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REVIEW

Epidemiology, Controversies, and Dilemmas of Perioperative Nutritional Risk/Malnutrition: A Narrative Literature Review

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Abstract: Current perioperative nutrition management is discouraging due to the under-recognition of clinical nutrition and the lagging development of clinical nutriology. This review aimed to identify and explore epidemiology, related adverse outcomes, controversies, and dilemmas of perioperative nutritional risk/malnutrition to call for further development of perioperative nutritional medicine. Databases including PubMed, Embase, Cochrane Library, Wanfang Database, China National Knowledge Infrastructure, China Biology Medicine disc, and Chongqing VIP Database were searched for articles published between January 1, 2014 and August 31, 2024 using the following MeSH terms: ("nutritional risk"[Title/Abstract] OR "malnutrition"[Title/Abstract] OR "undernutrition"[Title/Abstract]) AND ("surgery"[Title/Abstract] OR "surgical"[Title/Abstract] OR "operative"[Title/Abstract] OR "operation"[Title/Abstract]). The incidence of nutritional risk was in the 20% range in patients undergoing elective surgery, 54% in older adults, 44–70% in patients with tumors or major elective surgeries, and 50–55% in children. The incidence of malnutrition ranged from 11–77% in surgical patients. Nutrition-related perioperative adverse events included mainly infection, wound healing disorders, reoperation and unplanned readmission, prolonged hospital stay, mortality, perioperative neurocognitive dysfunction, and venous thrombosis. Current controversies and dilemmas in this field include the low rates of nutrition screening and medical nutrition therapy, numerous nutrition screening tools and malnutrition diagnostic criteria, no consensus on optimal assessment method, low level of evidence-based clinical nutrition research and lack of in-depth mechanistic studies, inconsistent timing of nutrition assessment, lack of reports for community hospitals, small hospitals, and low/middle-income countries or regions, and under-recognition of micronutrient malnutrition. It is, therefore, necessary for perioperative patients to undergo nutritional screening at the first outpatient visit before surgery and/or on admission. Perioperative nutritional management needs urgent attention and requires a multidisciplinary team, including anesthesia, nursing, nutrition, and surgery.

Plain Language Summary:

- Proper nutrition around the time of surgery is a crucial aspect of patient care and contributes to enhanced recovery and lower rates of complications.
- Nutritional risk/malnutrition remains under-recognized and untreated in perioperative patients worldwide, especially in lower-income regions.
- We reviewed 10 years of medical literature to assess the causes and challenges to proper nutrition for patients undergoing surgery. We found that older adults, children, and those with other medical conditions or in poverty were at the most risk.
- The incidence of nutritional risk was in the 20% range in patients undergoing elective surgery, 54% in older adults, 44–70% in patients with tumors or major elective surgeries, and 50–55% in children. The incidence of malnutrition ranged from 11–77% in surgical patients.

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We provide targeted suggestions for improving nutrition for those undergoing surgery, including better screening, improved studies and trials, a team medical approach, better documentation, and addressing vitamin and mineral deficiencies.

Keywords: perioperative nutrition, medical quality and safety, nutritional risk, preoperative risk factors, adverse outcomes

Introduction

Disease-related malnutrition, which refers to malnutrition resulting from disease rather than poverty, is a global public health issue. This condition is often associated with substantially increased morbidity, disability, short- and long-term mortality, significantly impaired recovery from illness, and high costs of care.[1–3] Most malnutrition in adult hospitalized patients is caused by disease-related malnutrition.[4,5] However, prior to the official release of the Global Leadership Initiative on Malnutrition (GLIM) criteria in 2019,[6] the terms "nutritional risk (ICD-10: R63.801)" and "malnutrition (ICD-10: E46.x00x003)" were often conflated, and the assessment criteria for both were somewhat confusing.[4,7] Nutritional risk refers to the risk that existing or potential nutritional and metabolic factors may cause adverse clinical outcomes such as decreased physiological function, increased complications, and mortality.[4,7,8] According to the World Health Organization (*https://www.who.int/health-topics/malnutrition#tab=tab_1.Accessed December 14, 2024*), malnutrition refers to deficiencies or excesses in nutrient intake, imbalance of essential nutrients, or impaired nutrient utilization. The double burden of malnutrition consists of both undernutrition and overweight and obesity, as well as diet-related noncommunicable diseases. However, in the narrow definition and the GLIM criteria, malnutrition is commonly defined clinically as a state of energy or nutrient deficiency caused by inadequate intake or impaired utilization, with an emphasis on "undernutrition", which manifests itself in four broad forms: wasting (low weight for height), stunting (low height for age), underweight (low weight for age) and micronutrient deficiencies. Therefore, nutritional risk/malnutrition is referred to as "undernutrition" in this review.

The diagnostic criteria for GLIM follow these three steps[5,6] (Table 1): First, nutritional risk screening (*use validated screening tools to determine if the patient is at nutritional risk*). Second, malnutrition assessment based on existing nutritional risks (*This includes phenotypic indicators, including involuntary weight loss, body mass index [BMI], muscle mass loss, and etiologic indicators, including decreased food intake or absorption, inflammation, or disease burden. Those who meet at least one phenotypic indicator and one etiologic indicator can be diagnosed with malnutrition*). Third, assess the severity of malnutrition *(If the weight loss is >10% within the last 6 months, if the weight loss over 6 months is >20%, or if the BMI is less than 18.5* kg/m^2 *with generally poor conditions, it is considered severe malnutrition. Moderate malnutrition% = total malnutrition% - severe malnutrition%)*. According to the GLIM criteria, assessing nutritional risk is the first step in diagnosing malnutrition. Patients who are malnourished inevitably have nutritional risks, but those with nutritional risks are not necessarily malnourished. Unfortunately, despite the known relationship

Table 1 The GLIM Diagnostic Criteria for Malnutrition

Diagnostic Scheme		**Criteria**	
Step One:	Nutritional risk screening	Use validated screening tools	
Step Two:	Malnutrition assessment[a]	Phenotypic: non-volitional weight loss, low BMI, and reduced muscle mass Etiologic: reduced food intake or assimilation, and inflammation or disease burden	
Step Three:	Malnutrition severity assessment[b]	Moderate	Severe
	Weight loss (%)	5–10% in 6 months, or 10–20% in ≥ 6 months	>10% in 6 months, or >20% in ≥ 6 months
	Low BMI (kg/m^2)	<20 if < 70 years, <22 if ≥ 70 years	<18.5 if < 70 years, <20 if ≥ 70 years
	Reduced muscle mass[c]	Mild to moderate deficit	Severe deficit

Notes: [a]Requires at least 1 Phenotypic criterion and 1 etiologic criterion. [b]Requires 1 phenotypic criterion. [c]There is no consensus on how best to measure and define reduced muscle mass, especially in the clinical setting, such as appendicular lean mass index (kg/m^2), mid-arm muscle, calf circumference, skeletal muscle index at the third lumbar vertebra, and grip strength may be used.
Abbreviation: BMI, body mass index.

between nutritional risk/malnutrition and poorer outcomes, clinical nutrition has not received sufficient attention worldwide,[9–12] and clinical nutriology has seriously lagged behind in terms of advances in clinical medicine. In China, the lack of clarity on the positioning and affiliation of clinical nutrition departments, shortage of clinical nutritionists, and low professional level of dieticians are common phenomena.[9] It was not until 2022 that the National Health Commission of China required secondary or higher general and cancer hospitals to establish clinical nutrition departments to standardize and promote the development of clinical nutrition. This situation raises concerns regarding the status of clinical nutrition, especially in low- and middle-income countries (LMICs) or impoverished regions, where it is likely to be even more problematic.[13]

In addition to disease-related appetite loss and medication-related side effects, surgery, anesthesia, pain, and psychosocial factors accelerate poor appetite and poor adherence to medical nutrition therapy in perioperative patients.[7,14,15] Therefore, perioperative patients face more severe nutritional problems, and perioperative medical quality control and safety management should focus on patients with nutritional risk/malnutrition. However, there is a lack of literature to comprehensively summarize the current epidemiology and development of perioperative nutritional risk/malnutrition. In addition, the current research on perioperative nutrition comes primarily from developed countries or regions, university teaching hospitals, or large tertiary hospitals. Concurrently, perioperative obesity (or overnutrition) has received a great deal of attention in the past few decades. This situation leads to the misconception that perioperative nutritional risk/malnutrition is not common. However, it is more likely that perioperative nutritional risk/malnutrition is overlooked, leading to inadequate diagnosis and a lack of comprehensive medical records.[8]

This literature review aimed to identify and explore the epidemiology, related adverse outcomes, controversies, and dilemmas of perioperative nutritional risk/malnutrition through studies undertaken over the last 10 years to further the development of perioperative nutritional medicine.

Materials and Methods

Search Strategy and Data Extraction Method

Databases comprising PubMed, Embase, Cochrane Library, Wanfang Academic Journal Full-text Database, China National Knowledge Infrastructure, China Biology Medicine disc, and Chongqing VIP Database were searched for articles published between January 1, 2014 and August 31, 2024 using the following MeSH terms: ("nutritional risk"[Title/Abstract] OR "malnutrition"[Title/Abstract] OR "undernutrition"[Title/Abstract]) AND ("surgery"[Title/Abstract] OR "surgical"[Title/Abstract] OR "operative"[Title/Abstract] OR "operation"[Title/Abstract]). The most relevant original studies, systematic reviews, and high-quality reviews were selected, and the original observational studies were used to explore the epidemiology of nutritional risk and malnutrition. All potentially relevant studies were manually searched based on the references in the identified studies. We excluded protocols, conference proceedings, comments, case reports, editorials, and studies that were not published in full text. Two reviewers performed the screening and data extraction independently. Data were synthesized narratively.

Results

Study Selection

The literature search identified 23,408 studies. After removal of duplicates, 12,950 articles were screened at the title and abstract stage for eligibility, with 12,848 not meeting the inclusion criteria and subsequently excluded. Of the 102 articles that proceeded to full-text screening, 16 original observational studies[7,8,10,15–27] from seven countries were eligible for this review of nutritional risk, with a sample size of 14,148 adults from the 14 included studies[7,8,10,15–25] and 333 children from the two included studies.[26,27] For the review of perioperative malnutrition, a total of 25 original observational studies[7,8,12,17–19,21,23,26,28–43] from over 75 countries were eligible. The sample size comprised 31,111 adults from 19 included studies[7,8,12,17–19,21,23,28–38] and 28,3756 children from the six included studies.[26,39–43] The selection process is summarized in a PRISMA flow diagram (Figure 1). The main characteristics of the studies are summarized in Table 2 and Table 3.

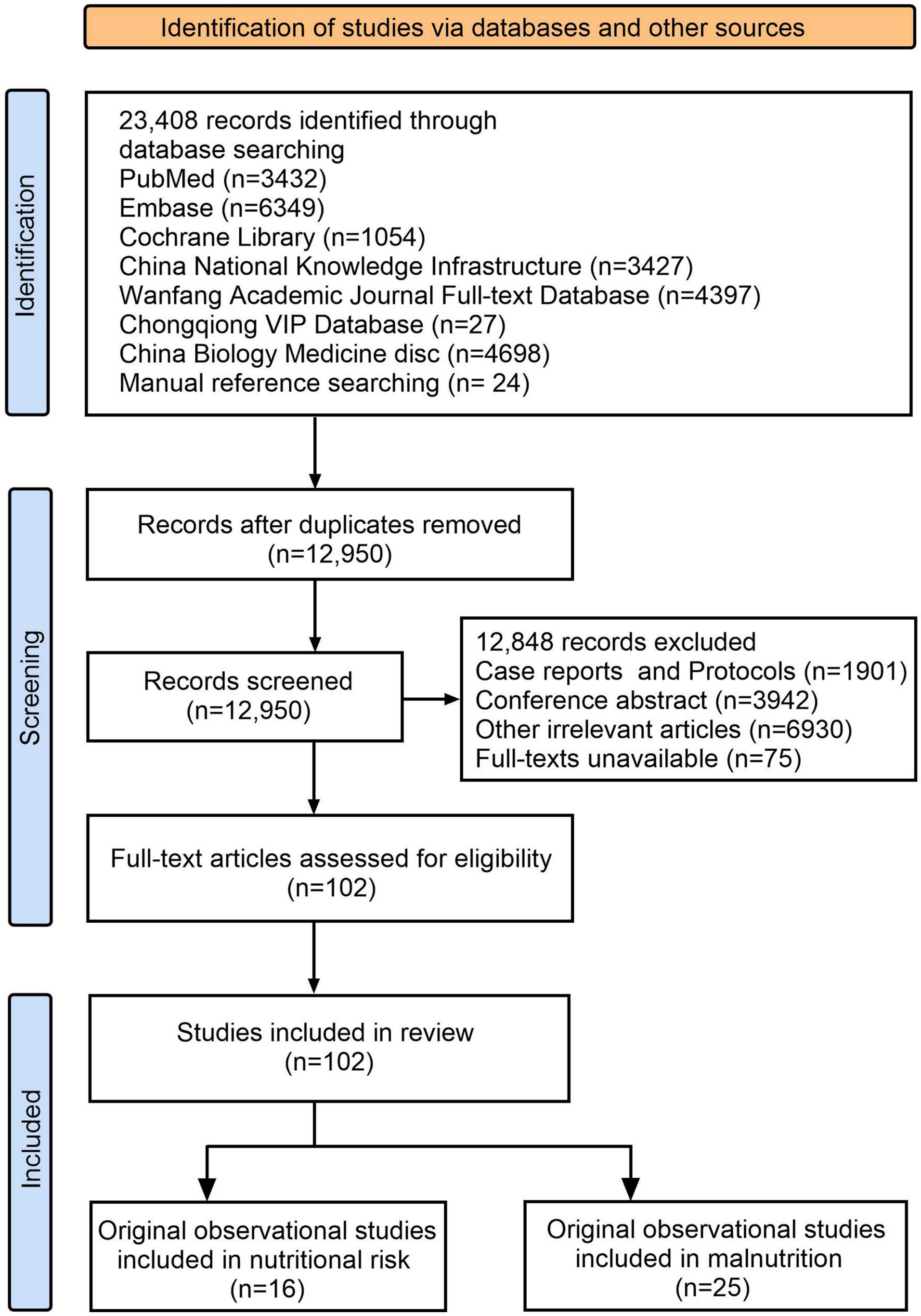

Figure 1 PRISMA Flow diagram of search history and study selection. PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analyses.

Screening Tools and Diagnostic Criteria

Screening Tools for Nutritional Risk

The most used screening tool was the Nutrition Risk Screen-2002 (NRS-2002; Supplementary Table 1), which is currently the only nutritional risk screening tool with a strong evidence-based foundation and the goal of improving clinical outcomes.[4,5,44] Additionally, attention to perioperative nutritional risk in children remained inadequate compared to that in adults (Table 2). The Screening Tool for Risk on Nutritional Status and Growth ($STRONG_{kids}$) was used as a nutritional screening tool for children (Table 2).[26,27] According to the NRS-2002 and $STRONG_{kids}$, even patients with overweight or obesity who are about to undergo or have undergone surgery may face nutritional risks.

Table 2 Characteristics of the Included Studies for Nutritional Risk

Study	Study Design	Country	Sample Size	Screening Tool (incidence, %)	Age[a] (year)	Study Time	Surgery Types	Data Source	Evaluation Time
Adult									
He 2024[16]	Retrospective	China	379	NRS-2002 (42.7)	68 (57, 78)	2019–2022	Elective surgery for hip fracture	Affiliated Hospital of Chengdu University	At admission
Zhou 2023[17]	Prospective	China	540	NRS-2002 (41.1)	55.3 ± 19.6	2020–2021	Gastrointestinal surgery	Shanghai Sixth People's Hospital	NR
Zhou 2023[18]	Prospective	China	332	NRS-2002 (44.3)	59.7 ± 12.5	2020–2022	Hepatopancreatobiliary tumor surgery	Ningbo Medical Center Lihuili Hospital	The first day after admission
			174	NRS-2002 (13.2)			Hepatopancreatobiliary non-tumor surgery		
Wang 2023[19]	Retrospective	China	140	NRS-2002 (70.0)	70.0 ± 7.3	2020–2022	Major hepatopancreatobiliary Surgery	Beijing Hospital	Within 24 h after admission
Zhao 2023[20]	Retrospective	China	136	NRS-2002 (68.4)	62 (38, 81)	2018–2019	Radical gastrectomy	Yantai Affiliated Hospital of Binzhou Medical University	NR
Tan 2022[21]	Prospective	China	1115	NRS-2002 (21.2), PONS (27.1), MNA-SF (71.9), MUST (37.4)	62.6 ± 10.8	2020	Abdominal surgery for digestive cancer	Zhongshan Hospital of Fudan University	At admission
Skeie 2021[7]	Retrospective	Norway	7582	NRS-2002 (21.2)	64 (50, 74)	2008–2018	Exclude terminal, pregnant and bariatric surgery	Haukeland University Hospital	NR
Zhang 2021[22]	Retrospective	China	915	NRS-2002 (53.6)	71.6 ± 5.2	2017–2019	Elective noncardiac surgery	Peking University First Hospital	NR
Yin 2021[23]	Prospective	China	360	NRS-2002 (70.3)	64.1 ± 7.7	2014–2019	Esophagectomy for esophageal cancer	Daping Hospital of Army Medical University	Within 24 h of admission
Thomas 2016[15]	Retrospective	Germany	1244	NRS-2002 (24.1)	57.3 ±15.7	2004–2008	Elective surgery	Klinikum der Universität München	On the day of admission
Geurden 2015[10]	Prospective	Belgium	208	NRS-2002 (51.4)	74.8 ± 6.6	NR	Major elective surgery	One university hospital and two community hospitals	At admission
Leonard 2023[24]	Retrospective	United States	275	MUST (31.3)	65.0 (55.5, 74.0)	2015–2020	Major head and neck surgeries	MedStar Georgetown University Hospital and MedStar Washington Hospital Center	Preoperative clinic visit

(*Continued*)

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Table 2 (Continued).

Study	Study Design	Country	Sample Size	Screening Tool (incidence, %)	Age[a] (year)	Study Time	Surgery Types	Data Source	Evaluation Time
Mays 2019[8]	Prospective	United States	280	MNA-SF (22.5)	72.9 ± 5.9	2018	Elective surgery	University of Alabama at Birmingham Medical Center	NR
Banning 2020[25]	Prospective	Netherlands	468	PG-SGA (24.1)	67.8 ± 9.9	2015–2018	Elective vascular surgery	University Medical Center Groningen	Last outpatient visit before surgery
Children									
Koofy 2021[26]	Prospective	Egypt	75	$STRONG_{kids}$ (50.7)	10 (1–60) months	2017–2018	Elective gastrointestinal surgery	Cairo University Specialized Pediatric Hospital	At admission and at discharge
Zhao 2015[27]	Prospective	China	258	$STRONG_{kids}$ (55.4)	1 month-15 years	2014	General surgery	Children's Hospital of Zhejiang University School of Medicine	At admission

Notes: [a]Age is presented as mean with standard deviation or median (interquartile range) or age range.

Abbreviations: MNA-SF, mini nutritional assessment short-form; MUST, malnutrition universal screening tool; NR, not reported; NRS-2002, nutritional risk screening-2002; PG-SGA, patient-generated subjective global assessment; PONS, perioperative nutrition screen; $STRONG_{kids}$, the screening tool for risk on nutritional status and growth.

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Table 3 Characteristics of the Included Studies for Malnutrition

Study	Study Design	Country	Sample Size	Diagnostic Criteria (Incidence, %)	Age^{a} (Year)	Study Time	Surgery Types	Sample Source	Evaluation Time
Adult									
GlobalSurg and NIHR Global Health Unit on Global Surgery 2023[28]	Prospective	75 countries	5709	GLIM (Severe malnutrition, 33.3)	64·8 ± 13·5	2018–2019	Elective surgery for colorectal or gastric cancer	381 hospitals	NR
Murnane 2023[29]	Retrospective	Australia	108	GLIM (77.2)	66.4 ± 9.9	2007–2018	Radical esophagogastric cancer surgery	School of Allied Health, Human Services and Sport, La Trobe University	NR
Thomas 2023[30]	Retrospective	Australia	224	GLIM (28.6), PG-SGA (17.0)	67·3 ± 14.4	2014–2016	Vascular surgery	Southern Adelaide Local Health Network	Within 72 h of admission
Wang 2023[19]	Prospective	China	140	GLIM (67.1)	70.0 ± 7.3	2020–2022	Major hepatopancreatobiliary Surgery	Beijing Hospital	1 to 2 days after admission
Wu 2023[31]	Prospective	China	396	GLIM (19.9)	56.2 ± 18.3	2020–2021	Emergency abdominal surgery	Shanghai Sixth People's Hospital,	Within 24 h of hospitalization
Zhou 2023[17]	Prospective	China	540	GLIM (11.9)	55.3 ± 19.6	2020–2021	Gastrointestinal surgery	Shanghai Sixth People's Hospital	NR
Zhou 2023[18]	Prospective	China	332	GLIM (36.8), PG-SGA (44.6), PNI (60.2)	59.7 ± 12.5	2020–2022	Hepatobiliary-pancreatic tumor surgery	Ningbo Medical Center Lihuili Hospital	The first day after admission
			174	GLIM (9.8), SGA (10.9), and PNI (32.2)		2020–2022	Hepatobiliary-pancreatic non-tumor surgery	Ningbo Medical Center Lihuili Hospital	The first day after admission
Liu 2022[32]	Retrospective	China	861	GLIM (18.8)	≥ 18	2015–2021	Cardiac surgery	Shanghai Tenth People's Hospital of Tongji University	At admission
Tan 2022[21]	Prospective	China	1115	GLIM (35.9), SGA (33.5)	62.6 ± 10.8	2020	Abdominal surgery for digestive cancer	Zhongshan Hospital of Fudan University	At admission
Wobith 2022[33]	Retrospective	Germany	260	GLIM (68.8)	70.2 ± 10.8	2017–2019	Major abdominal cancer surgery	Klinikum St. Georg gGmbH Leipzig	Within 30 days before surgery and admission

(*Continued*)

Table 3 (Continued).

Study	Study Design	Country	Sample Size	Diagnostic Criteria (Incidence, %)	Age[a] (Year)	Study Time	Surgery Types	Sample Source	Evaluation Time
Yin 2021[23]	Prospective	China	360	GLIM (33.3), ESPEN 2015 (12.2), and PG-SGA (23.1)	64.1 ± 7.7	2014–2019	Esophagectomy for esophageal cancer	Daping Hospital of Army Medical University	Within 24 h of admission
Jin 2024[34]	Retrospective	China	415	BMI or ALB (18.1)	NR	2018–2021	Hepatocellular carcinoma hepatectomy	First Affiliated Hospital of Chongqing Medical University	Within 30 days before operation
Meyer 2021[35]	Retrospective	Germany	599	TP<6.0 g/dL (11.4)	77 ± 5	2018–2019	Elective orthopedic surgery	University Hospital Regensburg	NR
Skeie 2021[7]	Retrospective	Norway	7582	ICD-10 (4.3)	64 (50, 74)	2008–2018	NR	Haukeland University Hospital	At discharge
Abahuje 2020[36]	Prospective	Rwanda	279	ASPEN (35.5), SGA, (27.2)	38 (26, 54)	2017	Emergency surgical	University of Kigali Teaching Hospital	Within 24 h after admission
Mays 2019[8]	Prospective	United States	280	MNA-SF (4.3)	72.9 ± 5.9	2018	Elective surgery	University of Alabama at Birmingham Medical Center	NR
Liu 2024[12]	Retrospective	United States	11411	GNRI (20.7)	≥ 65	2015–2021	Total shoulder arthroplasty	ACS NSQIP database	NR
Unosawa 2019[37]	Retrospective	Japan	287	GNRI (17.8)	68.5 ± 11.4	2016–2018	Elective cardiac surgery	Nihon University Itabashi Hospital	NR
Versteeg 2019[38]	Prospective	Netherlands	39	PG-SGA (92.3)	62.2 ± 10.5	NR	Spinal metastases surgery	University Medical Center Utrecht	NR
Children									
Sekhon 2023[39]	Retrospective	Canada	69	WAZ (11.6), HAZ (15.9), BMIZ (5.8)	3.5 (2.9–4.1) years	1997–2018	Fontan surgery	Stollery Children's Hospital	Within 1 month before surgery, at discharge
Escher 2021[40]	Retrospective	United States	855	WAZ (10.8), HAZ (20.0)	NR	2006–2018	Cleft Lip and Palate Surgery	Children's Minnesota	At surgery
Koofy 2021[26]	Prospective	Egypt	75	SGNA (18.7)	10 (1–60) months	2017–2018	Elective gastrointestinal surgery	Cairo University Specialized Pediatric Hospital	At admission and at discharge

Roberson 2021[41]	Retrospective	United States	282056	Stunting, wasting, requiring nutritional support, and/or hypoalbuminemia (19.4)	Neonate, infant, child, adolescent	2016 −2018	All pediatric surgery	ACS NSQIP-Pediatric database	At admission
Fitria 2019[42]	Prospective	Indonesia	185	WAZ (64.3), HAZ (60.0)	12.6 ± 8.6 months	2013–2014	Congenital heart defects surgery	Harapan Kita National Cardiovascular Center	1 day prior to surgery and at discharge
Ladd 2018[43]	Retrospective	United States	516	BMIZ (32.4)	5–18 years	2012–2015	Patients with Crohn disease underwent bowel surgery	ACS NSQIP-Pediatric database	NR

Notes: [a]Age is presented as mean with standard deviation or median (interquartile range) or age inclusion criteria or age range.
Abbreviations: ALB, albumin; ACS NSQIP, National Surgical Quality Improvement Program of the American College of Surgeons; ASPEN, American Society for Parenteral and Enteral Nutrition; BMI, body mass index; BMIZ, body mass index z-score; ESPEN 2015, 2015 consensus statement by the European Society for Clinical Nutrition and Metabolism; GLIM, Global Leadership Initiative on Malnutrition; GNRI, geriatric nutritional risk index; HAZ, height-for-age; ICD-10, international classification of diseases, tenth revision; MNA-SF, mini nutritional assessment short-form; PG-SGA, patient-generated subjective global assessment; PNI, prognostic nutritional index; SGNA, subjective global nutritional assessment; TP, total protein; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score.

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Other nutritional screening tools for adult perioperative patients included the Mini Nutritional Assessment Short-Form (MNA-SF),[8,21] malnutrition universal screening tool,[21,24] patient-generated subjective global assessment (PG-SGA)[25] and perioperative nutrition screening (PONS)[21] (Table 2).

Malnutrition (Undernutrition)

The most used diagnostic criteria were the GLIM criteria for adults, the "Z-score below −2" for weight-for-age, height-for-age, and weight-for-height based on the World Health Organization criteria (*https://www.who.int/tools/child-growth-standards*. *Accessed September 30, 2024*) for children (Table 3).

In addition, albumin (ALB),[34] BMI,[34] geriatric nutritional risk index,[37] MNA-SF,[8] PG-SGA,[38] prognostic nutritional index (PNI),[18] SGA,[36] and serum total protein (TP)[35] were used to diagnose malnutrition in adult perioperative patients (Table 3).

Incidence

The incidence of nutritional risk/malnutrition varied across nutritional screening tools, diagnostic criteria for malnutrition, patient characteristics, types of disease and surgery, regions and ethnicities, and healthcare systems.[10]

Incidence of Preoperative Nutritional Risk (TABLE 2)

The incidence of nutritional risk, using the NRS-2002, was 21.2%[7] to 24.1%[15] in patients undergoing elective surgery, 53.6%[22] in older adults, and 44.3%[18] to 70.3%[23] in patients with tumors or major elective surgeries. The incidence of nutritional risk in children, according to $STRINGO_{kids}$, ranged from 50.7%[26] to 55.4%.[27]

Incidence of Preoperative Malnutrition (TABLE 3)

When employing the GLIM criteria, the incidence of malnutrition in surgical patients was 33.3%[28] to 77.2%[29] in patients with cancer, 18.8%[32] to 28.6%[30] in patients with cardiovascular disease, 67.1%[19] in patients with major hepatobiliary disease, 11.9%[17] in patients with gastrointestinal disease, and 19.9%[31] in patients undergoing emergency abdominal surgery. The incidence of malnutrition in all pediatric perioperative patients was 19.4%.[41] The prevalence of malnutrition was 32.4%[43] in children aged 5–18 years with Crohn's disease who underwent intestinal surgery, 10.8%[40] to 20.0%[40] in children who underwent cleft lip and palate surgery, 5.8%[39] to 15.9%[39] in children under 18 years who underwent Fontan surgery, and 60.0%[42] to 64.3%[42] in children younger than 36 months who underwent surgery for congenital heart defects, using the weight-for-age Z-score, height-for-age Z-score, or weight-for-height Z-score criteria. These data are even more alarming when considering that 50% of patients experience a further significant decrease in body weight during their hospital stay.[15]

Pathogenesis

Several causes lead to nutritional risk/malnutrition in perioperative patients, including the underlying pathologic processes of disease, inflammation and stress reaction during surgery, and decreased intake due to perioperative fasting and delayed recovery of bowel function.[36] The major pathogenic mechanisms are as follows.[44,45]

Insufficient Intake

Insufficient intake can be due to illness, surgery, pain, fasting, and postoperative nausea and vomiting (PONV).

Increase in Consumption

Inflammatory reactions, oxidative stress, and pain lead to high energy consumption in the body.

Reduction in Bioavailability

Decreased bioavailability of nutrients can be due to diarrhea, PONV, and digestion and absorption disorders.

Metabolic Abnormalities

Metabolic abnormalities are associated with severe diabetes, hyperthyroidism, and liver and kidney failure.

Risk Factors

The identification of perioperative risk factors is essential not only for the prevention and management of nutritional risk/malnutrition but also for improving clinical outcomes in perioperative patients. Perioperative nutritional risk/malnutrition is the result of multiple risk factors and dimensions interacting in the aforementioned pathogenesis. Based on existing research, the major risk factors are as follows (Figure 2):

Advanced and Young Age

Older people have a higher incidence of nutritional risk/malnutrition than adults, owing to their poor baseline conditions, multiple comorbidities, and complex and variable conditions.[45] The British Association for Parental and Enteral Nutrition conducted nutritional screening of 31,637 hospitalized patients in the UK from 2007 to 2011 and found that the nutritional risk was associated with advanced age.[46]

In addition, malnutrition is a highly prevalent condition in hospitalized pediatric patients and has been shown to be associated with increased incidence in pediatric surgery.[41] Children aged 1–60 months were vulnerable to malnutrition.[26] Among the perioperative children, those aged <5 years had the highest nutritional risk, especially those aged <2 years.[40]

Sex

Some reports have shown that among perioperative patients, women are more prone to malnutrition than men, especially those aged over 65 years.[46,47] However, Thomas et al[15] found that the male sex was an independent risk factor for nutritional risk during elective surgery. Other studies have reported no association between sex and nutritional risk/malnutrition.[36,48,49] Therefore, sex-related differences in nutritional risk/malnutrition may depend on the study population.

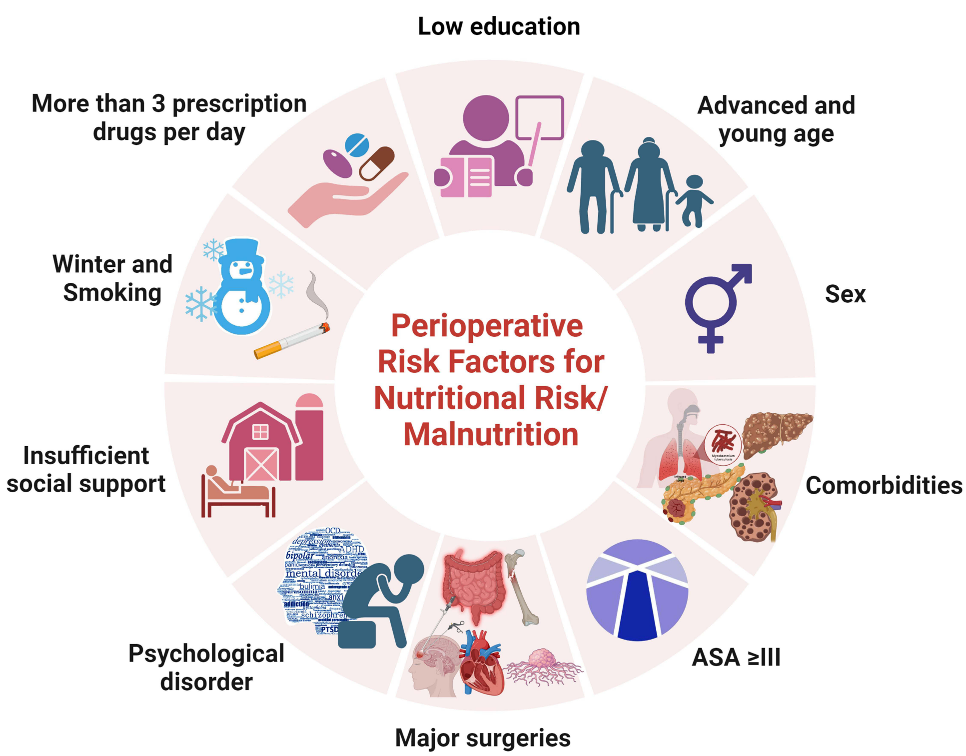

Figure 2 Perioperative risk factors for nutritional risk/malnutrition. Created in BioRender. He, M. (2025) https://BioRender.com/s25t382..
Abbreviations: ASA, American Society of Anesthesiologists Physical Status Classification.

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Comorbidities

Patients with chronic wasting diseases or metabolic abnormalities, such as malignancy,[38,50] atrophic gastritis,[51] chronic renal failure,[52,53] cirrhosis,[54,55] chronic obstructive pulmonary disease,[56] tuberculosis,[57] and systemic lupus erythematosus[58] have a higher incidence of perioperative nutritional risk/malnutrition.

American Society of Anesthesiologist (ASA) Physical Status Classification

The ASA physical status classification is mainly based on the physical condition and perioperative risk, with postoperative complications and mortality increasing with higher ASA grades.[59] Patients with higher ASA grades have a higher incidence of nutritional risk/malnutrition[17,59] We recommend that the ASA level ≥ 3 be the threshold for this risk factor.[59]

Major Surgeries (Not Specified [Classified by Doctor])

Patients undergoing gastrointestinal,[26,60] malignancy,[38,50] heart and great vessels,[37,47,61] spine,[62] hip,[63,64] cranial, bariatric,[65,66] and cleft lip and palate surgeries[40] are at high nutritional risk and susceptible to malnutrition.

Psychological Disorders and Insufficient Social Support

Psychological disorders caused by illness, surgical trauma, and concomitant treatment during hospitalization, such as anxiety, depression, and cognitive impairment, may increase the nutritional risk.[45,49] Patients living in poverty, living alone, and with insufficient social support are at increased nutritional risk.[45]

Other Factors

Winter,[46] smoking,[47] taking more than three prescription drugs per day,[10] and lower educational levels[10] were reported to be associated with increased nutritional risk/malnutrition.

Nutritional Risk/Malnutrition-Related Adverse Perioperative Outcomes

Postoperative complication rates for patients with nutritional and non-nutritional risk undergoing elective surgery were 17% and 7%, respectively.[15] The incidence of postoperative adverse events in patients with malnutrition is 2–4 times higher than that in patients without malnutrition.[35] Nutrition-related perioperative adverse events included infection, wound healing disorders, reoperation and unplanned readmission, prolonged hospital stay, mortality, perioperative neurocognitive dysfunction (PND), and venous thrombosis (Figure 3).

Infection

Malnutrition contributes to significantly worse postoperative surgical-site infections (SSIs),[28,67,68] and preoperative malnutrition occurs in 85% of patients with SSIs.[69] Patients with preoperative serum ALB <3.3 g/L have been reported to have a 3-fold increased SSI risk.[67] Tan et al[21] found that patients with preoperative malnutrition who underwent abdominal surgery for gastrointestinal cancer showed a 2.2-fold increase in postoperative infection-related complications. A high incidence of preoperative malnutrition is associated with pulmonary complications after esophagogastric cancer surgery.[29] In addition, nutritional status is significantly correlated with postoperative infections in children, including pneumonia, urinary tract infections, and central venous catheter-associated bloodstream infections, especially those receiving preoperative nutritional support, experiencing developmental delay, or having hypoalbuminemia.[41,43]

Wound Healing Disorders

It is widely recognized that malnutrition can lead to impaired wound healing.[12,25,35,40] In geriatric patients undergoing elective orthopedic surgery, malnutrition increased the risk of wound healing problems approximately six-fold.[35]

Reoperation and Readmission

The nutritional status of patients significantly correlated with the rate of reoperation.[12,43] Meyer et al[35] reported that malnutrition increased the risk of reoperation by 1.6 times in older adult patients undergoing elective orthopedic surgery. There is also a significant positive correlation between nutritional risk/malnutrition and patient readmission rates within 30 days of discharge.[12,15,21]

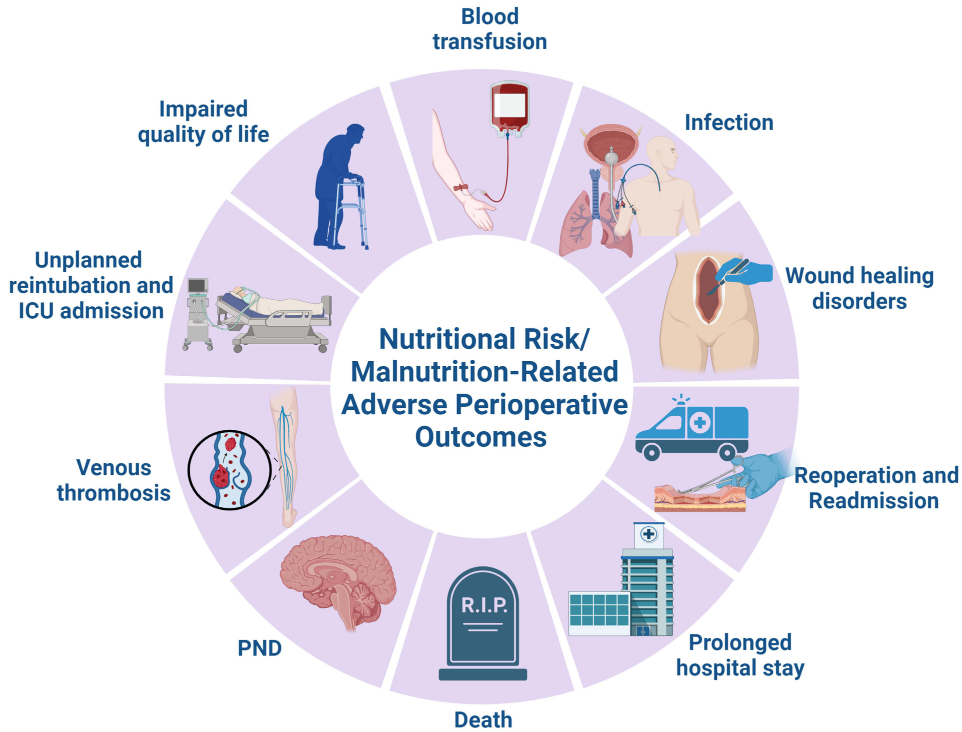

Figure 3 Nutritional risk/malnutrition-related adverse perioperative outcomes. Created in BioRender. He, M. (2025) https://BioRender.com/s25t382..
Abbreviations: ICU, intensive care unit; PND, perioperative neurocognitive dysfunction.

Prolonged Hospital Stay

Patients with nutritional risk/malnutrition have higher rates of perioperative complications, which undoubtedly result in prolonged hospital stays. The lengths of hospital stay for adult patients undergoing elective surgery with and without nutritional risk were 13 and 7 days, respectively.[15] Unosawa et al[37] reported that malnutrition is an independent risk factor for patients undergoing elective cardiac surgery who have been hospitalized for more than 1 month, with a risk 3.4 times higher than that for patients with normal nutrition. Ladd et al[43] reported that among children with Crohn's disease who underwent bowel resection, the length of hospital stay was 12 days for severely malnourished children and 6 days for children with normal nutrition.

Mortality

Nutritional risk/malnutrition leads to increased risk of mortality in perioperative patients.[12,48,63,70] Abahuje et al[36] found that malnutrition on admission was an independent risk factor for perioperative death in 279 patients undergoing emergency surgery at the University of Kigali Teaching Hospital in Rwanda. The mortality rate in patients undergoing emergency surgery with malnutrition was 27.25-times that of patients with normal nutrition.[36] According to Feng et al,[48] preoperative malnutrition can lead to a 2.5-fold increase in long-term postoperative mortality.

Perioperative Neurocognitive Dysfunction

Nutrition is involved in neurodegeneration, and malnutrition is associated with an increased risk of neurodegenerative diseases, especially in women, older individuals, and patients with hypertension.[71] Patients with good nutritional status have better postoperative cognitive function.[64] Preoperative nutritional risk/malnutrition are independent risk factors for PND.[72–74] It has been reported that patients with nutritional risk undergoing coronary artery bypass grafting have a 1.56 to 6.32-fold increased risk of postoperative delirium.[72,73] In addition, preoperative enteral-enriched nutrition improves postoperative cognitive impairment in rats.[75] Therefore, some researchers have suggested that nutritional interventions should be implemented in patients with nutritional risk/malnutrition to reduce the risk of PND.[64]

Venous Thrombosis

Evidence shows that nutritional risk/malnutrition is a high-risk factor for venous thrombosis, especially in patients with tumors[76,77] or fractures[78] or those undergoing major surgery.[79,80] Lijfering et al[81] considered that nutritional interventions may reduce the risk of venous thrombosis but also noted that this is difficult to confirm through prospective clinical trials due to limitations in clinical ethics, follow-up, and survivor bias. The ability of nutritional interventions to prevent cerebral microvascular thrombosis[82] and deep venous thrombosis[83] has been demonstrated in rat models.

Other Adverse Outcomes

Nutritional risk/malnutrition increases the risk of unplanned reintubation,[12] unplanned intensive care unit admission,[35] failure to wean off a ventilator within 48 hours,[12] non-home discharge,[12] perioperative blood transfusion,[12,17,26] postoperative fistula formation,[24,40] and postoperative long-term bedridden state,[37] resulting in decreased short- and long-term quality of life after surgery.[84]

Discussion

Low Rates of Perioperative Nutrition Screening and Medical Nutrition Therapy

Although perioperative nutritional risk/malnutrition-related adverse effects have been widely recognized and reported, the importance of nutrition management in clinical medicine is not well understood by clinical medical teams, and perioperative nutrition screening and medical nutrition therapy rates remain low.[1,15] In some regions of Western Europe and the United States, only 20% to 38% of perioperative patients undergo nutritional risk screening during the perioperative period.[47] In 2016, a survey questionnaire from 325 trauma and orthopedic departments in Germany showed that only 56% of perioperative patients underwent nutritional assessment.[11] Another survey of gastrointestinal surgeons in Europe showed that nutritional risk screening was common prior to surgery (62% in Italy to 96% in Poland) but less frequently performed postoperatively (19% in Poland to 54% in Germany), using varied screening methods.[85] A study from three Belgian hospitals found that none of the patients undergoing elective major surgery received preoperative dietary advice, nutritional counseling, or nutrient supplementation.[10] Malnutrition in older adults is overlooked and underdiagnosed in the United States, affecting up to 60% of hospitalized patients aged 65 years and older, with less than 5% documented in medical records.[8]

Numerous Nutritional Screening Tools and Malnutrition Diagnosis Criteria: No Consensus on the Optimal Assessment Method

Although the GLIM proposed a consensus-based framework to standardize the diagnosis of malnutrition worldwide, it has not been widely disseminated and effectively applied.[21,33,85] The evidence obtained using the GLIM criteria is still insufficient based on the guidelines outlined by Keller et al,[86] and other tools for nutrition assessment are still being developed and used.[36,87] The confusion between nutritional risk and malnutrition is common in clinical practice.[10]

Various Nutritional Risk Screening Tools and Diagnostic Criteria for Malnutrition

Wide variation exists in approaches to screen malnutrition risk or identify malnutrition in surgical patients, using a range of tools and nutrition markers.[88] European countries recommend the NRS-2002 as the preferred tool for nutritional risk assessment of hospitalized patients.[89–91] The PONS is recommended by the American Society for Enhanced Recovery for perioperative nutritional screening.[92] According to a survey questionnaire from Germany,[11] the most commonly used nutritional risk screening tool is BMI (74%), followed by the MNA (30%), laboratory indicators (ALB and TP, 29%), and NRS-2002 (19%).

Anthropometry Has Not Been Widely Used in Clinical Practice

Except for the widespread use of BMI, other anthropometric measures such as abdominal circumference, arm circumference, and triceps skinfold thickness are rarely used in clinical practice. However, severe protein-calorie malnutrition requires evidence of changes in body composition and cannot be extrapolated solely from anthropomorphic measures.[41]

Laboratory Indicators for Nutritional Assessment are Controversial

Due to the simplicity and ease of obtaining laboratory indicators for perioperative patients, ALB,[93] TP,[35] prealbumin,[93] hemoglobin,[94,95] and PNI,[96,97] have been used clinically to aid in the assessment of patient nutritional status. Historically, malnutrition has been identified in perioperative patients using laboratory values such as ALB.[34,93] In emergency general surgery, the most commonly used primary or secondary marker of nutritional status to define malnutrition was BMI, followed by ALB level.[88] Most of these studies defined malnutrition as ALB <3.5 g/dL[34,35] and focused on the impact of hypoproteinemia on perioperative prognosis,[67] such as increased incidence of SSIs, pneumonia, urinary tract infections, and sepsis. However, the assessment of nutritional status using laboratory indicators is limited and controversial because of factors such as stress response, inflammation, infusion, and acute and chronic blood loss during the perioperative period.

Lack of Full Consideration of Perioperative Nutrition Risk/Malnutrition Symptoms

Symptoms such as nausea, taste changes, fatigue, pain, and decreased activity are not fully considered in perioperative nutritional risk screening.

An ideal method should accurately assess the nutritional status of the body and predict nutrition-related complications. High sensitivity, good specificity, and simplicity are the main requirements for the development of nutritional assessment methods for clinical practice. Multiple nutritional screening or assessment methods may be used simultaneously for the comprehensive assessment of nutritional risk/malnutrition.

Low Evidence-Based Clinical Nutrition Research and Lack of in-Depth Mechanistic Studies

Due to clinical ethical issues, multiple clinical confounders, follow-up limitations, and survivor bias, current research in clinical nutrition is mainly focused on observational studies (many of them retrospective) and surveys, making it difficult to verify the impact of nutritional interventions on patient outcomes through randomized controlled trials.[81,98] Considering the basic condition of the patient, the severity of the disease, the comprehensive medical level, and the important role of surgery and anesthesia, it is difficult to explain the role of nutritional intervention in the overall prognosis of the disease. A recent landmark trial[99] used perioperative amino acids infusion to reduce the occurrence of acute kidney injury in cardiac surgery. Explaining the mechanisms by which amino acids influence renal function will provide a deeper understanding of the physiological basis for nutritional interventions.

However, the lagging development of clinical nutrition and the shortage of clinical nutritionists have limited the development of basic clinical nutrition research and in-depth mechanism exploration, making it difficult to elucidate the relationship between nutritional risk/malnutrition and adverse outcomes at the pathophysiological, genetic, or molecular levels.

Inconsistent Timing of Nutritional Assessment

The preoperative period may represent an attractive window for nutritional assessment and the initiation of therapy to optimize the patient's nutritional status and physical function prior to surgery. Numerous studies have shown that preoperative nutritional status is most strongly associated with perioperative adverse outcomes.[100] The first outpatient visit before surgery[15] is the ideal time point for preoperative nutritional screening because it can better predict perioperative risks while avoiding additional medical interventions and the impact of disease progression on nutritional assessment. In this setting, an additional preoperative hospital stay for nutritional support could be ruled out, whereas the positive effects on the postoperative course could be achieved.[15] In addition, the first day after admission,[18,19] as recommended by the ESPEN and Chinese Society for Parenteral and Enteral Nutrition guidelines, is also an ideal time to perform preoperative nutritional screening.

Multidisciplinary Collaboration is Required for Perioperative Nutrition Management

Since clinical nutritionists are not directly involved in the process of diagnosing and treating disease, there is currently a disconnect between the aim of nutritionists and the needs of hospitalized patients. Nutritionists cannot obtain the patient's nutritional diagnosis and treatment needs in a timely manner, and the patients lack subjective initiative in clinical nutrition treatment. Furthermore, surgeons, anesthesiologists, and nurses play a crucial role in diagnosing and

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managing conditions in the perioperative period. Regrettably, the intricacies of malnutrition's evaluation and management are not widely comprehended by these professionals.[101] In addition, pain, PONV, and fasting are important causes of increased nutritional risk and poor adherence to nutritional interventions in perioperative patients. Therefore, perioperative nutrition therapy requires a multidisciplinary team,[8] including anesthesia, nursing, nutrition, and surgeons. Considering the impact of nutrition on the long-term prognosis of patients,[39] long-term nutritional follow-up and the involvement of rehabilitation therapists are also required after discharge. More importantly, given the prevalence of perioperative nutritional risk/malnutrition worldwide, a foundation in understanding nutritional issues is essential for anesthesiologists, surgeons, and nurses. This is a topic that is typically bypassed in medical education programs.

Lack of Reports for Community Hospitals, Small Hospitals, LMICs, or Poor Regions

Current research on perioperative nutrition mostly comes from developed countries or regions, university teaching hospitals, or large tertiary hospitals. However, perioperative nutritional risk/malnutrition may be more severe in community hospitals, small hospitals, LMICs, or poor regions, leading to alarming perioperative adverse outcomes. An international multicenter study from the GlobalSurg Collaborative and NIHR Global Health Unit on Global Surgery showed that the burden of severe malnutrition following elective surgery for colorectal or gastric cancer is disproportionately high in LMICs (62.5%) and upper-middle-income countries (44.4%).[28] It is essential to reduce knowledge gaps regarding malnutrition and perioperative mortality in high-income countries and LMICs.[13]

Under-Recognition of Micronutrient Malnutrition

Current studies have focused primarily on the impact of protein-energy malnutrition on adverse perioperative patient outcomes. However, little is known about the impact of micronutrient malnutrition, such as vitamins and minerals.[35] Epidemiological studies have shown that the incidences of vitamin D, vitamin B12, and folate deficiencies are high, especially in the older adult population. Recent studies have shown that bariatric surgery leads to micronutrient deficiencies.[102] Patients undergoing elective orthopedic surgery with severe vitamin D deficiency (<12 ng/mL) exhibit a higher rate of postoperative falls.[35] Therefore, it is necessary to pay attention to perioperative micronutrient malnutrition.[35]

Conclusion

According to the National Surgical Quality Improvement Program of the American Association of Surgeons, malnutrition is one of the few modifiable preoperative risk factors associated with poor perioperative outcomes. Given the prevalence and underestimation of preoperative nutritional risk/malnutrition and its associated adverse outcomes, perioperative patients should undergo nutritional screening at the first outpatient visit before surgery and/or on admission. Early, timely, and comprehensive nutritional intervention during the perioperative period is expected to improve medical quality and safety, enhanced recovery after surgery, and clinical patient outcomes. Most importantly, a multidisciplinary team is needed to collaborate in the implementation of perioperative nutrition management. Given that the prevention and treatment of patients with malnutrition risk or malnutrition usually require a period much longer than the anticipated length of stay, research on the relationship between perioperative nutrition and disease prognosis and its potential mechanisms, targeted prevention, and the development of nutritional supplements may be new directions for study in this field in the future.

Abbreviations

ALB, Albumin; ASA, American Society of Anesthesiologist; BMI, Body mass index; GLIM, Global Leadership Initiative on Malnutrition; LMICs, Low- and middle-income countries; MNA-SF, MiniNutritional Assessment Short-Form; NRS-2002, Nutrition Risk Screen-2002; PG-SGA, Patient-generated subjective global assessment; PND, Perioperative neurocognitive dysfunction; PNI, Prognostic nutritional index; PONS, Perioperative nutrition screening; SGA, Subjective global assessment; SSIs, Surgical-site infections; $STRINGO_{kids,}$ Screening Tool for Risk on Nutritional Status and Growth; TP, Total protein.

Data Sharing Statement

Data sharing does not apply to this article.

Author Contributions

All authors made a significant contribution to the work reported, either in the conception, study design, execution, acquisition of data, and analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; approved the final version of the manuscript to be published; agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare they have no competing interests in this work.

References

1. Linthicum MT, Thornton Snider J, Vaithianathan R, et al. Economic burden of disease-associated malnutrition in China. *Asia Pac J Public Health*. 2015;27(4):407–417. doi:10.1177/1010539514552702
2. Schuetz P, Seres D, Lobo DN, Gomes F, Kaegi-Braun N, Stanga Z. Management of disease-related malnutrition for patients being treated in hospital. *Lancet*. 2021;398(10314):1927–1938. doi:10.1016/S0140-6736(21)01451-3
3. Garcia-Almeida JM, Garcia-Garcia C, Ballesteros-Pomar MD, et al. Expert consensus on morphofunctional assessment in disease-related malnutrition. grade review and delphi study. *Nutrients*. 2023;15(3):612. doi:10.3390/nu15030612
4. Yue X, Zhang X, Wang Y, et al. Terminology interpretation of nutritional risk screening (NRS 2002-01.017) and malnutrition diagnosis (GLIM-phenotypic criteria 01.028, etiologic criteria 01.029). *Chin J Clin Nutr*. 2021;29(2):123–128.
5. Chinese Society for Parenteral and Enteral Nutrition(CSPEN). Undernutrition-support-outcome- cost/effectiveness (NUSOC). nutritional risk screening and GLIM steps 2 and 3 for the diagnosis of malnutrition and severity of malnutrition (consensus 2020). *Chin J Clin Nutr*. 2020;28 (4):193–200.
6. Cederholm T, Jensen GL, Correia M, et al. GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. *Clin Nutr*. 2019;38(1):1–9. doi:10.1016/j.clnu.2018.08.002
7. Skeie E, Sygnestveit K, Nilsen RM, Harthug S, Koch AM, Tangvik RJ. Prevalence of patients "at risk of malnutrition" and nutritional routines among surgical and non-surgical patients at a large university hospital during the years 2008-2018. *Clin Nutr*. 2021;40(7):4738–4744. doi:10.1016/j.clnu.2021.05.029
8. Mays LC, Drummonds JW, Powers S, Buys DR, Watts PI. Identifying geriatric patients at risk for malnutrition: a quality improvement project. *J Nutr Gerontol Geriatr*. 2019;38(2):115–129. doi:10.1080/21551197.2019.1604464
9. Li X, Shi L, Zhang Y, et al. Investigation and analysis of clinical nutrition departments in 230 second-level and above hospitals in Western China in 2019. *Lab Med Clin*. 2020;17(15):2175–2178.
10. Geurden B, Franck E, Weyler J, Ysebaert D. The risk of malnutrition in community-living elderly on admission to hospital for major surgery. *Acta Chir Belg*. 2015;115(5):341–347. doi:10.1080/00015458.2015.11681126
11. Barthel J, Fischer M, Aigner R, et al. Detection of malnutrition in geriatric trauma patients: a reassessment. *Der Unfallchirurg*. 2019;122 (11):864–869. doi:10.1007/s00113-018-0595-3
12. Liu SH, Cerri-Droz P, Loyst RA, et al. The geriatric nutritional risk index as a strong predictor of adverse outcomes following total shoulder arthroplasty. *JSES International*. 2024;8(1):152–158. doi:10.1016/j.jseint.2023.08.022
13. Fatiregun OA, Bakewell N. Malnutrition after cancer surgery in low-income and middle-income countries. *Lancet Glob Health*. 2023;11(3): e302–e303. doi:10.1016/S2214-109X(23)00022-0
14. Poudineh S, Shayesteh F, Kermanchi J, et al. A multi-centre survey on hospital malnutrition: result of PNSI study. *Nutr J*. 2021;20(1):87. doi:10.1186/s12937-021-00741-1
15. Thomas MN, Kufeldt J, Kisser U, et al. Effects of malnutrition on complication rates, length of hospital stay, and revenue in elective surgical patients in the G-DRG-system. *Nutrition*. 2016;32(2):249–254. doi:10.1016/j.nut.2015.08.021
16. He M, Peng R, Tian J, Liu X, Deng L, Wu Q. Relationship between perioperative nutrition risk and venous thromboembolism in patients with hip fracture. *Tianjin Med J*. 2024;52(1):97–101.
17. Zhou X, Liu R, Wu Y, Jia Z, Jia Z. Prospective observational study on GLIM criteria for malnutrition: an independent risk factor for predicting postoperative morbidity in patients undergoing gastrointestinal surgery. *J Gastrointest Surg*. 2023;27:1950–1953. doi:10.1007/s11605-023-05689-7
18. Zhou L, Fu J, Ding Z, Jin K, Wu R, Ye LX. Comparison of GLIM, SGA, PG-SGA, and PNI in diagnosing malnutrition among hepatobiliary-pancreatic surgery patients. *Front Nutr*. 2023;10:1116243. doi:10.3389/fnut.2023.1116243
19. Wang L, Li P, Hu Y, et al. Relationship between preoperative malnutrition, frailty, sarcopenia, body composition, and anthropometry in elderly patients undergoing major pancreatic and biliary surgery. *Front Nutr*. 2023;10:1135854. doi:10.3389/fnut.2023.1135854

20. Zhao A, Hou C, Li Y, Liu Y. Preoperative low muscle mass and malnutrition affect the clinical prognosis of locally advanced gastric cancer patients undergoing radical surgery. *Front Oncol*. 2023;13:1156359. doi:10.3389/fonc.2023.1156359
21. Tan S, Wang J, Zhou F, et al. Validation of GLIM malnutrition criteria in cancer patients undergoing major abdominal surgery: a large-scale prospective study. *Clin Nutr*. 2022;41(3):599–609. doi:10.1016/j.clnu.2022.01.010
22. Zhang F, He ST, Zhang Y, Mu DL, Wang DX. Malnutrition is not related with emergence delirium in older patients after noncardiac surgery. *Bmc Geriatr*. 2021;21(1):319. doi:10.1186/s12877-021-02270-2
23. Yin L, Cheng N, Chen P, et al. Association of malnutrition, as defined by the PG-SGA, ESPEN 2015, and GLIM criteria, with complications in esophageal cancer patients after esophagectomy. *Front Nutr*. 2021;8:632546. doi:10.3389/fnut.2021.632546
24. Leonard JA, Hayden JA, Tripuraneni PS, Maxwell JH, Giurintano JP. Malnutrition universal screening tool predicts postoperative complications following major head and neck cancer surgery. *Head Neck*. 2023;45(3):604–611. doi:10.1002/hed.27273
25. Banning LBD, Ter Beek L, El Moumni M, et al. Vascular surgery patients at risk for malnutrition are at an increased risk of developing postoperative complications. *Ann Vasc Surg*. 2020;64:213–220. doi:10.1016/j.avsg.2019.10.037
26. Koofy NE, Eldin HMN, Mohamed W, Gad M, Tarek S, Tagy GE. Impact of preoperative nutritional status on surgical outcomes in patients with pediatric gastrointestinal surgery. *Clin Exp Pediatr*. 2021;64(9):473–479. doi:10.3345/cep.2020.00458
27. Zhao X. *Clinical Application and Evaluation of the STRONGkids Nutritional Risk Screening in Children Hospitalized in the Department of General Surgery dissertation*. China: Zhejiang University; 2015.
28. GlobalSurg C, Surgery NGHUo G, Ghosh D. Impact of malnutrition on early outcomes after cancer surgery: an international, multicentre, prospective cohort study. *Lancet Glob Health*. 2023;11(3):e341–e349. doi:10.1016/S2214-109X(22)00550-2
29. Murnane LC, Forsyth AK, Koukounaras J, et al. Malnutrition defined by GLIM criteria identifies a higher incidence of malnutrition and is associated with pulmonary complications after oesophagogastric cancer surgery, compared to ICD-10-defined malnutrition. *J Surg Oncol*. 2023;128(5):769–780. doi:10.1002/jso.27366
30. Thomas J, Delaney C, Miller M. The ability of the Global Leadership Initiative on Malnutrition (GLIM) to diagnose protein-energy malnutrition in patients requiring vascular surgery: a validation study. *Br J Nutr*. 2022;129:1–16. doi:10.1017/S0007114522001660
31. Wu Y, Liu RT, Zhou XY, Fang Q, Huang D, Jia ZY. The global leadership initiative on malnutrition criteria for diagnosis of malnutrition and outcomes prediction in emergency abdominal surgery. *Nutrition*. 2023;119:112298. doi:10.1016/j.nut.2023.112298
32. Liu Z, Shen Z, Zang W, et al. Development and validation of global leadership initiative on malnutrition for prognostic prediction in patients who underwent cardiac surgery. *Nutrients*. 2022;14(12):2409.
33. Wobith M, Herbst C, Lurz M, Haberzettl D, Fischer M, Weimann A. Evaluation of malnutrition in patients undergoing major abdominal surgery using GLIM criteria and comparing CT and BIA for muscle mass measurement. *Clin Nutr Espen*. 2022;50:148–154. doi:10.1016/j.clnesp.2022.06.004
34. Jin W, Jiang S, Chen A, Chen Y. Effect of preoperative malnutrition based on albumin and BMI on hepatocellular carcinoma surgery and prediction of risk factors of complications. *J Gastrointest Cancer*. 2024;55:511–518. doi:10.1007/s12029-023-01008-0
35. Meyer M, Leiss F, Greimel F, et al. Impact of malnutrition and vitamin deficiency in geriatric patients undergoing orthopedic surgery. *Acta Orthop*. 2021;92(3):358–363. doi:10.1080/17453674.2021.1882092
36. Abahuje E, Niyongombwa I, Karenzi D, et al. Malnutrition in acute care surgery patients in Rwanda. *World J Surg*. 2020;44(5):1361–1367. doi:10.1007/s00268-019-05355-7
37. Unosawa S, Taoka M, Osaka S, et al. Is malnutrition associated with postoperative complications after cardiac surgery? *J Cardiac Surg*. 2019;34(10):908–912. doi:10.1111/jocs.14155
38. Versteeg AL, van Tol FR, Lehr AM, Oner FC, Verlaan JJ. Malnutrition in patients who underwent surgery for spinal metastases. *Ann Transl Med*. 2019;7(10):213. doi:10.21037/atm.2019.04.53
39. Sekhon R, Foshaug RR, Kantor PF, et al. Incidence and impact of malnutrition in patients With Fontan physiology. *JPEN J Parenter Enteral Nutr*. 2023;47(1):59–66. doi:10.1002/jpen.2437
40. Escher PJ, Zavala H, Lee D, Roby BB, Chinnadurai S. Malnutrition as a risk factor in cleft lip and palate surgery. *Laryngoscope*. 2021;131(6):E2060–E2065. doi:10.1002/lary.29209
41. Roberson ML, Egberg MD, Strassle PD, Phillips MR. Measuring malnutrition and its impact on pediatric surgery outcomes: a NSQIP-P analysis. *J Pediatr Surg*. 2021;56(3):439–445. doi:10.1016/j.jpedsurg.2020.10.001
42. Fitria L, Caesa P, Joe J, Marwali EM. Did malnutrition affect post-operative somatic growth in pediatric patients undergoing surgical procedures for congenital heart disease? *Pediatr Cardiol*. 2019;40(2):431–436. doi:10.1007/s00246-018-2022-5
43. Ladd MR, Garcia AV, Leeds IL, et al. Malnutrition increases the risk of 30-day complications after surgery in pediatric patients with Crohn disease. *J Pediatr Surg*. 2018;53(11):2336–2345. doi:10.1016/j.jpedsurg.2018.04.026
44. Hersberger L, Bargetzi L, Bargetzi A, et al. Nutritional risk screening (NRS 2002) is a strong and modifiable predictor risk score for short-term and long-term clinical outcomes: secondary analysis of a prospective randomised trial. *Clin Nutr*. 2020;39(9):2720–2729. doi:10.1016/j.clnu.2019.11.041
45. Mao Y, Wu J, Liu G, et al. Chinese geriatrics society. Chinese expert consensus on prevention and intervention for the elderly with malnutrition (2022). *Chin J Geriatr*. 2022;41(7):749–759.
46. BAPEN. Nutrition screening surveys in hospitals in wales. 2017. Available from: https://www.bapen.org.uk/pdfs/nsw/bapen-nsw-wales.pdf. Accessed 31, December 2024.
47. Beek LT, Banning LBD, Visser L, et al. Risk for malnutrition in patients prior to vascular surgery. *Am J Surg*. 2018;216(3):534–539. doi:10.1016/j.amjsurg.2017.11.038
48. Feng L, Chen W, Ping P, et al. Preoperative malnutrition as an independent risk factor for the postoperative mortality in elderly Chinese individuals undergoing hip surgery: a single-center observational study. *Ther Adv Chronic Dis*. 2022;13:20406223221102739. doi:10.1177/20406223221102739
49. Ringaitiene D, Gineityte D, Vicka V, et al. Preoperative risk factors of malnutrition for cardiac surgery patients. *Acta Med Litu*. 2016;23(2):99–109. doi:10.6001/actamedica.v23i2.3326
50. Kubota T, Shoda K, Konishi H, Okamoto K, Otsuji E. Nutrition update in gastric cancer surgery. *Ann Gastroenterol Surg*. 2020;4(4):360–368. doi:10.1002/ags3.12351

51. Zilli A, Cavalcoli F, Conte D, Ciafardini C, Massironi S. OC.09.3: nutritional deficiencies in patients with chronic atrophic autoimmune gastritis. *Digest Liver Dis*. 2017;49:e99–e100. doi:10.1016/S1590-8658(17)30348-1
52. Bousquet-Santos K, Costa L, Andrade JML. Nutritional status of individuals with chronic renal failure in hemodialysis in the Unified Health System. *Cien Saude Colet*. 2019;24(3):1189–1199. doi:10.1590/1413-81232018243.11192017
53. D'Alessandro C, Benedetti A, Di Paolo A, Giannese D, Cupisti A. Interactions between food and drugs, and nutritional status in renal patients: a narrative review. *Nutrients*. 2022;14(1):212. doi:10.3390/nu14010212
54. Haj Ali S, Abu Sneineh A, Hasweh R. Nutritional assessment in patients with liver cirrhosis. *World J Hepatol*. 2022;14(9):1694–1703. doi:10.4254/wjh.v14.i9.1694
55. Kawaguchi T, Kato A. Recent progress of nutritional management for liver cirrhosis. *J Nutr Sci Vitaminol*. 2022;68:S73–S75. doi:10.3177/jnsv.68.S73
56. Rolo Silvestre C, Dias Domingues T, Mateus L, et al. The nutritional status of chronic obstructive pulmonary disease exacerbators. *Can Respir J*. 2022;2022:3101486. doi:10.1155/2022/3101486
57. Chhabra S, Kashyap A, Bhagat M, Mahajan R, Sethi S. Anemia and Nutritional Status in Tuberculosis Patients. *Int J Appl Basic Med Res*. 2021;11(4):226–230. doi:10.4103/ijabmr.ijabmr_76_21
58. Correa-Rodriguez M, Pocovi-Gerardino G, Callejas-Rubio JL, et al. The prognostic nutritional index and nutritional risk index are associated with disease activity in patients with systemic lupus erythematosus. *Nutrients*. 2019;11(3):638. doi:10.3390/nu11030638
59. Ryan SP, Politzer C, Green C, Wellman S, Bolognesi M, Seyler T. Albumin versus American Society of Anesthesiologists Score: which is more predictive of complications following total joint arthroplasty? *Orthopedics*. 2018;41(6):354–362. doi:10.3928/01477447-20181010-05
60. Seo JM, Joshi R, Chaudhary A, et al. A multinational observational study of clinical nutrition practice in patients undergoing major gastrointestinal surgery: the nutrition insights day. *Clin Nutr Espen*. 2021;41:254–260. doi:10.1016/j.clnesp.2020.11.029
61. Toth K, Szabo A, Menyhard J, et al. Poor preoperative nutritional status, but not hormone levels, are associated with mortality after cardiac surgery. *J Cardiothorac Vasc Anesth*. 2022;36(8):3074–3083. doi:10.1053/j.jvca.2022.04.035
62. Qureshi R, Rasool M, Puvanesarajah V, Hassanzadeh H. Perioperative nutritional optimization in spine surgery. *Clin Spine Surg*. 2018;31(3):103–107. doi:10.1097/BSD.0000000000000579
63. Bell JJ, Pulle RC, Crouch AM, Kuys SS, Ferrier RL, Whitehouse SL. Impact of malnutrition on 12-month mortality following acute hip fracture. *ANZ J Surg*. 2016;86(3):157–161. doi:10.1111/ans.13429
64. Wang HP, Liang J, Kuo LM, Chen CY, Shyu Y-IL. Trajectories of nutritional status and cognitive impairment among older Taiwanese with hip fracture. *J Nutr health aging*. 2017;21(1):38–45. doi:10.1007/s12603-016-0756-4
65. Steenackers N, Van der Schueren B, Augustijns P, Vanuytsel T, Matthys C. Development and complications of nutritional deficiencies after bariatric surgery. *Nutr Res Rev*. 2022;35:1–36. doi:10.1017/S0954422421000020
66. O'Kane M. Nutritional consequences of bariatric surgery - prevention, detection and management. *Curr Opin Gastroenterol*. 2021;37(2):135–144. doi:10.1097/MOG.0000000000000707
67. Son HJ, Roh JL, Choi SH, Nam SY, Kim SY. Nutritional and hematologic markers as predictors of risk of surgical site infection in patients with head and neck cancer undergoing major oncologic surgery. *Head Neck*. 2018;40(3):596–604. doi:10.1002/hed.25031
68. Xie J, Du Y, Tan Z, Tang H. Association between malnutrition and surgical site wound infection among spinal surgery patients: a meta-analysis. *Int Wound J*. 2023;20(10):4061–4068. doi:10.1111/iwj.14297
69. Ushirozako H, Hasegawa T, Yamato Y, et al. Does preoperative prognostic nutrition index predict surgical site infection after spine surgery? *Eur Spine J*. 2021;30(6):1765–1773. doi:10.1007/s00586-020-06622-1
70. Toth K, Szabo A, Nagy A, et al. Preoperative nutritional state is associated with mid- and long-term mortality after cardiac surgery. *Ann Palliat Med*. 2021;10(11):11333–11347. doi:10.21037/apm-21-1015
71. Bianchi VE, Herrera PF, Laura R. Effect of nutrition on neurodegenerative diseases. A systematic review. *Nutr Neurosci*. 2021;24(10):810–834. doi:10.1080/1028415X.2019.1681088
72. Ringaitiene D, Gineityte D, Vicka V, et al. Impact of malnutrition on postoperative delirium development after on pump coronary artery bypass grafting. *J Cardiothorac Surg*. 2015;10:74.
73. Velayati A, Vahdat Shariatpanahi M, Shahbazi E, Vahdat Shariatpanahi Z. Association between preoperative nutritional status and postoperative delirium in individuals with coronary artery bypass graft surgery: a prospective cohort study. *Nutrition*. 2019;66:227–232. doi:10.1016/j.nut.2019.06.006
74. Yang Y, Zhao X, Gao L, Wang Y, Wang J. Incidence and associated factors of delirium after orthopedic surgery in elderly patients: a systematic review and meta-analysis. *Aging Clin Exp Res*. 2021;33(6):1493–1506. doi:10.1007/s40520-020-01674-1
75. Hovens IB, van Leeuwen BL, Falcao-Salles J, de Haan JJ, Schoemaker RG. Enteral enriched nutrition to prevent cognitive dysfunction after surgery; a study in rats. *Brain Behav Immun Health*. 2021;16:100305. doi:10.1016/j.bbih.2021.100305
76. Takayoshi K, Kusaba H, Aikawa T, et al. Hypoalbuminemia for the prediction of venous thromboembolism and treatment of direct oral anticoagulants in metastatic gastric cancer patients. *Gastric Cancer*. 2019;22(5):988–998. doi:10.1007/s10120-019-00930-2
77. Sari M, Ilhan Y, Sezgin Goksu S, Kostek O, Tatli AM, Coskun HS. The relationship between nutritional parameters and thrombosis risk in cancer patients. *Nutr Cancer*. 2022;74(4):1370–1375. doi:10.1080/01635581.2021.1952631
78. He M, Fan Q, Zhu Y, et al. The need for nutritional assessment and interventions based on the prognostic nutritional index for patients with femoral fractures: a retrospective study. *Perioper Med*. 2021;10(1):61. doi:10.1186/s13741-021-00232-1
79. Xin X, Huang H, Lu W, et al. Albumin concentration is a candidate indicator for predicting the risk of calf venous thromboembolism in patients undergoing gynecologic surgery. *Int J Gynecol Obstet*. 2022;156(1):139–144. doi:10.1002/ijgo.13675
80. Iguchi T, Sugimachi K, Mano Y, et al. The preoperative prognostic nutritional index predicts the development of deep venous thrombosis after pancreatic surgery. *Anticancer Res*. 2020;40(4):2297–2301.
81. Lijfering WM, Cannegieter SC. Nutrition and venous thrombosis: an exercise in thinking about survivor bias. *Res Pract Thromb Haemost*. 2019;3(1):6–8. doi:10.1002/rth2.12174
82. Noguchi T, Ikeda K, Sasaki Y, Yamori Y. Nutritional prevention on hypertension, cerebral hemodynamics and thrombosis in stroke-prone spontaneously hypertensive rats. *Cell Mol Neurobiol*. 2004;24(5):599–638. doi:10.1023/B:CEMN.0000036401.41492.24

83. Tokajuk A, Zakrzeska A, Chabielska E, Car H. Whey protein concentrate limits venous thrombosis in rats. *Appl Physiol Nutr Metab*. 2019;44 (8):907–910. doi:10.1139/apnm-2018-0788
84. Kim E, Lee DH, Jang JY. Effects of preoperative malnutrition on postoperative surgical outcomes and quality of life of elderly patients with periampullary neoplasms: a single-center prospective cohort study. *Gut Liver*. 2019;13(6):690–697. doi:10.5009/gnl18469
85. Duran-Poveda M, Bonavina L, Reith B, Caruso R, Klek S, Senkal M. Nutrition practices with a focus on parenteral nutrition in the context of enhanced recovery programs: an exploratory survey of gastrointestinal surgeons. *Clin Nutr Espen*. 2022;50:138–147. doi:10.1016/j.clnesp.2022.06.007
86. de van der Schueren MAE, Keller H, Consortium G, et al. Global Leadership Initiative on Malnutrition (GLIM): guidance on validation of the operational criteria for the diagnosis of protein-energy malnutrition in adults. *Clin Nutr*. 2020;39(9):2872–2880. doi:10.1016/j.clnu.2019.12.022
87. Langley-Evans SC. Nutrition screening tools: still no consensus 40 years on. *J Hum Nutr Diet*. 2021;34(6):923–925. doi:10.1111/jhn.12952
88. Ashmore DL, Rashid A, Wilson TR, Halliday V, Lee MJ. Identifying malnutrition in emergency general surgery: systematic review. *BJS Open*. 2023;7(5). doi:10.1093/bjsopen/zrad086
89. Dahl H, Warz SI, Welland NL, Arnesen I, Marti HP, Dierkes J. Factors associated with nutritional risk in patients receiving haemodialysis assessed by Nutritional Risk Screening 2002 (NRS2002). *J Ren Care*. 2022;48(2):112–118. doi:10.1111/jorc.12374
90. Oh SE, Park JS, Jeung HC. Pre-treatment nutritional risk assessment by NRS-2002 predicts prognosis in patients with advanced biliary tract cancer: a single center retrospective study. *Clin Nutr Res*. 2022;11(3):183–193. doi:10.7762/cnr.2022.11.3.183
91. Enhanced Chinese Society for Parenteral and Enteral Nutrition. Committee of China Medicine Education Recovery After Surgery Association. Chinese expert consensus on perioperative nutritional support in enhanced recovery after surgery (2019 edition). *Chin J Dig Surg*. 2019;18 (10):897–902.
92. Wischmeyer PE, Carli F, Evans DC, et al. American society for enhanced recovery and perioperative quality initiative joint consensus statement on nutrition screening and therapy within a surgical enhanced recovery pathway. *Anesth Analg*. 2018;126(6):1883–1895. doi:10.1213/ANE.0000000000002743
93. Sugumar D, Arockiaraj J, Amritanand R, David KS, Krishnan V. Role of biochemical nutritional parameters as predictors of postoperative morbidity in major spine surgeries. *Asian Spine J*. 2021;15(4):504–511. doi:10.31616/asj.2020.0180
94. Moorthy D, Merrill R, Namaste S, Iannotti L. The impact of nutrition-specific and nutrition-sensitive interventions on hemoglobin concentrations and anemia: a meta-review of systematic reviews. *Adv Nutr*. 2020;11(6):1631–1645. doi:10.1093/advances/nmaa070
95. Elhag W, El Ansari W. Multiple nutritional deficiencies among adolescents undergoing bariatric surgery: who is at risk? *Surg Obes Relat Dis*. 2022;18(3):413–424. doi:10.1016/j.soard.2021.10.024
96. Dursun A, Ertekin SC, Tuncer GK, Karaali C, Sert I. Prognostic nutritional index in short-term postoperative outcomes in hepaticojejunostomy. *J Coll Physicians Surg Pak*. 2022;32(7):864–868.
97. Barutcu Atas D, Tugcu M, Asicioglu E, et al. Prognostic nutritional index is a predictor of mortality in elderly patients with chronic kidney disease. *Int Urol Nephrol*. 2022;54(5):1155–1162. doi:10.1007/s11255-021-03002-6
98. Schroer WC, LeMarr AR, Mills K, Childress AL, Morton DJ, Reedy ME. 2019 chitranjan S. ranawat award: elective joint arthroplasty outcomes improve in malnourished patients with nutritional intervention: a prospective population analysis demonstrates a modifiable risk factor. *Bone Joint J*. 2019;101:17–21. doi:10.1302/0301-620X.101B7.BJJ-2018-1510.R1
99. Landoni G, Monaco F, Ti LK, et al. A randomized trial of intravenous amino acids for kidney protection. *N Engl J Med*. 2024;391(8):687–698. doi:10.1056/NEJMoa2403769
100. Hill A, Arora RC, Engelman DT, Stoppe C. Preoperative treatment of malnutrition and sarcopenia in cardiac surgery: new frontiers. *Crit Care Clin*. 2020;36(4):593–616. doi:10.1016/j.ccc.2020.06.002
101. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ. Evaluation of malnutrition in orthopaedic surgery. *J Am Acad Orthop Surg*. 2014;22 (3):193–199. doi:10.5435/JAAOS-22-03-193
102. Lange J, Konigsrainer A. Malnutrition as a complication of bariatric surgery - a clear and present danger? *Visc Med*. 2019;35(5):305–311. doi:10.1159/000503040