: Studies that employ MUST as an assessment tool and provide clear, quantifiable outcomes regarding hospital stays, complications, infection rates, or survival rates. This can include direct comparisons of MUST scores with clinical outcomes and the impact of nutritional interventions guided by MUST. (5) Language: Only peer-reviewed articles published in English will be included to ensure the feasibility of comprehensive review and analysis.

The exclusion criteria were defined as follows: (1) Non-human studies: Research involving in vitro or animal models will be excluded to maintain the focus on clinical outcomes in human patients. (2) Broad nutritional focus: Studies not specifically examining the use of MUST in colorectal cancer patients, or those that do not distinguish the outcomes of using MUST from other nutritional screening tools, will be excluded. (3) Lack of specific outcomes: Studies that do not provide clear, measurable outcomes related to the predictive value of MUST for hospital outcomes or lack sufficient detail for a thorough analysis will be omitted. (4) Grey literature: To ensure the integrity and reliability of the review, grey literature, including non-peer-reviewed articles, conference abstracts, general reviews, commentaries, and editorials, will be excluded.

Definitions

In this systematic review, the MUST survey is defined as a standardized tool aimed at identifying adults who are malnourished or at risk of malnutrition. The choice of MUST for this review is based on its widespread recognition and application in both hospital and community settings, and its potential impact on the management and outcomes of patients with colorectal cancer.

Nutritional screening in oncology, specifically in the context of colorectal cancer, refers to the process of identifying patients who are malnourished or at risk of malnutrition to facilitate early interventions.

Data Collection Process

The data collection process for this systematic review began with the identification and removal of 148 duplicate entries from the initial search results across PubMed, Scopus, and Embase databases. Subsequently, two independent reviewers conducted a meticulous screening of abstracts and titles from a preliminary tally of 1198 articles, using predefined inclusion and exclusion criteria focused on the utilization of the MUST tool in predicting hospital outcomes for colorectal cancer patients. This step was crucial to ensure that the studies selected were directly relevant to the review's objectives. Any discrepancies encountered between the reviewers were resolved through discussion or, when needed, by consulting a third reviewer to reach a consensus. This process led to the selection of 355 articles deemed potentially relevant. Following a detailed full-text review, 7 studies were ultimately included in the review, as presented in Figure 1. This selection strategy was designed to ensure that

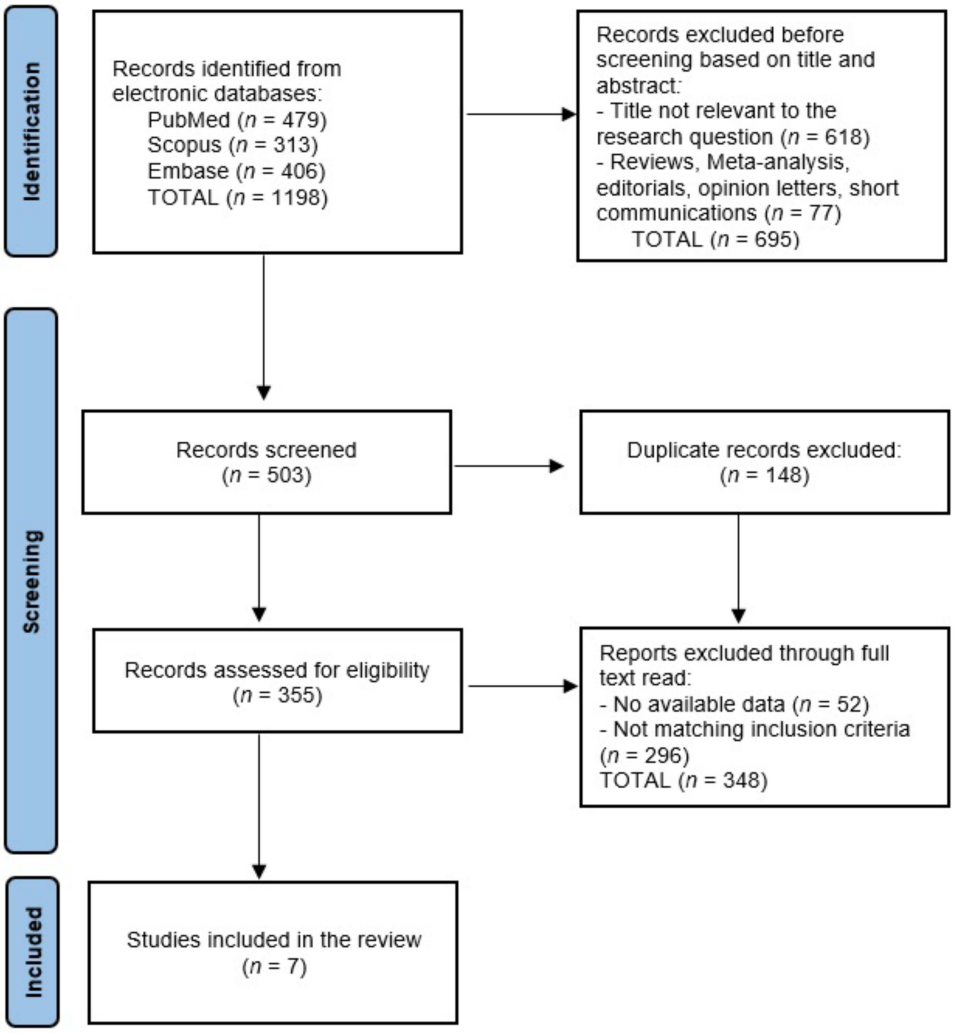

Figure 1 PRISMA Flow Diagram. Flowchart description of the steps taken to select studies for this systematic review based on the PRISMA protocol.

the studies incorporated into the final analysis were pertinent and of high quality, providing a thorough insight into the predictive value of MUST in the clinical outcomes of colorectal cancer patients.

Risk of Bias and Quality Assessment

Our review utilized a combined qualitative and quantitative approach for the quality assessment of studies and risk of bias evaluation. The observational studies' quality was gauged using the Newcastle–Ottawa Scale,[29] which examines three main areas: selection of study groups, their comparability, and the determination of exposure or outcome. This scale allows for a detailed quality assessment, highlighting studies of high methodological rigor. Each study was independently reviewed by two researchers for quality, with any discrepancies resolved through discussion or a third researcher's input, ensuring the evaluation's objectivity and repeatability.

Results

Study Characteristics

The systematic review scrutinized seven studies,[30–36] as detailed in Table 1. These studies varied from a variety of countries, including the United Kingdom,[30,33,35] Taiwan,[31] The Netherlands,[32] Spain,[34] and China,[36] reflecting a broad international interest in the topic. Conducted between 2010 and 2022, the majority of these studies adopted a prospective cohort design, with the exception of Almasaudi et al,[33] which was retrospective, and Xie et al,[36] which employed a cross-sectional approach. The quality of these studies was predominantly rated as medium, except for Abbass et al[35] from the United Kingdom, which was distinguished with a high-quality rating. This distribution of study qualities suggests a general reliability in the findings, with Abbass et al's study standing out for its exceptional methodological rigor.

Patients' Characteristics

Table 2 provides an in-depth look at the patient characteristics across seven selected studies. These studies collectively encompassed a sample size of 1950 patients, highlighting diverse patient demographics and crucial clinical parameters, including BMI, which plays a significant role in assessing nutritional risk and subsequent outcomes in colorectal cancer treatment. The patient age across these studies showed a broad range but typically reflected the more common age demographic affected by colorectal cancer, with mean ages from 62.1 years in Tu et al[31] to 69.9 years in Páramo-Zunzunegui et al.[34] Gender distribution varied slightly, with male predominance noted in most studies, such as 62.1% in Burden et al[30] and slightly less in Abbass et al[35] with 57%.

BMI data, crucial for understanding the nutritional status of patients, were detailed across several studies, showcasing a wide distribution of nutritional states. For instance, Burden et al[30] reported BMI ranges indicating a significant portion of patients with a BMI ≥25 (60.5%), reflecting a potentially overweight to obese status. Similar patterns were observed in

Table 1 Characteristics of Studies Evaluating the Malnutrition Universal Screening Tool (MUST) in Predicting Hospital Outcomes for Colorectal Cancer Patients

Study & Author	Country	Study Year	Study Design	Study Quality
1 [30] Burden et al	United Kingdom	2010	Prospective cohort	Medium
2 [31] Tu et al	Taiwan	2012	Prospective cohort	Medium
3 [32] van der Kroft et al	The Netherlands	2018	Prospective cohort	Medium
4 [33] Almasaudi et al	United Kingdom	2019	Retrospective cohort	Medium
5 [34] Páramo-Zunzunegui et al	Spain	2020	Prospective cohort	Medium
6 [35] Abbass et al	United Kingdom	2020	Prospective cohort	High
7 [36] Xie et al	China	2022	Cross-sectional	Medium

Table 2 Demographic and Clinical Characteristics of Colorectal Cancer Patients Assessed in Studies on MUST

Study Number	Sample Size	Age (Years)	Gender Distribution	Comparison Group	BMI
1 [30] Burden et al	87	Mean: 64.5, Range: 23–90	Men: 54 (62.1%), Women: 33 (37.9%)	SGA	<20 (9.3%), 20–24.9 (30.2%), ≥25 (60.5%)
2 [31] Tu et al	45	Mean: 62.1	Men: 25 (56%), Women: 33 (44%)	SGA and NRI	<18.5 (4.4%), 18.5–24 (48.9%), 24–27 (24.4%), >27 (22.2%)
3 [32] van der Kroft et al	80	Mean: 69	Men: 51 (63.7%), Women: 29 (36.3%)	Sarcopenic vs non-Sarcopenic	>30 (67% sarcopenic vs 33% non-sarcopenic)
4 [33] Almasaudi et al	363	Mean: 66	Men: 199 (54.8%), Women: 164 (45.2%)	MUST nutritional risk (low, medium, high)	<20 (8%), 20–24.9 (27%), 25–29.9 (34%), ≥30 (31%)
5 [34] Páramo-Zunzunegui et al	130	Mean: 69.9	Men: 85 (65.4%), Women: 45 (34.6%)	Symptomatic vs asymptomatic	<18.5 (2.1%), 18.5–24 (23%), 24–27 (51.8%), >27 (23%)
6 [35] Abbass et al	984	Mean: 68, Range: 23–93	Men: 57%, Women: 43%	MUST 0 vs MUST 1-≥2	NR
7 [36] Xie et al	301	Mean: 62.7, Range: 24–87	Men: 178 (59.1%), Women: 123 (40.9%)	NRS, MNA-SF, MST, NRI, SGA	Mean: 23.7

Abbreviations: NR, not reported; BMI, Body Mass Index; SGA, Subjective Global Assessment; NRI, Nutritional Risk Index.

Almasaudi et al,[33] where 65% of participants had a BMI of 25 or higher. The highest prevalence of underweight patients was of 9.3% in the study by Burden et al,[30] 8% in the study by Almasaudi et al,[33] and 4.4% in the study by Tu et al.[31]

The comparison groups within these studies were diverse, ranging from assessments based on SGA in Burden et al[30] to more detailed nutritional risk indices such as MUST in Almasaudi et al[33] and a combination of NRS, MNA-SF, MST, NRI, and SGA in Xie et al.[36]

Disease Characteristics

Table 3 outlines the disease characteristics from seven studies within the systematic review focusing on the MUST as a predictor for hospital outcomes in colorectal cancer patients. Starting with the stage of cancer, the studies exhibited a spectrum from early to advanced stages, indicating a diverse patient population. For instance, Burden et al[30] reported a distribution across all four stages, with the majority in Stage 2 (43%), while Abbass et al[35] had a considerable number of patients in Stage 2 (40.4%) and Stage 3 (35.7%).

The treatments administered ranged from elective surgeries, with a high percentage noted in Abbass et al[35] where 95.1% of patients at low MUST nutritional risk underwent elective surgery, to the use of laparoscopy as reported by Xie et al[36] with 78.1% of surgeries performed laparoscopically. This diversity in treatment approaches reflects the evolving nature of colorectal cancer management and the role of nutritional status in determining the appropriate surgical intervention.

Complications varied significantly across the studies, with Almasaudi et al[33] reporting a Clavien-Dindo classification of 1–2 in 28% of cases and 3–5 in 6% of cases. In comparison, Abbass et al[35] noted complications in 38% of patients with low MUST risk versus 41.4% with high MUST risk, and a more severe complication rate (Clavien-Dindo 3–5) was higher in the high MUST risk group (13.2%) than in the low MUST risk group (8.5%). This suggests that higher nutritional risk may correlate with an increased risk of postoperative complications.

Table 3 Overview of Disease Characteristics and Treatment Details in Colorectal Cancer Studies Involving MUST

Study Number	Time of Assessment	Cancer Type/ Stage	Medical/Surgical History	Treatment	Complications
1 [30] Burden et al	2–4 weeks prior to surgery	Stage 1 (10%), Stage 2 (43%), Stage 3 (37%), Stage 4 (8%)	NR	Sigmoid colectomy (6%), Anterior resection (39%), Right hemicolectomy (12%), Hartmann's procedure (10%), Abdominoperineal resection (17%), Left hemicolectomy (5%), Laparotomy (3%), Pelvic clearance (3%)	NR
2 [31] Tu et al	3 months before and during hospitalization	Stage 4: 12 (27%), Liver metastasis 8 (66.6%), Peritoneal metastasis 2 (16.6%)	NR	Elective surgery for tumor removal, Adjuvant treatment 68.8%	NR
3 [32] van der Kroft et al	Upon hospital admission for nutritional screening; CT scans used for sarcopenia measurements before surgery.	Stage 1 (28%), Stage 2 (21%), Stage 3 (32%), Stage 4 (19%)	Charlson >3: 39% Sarcopenic vs 61% non-Sarcopenic, Perioperative transfusion 31% Sarcopenic vs 69% non-Sarcopenic	Elective surgery 44%, Laparoscopic 56%, Neoadjuvant therapy 8 weeks for rectal cancer.	Anastomotic leak: 6%, Wound infection: 6%, Sepsis: 5%
4 [33] Almasaudi et al	Nutritional assessment during preoperative period; CT scans 3 months prior to surgery	Stage 0–2 (64%), Stage 3 (32%), Stage 4 (2%)	ASA grade 3–4: low MUST nutritional risk (28%), high MUST nutritional risk (45%), mGPS 1–2: low MUST nutritional risk (19%), high MUST nutritional risk (45%)	Elective surgery for tumor removal	Clavien-Dindo 1–2 (28%), Clavien-Dindo 3–5 (6%)
5 [34] Páramo-Zunzunegui et al	Nutritional assessment preoperative and weight measurements 3–6 months postoperative	Colon (38.9%), Rectal (61.1%)	ASA 3–4: 29.2%	NR	5% hypoalbuminemia, 16.5% prealbumin deficiency, 20.9% hypoproteinemia.
6 [35] Abbass et al	Nutritional assessment during preoperative period.	Colon (59.8%), Rectal (40.2%), Stage 1 (23.9%), Stage 2 (40.4%), Stage 3 (35.7%)	ASA grade 3–4: low MUST nutritional risk (33.2%), high MUST nutritional risk (41.4%)	Elective surgery 95.1% for low MUST nutritional risk vs 87.4% in high risk	Complications: Low MUST risk (38%) vs high MUST risk (41.4%), Clavien-Dindo 3–5 low MUST risk (8.5%) vs high MUST risk (13.2%)
7 [36] Xie et al	Nutritional assessment within 48 hours from admission	Colon (45.2%), Rectal (54.8%)	Comorbidities (38.2%)	Laparoscopy 78.1%	Grade 2 complications (27.6%)

Abbreviations: NR, not reported; GPS, Glasgow Prognostic Score.

https://doi.org/10.2147/JMDH.S474215 DovePress

Medical and surgical history was less detailed in these summaries, with most studies not reporting or specifying the extent of prior medical interventions or conditions that could influence surgical outcomes. However, the presence of comorbidities was noted, such as in Xie et al[36] where 38.2% of patients had comorbid conditions, highlighting the complexity of managing colorectal cancer patients who may have multiple health issues.

Nutritional Status and Outcomes

Table 4 presents an overview of the nutritional status and outcomes of patients with CRC across seven studies. Burden et al[30] reported a spectrum of MUST risk scores with over half of the patients at low risk, and significant findings indicating malnourished patients had notably lower handgrip strength and fat-free mass. This study demonstrated a direct correlation between malnutrition, as defined by MUST scores, and increased hospital stay lengths, emphasizing the impact of nutritional status on postoperative recovery and complications. This study also found strong associations between improved nutritional status and better quality of life and functionality outcomes, such as the EuroQol-5 Dimensions and sit-to-stand test scores.

Similarly, Tu et al[31] and Almasaudi et al[33] found a direct association between MUST scores and LOS, with higher MUST scores correlating with longer hospital stays. Tu et al highlighted the utility of MUST in routine nutritional evaluation, praising its efficiency and ease of use despite the higher specificity of other assessments like SGA and NRI. Almasaudi et al noted an increased mortality rate among patients at medium or high risk of malnutrition, underscoring MUST's role as an independent risk marker in CRC surgery.

Van der Kroft et al[32] and Abbass et al[35] provided insights into how MUST scores are associated with postoperative complications, with van der Kroft et al finding that a MUST score ≥2 significantly increased the risk of such complications. Abbass et al further confirmed the combination of MUST and modified Glasgow Prognostic Score (mGPS) as effective predictors of hospital stay and survival in CRC patients, demonstrating the compound value of nutritional and inflammatory markers in clinical assessments.

Páramo-Zunzunegui et al[34] and Xie et al[36] highlighted the high prevalence of nutritional risk among CRC patients and the importance of MUST in routine nutritional evaluations. Xie et al specifically noted the Nutritional Risk Screening (NRS) as a significant predictor for postoperative complications, indicating the importance of comprehensive nutritional assessments beyond MUST alone.

Collectively, these studies underscore the significance of using MUST in conjunction with other nutritional and clinical assessments to improve clinical outcomes and reduce healthcare costs for CRC patients. They reveal a consistent trend that malnutrition, as identified by MUST, adversely affects recovery, increases hospital LOS, and is associated with higher rates of postoperative complications and mortality. These findings advocate for the incorporation of MUST into preoperative assessments to guide nutritional interventions and support recovery in CRC patients.

Discussion

Summary of Evidence

The systematic review highlights the diverse stages of colorectal cancer among patients, ranging from early to advanced, underscoring the varied prognosis and treatment challenges across the spectrum. The significance of nutritional screening lies in the high prevalence of malnutrition among colorectal cancer patients, which can affect treatment tolerance, recovery, and overall survival. Nutritional screening encompasses the assessment of dietary intake, weight history, physical symptoms affecting food intake (such as nausea, vomiting, or bowel obstruction), and the presence of factors that increase nutritional needs (such as metabolic stress or catabolism induced by cancer). In colorectal cancer care, nutritional screening aims to tailor nutritional support to individual patient needs, thereby improving clinical outcomes and enhancing the quality of life. The implementation of tools like MUST in this process is crucial for the timely identification and management of nutritional issues in this patient population.

Our review confirms the utility of the MUST in assessing nutritional risk and its implications for hospital outcomes in colorectal cancer patients. While our findings underscore the effectiveness of MUST, they do not extend to advocating for broader evidence-based protocols involving physical activity or comprehensive nutritional assessments beyond the

Table 4 Summary of Magnesium Outcomes and Measurements per MUST Survey in Studies of Colorectal Cancer Patients

Study Number	Nutritional Status (MUST)	Other Nutritional Measurements	Hospitalization	Outcomes	Conclusion
1 [30] Burden et al	Low MUST risk score (54.3%), Moderate MUST risk score (23.5%), High MUST risk score (22.2%)	Handgrip strength: significantly lower in malnourished patients (mean 19.4 kg vs 27.3 kg). Fat free mass: significantly less in patients with >10% weight loss (mean 39.7 kg) vs those with <10% weight loss (mean 51.9 kg).	Median LOS: 14 days Mean LOS: 26.6 days >10% weight loss: median LOS of 19 days, mean LOS 20 days, vs <10% weight loss: (median LOS 14 days, mean LOS 19 days).	Significant weight loss and reduced fat free mass in malnourished patients indicate a severe impact of malnutrition on recovery and potentially on the occurrence of postoperative complications	Usefulness of MUST assessment vs SGA.
2 [31] Tu et al	Preoperative: Low MUST risk score 55.5% - mean 1.5, Postoperative: Low MUST risk score 55.5% - mean 5.3, Sensitivity 96, Specificity 75	SGA: Preoperative, A 64.4% - mean 1.7, SGA: Postoperative A 64.4% - mean 5.1, NRI: Preoperative <100 53.3% - mean 7.4, Postoperative <100 53.3% - mean 4.6	Mean LOS: 17.1 days	Preoperative weight loss: 1.8kg for LOS 8–10 days, Postoperative weight loss: 4.5kg for LOS 8–10 days	MUST is useful for routine nutritional evaluation due to its efficiency, ease of use, and low cost, despite findings that SGA and NRI may have higher specificity
3 [32] van der Kroft et al	≥2 MUST risk score: 16%	Sarcopenia: 52%	Muscle attenuation >median 34.1: 38.3% Sarcopenic vs 11% non-Sarcopenic	MUST score ≥2 significantly associated with higher risk of post-operative complications; Sarcopenia and muscle attenuation not significantly associated when corrected for age and ASA.	CT-measured sarcopenia offered little additional value over MUST in predicting post-operative morbidity, emphasizing the significance of simple, easy-to-use nutritional screening tools like MUST in clinical practice.
4 [33] Almasaudi et al	Preoperative: Medium-High nutritional risk (21%)	Low SMI: low MUST nutritional risk (45%), high MUST nutritional risk (76%)	LOS >7 days: low MUST nutritional risk (49%), high MUST nutritional risk (78%), MUST was independently associated with the length of hospital stay (OR: 2.17)	An increased number of deaths were observed for patients at medium or high risk of malnutrition (HR: 1.45)	The MUST score is an independent marker of risk in those undergoing surgery for colorectal cancer, important in preoperative assessment to improve clinical outcomes and reduce healthcare costs.
5 [34] Páramo-Zunzunegui et al	MUST 0 (30%), MUST 1–2 (44.9%), MUST >2 (25%)	Weight loss 5–10kg: 18.5% in asymptomatic patients vs 32.8% in symptomatic patients, 59% at nutritional risk	NR	Symptomatic patients 48.8% altered parameters vs 61.2% symptomatic patients.	MUST is useful for routine nutritional evaluation due to its efficiency, ease of use, and low cos
6 [35] Abbass et al	MUST 0 (82.3%), MUST 1-≥2 (17.7%)	Low SMI: low MUST nutritional risk (46.5%), high MUST nutritional risk (66.7%)	LOS >7 days: low MUST nutritional risk (51.4%), high MUST nutritional risk (69%)	mGPS is a significant predictor of complications when MUST = 0 (HR: 1.29)	MUST and mGPS combination effectively predict hospital stay and survival in operable CRC patients.
7 [36] Xie et al	1–2 MUST risk score (44.9%), >2 MUST risk score (25%), Risk of malnutrition (39.5%), Sensitivity 73.1%, Specificity 75.8%	Weight loss in the last 3–6 months: <5kg (19.4%); 5–10kg (20.7%); >10kg (2.1%), Risk of malnutrition: NRS (41.5%), MNA-SF (46.2%), MST (30.6%), NRI (25.2%), SGA (43.5%)	Mean LOS: 19.2 days	NRS was the only significant predictor for postoperative complications based on malnutrition risk (OR: 2.40), compared with MUST.	High prevalence of nutritional risk among colorectal cancer patients scheduled for surgery. MUST score was not a significant independent predictor.

Abbreviations: NR, Not Reported; SMI, Skeletal Muscle Index; MUST, Malnutrition Universal Screening Tool; LOS, Length of Stay; ASA, American Society of Anesthesiologists; SGA, Subjective Global Assessment; NRI, Nutritional Risk Index; mGPS, Modified Glasgow Predictive Score.

https://doi.org/10.2147/JMDH.S474215 DovePress

scope of this tool. Thus, any conclusions regarding the development of such protocols should be approached with caution, acknowledging the specific focus and limitations of our study on MUST.

The distribution of cancer stages, as detailed in studies like Burden et al[30] and Abbass et al,[35] provides a broad view of the CRC population, revealing a substantial segment in the intermediate stages of disease. This stage distribution is crucial as it influences treatment decisions and potential outcomes, necessitating a tailored approach to managing each patient. The varied stages of cancer underscore the necessity of incorporating comprehensive nutritional assessments, like MUST, into the pre-treatment evaluation to better stratify patients according to their risk and customize their treatment plans accordingly.

The treatment modalities reported across the studies reflect the evolving landscape of CRC management, highlighting the significant role that nutritional status plays in determining the most appropriate surgical intervention. Therefore, it emphasizes the importance of preoperative nutritional assessment in minimizing surgical risks and enhancing recovery, further advocating for the integration of nutritional screening tools like MUST in the preoperative workup.

The correlation between higher nutritional risk and increased postoperative complications, as indicated by the data from Almasaudi et al[33] and Abbass et al,[35] is particularly noteworthy. The findings suggest that patients with elevated MUST scores are more susceptible to severe postoperative complications, highlighting the critical role of nutritional status in patient recovery and long-term outcomes. This relationship between malnutrition and adverse surgical outcomes underscores the need for preemptive nutritional interventions to mitigate risks and improve the prognosis for CRC patients.

However, the lack of detailed medical and surgical histories in these studies presents a limitation to fully understanding the influence of previous health conditions on surgical outcomes and nutritional status. Despite this, the mention of comorbidities in studies like that of Xie et al[36] alludes to the complexity of managing CRC patients, who often present with multiple health issues. This complexity, coupled with the demonstrated impact of nutritional risk on outcomes, solidifies the argument for a holistic approach to patient care, integrating nutritional assessment and management as a fundamental component of CRC treatment protocols.

The study by Tagawa et al[37] explored the nutritional status of outpatient colorectal cancer patients undergoing chemotherapy, utilizing the MUST to assess its efficacy and correlation with adverse events. Among the 34 patients with advanced or recurrent colorectal cancer studied between April and December 2010, 47.1% were identified as high-risk and requiring nutritional care, showing significant reductions in body weight and BMI, alongside notably higher incidences of appetite loss and fatigue compared to the low-risk group. While this study underscores the importance of nutritional assessment in managing the adverse effects of outpatient chemotherapy and highlights MUST's potential as a simplified screening tool, it was not included in our systematic review due to its focus on outpatients receiving chemotherapy and hospital outcomes were our primary concern. Additionally, the study being in Japanese posed a language barrier for inclusion in our review, which focused on English language studies.

Lewandowska et al[38] and Ziętarska et al[4] both underscore the critical role of malnutrition in CRC patients' treatment outcomes, stressing the importance of nutritional status assessments and interventions. Lewandowska et al highlight the widespread issue of malnutrition among CRC patients, noting its detrimental effects on survival rates, quality of life, and therapy effectiveness. They recommend personalized nutritional therapy, including light, low-fat foods and, in specific cases, dietary adjustments like lactose and gluten exclusion. Ziętarska et al, through quantitative analysis, revealed that 75% of CRC patients exhibit pre-cachexia, with 73.3% moderately malnourished and 2.7% severely malnourished. They found a significant correlation between appetite and patients' functional status, emphasizing the need for early and adequate nutritional interventions. Both studies align with the assertion that evaluating and addressing malnutrition is essential for improving CRC treatment efficacy and patient quality of life, reinforcing the importance of integrating nutritional care into CRC management protocols.

The study by Burden et al[39] delved into the critical issue of preoperative malnutrition in colorectal cancer patients and its implications on postoperative outcomes, underscoring the necessity for nutritional assessment and intervention. It was reported that 44% of their patients were at nutritional risk preoperatively, with a significant portion of these patients (31%) improving their nutritional status during prehabilitation. Conversely, Gupta et al[40] emphasized the high prevalence of preoperative malnutrition and advocated for comprehensive nutritional assessments using tools like SGA, PG-SGA, and MUST. They suggested considering various nutritional interventions, including trimodal prehabilitation and

supplementation with arginine and N-3 fatty acids, to enhance postoperative recovery. Both studies underscored the importance of addressing malnutrition to improve surgical outcomes in colorectal cancer patients. However, Gupta et al provided a broader perspective on potential nutritional interventions and the need for their integration into preoperative care to mitigate the adverse effects of malnutrition.

Håkonsen et al[41] and Ruan et al[42] both examine the effectiveness of nutritional assessment tools in identifying malnutrition among colorectal cancer patients, yet their findings illuminate distinct facets of diagnostic accuracy and clinical implications. Håkonsen et al conducted a methodical review to assess the diagnostic test accuracy of instruments like the Malnutrition Screening Tool (MST), Nutritional Risk Index (NRI), and the MUST against Subjective Global Assessment (SGA) and Patient Generated Subjective Global Assessment (PG-SGA). Their results highlighted varying levels of sensitivity and specificity: MUST demonstrated a high sensitivity of 96% against SGA, indicating excellent diagnostic accuracy, while its effectiveness diminished significantly when compared to PG-SGA, with sensitivity dropping to 72% and specificity to 48.9%. On the other hand, Ruan et al presented a comparative analysis of the Nutritional Risk Screening 2002 (NRS-2002), Global Leadership Initiative on Malnutrition (GLIM) criteria, and PG-SGA, emphasizing NRS-2002's superior specificity (0.90) in identifying patients without nutritional deficits. Their study underscored the simplicity and efficacy of NRS-2002 in clinical settings, suggesting its potential as a preferred tool for colorectal cancer patients. While Håkonsen et al point out the varied diagnostic accuracies of different tools and advocate for a combined use of clinical judgment and assessments like SGA or PG-SGA, Ruan et al highlight NRS-2002's advantage in specificity and ease of use, proposing it as an effective standalone screening method for nutritional assessment in colorectal cancer care.

Zhang et al[43] and Monfino et al[44] examined malnutrition screening in cancer patients, highlighting the importance of effective tools. Zhang et al's observational study compared NRS2002, MUST, and PG-SGA against the GLIM criteria, revealing that 24.8% and 15.4% of patients were at moderate and high risk of malnutrition according to NRS2002 and MUST, respectively. NRS2002 most aligned with GLIM (AUC = 0.896) compared to MUST (AUC = 0.757). PG-SGA, despite its sensitivity, shows a low positive predictive value. Monfino et al stress the urgency of early malnutrition screening and personalized nutritional therapy to enhance outcomes. While Monfino et al advocate for the general use of screening tools and the GLIM criteria for diagnosing malnutrition, Zhang et al provide concrete data, suggesting NRS2002's superiority for its alignment with GLIM, aiding in accurate malnutrition identification in cancer care.

Finally, another review by Wimmer at al[45] explored the methods for early identification of cancer-related malnutrition before and after surgery, involving 926 patients. Similarly to our findings, it was observed that despite the diversity of tools available, the review underscored a significant gap: a lack of evidence-based standardization for early malnutrition detection in colorectal cancer patients within oncology clinical practice. Moreover, the involvement of different health professional groups in the assessment process lacked standardized roles, pointing to a disjointed approach to nutritional screening. Notably, physical activity, an important aspect of overall nutritional status, was absent from the screening tools reviewed. This omission highlights a critical area for future development and integration into comprehensive nutritional assessments. Therefore, our findings emphasize the urgent need for standardized, evidence-based protocols that include a holistic view of patients' nutritional status, incorporating physical activity to improve early malnutrition detection and outcomes in colorectal cancer care.

Limitations

The systematic review faced several limitations that are crucial for interpreting its findings. First, the inclusion criteria limited the analysis to English language publications, potentially omitting relevant studies in other languages that could enrich the understanding of the MUST's effectiveness. Additionally, the review's scope, focusing exclusively on MUST and its predictive value for hospital outcomes in colorectal cancer patients, might have overlooked the potential benefits or comparability of other nutritional screening tools. The reliance on published literature also meant that unpublished studies or grey literature, which might contain important insights or data, were excluded, possibly introducing publication bias. Furthermore, the heterogeneity in study designs, ranging from prospective cohorts to cross-sectional analyze High MUST scores correlate with increased susceptibility to complications; however, the potential confounding effect of a higher proportion of emergency surgeries must be considered. Lastly, the absence of randomized controlled trials and prospective research among the reviewed studies limits the ability to establish causality between MUST scores and patient outcomes, highlighting the need for further high-quality research in this area.

Conclusion

The systematic review substantiates the importance of the Malnutrition Universal Screening Tool as a potential predictor of hospital outcomes in colorectal cancer patients, particularly in identifying individuals at higher risk of prolonged hospitalization and increased postoperative complications. However, its limitations should guide clinical utility. The data illustrates that patients with higher MUST scores endure extended stays and greater complication rates, reinforcing MUST's significance in preoperative assessment and the necessity for its incorporation into clinical practice. This review advocates for the utilization of MUST to guide nutritional interventions, aiming to improve patient outcomes and diminish healthcare costs, while suggesting further exploration into its application to enhance its efficacy in patient management strategies.

Acknowledgments

The article processing charge was paid by the Victor Babes University of Medicine and Pharmacy Timisoara.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Marcellinaro R, Spoletini D, Grieco M, et al. Colorectal Cancer: current Updates and Future Perspectives. *J Clin Med*. 2023;13(1):40. doi:10.3390/jcm13010040
2. Hossain MS, Karuniawati H, Jairoun AA, et al. Colorectal Cancer: a Review of Carcinogenesis, Global Epidemiology, Current Challenges, Risk Factors, Preventive and Treatment Strategies. *Cancers*. 2022;14(7):1732. doi:10.3390/cancers14071732
3. Dolghi A, Buzatu R, Dobrescu A, et al. Phytochemical Analysis and In Vitro Cytotoxic Activity against Colorectal Adenocarcinoma Cells of Hippophae rhamnodies L. Cymbopogon citratus (D.C.) Stapf, and Ocimum basilicum L. *J Essent Oil Bear Plants*. 2021;10(12):2752.
4. Feier CVI, Santoro RR, Faur AM, Muntean C, Olariu S. Assessing Changes in Colon Cancer Care during the COVID-19 Pandemic: a Four-Year Analysis at a Romanian University Hospital. *J Clin Med*. 2023;12(20):6558. doi:10.3390/jcm12206558
5. AlZaabi A, AlHarrasi A, AlMusalami A, et al. Early onset colorectal cancer: challenges across the cancer care continuum. *Ann Med Surg*. 2022;82:104453. doi:10.1016/j.amsu.2022.104453
6. Kim DH. Nutritional issues in patients with cancer. *Intest Res*. 2019;17(4):455–462. doi:10.5217/ir.2019.00076
7. Mercier BD, Tizpa E, Philip EJ, et al. Dietary Interventions in Cancer Treatment and Response: a Comprehensive Review. *Cancers*. 2022;14(20):5149. doi:10.3390/cancers14205149
8. Dobrescu A, Copaescu C, Zmeu B, et al. Ghrelin Levels and Hunger Sensation after Laparoscopic Sleeve Gastrectomy Compared with Laparoscopic Greater Curvature Plication in Obese Patients. *Clin Lab*. 2020;66(5). doi:10.7754/Clin.Lab.2019.191012
9. Jianu C, Rusu LC, Muntean I, et al. In Vitro and In Silico Evaluation of the Antimicrobial and Antioxidant Potential of Thymus pulegioides Essential Oil. *Antioxidants*. 2022;11(12):2472. doi:10.3390/antiox11122472
10. Martínez-Escribano C, Arteaga Moreno F, Pérez-López M, et al. Malnutrition and Increased Risk of Adverse Outcomes in Elderly Patients Undergoing Elective Colorectal Cancer Surgery: a Case-Control Study Nested in a Cohort. *Nutrients*. 2022;14(1):207. doi:10.3390/nu14010207
11. Muscaritoli M, Lucia S, Farcomeni A, et al. PreMiO Study Group. Prevalence of malnutrition in patients at first medical oncology visit: the PreMiO study. *Oncotarget*. 2017;8(45):79884–79896. doi:10.18632/oncotarget.20168
12. Bossi P, De Luca R, Ciani O, D'Angelo E, Caccialanza R. Malnutrition management in oncology: an expert view on controversial issues and future perspectives. *Front Oncol*. 2022;12:910770. doi:10.3389/fonc.2022.910770
13. Georgescu D, Iurciuc M, Ionita I, et al. Portal Vein Thrombosis and Gut Microbiota: understanding the Burden. *Rev Chim*. 2019;70(6):2181–2185. doi:10.37358/RC.19.6.7301
14. Reber E, Schönenberger KA, Vasiloglou MF, Stanga Z. Nutritional Risk Screening in Cancer Patients: the First Step Toward Better Clinical Outcome. *Front Nutr*. 2021;8:603936. doi:10.3389/fnut.2021.603936
15. Faur FI, Clim IA, Pasca P, et al. Low Cost and Reproductible Method to Obtain Mapping of Lymphatic Drainage in Patient with Early Endometrial Cancer. *Chirurgia*. 2023;118(2):153. doi:10.21614/chirurgia.2837
16. Bellanti F, Lo Buglio A, Quiete S, Vendemiale G. Malnutrition in Hospitalized Old Patients: screening and Diagnosis, Clinical Outcomes, and Management. *Nutrients*. 2022;14(4):910. doi:10.3390/nu14040910
17. KC A, Poudel BD, Shilpakar R, et al. Malnutrition among Cancer Patients in a Tertiary Care Centre: a Descriptive Cross-sectional Study. *JNMA J Nepal Med Assoc*. 2022;60(255):959–961. doi:10.31729/jnma.7616
18. Wan Q, Yuan Q, Zhao R, et al. Prognostic value of cachexia index in patients with colorectal cancer: a retrospective study. *Front Oncol*. 2022;12:984459. doi:10.3389/fonc.2022.984459
19. Faur IF, Dobrescu A, Clim AI, et al. The Value of Tumor Infiltrating Lymphocytes (TIL) for Predicting the Response to Neoadjuvant Chemotherapy (NAC) in Breast Cancer according to the Molecular Subtypes. *Biomedicines*. 2023;11(11):3037. doi:10.3390/biomedicines11113037
20. Shibata M, Fukahori M, Kasamatsu E, Machii K, Hamauchi S. A Retrospective Cohort Study to Investigate the Incidence of Cachexia During Chemotherapy in Patients with Colorectal Cancer. *Adv Ther*. 2020;37(12):5010–5022. doi:10.1007/s12325-020-01516-6
21. Gebremedhin TK, Cherie A, Tolera BD, Atinafu BT, Demelew TM. Prevalence and risk factors of malnutrition among adult cancer patients receiving chemotherapy treatment in cancer center, Ethiopia: cross-sectional study. *Heliyon*. 2021;7(6):e07362. doi:10.1016/j.heliyon.2021.e07362
22. Kaźmierczak-Siedlecka K, Skonieczna-żydecka K, Folwarski M, Ruszkowski J, Świerblewski M, Makarewicz W. Influence of malnutrition stage according to GLIM 2019 criteria and SGA on the quality of life of patients with advanced cancer. Influencia del grado de desnutrición según los criterios GLIM 2019 y el método SGA sobre la calidad de vida de los pacientes con cáncer avanzado. *Nutr Hosp*. 2020;37(6):1179–1185. doi:10.20960/nh.03185

23. Karsegard VL, Ferlay O, Maisonneuve N, et al. Outil de dépistage simplifié de la dénutrition: malnutrition Universal Screening Tool (MUST) [Simplified malnutrition screening tool: malnutrition Universal Screening Tool (MUST)]. *Rev Med Suisse Romande*. 2004;124(10):601–605.
24. Boléo-Tomé C, Monteiro-Grillo I, Camilo M, Ravasco P. Validation of the Malnutrition Universal Screening Tool (MUST) in cancer. *Br J Nutr*. 2012;108(2):343–348. doi:10.1017/S000711451100571X
25. Kaegi-Braun N, Schuetz P, Mueller B, Kutz A. Association of Nutritional Support with Clinical Outcomes in Malnourished Cancer Patients: a Population-Based Matched Cohort Study. *Front Nutr*. 2021;7:603370. doi:10.3389/fnut.2020.603370
26. Song C, Shi H. Diagnosis of malnutrition in cancer patients. *Cancer Biol Med*. 2024;20(12):963–966. doi:10.20892/j.issn.2095-3941.2023.0473
27. Chao PC, Chuang HJ, Tsao LY, et al. The Malnutrition Universal Screening Tool (MUST) and a nutrition education program for high risk cancer patients: strategies to improve dietary intake in cancer patients. *Biomedicine*. 2015;5(3):17. doi:10.7603/s40681-015-0017-6
28. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst Rev*. 2021;10(1):89. doi:10.1186/s13643-021-01626-4
29. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol*. 2010;25(9):603–605. doi:10.1007/s10654-010-9491-z
30. Burden ST, Hill J, Shaffer JL, Todd C. Nutritional status of preoperative colorectal cancer patients. *J Hum Nutr Diet*. 2010;23(4):402–407. doi:10.1111/j.1365-277X.2010.01070.x
31. Tu MY, Chien TW, Chou MT. Using a nutritional screening tool to evaluate the nutritional status of patients with colorectal cancer. *Nutr Cancer*. 2012;64(2):323–330. doi:10.1080/01635581.2012.650778
32. van der Kroft G, Bours DMJL, Janssen-Heijnen DM, van Berlo DCLH, Konsten DJLM. Value of sarcopenia assessed by computed tomography for the prediction of postoperative morbidity following oncological colorectal resection: a comparison with the malnutrition screening tool. *Clin Nutr ESPEN*. 2018;24:114–119. doi:10.1016/j.clnesp.2018.01.003
33. Almasaudi AS, McSorley ST, Dolan RD, Edwards CA, McMillan DC. The relation between Malnutrition Universal Screening Tool (MUST), computed tomography-derived body composition, systemic inflammation, and clinical outcomes in patients undergoing surgery for colorectal cancer. *Am J Clin Nutr*. 2019;110(6):1327–1334. doi:10.1093/ajcn/nqz230
34. Páramo-Zunzunegui J, Ramos-Carrasco A, Alonso-García M, Cuberes-Montserrat R, Rodríguez-Caravaca G, Durán-Poveda M. Altered Preoperative Nutritional Status in Colorectal Cancer: a Not So Infrequent Issue. *J Nutr Metab*. 2020;2020:5049194. doi:10.1155/2020/5049194
35. 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 Clin Rep*. 2020;5(4):99–107. doi:10.1002/crt2.25
36. Xie B, Sun Y, Sun J, Deng T, Jin B, Gao J. Applicability of five nutritional screening tools in Chinese patients undergoing colorectal cancer surgery: a cross-sectional study. *BMJ Open*. 2022;12(5):e057765. doi:10.1136/bmjopen-2021-057765
37. Tagawa M, Myotoku M, Iwamoto C, et al. Nutritional assessment employing the malnutrition universal screening tool for patients with colorectal cancer undergoing outpatient chemotherapy. *Gan To Kagaku Ryoho*. 2013;40(9):1185–1188.
38. Lewandowska A, Religioni U, Czerw A, et al. Nutritional Treatment of Patients with Colorectal Cancer. *Int J Environ Res Public Health*. 2022;19(11):6881. doi:10.3390/ijerph19116881
39. Burden ST, Bibby N, Donald K, et al. Nutritional screening in a cancer prehabilitation programme: a cohort study. *J Hum Nutr Diet*. 2023;36(2):384–394. doi:10.1111/jhn.13057
40. Gupta A, Gupta E, Hilsden R, et al. Preoperative malnutrition in patients with colorectal cancer. *Can J Surg*. 2021;64(6):E621–E629. doi:10.1503/cjs.016820
41. Håkonsen S, Pedersen P, Bath-Hextall F, Kirkpatrick P. Diagnostic test accuracy of nutritional tools used to identify undernutrition in patients with colorectal cancer: a systematic review. *JBI Database Syst Rev Implement Rep*. 2015;13(4):141.1. doi:10.11124/01938924-201513040-00012
42. Ruan X, Wang X, Zhang Q, et al. The performance of three nutritional tools varied in colorectal cancer patients: a retrospective analysis. *J Clin Epidemiol*. 2022;149:12–22. doi:10.1016/j.jclinepi.2022.04.026
43. 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. doi:10.1016/j.nut.2020.111072
44. Molfino A, Imbimbo G, Laviano A. Current Screening Methods for the Risk or Presence of Malnutrition in Cancer Patients. *Cancer Manag Res*. 2022;14:561–567. doi:10.2147/CMAR.S294105
45. Wimmer E, Glaus A. Early identification of cancer-related malnutrition in patients with colorectal cancer before and after surgery: a literature review. *Support Care Cancer*. 2022;30(11):8775–8783. doi:10.1007/s00520-022-07230-z