Comparative Effectiveness Review
Number 249

Malnutrition in Hospitalized Adults: A Systematic Review

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None of the investigators have any affiliations or financial involvement that conflicts with the material presented in this report.

The information in this report is intended to help healthcare decision makers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of healthcare services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of healthcare in the United States.

In fiscal year 2020, Congress requested that AHRQ convene a panel of experts charged with developing quality measures for malnutrition-related hospital readmissions. These measures would be intended to support assigning accountability for the assessment and treatment of malnutrition in hospitalized adults, with an emphasis on the needs of older frail adults. This systematic review is intended to support the efforts of the panel.

The reports and assessments provide organizations with comprehensive, evidence-based information on common medical conditions and new healthcare technologies and strategies. They also identify research gaps in the selected scientific area, identify methodologic and scientific weaknesses, suggest research needs, and move the field forward through an unbiased, evidence-based assessment of the available literature. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for healthcare quality improvement projects throughout the Nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that the EPC evidence reports and technology assessments, when appropriate, will inform individual health plans, providers, and purchasers as well as the healthcare system as a whole by providing important information to help improve healthcare quality.

If you have comments on this evidence report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

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Before publication of the final evidence report, the EPCs sought input from independent peer reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

Peer reviewers must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential nonfinancial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

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Malnutrition in Hospitalized Adults: A Systematic Review

Structured Abstract

Objectives. To review the association between malnutrition and clinical outcomes among hospitalized patients, evaluate effectiveness of measurement tools for malnutrition on clinical outcomes, and assess effectiveness of hospital-initiated interventions for patients diagnosed with malnutrition.

Data sources. We searched electronic databases (Embase®, MEDLINE®, PubMed®, and the Cochrane Library) from January 1, 2000, to June 3, 2021. We hand-searched reference lists of relevant studies and searched for unpublished studies in ClinicalTrials.gov.

Review methods. Using predefined criteria and dual review, we selected (1) existing systematic reviews (SRs) to assess the association between malnutrition and clinical outcomes, (2) randomized and non-randomized studies to evaluate the effectiveness of malnutrition tools on clinical outcomes, and (3) randomized controlled trials (RCTs) to assess effectiveness of hospital-initiated treatments for malnutrition. Clinical outcomes of interest included mortality, length of stay, 30-day readmission, quality of life, functional status, activities of daily living, hospital acquired conditions, wound healing, and discharge disposition. When appropriate, we conducted meta-analysis to quantitatively summarize study findings; otherwise, data were narratively synthesized. When available, we used pooled estimates from existing SRs to determine the association between malnutrition and clinical outcomes, and assessed the strength of evidence.

Results. Six existing SRs (including 43 unique studies) provided evidence on the association between malnutrition and clinical outcomes. Low to moderate strength of evidence (SOE) showed an association between malnutrition and increased hospital mortality and prolonged hospital length of stay. This association was observed across patients hospitalized for an acute medical event requiring intensive care unit care, heart failure, and cirrhosis. Literature searches found no studies that met inclusion criteria and assessed effectiveness of measurement tools. The primary reason studies did not meet inclusion criteria is because they lacked an appropriate control group. Moderate SOE from 11 RCTs found that hospital-initiated malnutrition interventions likely reduce mortality compared with usual care among hospitalized patients diagnosed with malnutrition. Low SOE indicated that hospital-initiated malnutrition interventions may also improve quality of life compared to usual care.

Conclusions. Evidence shows an association between malnutrition and increased mortality and prolonged length of hospital stay among hospitalized patients identified as malnourished. However, the strength of this association varied depending on patient population and tool used to identify malnutrition. Evidence indicates malnutrition-focused hospital-initiated interventions likely reduce mortality and may improve quality of life compared to usual care among patients diagnosed with malnutrition. Research is needed to assess the clinical utility of measurement tools for malnutrition.

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Evidence Summary

Main Points

Association Between Malnutrition and Clinical Outcomes

- Patients requiring intensive care unit (ICU) care and diagnosed with malnutrition (using Subjective Global Assessment [SGA]) may have higher hospital mortality compared to well-nourished patients requiring ICU care.
- Patients requiring ICU care and diagnosed with malnutrition (using SGA) are likely to experience prolonged hospital length of stay compared to well-nourished patients requiring ICU care.
- Patients requiring ICU care and diagnosed with malnutrition (using Mini Nutritional Assessment [MNA]) may experience more hospital acquired complications compared to well-nourished patients requiring ICU care.
- Patients hospitalized due to traumatic injury and screened at risk of malnutrition (using Nutritional Risk Screening [NRS]-2002) may experience more hospital acquired conditions compared to well-nourished patients.
- Patients hospitalized with heart failure and diagnosed with malnutrition (using several different measurement tools) may have higher mortality compared to well-nourished patients with heart failure.
- Patients hospitalized with cancer and diagnosed with malnutrition (using SGA) may experience prolonged hospital length of stay compared to well-nourished patients.
- Patients hospitalized with cirrhosis awaiting transplantation and diagnosed with malnutrition (using SGA) may have higher pre-transplant mortality compared to well-nourished patients.

Effectiveness of Screening on Clinical Outcomes

- No studies met inclusion criteria to address effectiveness of screening or diagnostic assessment on clinical outcomes, primarily because studies lacked an appropriate control group.
- This evidence gap underscores the need for future research that addresses the effectiveness of various measurement tools for malnutrition on clinical outcomes. Such research is vital to standardize malnutrition assessment and further understand its downstream implications on patient-relevant outcomes.

Effectiveness of Hospital-Initiated Interventions for Malnutrition

- Hospital-initiated malnutrition interventions (i.e., specialized nutrition care, protein/calorie supplementation) likely decrease mortality compared to usual care.
- Hospital-initiated malnutrition interventions may improve quality of life compared to usual care.

- No difference was observed between hospital-initiated malnutrition interventions and usual care for length of stay, readmission rates, and hospital acquired conditions compared to usual care.
- Evidence was insufficient to address the effect of hospital-initiated malnutrition interventions on activities of daily living and discharge disposition compared to usual care.

Background and Purpose

In fiscal year 2020, Congress requested that the Agency for Healthcare Research and Quality (AHRQ) convene a panel of experts charged with developing quality measures for malnutrition-related hospital readmissions. At AHRQ's request, we conducted a systematic review to inform the potential development of these measures. Our Key Questions addressed the following: (1) reviewing the association between malnutrition and clinical outcomes, (2) evaluating the effectiveness of measurement tools of malnutrition on clinical outcomes, and (3) assessing the effectiveness of hospital-initiated interventions to treat patients diagnosed with malnutrition. Understanding downstream consequences of malnutrition screening is extremely important as US hospitals are mandated to provide nutrition screening for all hospitalized patients within 24 hours of admission.

Methods

Electronic databases (MEDLINE®, Embase®, and Cochrane Library) were searched from January 1, 2000, to June 3, 2021. We hand-searched the reference lists of relevant studies and searched for unpublished studies in ClinicalTrials.gov.

Using predefined criteria, we selected (1) existing systematic reviews (SRs) assessing the association between malnutrition and clinical outcomes, (2) randomized and non-randomized studies evaluating the effectiveness of screening or diagnostic assessment on clinical outcomes, and (3) randomized controlled trials (RCTs) assessing hospital-initiated treatments for malnutrition. We only included studies of hospitalized patients aged 18 years or older.

Malnutrition was defined based on commonly available diagnostic assessment tools, such as SGA, or MNA. Interventions of interest included measurement tools and treatments initiated within the hospital and intended to impact nutritional status. Clinical outcomes of interest included mortality, length of stay, 30-day readmission, quality of life, functional status, activities of daily living, hospital acquired condition, wound healing, and discharge disposition.

Data syntheses were performed using methods consistent with those outlined in the AHRQ Methods Guide (Methods Guide for Effectiveness and Comparative Effectiveness Reviews | Effective Health Care Program [(ahrq.gov)].

Results

A total of 17 studies (6 SRs and 11 RCTs) met eligibility criteria for inclusion. Existing SRs found that patients screened or diagnosed with malnutrition (using various measurement tools) may be at increased risk of hospital mortality compared to well-nourished patients (Strength of evidence [SOE]: Low). This association was observed among patients hospitalized for acute medical conditions, heart failure, and cirrhosis. Malnutrition (diagnosed using SGA) was also independently associated with prolonged hospital length of stay among patients hospitalized with acute medical conditions (SOE: Moderate) or cancer (SOE: Low). Finally, malnutrition

(diagnosed using MNA or screened using NRS-2002) was found to be associated with increased hospital acquired conditions among patients hospitalized due to traumatic injury or acute medical conditions compared to well-nourished patients (SOE: Low).

To assess clinical utility of measurement tools we sought to identify prospectively controlled studies in which some patients were screened or assessed for malnutrition while other patients were either (1) not screened or assessed or (2) assessed with a reference standard (i.e., imaging or SGA). However, we identified no studies meeting these criteria.

We identified 11 RCTs indicating that some interventions improve clinical outcomes among malnourished patients (screened at risk or diagnosed with malnutrition using commonly available measurement tools). Specifically, we found that hospital-initiated malnutrition interventions (i.e., specialized nutrition care and increased protein/calorie provision) likely reduce mortality compared to usual care (SOE: moderate); these interventions may also improve quality of life (SOE: Low). However, evidence was insufficient or showed no difference for other outcomes (length of stay, activities of daily living, discharge disposition, hospital acquired conditions, or adverse events).

Limitations and Suggestions for Future Research

No studies met criteria to address clinical effectiveness of measurement tools. Eleven RCTs assessed hospital-initiated malnutrition interventions. Furthermore, although SRs assessing the association between malnutrition and clinical outcomes included a combined 80 studies, only 43 used a known tool to measure malnutrition and could be included for this review.

This evidence base reveals several shortcomings of the published literature on malnutrition in hospitalized patients. First, only a relatively small number of studies used commonly available measurement tools to identify malnutrition. Instead, many studies identified malnutrition using only biometric measures, such as serum albumin levels, body mass index, and weight.[1,2] Future studies assessing the impact of malnutrition on outcomes or evaluating malnutrition interventions should use known tools to establish malnutrition status.

The absence of studies addressing the clinical utility (effectiveness) of measurement tools for nutrition screening and diagnostic assessment (Key Question 2) does not necessarily imply that these tools are ineffective. Instead, it highlights two important knowledge gaps in current literature. First, is the need for controlled studies assessing their effectiveness in hospitalized adults. Understanding downstream consequences of malnutrition screening, including subsequent diagnostic assessment, management, and clinical outcomes is extremely important as US hospitals are mandated to provide nutrition screening for all hospitalized patients within 24 hours of admission. Further research could also support alignment of screening efforts with similar tools across different institutions.

Second, is the need to establish an accepted reference gold standard for diagnosing malnutrition in hospitalized patients. Through discussions with our Technical Expert Panel (TEP), we recognized that there currently is no universally agreed upon gold standard for malnutrition assessment and measurement. For the purposes of this report, we selected, with input from our TEP and subject matter experts, imaging modalities to quantify and evalute body composition (i.e., muscle and adipose tissues) as the gold standard and SGA as a semi-gold standard for classifying malnutrition. However, use of imaging specifically to assess malnutrition is infrequent and has important limitations, including cost, radiation exposure, and need for serial studies. Consensus regarding objective measures to define a gold standard for diagnosing malnutrition are critical to advance clinical care and research.

Finally, studies addressing efficacy of malnutrition-focused interventions only addressed specialized nutrition care (consultation with a dietitian to set goals for protein and calorie intake) or increased protein/calorie provision. These studies had several shortcomings, including high risk of bias and poor reporting of adverse events. These limitations, along with inconsistencies in the findings for some outcomes and lack of precision for others, downgraded the overall strength of the evidence to low or insufficient for most outcomes. Future studies need to clearly indicate any harms associated with treatment.

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Introduction

Background

Malnutrition among hospitalized patients remains a serious issue affecting more than 30 percent of hospitalized patients in the United States.[1] According to the American Society for Parenteral and Enteral Nutrition (ASPEN), malnutrition results from a "combination of varying degrees of overnutrition or undernutrition with or without inflammatory activity that leads to a change in body composition and diminished function."[2] The World Health Organization (WHO) categorizes malnutrition into two broad groups—undernutrition and overweight or obesity.[3] Malnutrition in both groups results from inadequate intake of macro and micronutrients, leading to nutritional imbalances and adverse body composition changes. Malnutrition resulting from undernutrition manifests in severe weight loss and muscle wasting. The etiology of malnutrition is heterogeneous, and can result from chronic starvation (e.g., anorexia nervosa), acute or chronic illness (e.g., certain cancers, sarcopenic obesity, major infections), and injury (e.g., burns, head trauma). Factors such as advanced age, immobilization, and low income can increase the risk of malnutrition.

Malnutrition is associated with high mortality and morbidity, functional decline, prolonged hospital stays, and increased healthcare costs.[4] An Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP) Statistical Brief reported 30-day all cause readmission was nearly 50 percent higher among patients with malnutrition compared to patients with no associated malnutrition.[5,6]

In 1995, the Joint Commission mandated universal screening of all hospitalized patients for malnutrition as part of general admission processes.[7] Findings from a national survey of hospital-based professionals representing ASPEN and other professional societies in the United States suggests high compliance with the screening mandate. The findings found 36.7 percent of respondents reporting completing nutrition screening at admission, 50.8 percent reporting doing so within 24 hours, and 69 percent reporting documenting the findings in the medical record.[7] However, while 71 percent of respondents indicated that screening information from medical records led to further nutritional assessment, only 26 percent reported that diagnosis of malnutrition was based on nutrition assessment. In a more recent survey of ASPEN members, 89 percent reported that a dietitian completed a nutrition assessment once an adult patient screened at high risk for malnutrition.[8] While these findings are positive, they still suggest opportunities for hospitals to improve their processes for identifying, diagnosing, and documenting malnutrition.

No national benchmarking of malnutrition in acute care hospitals currently exists in the United States.[9] Recently, the Academy of Nutrition and Dietetics (AND) along with Avalere Health developed a composite measure for malnutrition now under consideration at the Centers for Medicare & Medicaid Services (CMS).[10] The measure, titled Global Malnutrition Composite Score, is intended to assess provider performance on following the recommended malnutrition workflow, which includes (1) completion of screening of all hospital patients, (2) further assessment of patients at risk for malnutrition, (3) appropriate documentation of malnutrition diagnosis, and (4) implementation of a nutrition care plan. This measure is specific to older adults (ages 65 and older) who are at higher risk of facing poor clinical outcomes and is intended for use in electronic health records.

For the implementation of these or other quality measures of malnutrition to be considered, screening and nutrition assessment must first be standardized across hospitals to accurately identify and monitor rates of malnutrition. However, variations in definitions and tools used to screen and diagnose malnutrition have made it difficult for hospitals to standardize this process.[11,12] National survey data indicate that only 38 percent of hospital professionals report using a recognized tool to screen for malnutrition, and only 23 percent report using one for further diagnostic assessment.[7] Currently, more than 20 different tools exist to assess nutritional status. Some tools were specifically developed to screen nutritional risk, while others are intended for diagnostic assessment. As in other fields, screening tools are designed to be sensitive but not specific, in order to identify patients "at risk" for malnutrition, who then warrant further diagnostic assessment. Then, a second assessment tool is utilized to formally diagnose patients with malnutrition who warrant targeted treatments.

Determining what tool to use can be challenging as the clinical literature often blurs the distinction between screening and diagnostic assessment by using tools interchangeably.[12,13] Unlike other commonly used screening tools for other clinical conditions, the difference between screening and diagnostic assessment for malnutrition is not about the degree of invasiveness, as both are questionnaires completed at patient bedside with incorporation of limited clinical data. The distinguishing feature is that screening tools are intended to be short and simple, in order to facilitate widespread use at the bedside by nurses and dietary technicians, while diagnostic assessments typically require more detailed assessment by a registered dietitian. Table 1 describes commonly available tools. As shown, there is significant overlap in the components across tools, and crossover between screening and diagnostic assessments, further blurring these categories. Screening tools are intended to identify "at risk" patients, who can then undergo formal diagnosis using a diagnostic tool. However, both in clinical practice and research, screening and diagnostic tools have often been used interchangeably, and patients without a formal diagnosis of malnutrition often receive interventions for malnutrition.

Table 1. Commonly available measurement tools and criteria for assessing nutritional status

Tool	Use	Population	Setting	Screening/Diagnosis Components
Malnutrition Screening Tool (MST)	Screening	Adults (includes the elderly)	Acute care, inpatient, outpatient, residential aged care facilities	Recent weight loss; recent poor food/nutrient intake
Malnutrition Universal Screening Tool (MUST)	Screening	Adults	Acute care and community	BMI, weight loss, acute disease effect score
Nutritional Risk Screening 2002 (NRS-2002)	Screening	Adults	Acute care	Recent weight loss, recent poor food/nutrient intake, BMI, and severity of disease
Nutritional Risk Index (NRI)	Screening	Adults (includes the elderly)	Hospital	Current and usual weight
Mini Nutritional Assessment-Short Form (MNA-SF)	Screening	Geriatric	Acute care, community, rehab, long-term care	Recent weight loss and diet history
Nutrition Risk in Critically Ill (NUTRIC) score	Screening	Adults (critically ill)	ICU	Age, severity of illness, co-morbidities, days in from hospital to ICU
Short Nutritional Assessment Questionnaire (SNAQ)	Screening	Adult	Hospital outpatients	Weight loss and dietary intake

Tool	Use	Population	Setting	Screening/Diagnosis Components
Adult Malnutrition Consensus characteristics (AMC)[14]	Diagnosis	Adult	Hospital	Weight loss, energy intake, body fat, muscle mass, fluid accumulation, and grip strength
Subjective Global Assessment (SGA)	Diagnosis	Adults (includes surgical patients, geriatric, oncology, and renal)	Acute care, rehab, residential or community	Medical history (weight, intake, symptoms, functional capacity, metabolic demand) and physical exam
Patient Generated Subjective Global Assessment (PG-SGA)	Diagnosis	Adults (includes oncology, renal and stroke)	Acute care	Medical history (weight, intake, gastro-intestinal symptoms, functional capacity) and physical exam
Mini Nutritional Assessment (MNA)	Diagnosis	Geriatric	Acute care, community, rehab, long-term care	Diet history, anthropometry, medical history, and functional history
Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition (AND and ASPEN) Malnutrition Consensus Criteria (MCC)[15]	Diagnosis	Adults	Hospital	Insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation (that may sometimes mask weight loss, diminished functional status as measured by handgrip strength
Global Leadership Initiative on Malnutrition (GLIM)[16]	Diagnosis	Adults	Hospital	AND-ASPEN's criteria, and etiologic influences (reduced food intake, hypercatabolic burden of disease) and phenotypic presentations (non-volitional weight loss, low body BMI, low skeletal muscle mass) of malnutrition
Nutrition Focused Physical Exam (NPFE)[17]	Diagnosis	Adults	Hospital	Insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation (that may sometimes mask weight loss), diminished functional status as measured by hand-grip strength

Source: Mueller et al. 2011[18] unless otherwise specified
BMI = body mass index; ICU = intensive care unit

To promote consistency in assessing malnutrition, AND and ASPEN jointly published a set of criteria for hospitals to use for diagnosing and documenting malnutrition in hospitalized patients. The criteria focus on the following six characteristics: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation (that may sometimes mask weight loss), and diminished functional status as measured by handgrip strength.[15] These criteria are the basis of the Adult Malnutrition Consensus diagnostic tool and the Nutrition Focused Physical Exam listed in Table 1, and are similar to the diagnostic criteria used in other tools, such as Subjective Global Assessment (SGA).

In 2016, the Global Leadership Institute on Malnutrition (GLIM) taskforce convened to develop a universal framework for assessing malnutrition.[16] The GLIM taskforce

recommendations were published in 2019 and include the following two-step approach to identify malnutrition: 1) screening for malnutrition using a valid tool, followed by 2) formal diagnostic assessment. The taskforce produced consensus-based criteria for formal assessment that incorporates AND-ASPEN's criteria, and includes both etiologic influences (reduced food intake, hypercatabolic burden of disease) and phenotypic presentations (non-volitional weight loss, low body mass index (BMI), low skeletal muscle mass) of malnutrition. To be diagnosed with malnutrition, patients must have at least one etiologic criterion and one phenotypic criterion. A diagnosis of severe malnutrition depends upon the severity of the phenotypic presentation. The GLIM recommendations have yet to be validated but represent the current consensus of experts in the field.[19]

Diagnosis of malnutrition in hospitalized patients allows clinicians to target appropriate nutrition-focused interventions. While some interventions, such as nutritional assessments, initiating oral nutrition supplements (ONS), diet changes, visits with registered dietitians, and tracking biomarkers, may be uniformly applied across populations, others, such as initiating enteral nutrition (EN) or parenteral nutrition (PN), may only be appropriate in specific cases. ASPEN and the American College of Gastroenterology (ACG) have published clinical practice guidelines addressing the initiation of EN and PN in adult hospitalized patients.[11,20] Since specific interventions for treatment of malnutrition have risks (e.g., risk of blood-stream infections with PN or complications from gastrostomy tube placement), identifying the appropriate context in which treatments are effective or harmful is important.

Purpose and Scope of the Systematic Review

In fiscal year 2020, Congress requested that AHRQ convene a panel of experts charged with developing quality measures for malnutrition-related hospital readmissions. These measures would support assigning accountability for the assessment and treatment of malnutrition in hospitalized adults, with an emphasis on the needs of older frail adults. This systematic review is intended to support the efforts of the panel by identifying and synthesizing published literature on the association between malnutrition and clinical outcomes among hospitalized patients, particularly those who may be at greater risk of malnutrition. This review also evaluates the effectiveness of screening and/or diagnostic assessment of malnutrition on clinical outcomes and the impact of hospital-initiated interventions for patients diagnosed with malnutrition. Findings from this review are intended to inform potential development of quality measures in malnourished hospital adults.

Organization of This Report

In the remaining three chapters of this report, we describe the methods for this systematic review, present results, and discuss overall findings. Within the Results chapter, we provide results of the literature searches, screening procedures, descriptions of included studies, key points, detailed syntheses of the findings, and strength-of-evidence tables. The Discussion chapter reviews key findings and strength of evidence, places findings in the context of clinical practice, examines the general applicability of the findings, discusses implications for decision making, describes limitations of the systematic review process and the evidence base, and identifies knowledge gaps requiring further research. The main body of the report is followed by nine appendixes: Appendix A. Search Strategy; Appendix B. Methods; Appendix C. Excluded Studies; Appendix D. Characteristics of Included Studies; Appendix E. Risk of Bias; Appendix F. Results From Included Studies; Appendix G. Forest Plots of Additional Analysis; Appendix H. Additional Information for Key Question 1; and Appendix I. Appendix References.

Methods

Review Approach

This Comparative Effectiveness Review follows the methods suggested in the Agency for Healthcare Research and Quality (AHRQ) "Methods Guide for Effectiveness and Comparative Effectiveness Reviews" (hereafter, "AHRQ Methods Guide").[21] Our methods are summarized in this section; for additional details, see the review protocol posted on the AHRQ Effective Health Care Program website (www.effectivehealthcare.ahrq.gov).

Role of the Technical Expert Panel

We convened a 5-member Technical Expert Panel (TEP) to provide guidance and feedback throughout systematic review (SR) development. The TEP included key stakeholders with expertise in malnutrition-related translational, epidemiologic, and clinical research as well as policy development, guideline creation, clinical care coordination, and quality metric development. (See the front matter of the report for TEP names, credentials, and affiliations). Several TEP members had first-hand experience with caring for hospitalized patients with malnutrition, utilizing available measurement tools, and administering various treatments. We sought TEP feedback on the scope and protocol of the review through real-time video-based one-on-one interviews, group meetings, and email communication. Subject matter experts (SMEs) were sometimes included in group meetings to facilitate discussions and help reach consensus when needed.

Input from the TEP informed the measurement tools selected for inclusion and patient populations included for each Key Question (KQ). Insights from the TEP (as well as SMEs) were particularly critical in selecting an appropriate comparator or gold standard for screening and diagnostic assessments (KQ 2). Ultimately, TEP members agreed that currently, no nutritional biomarker or imaging technique is widely accepted as a gold standard to use to validate screening or diagnostic tools. However, radiographic imaging and Subjective Global Assessment (SGA) were felt to be the most highly respected and commonly used in the field. Therefore, these were identified as "semi-gold" standards and were specified as appropriate comparators for determining tool effectiveness in KQ 2. Finally, we sought input from TEP members on methodologic approaches to best inform creation of quality metrics. One TEP member with expertise in this area provided useful context to ensure extraction of relevant data, such as categorization of patient populations, malnutrition definitions, and outcome specifications.

Key Questions

The intent of the following KQs is to identify evidence to inform the development of quality measures related to malnutrition in hospitalized adult patients. These questions underpin the pathway of care linking patients at risk of malnutrition to clinical outcomes.

Key Question 1. What is the association between malnutrition and clinical outcomes among hospitalized patients?

a. How do outcomes vary depending on measures or tools used to detect malnutrition?

b. Are patient-related risk factors, such as increased age or certain pre-existing health conditions, associated with poorer clinical outcomes?

Key Question 2. What is the effectiveness of screening or diagnostic assessment for malnutrition among hospitalized adults?

a. In studies that report on clinical outcomes, what is the accuracy of screening or diagnostic tools for malnutrition?

b. In studies that report on clinical outcomes, what is the effectiveness of screening or diagnostic tools on measures of nutrition (nutritional stores)?

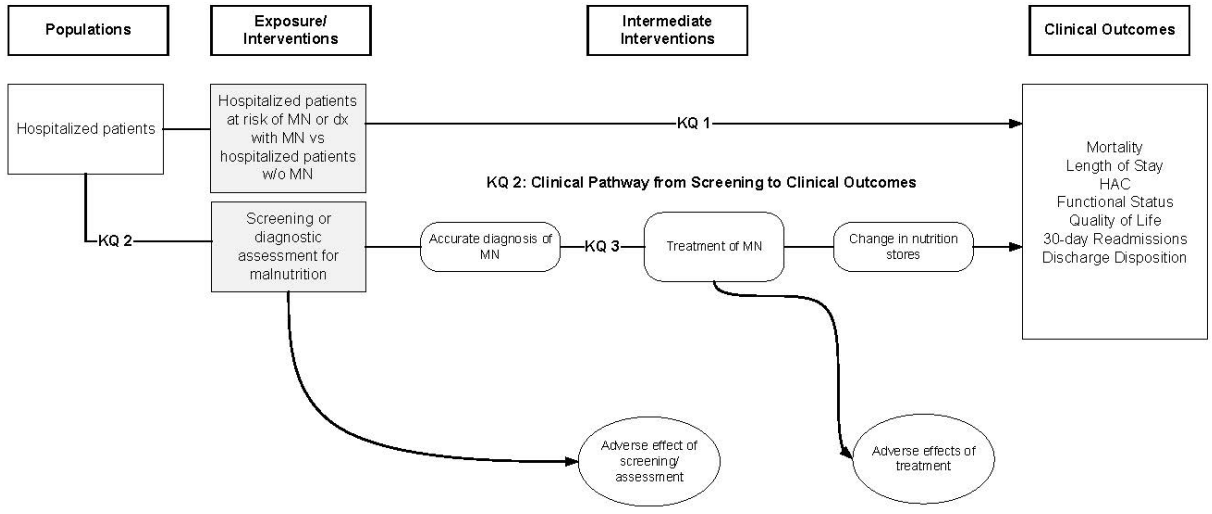
c. What is the impact of the use of screening or diagnostic tools on clinical outcomes?

Key Question 3. Among patients diagnosed with malnutrition, what is the effectiveness of hospital-initiated interventions used to treat malnutrition on clinical outcomes?

Analytic Framework

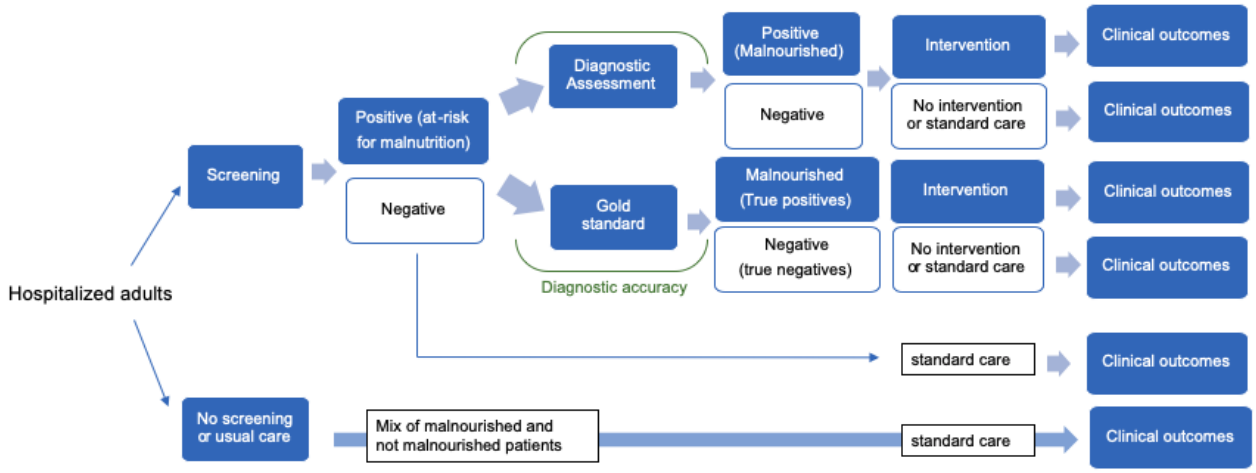
Figure 1 presents the analytical framework, which visually presents the pathway of hospitalized patients who undergo screening for malnutrition. It depicts movement along several exposures beginning with screening, moving to further assessment and treatment, and ultimately ending with clinical outcomes. Figure 2 shows the overall schematic of potential study designs for this review, incorporating the process of screening, followed by diagnosis. It also depicts the control and comparator groups with appropriate reference standards as determined by the TEP.

Figure 1. Analytic framework for malnutrition in hospitalized adults



HAC = hospital acquired conditions; KQ = Key Question; MN = malnutrition

Figure 2. Study design schematic



Study Selection

To identify articles relevant to each KQ, Evidence-based Practice Center (EPC) librarians conducted a comprehensive literature search including studies from January 2000 to June 3, 2021, searching MEDLINE®, Embase.com, Cochrane Central Register of Controlled Trials, and ClinicalTrials.gov. They also searched for gray literature in websites of the following organizations: Centers for Disease Control and Prevention (CDC), Medscape, National Academy of Medicine, the United States Food and Drug Administration (FDA), AHRQ, American Society for Parenteral and Enteral Nutrition (ASPEN), and Academy of Nutrition and Dietetics (AND), and hand-searched reference lists of relevant studies and searched for unpublished studies. Literature searches were updated during the public comment and peer review period to capture any new publications. Search strategies are available in Appendix A.

Studies were selected for inclusion using pre-established population, intervention, comparator, outcome, timing, and setting specifications (Table 2). Literature screening was performed in duplicate using the database Distiller SR (Evidence Partners, Ottawa, Canada). Literature search results were initially screened by title for relevancy. Relevant abstracts were screened against the inclusion and exclusion criteria in duplicate. Studies that met inclusion criteria were retrieved in full and the full study was screened again in duplicate against inclusion and exclusion criteria. Disagreements were resolved by consensus discussion between the two original screeners. Further details about study selection processes are provided in Appendix B.

Table 2. PICOTS (population, intervention, comparator, outcome, timing, setting)

Category	Definition
Population	**Key Question 1 and 2:** Hospitalized adults aged 18 years or older. **Key Question 1b:** Subgroups include adults with no risk of malnutrition, adults with risk of malnutrition, and adults with baseline malnutrition. Risk factors of interest to this report include: • Older patients (>65 years) • Racial and ethnic minorities • Low income (e.g., Medicaid beneficiaries) • Patients with malignancy • Patients with gastrointestinal disease and subsequent malabsorption, including ulcerative colitis and Crohn's disease • Patients with chronic liver disease • Patients with stroke • Patients with chronic kidney disease • Patients with dementia • Patients with critical illness • Sepsis/infection **Key Question 3:** Adults diagnosed with protein-energy malnutrition.*
Interventions/ Exposures	**Key Question 1:** Positive screening for nutrition risk and/or diagnosis of malnutrition vs no malnutrition. **Key Question 2:** Malnutrition measurement tools (utilized within the U.S., Australia, New Zealand, Canada, and Europe). Examples of tools of interest include: *Screening* • Malnutrition Screening Tool (MST) • Malnutrition Universal Screening Tool (MUST) • Nutritional Risk Index (NRI) • Nutrition Risk in Critically Ill (NUTRIC) score *Diagnostic Assessment* • Subjective Global Assessment (SGA) • Patient Generated Subjective Global Assessment (PS-SGA) • Mini Nutritional Assessment (MNA) • AND (Academy of Nutrition and Dietetics)-ASPEN (American Society for Parenteral and Enteral Nutrition) Malnutrition Consensus Criteria (MCC) • Global Leadership Initiative on Malnutrition (GLIM) **Key Question 3:** Hospital-initiated malnutrition interventions. Examples of interventions include: • Parenteral nutrition • Enteral nutrition • Oral nutrition supplements • Nutrition team consultation, includes dietitian counseling • Pharmacologic interventions
Comparators	**Key Question 1:** Hospitalized patients without malnutrition, or direct comparisons of different definitions of malnutrition. **Key Questions 2:** For screening tools: no screening. For diagnostic assessments: no assessment or imaging modalities to assess body composition and muscle mass (i.e. nutrition stores) or SGA as the reference standard. **Key Question 3:** Usual care or another hospital-initiated malnutrition-related intervention.

Category	Definition
Outcomes	Clinical outcomes (All Key Questions) • Mortality (inpatient and 30-day) • Length of stay • 30-day readmission • Quality of life • Functional status includes gait speed, Eastern Cooperative Oncology Group (ECOG) scale of performance status, Karnofsky Index, handgrip strength, days on ventilator • Activities of daily • Hospital Acquired Condition (HAC, conditions people experience from their time in a hospital, such as pressure sores and hip fractures after surgery) • Wound healing • Discharge disposition Intermediate Outcomes (KQ 2) Diagnostic accuracy outcomes: • Sensitivity • Specificity • Predictive value • Area under the curve Intermediate Outcomes (KQ 2 or KQ 3) • Nutrition Stores: Direct measures of nutrition status during and post hospitalization. Examples include: • Cross-sectional areas for lumbar skeletal muscle and adipose tissue • Skeletal Muscle Index • Regional or total fat mass and muscle mass assessed using validated gold standard methods, such as body composition measures derived through Computed Tomography (CT) scans, Dual X-ray Absorptiometry (DXA), and Magnetic Resonance Imaging (MRI)
Timing	Up to 30 days post-discharge.
Setting	Acute care hospitalizations.
Study Design	**Key Question 1**: Systematic reviews of relevant study designs (RCTs, prospective cohort trials, or cross-sectional studies). • We did not include systematic reviews of isolated micro-nutrient deficiencies, such as cobalamin or iron deficiencies **Key Question 2**: Randomized or non-randomized comparative trials; retrospective studies were not considered for inclusion for this Key Question as these types of study designs are subject to biases that reduce the reliability of the findings. **Key Question 3:** RCTs.

* Due to the paucity of literature identified for KQ 3 in which patients were diagnosed with malnutrition using diagnostic assessment tools (such as SGA or MNA), we accepted studies in which patients were identified as at-risk of malnutrition using cutoff scores on screening tools (such as NRS-2002 and MUST).
KQ = Key Question; RCT = randomized controlled trial

Data Extraction

Data were extracted from included studies into standardized forms in Microsoft Word. All relevant study-level and patient-level characteristics were extracted (author, year, study design, setting, country, sample size, eligibility criteria, intervention, comparator, screening/diagnostic instrument, population characteristics, clinical conditions, and results). For SRs addressing Key Question 1 (KQ 1), we also extracted information about the search strategy, study selection, and

final number of included studies. For studies that contained data points displayed in survival curves or other figures, we used WebPlotDigitizer v 4.4 to extract relevant data.[22] A single trained reviewer extracted the relevant data from each included article into evidence tables. A second member of the team reviewed all data extractions for completeness and accuracy. Discrepancies were resolved through team discussion.

Risk of Bias Assessment

Risk of bias (ROB) of individual studies and existing SRs was assessed by an independent reviewer and quality checked by a second reviewer. Discrepancies in ROB were addressed through consensus discussion.

Primary Studies

To judge the ROB of the individual randomized controlled trials (RCTs), we used the Cochrane Risk of Bias 2.0 tool (ROB 2).[23] This tool assesses ROB along the following domains: randomization process, deviations from intended interventions, attrition, and reporting bias. Overall summary ROB assessments for each study were classified as low risk of bias, some concerns, or high risk of bias based upon the collective ROB inherent in each domain and confidence that results are believable given the study's limitations.

Observational studies were assessed using the Risk of Bias in Non-randomized Studies (ROBINS-I) tool.[24] The ROBINS-I tool measures potential bias along the following domains: confounding, selection of participants, classification of intervention, deviation from intervention, missing data, measurement of outcomes, and reported results. The categories for risk of bias judgements are low risk, moderate risk, serious risk, and critical risk of bias. We did not exclude studies rated high ROB *a priori*, but did consider them the least reliable when synthesizing the evidence, particularly when discrepancies among studies were present.

Systematic Reviews

We assessed ROB of SRs included for KQ 1 using the Risk of Bias in Systematic Reviews (ROBIS) tool.[25] This tool covers four domains which may introduce bias: study eligibility criteria, identification and selection of studies, data collection and study appraisal, and data synthesis and findings. The instrument includes signaling questions to assess potential bias in each domain. We classified the overall ROB for each review as low or high. For primary studies included in the SRs, we relied on the quality ratings or ROB assessments performed in the systematic review if the review used a standardized method for assessing quality (e.g., Newcastle-Ottawa Scale, Cochrane tool).

We rated SRs low ROB if they used multiple sources in the literature search, applied predefined inclusion and exclusion criteria, assessed study quality using an appropriate tool, used methods to reduce errors in data abstraction and quality rating (e.g., multiple independent reviewers), used appropriate methods for evidence synthesis (qualitative or quantitative), and used an explicit system for considering the body of evidence (that included major domains of strength of evidence [e.g., risk of bias, consistency, precision, and directness]). If SRs were found to have shortcomings in one or more of these areas, we only included the SR if we determined it was possible to address the shortcomings (e.g., by assessing the quality of primary studies ourselves or independently determining the strength of evidence from the information provided in the review). For example, if the methods used by SR authors to assess the risk of bias

of individual studies were unclear, we assessed the quality of individual studies ourselves, using methods described previously.

Data Synthesis and Analysis

We summarized all included studies in narrative form and in summary tables presenting key features of study populations, design, intervention, outcomes, setting (including geographic location), and results.

We conducted meta-analysis, whenever appropriate (i.e., ≥ 2 studies addressing the same populations, interventions, comparators, outcomes, timings, and settings (PICOTS) and providing point estimates and dispersion measures), to quantitatively summarize study findings. Relative risk and corresponding 95 percent confidence intervals were extracted or calculated for binary outcomes. For continuous outcomes, we used mean differences weighted by sample size. If primary studies reported a continuous outcome using different scales (e.g., quality of life), we used standardized mean differences and converted the direction of all measures (e.g., all higher score represents better outcome). For continuous outcomes, we used means and standard deviations to conduct meta-analyses; if medians were extracted, they were converted to means using the quantile-estimation method.[26] We conducted all meta-analyses using the DerSimonian and Laird random effect model with Hartung-Knapp-Sidik-Jonkman variance correction.[27,28] Meta-analyses were performed by transferring data from standardized extraction forms into Microsoft Excel and importing study-level data into Stata 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP).[29]

We used the I^2 test to evaluate statistical heterogeneity; an I^2 of 50 percent or more indicated the presence of substantial heterogeneity. We performed subgroup analysis to assess if treatment effects varied by age, definition of malnutrition, type of treatment, follow-up time, and co-morbid conditions. When meta-analysis was not possible (due to limitations in number of studies or reported data) or judged to be inappropriate (e.g., due to large clinical heterogeneity in population and treatments), data were synthesized using a descriptive, narrative review approach.

For KQ 1, we reported meta-analytic findings from included SRs if we judged appropriate pooling methods were used (e.g., random effects model in the presence of statistical heterogeneity). When SR authors did not perform meta-analysis due to clinical or statistical heterogeneity, we qualitatively synthesized reported findings for outcomes of interest. Findings for all outcomes of interest were synthesized and reported by nutritional screening or assessment tool. We did not conduct updated meta-analysis or qualitative summary of evidence from newer studies (e.g., published after publication of the review). However, we summarized key characteristics of both (1) relevant primary studies identified, but not captured in included SRs, and (2) relevant studies published after included SRs in Appendix H.

Grading the Strength of the Body of Evidence

We appraised the strength of evidence (SOE) for key outcomes according to methods as described in the AHRQ Methods Guide.[21] The overall strength of evidence was determined based on assessment of study limitations (or ROB, graded low, moderate, or high); consistency of results across trials (graded consistent, inconsistent, or for single studies, unknown); the directness of the evidence linking the interventions with clinical outcomes (graded direct or indirect); effect estimate precision (graded precise or imprecise); and reporting bias (suspected or undetected). Based on these assessments, SOE was appraised as high, moderate, low, or insufficient to estimate an effect (See Appendix B for more information on Grading the SOE).

Plain-language statements are used in the main points of the Evidence Summary and key points of the Results to convey the SOE: High SOE is described as "is associated with" or simply "reduces/increases;" moderate SOE is described as “likely” or "probably;" and low SOE is described as “may be” or "might be." To ensure consistency and validity of assessments, the strength of evidence grade was reviewed by the entire team of investigators prior to assigning a final grade.

Bodies of evidence consisting of RCTs were initially considered high SOE and downgraded depending on study limitations. In contrast, bodies of evidence consisting of observational studies were initially considered low SOE. Observational studies pose a greater risk of having study limitations because of the typically higher risk of bias due to lack of randomization. However, per AHRQ Methods Guide, EPCs can move up the initial SOE grade for observational studies to moderate if study ROB was rated low or moderate and the study authors performed analyses to control for risk of bias. For reviews that addressed KQ 1 and included cohort trials, we rated the initial SOE as moderate if the authors of the reviews rated the ROB of included studies as low or moderate and indicated that studies conducted analyses to control for critical confounders, such as age and severity of illness.

To assess SOE of findings from existing SRs, if reviews utilized a grading system similar to that described in AHRQ’s methods guide, we used the SOE ratings reported by review authors. If reviews used a compatible grading system (e.g., GRADE system), we translated the review’s evidence ratings to AHRQ’s SOE ratings. If the review did not assess the overall quality of the evidence, we assessed it ourselves, using AHRQ’s grading system (provided evidence was reported in a manner that allowed us to judge the overall risk of bias, consistency, directness, and precision of evidence). However, if reviews reported insufficient information to allow for accurate appraisal, we did not attempt to rate the SOE.

Applicability

We followed procedures outlined in the AHRQ Methods Guide to assess the applicability of the findings within and across studies.[21] Applicability for each outcome was summarized and presented qualitatively using the PICOTS framework and not a specific checklist or scale. Several *a priori* patient factors may limit the applicability of findings, including age, gender, comorbidities, and illness severity. The following population relevant measures are frequently used within hospital settings to measure severity of illness: Sequential Organ Failure Assessment (SOFA score), Simplified Acute Physiology Score (SAPSII), and Acute Physiology and Chronic Health Evaluation (APACHE).

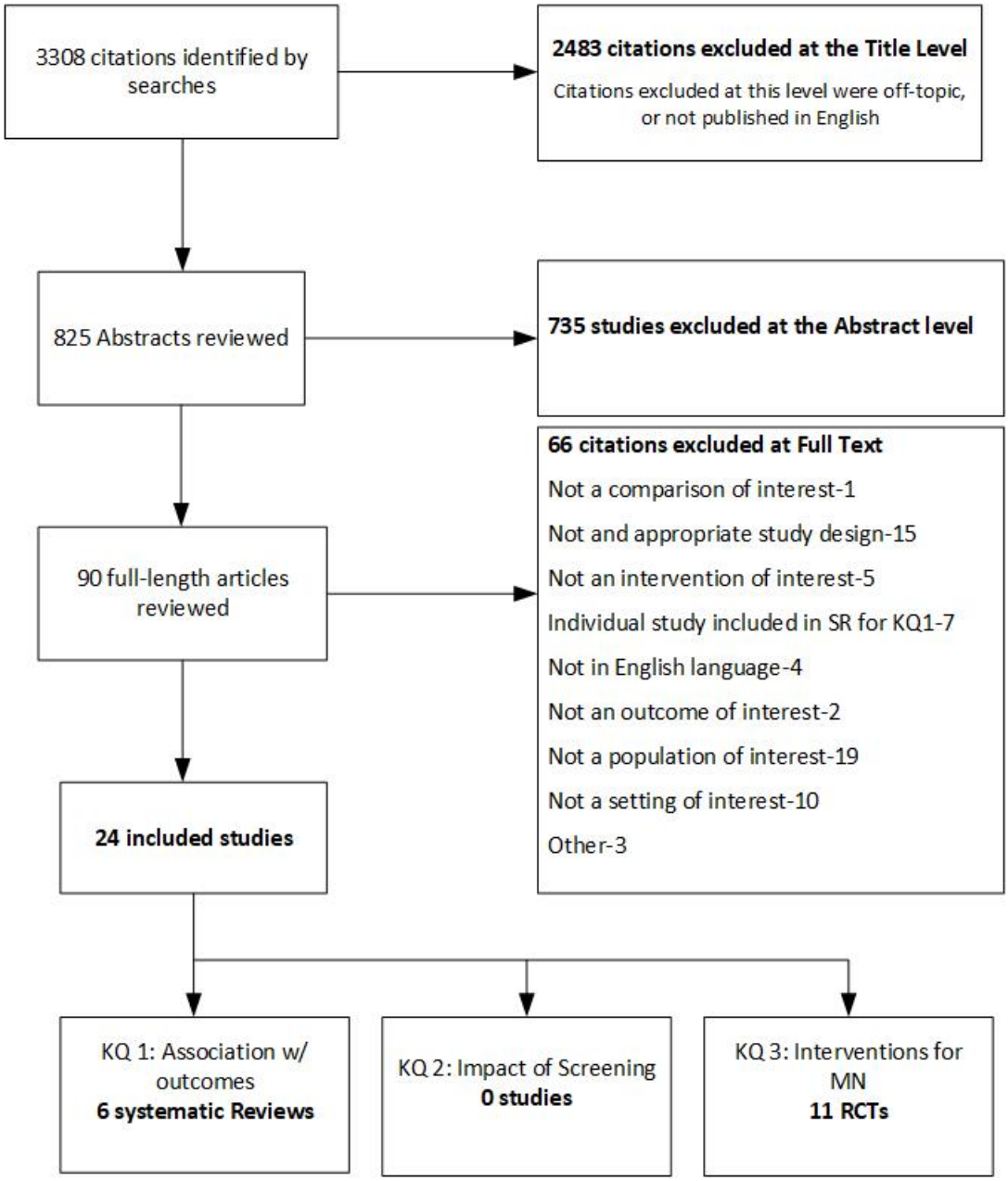
Small sample size may be an important limitation in many studies and addressing this through meta-analysis may be challenging if there is substantial heterogeneity in study design, intervention, and outcome reporting. Confounding factors such as the severity of illness that studies are unable to or fail to control may impact the relationship between malnutrition and clinical outcomes. We reported any limitations in applicability of individual studies within evidence tables and limitations of applicability of the whole body of evidence in the summary of evidence tables.

Results

Search Results

Electronic searches identified 3,308 citations. After title and abstract screening, 83 required full text review and 17 studies met eligibility criteria for inclusion in this review (Figure 3). A list of the studies excluded at the full-text review stage is in Appendix C. The primary reasons for exclusion were wrong patient population (e.g., patients not hospitalized or did not meet criteria for malnutrition for Key Question [KQ] 3), not an appropriate study design (e.g., retrospective or did not include appropriate care pathway for KQ 2), and wrong setting (e.g., took place outside of eligible countries).

Figure 3. Study flow diagram



. KQ = Key Question; MN = malnutrition; RCTs = randomized controlled trials; SRs = systematic reviews

Below we provide the report results, including the Key Points for each Key Question, and describe the included evidence, as well as the data synthesis and a summary of the strength of evidence. Details on results of literature searches, included studies, and the strength of evidence can be found in Appendix F.

Key Question 1. What is the association between malnutrition and clinical outcomes among hospitalized patients?

a. How do outcomes vary depending on measures or tools used to detect malnutrition?
b. Are patient-related risk factors, such as increased age or certain pre-existing health conditions, associated with poorer clinical outcomes?

Description of Included Evidence

Our searches identified 6 systematic reviews (SRs) (including 43 relevant unique studies) evaluating the association between malnutrition and clinical outcomes among hospitalized patients. The patient population, tools used to assess malnutrition, and outcomes reported varied across SRs and, in some cases, among studies included in the reviews. Key characteristics of the SRs and their included studies are summarized in Table 3. Detailed information about the reviews and included studies is provided in Appendix D (Table D-1 to Table D-2). Evidence from some studies included in these reviews was not considered in this report as these studies did not meet inclusion criteria. For instance, we did not consider evidence from retrospective studies (except when combined with prospective studies in a meta-analysis), studies of non-hospitalized patients, or studies that did not use commonly available measurement tools to assess malnutrition.

Most studies included in the SRs were prospective cohort trials in which patients were hospitalized for a range of conditions, including traumatic injury,[30] acute medical conditions requiring care in the intensive care unit (e.g., pneumonia, acute kidney failure),[31] heart failure,[32] cancer,[33] chronic obstructive pulmonary disease (COPD),[34] and liver transplant.[35] Malnutrition prevalence varied across the included studies, ranging from 7 percent to 90 percent depending on patient population and tool used to diagnose malnutrition. Many studies used screening tools, such as the Nutritional Risk Screening-2002 (NRS-2002) or the Malnutrition Universal Screening Tool (MUST), to categorize patients with malnutrition.

Using the Risk of Bias in Systematic Reviews (ROBIS) instrument, we rated the risk of bias (ROB) of 5 of the 6 included SRs as Low (see Table E-1 in Appendix E for ratings). Study eligibility, data collection, study appraisal, and synthesis of findings of these SRs were clearly described and appropriate. One SR did not use a formal tool to assess the ROB of included studies but provided sufficient information about study design and methods to allow us to appraise individual study ROB. The ROB of the studies included in the SRs ranged from low to high, with review authors rating most of the studies within the moderate range.

Table 3. Key characteristics of included systematic reviews

Reference	Total Studies Included in SR	Number of Relevant Studies Reporting Outcomes of Interest	Patient Populations % With Malnutrition	Screening/ Diagnostic Tools of Interest for Malnutrition*	Outcomes Reported	Type of Synthesis
Dijkink et al. 2020[30]	13 cohort trials (11 prospective, 2 retrospective)	8	Traumatic injury 7 to 76%, dx based on SGA or MNA in 6 studies	**Screening tools:** NRS-2002: 2 studies **Diagnostic tools:** MNA: 4 studies SGA: 2 studies	Mortality, length of stay, 30-day readmission, HAC	Qualitative
Ney et al. 2019[35]	47 cohort trials (type of cohort trial not reported)	3	Cirrhosis 8.0% to 100% based on SGA	**Screening tools:** no studies **Diagnostic tools:** SGA: 3 studies	Pre-and Post-mortality, ICU length of stay	Quantitative meta-analysis
Muscariotoli et al. 2018[34]	15 studies (12 prospective cohort studies and 3 database studies)	7	Various conditions, including general medicine, COPD, heart failure, and pneumonia NR	**Screening tools:** NRI: 1 study MUST: 1 study **Diagnostic tools:** SGA: 3 studies MNA: 2 studies	30-day readmission	Qualitative
Lew et al. 2016[31]	20 prospective cohort trials (15 were used to assess outcomes)	6	Acute medical conditions requiring ICU care (e.g., acute kidney failure) 37.8 to 78.1%, all dx with SGA or MNA	**Screening tools:** NRS-2002: 4 studies MUST: 3 studies MNA-SF: 1 study PINI: 1 study **Diagnostic tools:** SGA: 10 studies MNA: 2 studies	Mortality, length of stay, 30-day readmission, HAC, wound healing, discharge disposition	Qualitative

Reference	Total Studies Included in SR	Number of Relevant Studies Reporting Outcomes of Interest	Patient Populations % With Malnutrition	Screening/ Diagnostic Tools of Interest for Malnutrition*	Outcomes Reported	Type of Synthesis
Lin et al. 2016[32]	17 trials (12 prospective cohort, 5 retrospective)	11	Heart failure General: 16 to 90% **By tool:** MNA: 16 to 90% GNRI: 22 to 48% NRI: 23 to 90% NRS: 57.3%	**Screening tools:** GNRI: 4 studies NRI: 3 studies MNA-SF: 2 studies SCORE: 1 study NRS-2002: 1 study CONUT: 1 study PNI: 1 study Other: 2 studies **Diagnostic tools:** MNA: 5 studies	Mortality, length of stay, HAC	Quantitative meta-analysis of mortality, other outcomes qualitative
Gupta et al. 2011[33]	8 cohort trials, (6 prospective, 2 retrospective)	8	Cancer Moderate to severe MN: 42%	**Screening tools:** no studies **Diagnostic tools:** SGA: 6 studies PG-SGA: 2 studies	Length of stay	Qualitative

* Studies that did not use a known tool to measure nutritional status were not included in this column.

CONUT = Controlling Nutritional Status Score; GNRI = Geriatric Nutritional Risk Index; HAC = hospital acquired condition; MNA = Mini Nutritional Assessment; MNA-SF = MNA-short form; MUST = Malnutrition Universal Screening Tool; NR = not reported; NRI = Nutritional Risk Index; NRS-2002 = Nutritional Risk Score, PINI = Prognostic Inflammatory and Nutrition Index; SGA = Subjective Global Assessment; SNAQ = Short Nutritional Assessment Questionnaire

Key Points

Patients Hospitalized for Traumatic Injury

- Patients hospitalized due to traumatic injury and screened at risk of malnutrition (using NRS-2002) may experience more hospital acquired conditions compared to well-nourished patients hospitalized for a traumatic injury. (strength of evidence [SOE]: Low)
- Evidence for other outcomes and measurement tools used to identify malnutrition (Subjective Global Assessment [SGA]) was insufficient to determine if malnutrition was associated with clinical outcomes among patients hospitalized for a traumatic injury.

Patients Hospitalized for an Acute Medical Condition Requiring Intensive Care Unit Care

- Patients requiring intensive care unit (ICU) care and diagnosed with malnutrition (using Subjective Global Assessment [SGA]) may have higher hospital mortality compared to well-nourished patients requiring ICU care.
  (SOE: Low)
- Patients requiring ICU care and diagnosed with malnutrition (using SGA) are likely to experience prolonged hospital length of stay compared to well-nourished patients requiring ICU care. (SOE: Moderate)
- Patients requiring ICU care and diagnosed with malnutrition (using Mini Nutritional Assessment [MNA]) may experience more hospital acquired conditions compared to well-nourished patients requiring ICU care. (SOE: Low) No other differences were observed using MNA to assess nutritional status.
- Evidence for other measurement tools used to identify malnutrition (Nutrition Risk Screening-2002, Malnutrition Universal Screening Tool, Mini Nutritional Assessment-Short Form, Short Nutritional Assessment Questionnaire, and Prognosis Inflammatory and Nutritional Index) was insufficient to determine if malnutrition was associated with clinical outcomes among patients requiring ICU care.

Patients Hospitalized for Decompensations of Chronic Disease

- Patients hospitalized with heart failure and diagnosed with malnutrition (using several different measurement tools) may have higher mortality compared to well-nourished patients with heart failure. (SOE: Low)
- Patients hospitalized with cancer and diagnosed with malnutrition (using SGA) may experience prolonged hospital length of stay compared to well-nourished patients (SOE: Low)
- Patients hospitalized with cirrhosis awaiting transplantation and diagnosed with malnutrition (using SGA) may have higher pre-transplant mortality compared to well-nourished patients. (SOE: Low)

Summary of Findings

Malnutrition Among Patients Hospitalized for Traumatic Injury or Acute Medical Conditions Requiring ICU Care

In traumatically injured patients, the relationship between nutritional status and clinical outcomes is complicated by the systemic pathophysiological responses to trauma, which may affect, as well as be affected by the patient's nutritional status.[30] Thus, the impact of nutritional status on clinical outcomes of patients who have experienced a traumatic injury or an acute medical event can be difficult to interpret.

Our literature search identified 2 SRs (including 14 relevant studies) that provided evidence on the association between malnutrition and clinical outcomes among patients hospitalized for a traumatic injury[30] or receiving ICU care for acute complications related to an existing medical condition or surgical procedure.[30,31] The SR by Lew et al. (2016) only considered findings from studies rated as low risk of bias (6 out of 14 included).[31] The median prevalence of malnutrition on admission across both SRs using the SGA or MNA was 37.9 percent, range 7 percent to 78 percent. The prevalence of malnutrition varied depending on the patient population, with older patients, patients in the ICU, and patients with acute kidney disease having higher rates of malnutrition. Table 4 presents the SOE ratings for all assessed outcomes by measurement tool. The table is organized by measurement tool and outcome and includes columns indicating what study provided the data (reference), findings and direction of findings (e.g., no association, increased/decreased occurrence of outcome), and strength of evidence rating.

Subjective Global Assessment

Four studies included in the SR by Lew et al. (2016) enrolling a total of 729 patients evaluated the association between malnutrition (diagnosed using SGA) and mortality among patients with acute medical conditions receiving care in the ICU.[31] Two studies demonstrated that patients requiring ICU care and diagnosed with malnutrition (MN) may be at increased risk of mortality compared to well-nourished (WN) patients. One study showed that patients with malnutrition were 8 times as likely as well-nourished patients to experience mortality (Fontes, 2014, n=185, adjusted odds ratio [AOR]: 8.12, 95 percent confidence interval [CI]: 2.94 to 22.42, $p<0.05$). The findings of the other study (Sheean et al 2013) enrolling 260 patients reported a mortality rate of 23 percent among patients diagnosed with malnutrition compared to 4.8 percent among well-nourished patients ($p<0.01$). Two other studies reported a non-significant trend toward an association between malnutrition and increased mortality.

One study from the SR by Dijkink et al (2020) enrolling 161 assessed the association between malnutrition (diagnosed using SGA) and mortality among patients admitted to the hospital for a traumatic injury.[30,31] However, the SOE for this outcome was rated insufficient as the sample size was small and the width of the confidence intervals surrounding the summary estimate suggested some uncertainty (Goiburu, 2006, n=161, relative risk [RR]: 4.0, 95 percent CI: 1.0 to 15.0). Table 5 presents the SOE ratings for all outcomes by measurement tool.

Four other studies (n=1,737, Caporossi, 2012; Merli, 2010; Lomivorotov, 2013; Sheean, 2013)[31] found that patients requiring ICU care and diagnosed with malnutrition (using SGA) were more likely to experience prolonged hospital length of stay compared to well-nourished patients (SOE: Moderate). Evidence on the association between malnutrition (diagnosed using SGA) and other clinical outcomes—30-day readmission, discharge disposition, and hospital acquired complications—was insufficient.

Mini Nutritional Assessment

The SRs included 3 studies using the MNA to measure the association of malnutrition with clinical outcomes.[30,31] However, these studies did not find any association between malnutrition and increased mortality or length of stay (Goisser, 2015, n=97; Lomivorotov, 2013, n=1193; Sheean, 2013, n=260). One study found that patients requiring ICU care and diagnosed with malnutrition (using MNA) may experience more hospital acquired complications compared to well-nourished patients requiring ICU care (Lomivorotov, 2013, n=1193, AOR: 1.60, 95percent CI: 1.10 to 2.20, SOE: Low)

Other Tools

Other studies included in the 2 SRs evaluated malnutrition using one of the following screening tools—Nutrition Risk Screening-2002 (NRS-2002), Malnutrition Universal Screening Tool (MUST), Mini Nutritional Assessment-Short Form, Short Nutritional Assessment Questionnaire, and Prognosis Inflammatory and Nutritional Index. Tools, such as the NRS-2002 and MUST, showed either no or inconsistent associations between malnutrition and poor clinical outcomes.

Table 4. Strength of evidence ratings by measurement tool for trauma injury/ICU patients

Intervention	Outcome	Population	Reference	Number and Type of Study (# Patients)	Direction of Association/Findings	Overall SoE/Domains
SGA	Mortality	Traumatic Injury	1 SR, Dijkink et al. 2020[30]	1 prospective cohort trial (161)	Inconclusive Goiburu et al. 2006, n=161, RR: 4.0, 95% CI: 1.0 to 15.0	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
SGA	Mortality	ICU	1 SR Lew et al. 2016[31]	4 prospective cohort trials (729)	Increased Fontes et al. 2014, n=185, AOR: 8.12, 95% CI: 2.94 to 22.42, p<0.05; Sheean et al. 2013, n=260, WN: 4.8%, MN: 23.0%, p<0.01 2 studies non-significant trend for increase (Capossi et al. 2012, n=246, AOR: 2.00, 95% CI: 0.50 to 7.60; Merli et al. 2010, n=38, p=0.10)	**Low** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (small sample size)
SGA	Length of Stay *Ratio statistics measure likelihood of staying longer	Traumatic Injury	1 SR, Dijkink et al. 2020[30]	1 prospective cohort trial (161)	Inconclusive Goiburu et al. 2006, n=161: Hosp >14 days, RR: 2.30, 95% CI: 1.2 to 4.7	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
SGA	Length of Stay *Ratio statistics measure likelihood of staying longer	ICU	1 SR Lew et al. 2016[31]	4 prospective cohort trials (1,737)	Increased Caporossi et al. 2012, n=246, AOR: 2.80, 95% CI: 1.50 to 7.70, p<0.01; Merli, 2010, n=38, ICU AHR 0.18, p<0.01, Hosp AHR 0.20, p<0.01 Smaller HR indicates longer LOS for MN pts. Lomivorotov 2013, n=1193, Hosp >2 days, AOR: 2.00, 95% CI: 1.10 to 3.70, p=0.02 1 study non-significant trend for increase (Sheean, 2013, n=260, ICU adjusted p=0.11; Hosp adjusted p=0.08)	**Moderate** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Precise

Intervention	Outcome	Population	Reference	Number and Type of Study (# Patients)	Direction of Association/Findings	Overall SoE/Domains
SGA	ICU readmission during index hospital stay	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort trial (185)	Inconclusive Fontes et al. 2014, AOR: 2.27, 95% CI: 1.08 to 4.80, p<0.005	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
SGA	HAC (delayed wound healing)	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort trial (38)	Inconclusive Merli et al. 2010, higher incidence of infection associated with MN compared to WN (4.5 vs 0.6 episodes per patient, adjusted, p<0.001)	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
SGA	Discharge Disposition	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort trial (260)	Inconclusive Sheean et al. 2013, 28.6% fewer MN pts discharged to home than well-nourished pts; adjusted p<0.001	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
MNA	Mortality	ICU	1 SR, Lew et al. 2016[31]	2 prospective cohort trials (1,453)	No association Lomivorotov et al. 2013, n=1193, p>0.05; Sheean et al. 2013, n=260, adj p=0.09	**Low** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (due to p>0.05)
MNA	Length of Stay	ICU	1 SR, Lew et al. 2016[31]	2 prospective cohort trials (1,752)	No association Lomivorotov et al 2013, n=1193, >2-day ICU stay, AOR: 1.40, 95% CI: 0.70 to 2.30; Sheean et al. 2013, n=260, adj p=0.17 Hosp, p=0.07 ICU	**Low** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (due to p>0.05)

Intervention	Outcome	Population	Reference	Number and Type of Study (# Patients)	Direction of Association/Findings	Overall SoE/Domains
MNA	HAC (post-operation complication)	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort trial (1,193)	Increased Lomivorotov et al. 2013, Post-op complications, AOR: 1.60, 95% CI: 1.10 to 2.20, p<0.01	**Low** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Precise (single study)
NRS-2002	Mortality	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort trial (260)	Inconclusive 1 study found MN associated with greater hospital mortality (Sheean et al. 2013, adjusted p=0.03) compared to WN	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
NRS-2002	Length of Stay	ICU	1 SR, Lew et al. 2016[31]	2 prospective cohort trials (1,453)	Inconclusive 1 of 2 studies found MN associated with increased LOS >2 days (Lomivorotov et al. 2013, n=1193, AOR: 1.80, 95% CI: 1.10 to 3.30) No difference: Sheean et al. 2013, n=260	**Insufficient** Risk of bias: Moderate Consistency: Inconsistent Directness: Direct Precision: Imprecise
NRS-2002	HAC	Traumatic injury	1 SR, Dijkink et al. 2020[30]	2 prospective cohort trials (2,163)	Increased Ihle et al. 2017, n=521: ≥1 AE associated with MN (p<0.001) Wintermeyer et al. 2019, n=1,642: ≥1 AE associated with MN (p<0.001)	**Low** Risk of bias: High Consistency: Consistent Directness: Direct Precision: Precise
MUST	Mortality	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (109)	Inconclusive Tripathy et al. 2014, found MN associated with 1-year mortality (AOR: 2.94, 95% CI: 1.10 to 8.00)	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)

Intervention	Outcome	Population	Reference	Number and Type of Study (# Patients)	Direction of Association/Findings	Overall SoE/Domains
MUST	Length of stay	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (1,193)	Inconclusive Lomivorotov et al. 2013, found no association, AOR >2 day of ICU stay: 1.20, 95% CI: 0.90 to 2.00, p=0.33	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
MUST	HAC	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (1,193)	Inconclusive Lomivorotov et al. 2013, found no association with post-operative complications, AOR: 1.3, 95% CI: 0.90 to 2.00), p=0.11	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
MNA-SF	Mortality	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (260)	Inconclusive Sheean et al. 2013, adj p<0.01 (no further details reported)	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
MNA-SF	Length of Stay	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (260)	Inconclusive Sheean et al. 2013, adj p=0.06 (no further details reported)	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
MNA-SF	Discharge Disposition	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (260)	Inconclusive Sheean et al. 2013, adj p=0.19 (no further details reported)	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)

Intervention	Outcome	Population	Reference	Number and Type of Study (# Patients)	Direction of Association/Findings	Overall SoE/Domains
SNAQ	Mortality	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (325)	Inconclusive van Venrooji et al. 2011, p>0.05 (no further details reported)	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
SNAQ	Length of Stay	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (325)	Inconclusive van Venrooji et al. 2011, p>0.05 (no further details reported)	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
SNAQ	HAC	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (1,193)	Inconclusive Lomivorotov et al. 2013, Post-operative complications, AOR: 1.30, 95% CI: 0.90 to 2.00, p=0.11	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
PINI	Mortality	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (83)	Inconclusive In Schlossmacher et al. 2002, p=0.49 (no further details reported)	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)
PINI	Length of Stay	ICU	1 SR, Lew et al. 2016[31]	1 prospective cohort (83)	Inconclusive Schlossmacher et al. 2002, p>0.05 (no further details reported)	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Imprecision: Imprecise (p>0.05)

Note: Following AHRQ guidance, we rated the initial SOE as moderate if the authors of the reviews rated the ROB of included studies as low or moderate and indicated that studies conducted analyses to control for critical confounders, such as age and severity of illness.

AHRQ = Agency for Healthcare Research and Quality; ARM = at risk of malnutrition; AOR = adjusted odds ratio; CI = confidence intervals; HAC = hospital acquired condition; HR = hazard ratio; MN = malnourished; ICU = intensive care unit; MNA = Mini Nutritional Assessment; MNA-SF = MNA-short form; MUST = Malnutrition Universal Screening Tool; NR = not reported; NRI = Nutritional Risk Index; NRS-2002 = Nutritional Risk Score, OR = odds ratio; PINI = Prognostic Inflammatory and Nutrition Index; ROB = risk of bias; RR = risk ratio; SNAQ = Short Nutritional Assessment Questionnaire; SOE = strength of evidence; WN = well-nourished

Malnutrition Among Patients Hospitalized for Decompensations of Chronic Disease

The relationship between chronic disease and malnutrition is complex. Malnutrition is a consequence, complication, and cause of deterioration of many chronic illnesses.[34] Chronic illnesses with an underlying condition of inflammation or oxidative stress have potential for increased risk of malnutrition because inflammation increases catabolism of amino acids in lean body mass and can ultimately reduce functionality. For instance, patients with heart failure (HF)-related malnutrition often enter a vicious cycle of undernutrition, inflammation, and cachexia.[34] Progression of this cycle begins with HF-related undernutrition, which leads to the exacerbation of fluid retention, inflammation, neurohormonal activation and, ultimately, further deterioration of nutritional status and poor prognosis.

We included 4 SRs (including 29 relevant unique studies) that focused on the association of malnutrition with clinical outcomes among patients hospitalized due to complications related to various chronic diseases, such as heart failure,[32] cancer,[33] COPD,[34] and liver transplant.[35] Prevalence of malnutrition across studies included in these SRs ranged from 8 percnetto 90 percent, with prevalence varying depending on patient population and tool used to identify malnutrition (Table D-2, Appendix D). For instance, prevalence among patients with HF ranged from 16 percent to 90 percent in studies using the MNA and 22 percent to 48 percent among studies using the Geriatric Nutritional Risk Index (GNRI). Table 5 presents the SOE ratings for all assessed outcomes by measurement tool. The table is organized by measurement tool and outcome and includes columns indicating what study provided the data (reference), findings and direction of findings (e.g., no association, increased/decreased occurrence of outcome), and strength of evidence rating.

Heart Failure

One SR (Lin et al. 2016) included 11 studies assessing the association between malnutrition and hospital outcomes in patients with heart failure.[32] Included studies measured malnutrition using MNA (5 studies), MNA-SF (2 studies), Nutritional Risk Index (NRI, 3 studies), and GNRI (4 studies). Four studies (n=472; Bonilla et al. 2011; Sargento et al. 2013; Aggarwal et al. 2013; Suzuki et al. 2015) demonstrated that patients hospitalized with heart failure and diagnosed with malnutrition (using MNA) may be at increased risk of mortality compared to well-nourished patients with heart failure (pooled hazard ratio [HR]: 4.32, 95 percent CI: 2.30 to 8.11, I^2=0.0 percent, SOE: Low). Of note, 1 small study (Sargento et al. 2013) included non-hospitalized heart failure patients. Studies using NRI and GNRI to identify patients at risk of malnutrition also demonstrated that risk of malnutrition may be associated with increased mortality. For other outcomes measured in this review (e.g., length of stay [LOS] and 30-day readmission), evidence was either not reported or insufficient to draw any conclusions about the association between malnutrition and other clinical outcomes.

Cancer

One SR (Gupta et al. 2011) included 6 prospective cohort studies assessing whether malnutrition measured using SGA in cancer patients was associated with increased hospital length of stay.[33] Five of these prospective cohort trials included a combined 1,930 patients of which a majority (n=1,354) had gastrointestinal cancers (Wu et al. 2010; Wu et al. 2009; Wakahara et al. 2007; Shirodkar et al. 2005; Ulander et al. 1998). Pooled analysis showed that

patients hospitalized with cancer and diagnosed with malnutrition (using SGA) may stay in the hospital on average up to 11 days longer than well-nourished patients (mean days: WN=13; MN=24, p<0.05). The remaining prospective cohort study (Laky et al. 2010, n=157) of patients with presumed or proven gynecological cancer found a non-significant trend towards prolonged hospital length of stay in patients identified as malnourished versus well-nourished using patient-generated SGA (PG-SGA).

COPD

One SR (Muscariotoli et al. 2018) included 2 studies that assessed the association between malnutrition and hospital readmission among patients hospitalized for complications related to COPD.[34] One study used MNA to identify malnutrition (Benedik et al., 2005), while the other study used MUST (Steer et al., 2010). Evidence from both studies was rated insufficient due to high risk of bias and imprecision.

Cirrhosis and Liver Transplant

One SR (Ney et al. 2019[35]) evaluated the association between malnutrition (diagnosed using the SGA) and clinical outcomes pre and post-liver transplant among patients hospitalized for cirrhosis. The SR included 3 studies which found that malnutrition may be associated with pre-transplant mortality (RR: 2.40, 95percentCI: 1.16 to 4.96; Ciocirlan et al., 2017; Nunes et al., 2017; Alvaras et al., 2005). Another 3 studies found insufficient evidence to support an association between malnutrition (diagnosed using the SGA) and post-transplant mortality (Bakshi et al., 2016; Stephenson et al., 2001; and Pikul et al., 1994). Similarly, the evidence was insufficient to support an association between malnutrition and post-transplant length of stay (Stephenson et al., 2001; Pikul et al., 1994).

Table 5. Strength of evidence ratings by measurement tool for patients with chronic diseases

Intervention	Outcome	Population	Reference	Number and Type of Study (Patients)	Direction of Association/Findings	Overall SoE/Domain
MNA	Mortality	Heart Failure	1 SR Lin et al. 2016[32]	3 prospective, 1 retrospective cohort trial (472)	Increased Pooled HR: 4.32, 95% CI: 2.30 to 8.11, I^2=0.0%; Bonilla et al. 2011; Sargento et al. 2013; Aggarwal et al. 2013; Suzuki et al. 2015	**Low** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (small sample size)
MNA-SF	Mortality	Heart Failure	1 SR Lin et al. 2016[32]	1 prospective, 1 retrospective cohort trial (212)	Inconclusive Pooled HR: 3.56, 95% CI: 1.41 to 9.00, I^2=0.0%; Yost et al. 2014; Sargento et al. 2013	**Insufficient** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (small sample size)
NRI	Mortality	Heart Failure	1 SR Lin et al. 2016[32]	2 prospective, 1 retrospective cohort trial (1,785)	Increased Pooled HR: 2.08, 95% CI: 1.60 to 2.71, I^2=44%; Aziz et al. 2011; Al-Naijer et al. 2015; Gouya et al. 2014	**Low** Risk of bias: High (no report of confounder analysis) Consistency: Consistent Directness: Direct Precision: Precise
GNRI	Mortality	Heart Failure	1 SR Lin et al. 2016[32]	2 prospective, 1 retrospective cohort trial (978)	Increased Pooled HR: 3.11, 95% CI: 1.69 to 5.74), I^2=70%; Narumi et al. 2013; Kinugasa et al. 2013; Kaneko et al. 2015	**Low** Risk of bias: High Consistency: Consistent Directness: Direct Precision: Precise
NRS-2002	Length of Stay	Heart Failure	1 SR Lin et al. 2016[32]	1 prospective cohort trial (131)	Inconclusive OR: 2.99, 95% CI: 1.33 to 6.73; Tevik et al. 2014	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)

Intervention	Outcome	Population	Reference	Number and Type of Study (Patients)	Direction of Association/Findings	Overall SoE/Domain
SGA	Length of Stay	Cancer	1 SR; Gupta et al. 2011[33]	5 prospective cohort trials (1,930)	Increased Mean days: WN=13; MN=24, p<0.05; Wu et al. 2010; Wu et al. 2009; Wakahara et al. 2007; Shirodkar et al. 2005; Ulander et al. 1998 *Mean days calculated by ECRI	**Low** Risk of bias: High Consistency: Consistent Directness: Direct Precision: Precise
PG-SGA	Length of Stay	Cancer	1 SR; Gupta et al. 2011[33]	1 prospective cohort trial (157)	Inconclusive AOR >5 days: 5.28 (0.98 to 28.5), p>0.05; Laky et al. 2010	**Insufficient** Risk of bias: Moderate Consistency: Unknown Directness: Direct Precision: Imprecise (p>0.05)
MNA	Readmission at 6 months	COPD	1 SR; Muscariotoli et al. 2018[34]	1 prospective cohort trial (108)	Inconclusive MN group Readmitted within 6 months; malnourished 67%; at-risk 39%; well-nourished 35%; p=0.10; Benedik et al. 2005	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Precision: Imprecise (p>0.05)
MUST	30-day Readmission	COPD	1 SR; Muscariotoli et al. 2018[34]	1 prospective cohort trial (547)	Inconclusive OR: 1.71, 95% CI: 1.04 to 2.83, p=0.034; Steer et al. 2010	**Insufficient** Risk of bias: High Consistency: Unknown Directness: Direct Precision: Imprecise (small sample size)
SGA	Mortality (pre-transplant)	Cirrhosis	1 SR; Ney et al. 2019[35]	3 prospective cohort trials (277)	Increased Pooled RR: 2.40, 95% CI: 1.16 to 4.96, I^2=14%; Ciocirlan et al. 2017; Nunes et al. 2017; Alvaras et al. 2005	**Low** Risk of bias: Moderate Consistency: Consistent Directness: Direct Precision: Imprecise (small sample size)

Intervention	Outcome	Population	Reference	Number and Type of Study (Patients)	Direction of Association/Findings	Overall SoE/Domain
SGA	Mortality (post-transplant)	Cirrhosis	1 SR; Ney et al. 2019[35]	3 prospective cohort trials (153)	Inconclusive Bakshi et al. 2016: RR: 0.66, 95% CI: 0.10 to 4.55; Stephenson et al. 2001: RR: 5.23, 95% CI: 1.07 to 25.54; Pikul et al. 1994, RR: 5.73, 95% CI: 0.36 to 97.2	**Insufficient** Risk of bias: High Consistency: Inconsistent Directness: Direct Imprecision: Imprecise (small sample size)
SGA	Length of Stay	Cirrhosis	1 SR; Ney et al. 2019[35]	2 prospective cohort trials (98)	Inconclusive Pooled RR: 4.35, 95% CI: 5.42 to 22.69, I^2=93%; Pikul et al. 1994; Stephenson et al. 2001	**Insufficient** Risk of bias: High Consistency: Consistent Directness: Direct Precision: Imprecise (small sample size)

Note: Following AHRQ guidance, we rated the initial SOE as moderate if the authors of the reviews rated the ROB of included studies as low or moderate and indicated that studies conducted analyses to control for critical confounders, such as age and severity of illness.

AOR = adjusted odds ration; CI = confidence intervals; HAC = hospital acquired condition; HR = hazard ratio; MNA = Mini Nutritional Assessment; MNA-SF = MNA-short form; MUST = Malnutrition Universal Screening Tool; NR = not reported; NRI = Nutritional Risk Index; NRS-2002 = Nutritional Risk Score, OR = odds ratio; PINI = Prognostic Inflammatory and Nutrition Index; RR = risk ratio; SNAQ = Short Nutritional Assessment Questionnaire

Key Question 2. What is the effectiveness of screening or diagnostic assessment for malnutrition among hospitalized adults?

a. In studies that report on clinical outcomes, what is the accuracy of screening or diagnostic tools for malnutrition?
b. In studies that report on clinical outcomes, what is the effectiveness of screening or diagnostic tools on measures of nutrition (nutritional stores)?
c. What is the impact of the use of screening or diagnostic tools on clinical outcomes?

Description of Included Evidence

Our literature searches found no studies that met inclusion criteria and addressed KQ 2 or its sub-questions.

We screened 38 abstracts of studies that potentially addressed KQ 2. Twenty-six were excluded for the following reasons: population not of interest, intervention not of interest, setting not of interest, addressed a different KQ, generally off-topic, and not in English. We reviewed 12 studies at the full text level and excluded 11 primarily for not having the appropriate study design to address the question. In most cases, studies were excluded at full-text level for not including an appropriate control. Appropriate controls for this KQ would include a non-exposed group of patients who did not receive screening or diagnostic assessment or a concurrent cohort of patients who received another screening or assessment tool (e.g., reference standard).

One prospective cohort study by Rypkema et al. (2003)[36] did compare diagnostic assessment of malnutrition to an appropriate control (no diagnostic assessment) with patients diagnosed with malnutrition subsequently receiving a nutritional intervention. However, in addition to including patients that screened positive for malnutrition, the study also included patients screening positive for additional diagnoses, such as dehydration or dysphagia, and failed to report outcomes for malnourished patients separately. We contacted the authors to request subgroup analysis results, but the data were no longer archived. Thus, this study was excluded.

Key Points

- We identified no studies that met inclusion criteria and addressed KQ 2 or its sub-questions.
- The primary reason studies did not meet inclusion criteria for KQ 2 was failure to have an appropriate control group.
- Evidence gaps for KQ 2 underscore the need for future research that addresses the effectiveness of screening for malnutrition on clinical outcomes. Such research is vital to establish the role of inpatient screening and its downstream implications on patient-relevant outcomes.

Summary of Findings

The goal of KQ 2 was to assess the clinical utility of malnutrition measurement tools (i.e., screening or diagnostic assessments) for malnutrition. Specifically, this question was intended to

determine whether performing malnutrition screening and/or diagnostic assessment prompts actions that change either nutritional stores or key clinical outcomes, such as mortality, length of stay, or hospital acquired complications.

Assessing the clinical utility of malnutrition measurement tools requires consideration of multiple study design factors, of which the most important are 1) inclusion of an appropriate control group and 2) reporting on changes in clinical outcomes. The most appropriate control for studies assessing the clinical utility of measurement tools would be patients who do not receive screening or diagnostic assessment. Without such a control group, it is not possible to determine if any observed study effects are attributable to the tool. In addition, to adequately assess clinical utility, studies would also need to report on changes in clinical outcomes. Thus, studies that are soley designed to measure diagnostic accuracy are not adequate for assessing clinical utility. Instead, diagnostic accuracy studies are focused on evaluating the sensitivity and specificity of a screening or diagnostic assessment tool compared with a reference standard, and typically do not include a non-exposed control group or report on associated clinical outcomes. Finally, other study designs, such as retrospective, before/after, and other non-prospective (or non-concurrent comparison) observational studies are problematic due to their potential for bias associated with confounder effects and patient selection.

Studies that would most directly inform KQ 2 would randomize hospitalized patients to a measurement tool vs. no measurement tool (See Figure 2 in the Methods section). However, in the US, hospital accreditation by The Joint Commission mandates screening. This existing mandate presents clear pragmatic challenges to randomizing U.S. patients to screening vs. no screening. Future trials could still randomize patients to different screening tools to assess the impact of various tools on clinical outcomes. Ideally, a study could screen all patients and randomize "at-risk" patients to SGA, no diagnostic assessment, or another tool (e.g., Global Leadership Initiative on Malnuttrition [GLIM]). Participants in both of these groups would then be identified as either malnourished, leading to an intervention, or not malnourished, resulting in no intervention or continued standard care. Another design could utilize all types of diagnostic assessments for "at-risk" patients, given that these assessments are non-invasive, and then randomize malnutrition interventions based on just one of these assessments. This would provide insight regarding the clinical course for patients who are false negatives and any potential harms of using specific tools.

Table 6 presents reasons studies were excluded at the full-text level for KQ 2. Several studies were screened that reported diagnostic accuracy and associated prognostic clinical outcomes. However, no studies were identified that allowed determination of the effectiveness of malnutrition screening or diagnostic assessment based on criteria presented in Figure 3 and described in our review protocol. While study design was the most common primary reason for exclusion, there were also important secondary reasons for exclusion. Aside from not having an appropriate control, eleven studies were also excluded because they did not include an appropriate reference standard comparator for diagnostic assessment.[37] Of these, eight did not include any comparator,[37] two used inappropriate reference standard comparators,[38,39] and one utilized historic controls.[40] No studies reviewed at the full-text level reported intermediate outcomes for direct measures of nutrition stores (KQ 2b).

Several randomized controlled trials (RCTs) that reached full-text review did not randomize patients to either a screening or diagnostic assessment tool, but instead randomized patients to an intervention for treatment after results of malnutrition testing in both arms were known, and were therefore included as part of KQ 3.[41,42] Similarly, if studies at full-text level screening were

nonrandomized, lacking a concurrent unexposed group, and reported only on association of malnutrition with outcomes, they were included in KQ 1 (if included within a systematic review).[32,43,44]

Table 6. Evaluation of PICOs of studies excluded at full-text level for Key Question 2

Reference	Tool Used (Screening or Diagnostic)	Population: Hospitalized Patients (Condition)	Intervention: Screened/Assessed for MN (Tool Used)	Control: Unexposed Arm	Comparator: Used Appropriate Reference Standard	Intermediate Outcome: Diagnostic Accuracy Outcomes (KQ 2a)	Intermediate Outcome: Direct Measures of Nutrition Stores (KQ 2b)	Outcomes: Clinical Outcomes
Zhang et al. 2021[45]	Screening and diagnostic	Yes (adult patients with cancer)	Yes (NRS-2002, MUST, PG-SGA, GLIM)	No*	No	Yes	No	No
Kroc et al. 2021[46]	Screening and diagnostic	Yes	Yes (SGA, NRS-2002)	No*	No	Yes	No	Yes
Thelia et al. 2020[9]	Diagnostic assessment	Yes (critical care patients)	Yes (GLIM)	No*	Yes (SGA)	Yes	No	No
Thomas et al. 2019[38]	Screening and diagnostic	Yes (vascular surgery patients)	Yes (MST, MUST, NRS-2002, MNA-SF)	No*	No (Used PG-SGA as reference standard)	Yes	No	Yes
Becker et al. 2019[47]	Diagnostic assessment	Yes	Yes (MNA)	No*	No	No	No	Yes
Omidvari et al. 2016[48] Systematic Review	Screening and diagnostic	Yes	Yes (Multiple)	NR*	NR	NR	NR	Yes
Lin et al. 2016[32] Systematic Review	Screening and diagnostic	Yes	Yes (Multiple)	NR* (included in KQ 1)	NR	NR	NR	Yes
Tapia et al. 2015[37]	Screening only	Yes	Yes (NRI, GNRI)	No*	Yes (SGA reported, but study did not use as reference standard)	No	No	Yes
Olveira et al. 2013[49]	Screening only	Yes	Yes (NRI, GNRI)	No*	Yes (SGA reported but study did not use as reference standard)	No	No	Yes

Reference	Tool Used (Screening or Diagnostic)	Population: Hospitalized Patients (Condition)	Intervention: Screened/Assessed for MN (Tool Used)	Control: Unexposed Arm	Comparator: Used Appropriate Reference Standard	Intermediate Outcome: Diagnostic Accuracy Outcomes (KQ 2a)	Intermediate Outcome: Direct Measures of Nutrition Stores (KQ 2b)	Outcomes: Clinical Outcomes
Lomivorotov et al. 2013[43]	Screening and diagnostic	Yes (scheduled heart valve surgery)	Yes (SNAQ, MUST, NRS-2002, MNA)	No* (included in KQ 1)	Yes (SGA)	Yes	No	Yes
Holyday et al. 2012[41]	Screening and diagnostic	Yes	Yes (MNA)	No* (included in KQ 3)	No	No	No	Yes
Velasco et al. 2011[44]	Screening and diagnostic	Yes	Yes (NRS-2002, MUST, MNA)	No*	Yes (SGA)	Yes	No	Yes
Kruizenga et al. 2005[40]	Screening only	Yes	Yes (SNAQ)	No* (Used historical controls)	No (Used historical controls)	No	No	Yes
Martins et al. 2005[39]	Screening and diagnostic	Yes	Yes (MNA, MUST, SGA)	No*	No (Used NRS as reference standard)	No	No	Yes
Johansen et al. 2004[42]	Screening only	Yes	Yes (NRS-2002)	No* (included in KQ 3)	No	No	No	Yes
Rypkema et al. 2003[36]	Diagnostic assessment	Yes	No* Screened with MNA-SF, but also included screening for dysphagia or dehydration	Yes	No*	No	No	Yes

*Primary reason for excluding study.

Legend: This table shows the key criteria for studies to meet inclusion for Key Question 2. The "control group" should be an unexposed cohort that did not receive the screening tool or diagnostic assessment. Appropriate reference standards include: For studies examining screening tools, the reference standard would be no screening or usual care, or a gold standard like imaging modalities to assess body composition or SGA. If a diagnostic tool was used, the reference standard should be radiographic imaging or SGA.

MNA = Mini Nutritional Assessment; MNA-SF = MNA-short form; MUST = Malnutrition Universal Screening Tool; NR = not reported; NRI = Nutritional Risk Index; NRS-2002 = Nutritional Risk Score, PICO = Patient, Intervention, Comparator, Outcome; PINI = Prognostic Inflammatory and Nutrition Index; SNAQ = Short Nutritional Assessment Questionnaire

Key Question 3. Among patients diagnosed with malnutrition, what is the effectiveness of hospital-initiated interventions used to treat malnutrition on clinical outcomes?

Description of Included Evidence

Our searches identified 11 RCTs (n=3,748) that met inclusion criteria and evaluated hospital-initiated interventions for patients hospitalized for various clinical conditions who were also identified as malnourished. For inclusion, all patients in these trials met criteria for malnutrition or at-risk for malnutrition as measured by one of the following tools: MNA, MUST, NRS-2002, PG-SGA, and SGA (see Table 7). One study assessed outcomes for well-nourished, at-risk, and malnourished patient subgroups separately.[41] All other studies focused solely on either malnourished, at-risk, or combined at-risk and malnourished patients. Below, we briefly describe characteristics about the included studies. More detailed information is presented in Table D-3 in Appendix D.

Study Characteristics

Patients enrolled in the included trials were hospitalized for a variety of conditions including cancer, cardiovascular disease, gastrointestinal disorder, heart failure, infectious disease, neurological disorder, pulmonary disease, renal disease, or stroke. Although most studies did not specify an admitting diagnosis for inclusion, two studies only included patients hospitalized for heart failure[50] or stroke.[51] Three studies had minimum age requirements for inclusion of 60,[52] 65,[53] and 75.[54] Four studies were large multicenter clinical trials.[42,50,53,55] Only one study (Deutz et al.) was performed in the U.S.[53] Of the remaining 10 studies, 2 were performed in Australia and the remainder in Europe. Study participants were generally older (mean age of patients ranged from 62 to 83.2). Mean BMI at admission ranged from 19.0 to 26.9, and mean weight ranged from 52.6 kg to 70.9 kg. Only one study reported on race and socioeconomic status.[53]

Interventions

Included RCTs assessed two types of interventions: specialized nutrition care and increased protein/calorie provision (see Table 8). Eight trials (n=2,965) assessed specialized nutrition care where patients received individualized consultation from nutrition specialists for goal setting and increasing patients' protein and calorie consumption during hospitalization.[41,42,50-52,55-57] The other 3 trials assessed increasing protein/calorie provision either through a high protein/high calorie oral supplement (containing beta-hydroxybeta-methylbutyrate),[53] a high protein/high calorie liquid supplement (with 500 kcal and 21 grams of protein),[54] or through protein and calorie fortified meal choices.[58] The control group in 9 of 11 studies was usual care without any modifiers to routine clinical practice.[41,42,50-52,54-56,58] Usual care in four studies could include a malnutrition care plan,[41] dietary consultation,[52] an oral nutrition supplement prescription,[56] or tube feeding[51] at the discretion of the provider. The remaining five studies provided no details describing usual care.[42,50,54,55,58] In one study of high protein/calorie nutritional supplementation, the control group received a placebo without other nutritional interventions.[53] In another study of specialized nutrition care,[57] patients were provided usual care along with an energy-dense supplement but not given any further nutritional instructions.

Of note, no studies assessing parenteral or enteral support interventions met criteria for inclusion, primarily because studies assessing these interventions did not restrict enrollment to patients who were diagnosed as at-risk of malnutrition or malnourished based on commonly available measurement tools. Instead, these studies relied on ICU admission, surgical status, or biometrics (e.g., BMI, serum albumin levels) as a proxy for malnutrition status.

Table 7. Characteristics of studies assessing the effect of hospital-initiated intervention to treat malnutrition

Study	Enrollment Requirement Malnutrition Status Based on Score	Intervention	Risk of Bias
Bonilla-Palomas 2016[50]	Malnourished MNA score <17	Specialized Nutrition Care	Some Concerns
Deutz 2016[53]	At-Risk & Malnourished SGA score B or C	Protein/Calorie Supplementation	Some Concerns
Gazzotti 2003[54]	At-Risk MNA score between 17 and 23.5	Protein/Calorie Supplementation	Some Concerns
Ha 2010[51]	At-Risk & Malnourished MUST score >0	Specialized Nutrition Care	High
Holyday 2011[41] At Risk	At-Risk MNA score between 17 and 23.5	Specialized Nutrition Care	High
Holyday 2011[41] Malnourished	Malnourished MNA score <17	Specialized Nutrition Care	High
Johansen 2004[42]	At-Risk & Malnourished NRS 2002 score ≥3	Specialized Nutrition Care	High
Munk 2014[57]	At-Risk & Malnourished NRS 2002 score ≥3	Protein/Calorie Supplementation	Some Concerns
Rufenacht 2011[58]	At-Risk & Malnourished NRS 2002 score ≥3	Specialized Nutrition Care	Some Concerns (mortality) High (other relevant outcomes)
Schuetz 2019[55]	At-Risk & Malnourished NRS 2002 score ≥3	Specialized Nutrition Care	Low (objective outcomes) High (quality of life)
Sharma 2017[52]	At-Risk & Malnourished PG SGA score B or C	Specialized Nutrition Care	High
Starke 2011[56]	At-Risk & Malnourished NRS 2002 score ≥3	Specialized Nutrition Care	Some Concerns (objective outcomes) High (quality of life)

Note: Due to the paucity of literature identified for Key Question 3 in which patients were diagnosed with malnutrition using diagnostic assessment tools (such as Subjective Global Assessment [SGA] or Mini Nutritional Assessemnt [MNA]), we accepted studies in which patients were identified as at-risk of malnutrition using cutoff scores on screening tools (such as NRS-2002 and MUST).

Risk of Bias Ratings

We assessed ROB separately for objective (e.g., mortality, readmissions, and length of stay) and subjective (e.g., quality of life) outcomes given differences in how these outcomes are measured. Domain level ROB, such as adequate randomization and allocation concealment, missing outcome data, and appropriate outcome measurement, informed overall ROB rating for each outcome. An overall ROB rating of low meant all domain level assessments were low, whereas a rating of high indicated that at least one domain level assessment was high. If a study contained a combination of low and some concerns for domain level assessments, the rater decided between an overall ROB of some concerns or high based on how the domain level assessment impacts confidence in the result. For one study,[52] we assessed risk of bias for readmissions separately from other objective outcomes because, in addition to the dietary intervention, the intervention group also received monthly telehealth calls. These telehealth visits after initial dietary consultation reinforced the intervention and potentially impacted outcomes. Table 7 summarizes the ROB across studies, and Table E-2 in Appendix E provides detailed ROB ratings at the study and outcome level.

Overall, a large proportion of studies (7 of 11 studies) were rated high risk of bias for at least one outcome.[41,42,51,52,55-57] The remaining studies (4 of 11) contained at least one outcome with some concerns.[50,53,54,58] Studies with domains rated as "some concerns" had problems such as failing to report adequate randomization, unknown allocation concealment techniques, or lack of clarity regarding whether all pre-specified outcomes were reported. In addition to these problems, studies with outcomes rated as "high" risk of bias had problems such as high dropout (over 20 percent), inadequate blinding of outcome assessors, or use of subgroup analyses to highlight statistically significant results.

Key Points

- Hospital-initiated malnutrition interventions (specialized nutrition care, protein/calorie supplementation) likely decrease mortality compared to usual care. (SOE: Moderate)
- Hospital-initiated malnutrition interventions may improve quality of life compared to usual care. (SOE: Low)
- No difference was observed between hospital-initiated malnutrition interventions and usual care for length of stay, readmission rates, and hospital acquired conditions compared to usual care. (SOE: Low)
- Evidence was insufficient to address the effect of hospital-initiated malnutrition interventions on activities of daily living and discharge disposition compared to usual care. (SOE: Insufficient)

Summary of Findings

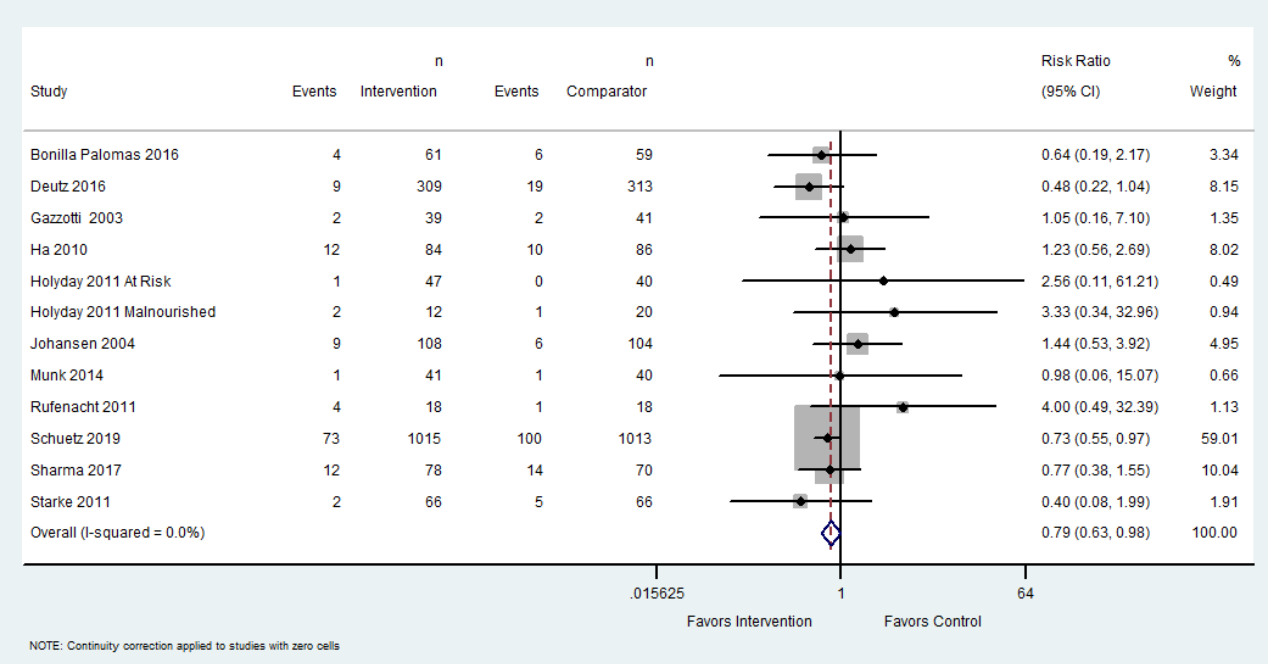
Compared to usual care, we found moderate quality evidence that hospital-initiated malnutrition interventions improved hospital-based mortality and low-quality evidence that it improves quality of life. For all other outcomes of interest, the evidence showed either no difference between groups or was considered insufficient due to study limitations and inconsistencies in the reported findings. Strength of evidence ratings for all outcomes considered are presented in Table 8. One study[50] was discontinued early because interim analysis determined a large beneficial effect. All other studies had no detected risk of reporting bias. We

describe findings by specific outcomes below. All study level findings are presented in Table F-2 in Appendix F, and all meta-analytic results are presented in Figures 4 and 5, as well as Figures G-1 to G-13 in Appendix G.

Mortality

All 11 studies reported on mortality with follow-up ranging from 7 days to 6 months. Pooled analysis of these studies found malnutrition-focused interventions reduced mortality by 21 percent when compared to usual care (RR: 0.79, 95 percent CI: 0.63 to 0.98, I^2=0.0 percent).[41,42,50-58] The pooled estimate was driven largely by one study,[55] which contributed nearly two-thirds of the weight (See Figure 4). This multicenter Swiss study (Schuetz et al. 2019) enrolled over 1,000 hospitalized patients per arm with a range of primary diagnoses including cancer, cardiovascular disease, and infection and meeting criteria for at-risk for malnutrition or malnourished. Patients were followed for one month, and the study was rated low risk of bias for objective outcomes. Compared to patients randomized to usual care (standard hospital food), the study found that nutritional support (creating individualized targets and strategies to achieve targets within 48 hours of admission) was associated with a 27 percent lower mortality risk (RR: 0.73, 95 percent CI: 0.55 to 0.97), similar to the pooled estimate.

Figure 4. Effect of hospital-initiated interventions on mortality, all studies



CI = confidence interval; n = number of patients

Subgroup analyses were performed on malnutrition status, follow-up time, and type of treatment (See Appendix G, Figures G2-G4). When examining each type of intervention, there were reductions of 18 percent and 44 percent in mortality risk for specialized nutrition care and protein/calorie supplements, respectively, but the findings were no longer statistically significant. When examining different follow-up times, there were significant decreases in one-month (post-discharge) mortality risk. Both inpatient mortality and greater than one-month (post-discharge) mortality risk were not different between treatments. However, findings for these subgroup

analyses are impacted by low statistical power and small sample sizes. Therefore, these results should be interpreted with these limitations in mind.

Length of Stay

Nine out of 11 studies reported on length of stay. Pooled analysis of 9 studies showed a non-significant decrease of 0.18 days (weighted mean difference [WMD]: -0.18, 95 percent CI: -0.55 to 0.19, SOE: Low)[41,42,51-56,58] This pooled estimate was driven largely by two studies.[53,55] One study (Schuetz et al.) compared individualized consultation with a dietitian against usual care and found a non-significant 0.10 day decrease in length of stay (WMD: -0.10, 95 percent CI: -0.67 to 0.47). The other study (Deutz et al.) randomized patients to receive an oral high protein/high calorie supplement or placebo and also found a non-significant 0.10 day decrease in length of stay (WMD: -0.10, 95 percent CI: -0.64 to 0.44).

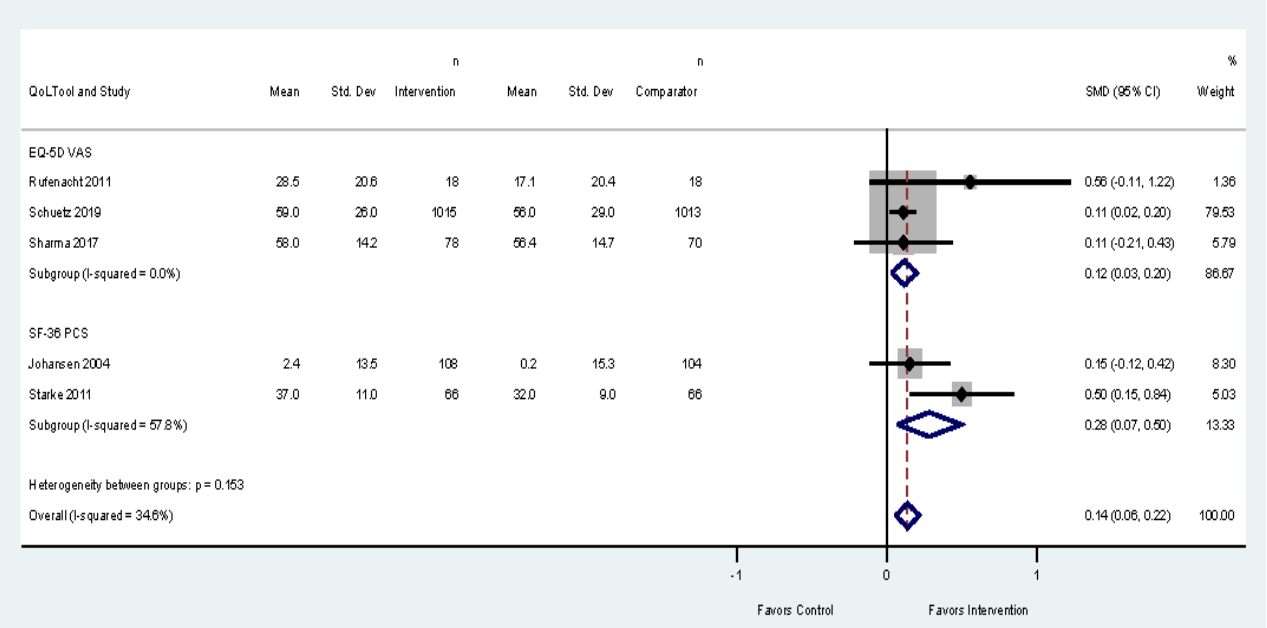
Readmissions

Seven out of 11 studies reported on readmissions with follow-up times ranging from 1 month to 6 months. The pooled estimate for readmission rates showed a non-significant decrease of 10 percent (RR: 0.90, 95 percent CI: 0.74 to 1.09) among patients who received a malnutrition-focused intervention.[41,50,52-56] The majority of the meta-analytic weight (around 85 percent) was based on 3 studies. Two of these studies specifically examined 30-day readmission rates,[53,55] whereas the other study[56] examined 6-month readmission. Since this was the follow-up time point with available data, we used this datapoint for our meta-analysis examining readmission. All individual studies contributing to the pooled estimate showed no significant difference.

Quality of Life

Six studies assessed the impact of specialized nutrition care on quality of life in at-risk and malnourished hospitalized patients. Four studies captured quality of life using the EuroQol five-dimension scale (EQ-5D),[51,52,55,57] and 2 studies used the 36-Item Short Form Health Survey (SF-36).[42,56] Study follow-up ranged from 1 to 3 months. Also, three studies reported change in quality of life from baseline,[42,53,57] whereas the other three reported quality of life scores at discharge.[52,55,56] Meta-analysis of data from 5 studies grouped by EQ-5D visual analogue scale (VAS) score or SF-36 physical component score (PCS) are shown in Figure 5. One study was not included due to inadequately reported data.[51] Pooled analysis found that compared to usual care, patients receiving specialized nutrition care had improved quality of life (standardized mean difference 0.14, 95 percent CI: 0.06 to 0.22, SOE: Low).

Figure 5. Effect of hospital-initiated interventions on quality of life, subgroup quality of life measurement tool



CI = confidence interval; EQ-5D; VAS = EuroQol 5 dimensional scale visual analogue scale; n = number of patients; SF-36 PCS = 36 item short form health survey physical component score; SMD = standardized mean difference

Activities of Daily Living

Two studies (Schuetz et al. 2019, Deutz et al. 2016) reported impact of hospital-initiated malnutrition interventions on activities of daily living (ADLs).[53,55] Both studies included at-risk and malnourished patients. Schuetz et al. found statistically significant improvement in functional status (measured by the Barthel Index) for patients randomized to specialized nutrition care at 1 month (compared to patients receiving standard hospital food).[55] However, a second, smaller study (Deutz et al) of 622 patients older than age 65 found that, compared to placebo, patients receiving an oral protein/calorie supplement had similar changes in ADLs (measured by Katz scores, p value not reported) at 1 month.[53] Given these mixed results and lack of any additional data to support pooled analysis, we judged the evidence insufficient to permit a conclusion.

Other Outcomes

Included studies also described the effect of hospital-initiated malnutrition interventions on hospital acquired conditions (HACs), adverse events, and discharge disposition. Designation of HACs or adverse events were based on author descriptions. Four studies reported the impact of hospital-initiated malnutrition interventions on HACs (secondary medical events or illnesses occurring during a hospital stay [e.g., acute kidney failure, infection, and stroke]). Three studies slightly favored the intervention on incidence of HACs.[52,55,56] The other study (Johansen et al. 2004) had no HACs in its control group, producing a very high relative risk score in favor of the control.[42] A pooled estimate of 4 studies with low strength of evidence found interventions were not associated with a statistically significant difference in HACs compared with usual care (RR: 0.89, 95 percent CI: 0.69 to 1.14).[42,52,55,56]

Three studies described the impact of hospital-initiated malnutrition interventions on occurrence of potentially treatment related adverse events (e.g. constipation, diarrhea,

hyperglycemia, and refeeding syndrome); these studies reported no difference in the number of patients experiencing adverse events across patients receiving intervention compared to the control arm (usual care).[53-55] Finally, only 2 studies reported the impact of hospital-initiated malnutrition interventions on discharge disposition. One study found no difference in patients discharged home (66.7 percent vs. 65 percent),[54] while the other study found no difference in patients discharged to a residential facility (7.7 percent vs 8.5 percent, p=0.09).[52] Evidence was insufficient to draw a conclusion regarding the effect of hospital-initiated malnutrition interventions on discharge disposition.

Comparison With Prior SRs

Two previous systematic reviews examined the impact of nutrition-focused interventions on hospitalized patients.[59,60] The most comprehensive review, Feinberg et al. (2017) included 244 RCTs.[59] Most studies included in this review did not meet our inclusion criteria due to publication date before 2000 (130 RCTs), at risk or malnourished status not confirmed by a commonly available measurement tool (105 RCTs), measurement tools not utilized in the United States, Australia, New Zealand, Canada, or Europe (2 RCTs), or not a comparison group of interest (1 RCT). Instead of using a commonly available measurement tool, many studies included in this review used ICU admission, surgical status, or biometrics (e.g., BMI, serum albumin, or weight loss) to identify patients as malnourished.

Only 6 studies included in Feinberg et al. 2017 met our criteria and were included. These studies examined mortality, quality of life, serious adverse events, BMI change, and weight change. Like our review, Feinberg and colleagues found that nutrition-focused interventions reduced mortality (RR: 0.94, 95 percent CI: 0.86 to 1.03). However, our review found a larger magnitude of effect which was also statistically significant. This difference may be in part because of a large multicenter study (Schuetz et al. 2019, 2,028 patients) published subsequent to the Feinberg review and included in ours.[55]

Another systematic review by Gomes et al. (2019) included 27 randomized and non-randomized controlled trials (published 1982 to 2019) evaluating the effectiveness of various nutritional support interventions (including dietary advice, changes in the organization of nutritional care, food fortification, extra snacks, oral nutrition supplements, and enteral tube feeding) used to treat non-critically ill hospitalized patients who were malnourished or at nutritional risk.[60] Patients were determined to be malnourished or at nutritional risk based on body mass index, the presence of a disease associated with malnutrition, or the use of a nutritional measurement tool. The review's primary outcome was mortality, but the review also considered secondary outcomes such as length of stay, readmission, functional outcomes, infection, protein/calorie intake, and weight change. A total of 8 studies overlapped between our review and Gomes's review. Generally, findings for mortality, length of stay, activities of daily living, and rates of infection were similar to our results. However, our review found that hospital-initiated malnutrition interventions were not associated with a statistically significant difference in readmission rates, while Gomes found a reduction.

Table 8. Strength of evidence ratings for interventions for malnutrition in patients diagnosed with malnutrition

Intervention/ Comparator	Outcome/ Followup	No Studies/No Patients	Direction/Findings	Risk of Bias	Consistency	Precision	Directness	Overall SoE
Any nutrition intervention versus usual care or placebo	Mortality 7 days to 6 months	11 RCTs[41,42,50-58] n=3,748	Decreased Pooled Estimate (11 studies): RR: 0.79 (95% CI: 0.63 to 0.98), Overall I^2=0.0%	Moderate	Consistent	Precise	Direct	Moderate
Any nutrition intervention versus usual care or placebo	Length of Stay	9 RCTs[41,42,51-56,58] n=3,592	No difference Pooled Estimate (9 studies): WMD: -0.18 (95% CI: -0.55 to 0.19), Overall I^2=35.5%	Moderate	Consistent	Imprecise	Direct	Low
Any nutrition intervention versus usual care or placebo	Readmissions 1 month to 6 months	7 RCTs[41,50,52-56*] n=3,249	No Difference Pooled Estimate (7 studies): RR: 0.90 (95% CI: 0.74 to 1.09), Overall I^2=8.1%	Moderate	Consistent	Imprecise	Direct	Low
Any nutrition intervention versus usual care	Quality of Life 1 month to 3 months	6 RCTs[42,51,52,55-57] n=2,726	Increased Pooled Estimate (5 studies): SMD: 0.14 (95% CI: 0.06 to 0.22), Overall I^2=34.6%	High	Consistent	Precise	Direct	Low
Any nutrition intervention versus usual care or placebo	Activities of Daily Living 3 months	2 RCTs[53,55] n=2,650	Inconclusive Barthel index favors intervention; Decline in functional status of ≥10%: favors intervention (1 RCT; n=2,028) Katz Score: Tx: 6 (Q1 6, Q3 6); CG: 6 (6, 6) (n=622; 1 RCT), p value NR	Low	Inconsistent	Imprecise (no information on 95% CIs of one of two estimates)	Direct	Insufficient
Any nutrition intervention versus usual care	Hospital Acquired Conditions 1 month to 3 months	4 RCTs[42,52,55,56] n=2,520	No Difference Pooled Estimate (4 studies): RR: 0.89 (95% CI: 0.69 to 1.14), Overall I^2=57.5%	Moderate	Consistent	Imprecise	Direct	Low

Intervention/ Comparator	Outcome/ Followup	No Studies/No Patients	Direction/Findings	Risk of Bias	Consistency	Precision	Directness	Overall SoE
Any nutrition intervention versus usual care	Discharge Disposition 2 months to 3 months	2 RCTs[52,54] n=228	Inconclusive Percent discharged home: ONS: 19.9 (2.0); CG: 20.2 (2.4) (n=80; 1 RCT); no difference Proportion of patients discharged to residential facility favors intervention (n=148; 1 RCT)	High	Inconsistent	Imprecise (no information on 95% CIs of one of two estimates)	Direct	Insufficient

*1-month, 3-month, and 6-month data extracted from survival analysis curves using a Web-based numerical data extraction tool (WebPlotDigitizer v 4.4) to estimate graphical data. 12-month mortality data matched text data, although, the survival analysis plot portrayed different results than described in text (Treatment 10.2% vs Control Group 36.1%). Data reported are from the survival analysis.

Note: We used the following 95% CI bounds recognized by GRADE and others to determine evidence of no difference: Summary estimates using ratio statistics: Lower CI 0.80 to Upper CI 1.25; Summary estimates using standardized mean difference: Lower CI -0.2 to Upper CI 0.2; Summary estimates using raw mean difference: Depends on measure or instrument; default is 20% difference on each side

CG = control group; CI = confidence interval; EQ-5D = EuroQol 5 dimension; NR = not reported; ONS = oral nutrition supplement; PCS = physical component summary; Q1 = first quartile; Q3 = third quartile; QoL = quality of life; RCT = randomized controlled trial; RR = relative risk; SF-36 = 36 item short form health survey; SMD = standardized mean difference; SOE = stenght of evidence; Tx = treatment; WMD = weighted mean difference

Discussion

In fiscal year 2020, Congress requested that the Agency for Healthcare Research and Quality (AHRQ) convene a panel of experts charged with developing quality measures for malnutrition-related hospital readmissions. At AHRQ's request, we conducted a systematic review to inform the deliberations and recommendations of this panel. We focused our Key Questions (KQs) on the following: 1) reviewing the association between malnutrition and clinical outcomes, 2) evaluating the effectiveness of screening and/or diagnostic assessment of malnutrition on clinical outcomes, and 3) assessing the effectiveness of hospital-initiated interventions to treat patients diagnosed with malnutrition

Findings in Relation to Decisional Dilemma(s)

Malnutrition and Clinical Outcomes

Our review confirmed that malnutrition (defined using commonly available measurement tools) is associated with poor clinical outcomes (KQ 1). Existing systematic reviews found low strength of evidence (SOE) that malnutrition may be associated with increased hospital mortality. This association was observed across patients hospitalized for acute medical conditions, heart failure, and cirrhosis. Moderate SOE also showed that malnutrition (diagnosed using Subjective Global Assessment [SGA]) was independently associated with prolonged hospital length of stay among patients hospitalized with acute medical conditions or cancer. Evidence for other measurement tools used to identify malnutrition (Nutritional Risk Screening-2002 [NRS-2002], Malnutrition Universal Screening Tool [MUST], Mini Nutritional Assessemt-Short Form [MNA-SF], Short Nutritional Assessment Questionnaire [SNAQ], and Prognosis Inflammatory and Nutritional Index PINI) was largely insufficient to determine if malnutrition was associated with clinical outcomes.

Malnutrition Screening and Interventions

Given the potentially detrimental effects of malnutrition, identifying patients who could benefit from further assessment or an intervention for malnutrition is crucial. Currently, U. S. hospitals are mandated to screen all hospitalized patients for malnutrition within 24 hours of admission. However, at present, whether such screening improves clinical outcomes remains unknown. Thus, KQ 2 aimed to assess if malnutrition screening and/or diagnostic assessment prompts actions that change either nutritional stores or key clinical outcomes, such as mortality, length of stay, readmissions, or hospital acquired complications.

As previously noted, we identified no studies addressing this question. Studies we excluded either lacked an unexposed group (i.e., no screening group) or used an inappropriate comparator (i.e., did not use an acceptable reference standard as a comparator). These studies were inadequate because without an unexposed group or appropriate control it was not possible to determine if any observed effects are attributable to screening or at least to a particular screening or diagnostic assessment tool. Additionally, retrospective studies or studies using a historical control group were not included given their high potential for biases related to confounding effects and patient selection.

While no studies addressed KQ 2, we did identify randomized controlled trials (RCTs) indicating that some malnutrition interventions improve clinical outcomes among patients who are diagnosed with malnutrition or screened at risk using commonly available measurement tools

(KQ 3). Specifically, we found moderate SOE from 11 RCTs that hospital initiated specialized nutrition care and increased protein/calorie provision likely reduce mortality compared to usual care. We also found that these interventions may improve quality of life (SOE: Low). The evidence, however, was either insufficient or showed no difference between groups for other outcomes: length of stay, readmissions, activities of daily living, discharge disposition, hospital acquired conditions, or adverse events. Of course, the benefits of hospital-initiated interventions on hospitalization associated outcomes such as length of stay, discharge disposition, and hospital associated complication may be limited as weeks to months are often required to resolve the deleterious impact of malnutrition.

Findings in Relation to What Is Known

Our review underscores many known limitations of research on nutritional measurement tools: these problems include varied definitions of malnutrition in the literature, lack of validated tools, and lack of an accepted reference standard.

As anticipated, we found malnutrition studies have employed a wide range of definitions for malnutrition. For example, one prior systematic review (SR) of nutrition-focused interventions for hospitalized patients by Feinberg et al. (2017)[59] included 244 RCTs. However, over 40 percent of these trials (105 of 244) did not use a commonly available measurement tool to confirm the diagnosis of malnutrition, instead relying on presence of severe disease, weight loss, body mass index (BMI) (or other biomarkers), or clinical opinion to define a malnourished population. Thus, we focused on more recent literature, our SR captured studies published from 2000 onwards to try to capture literature better aligned with current recommendations for screening and diagnosis established by the Global Leadership Initiative on Malnutrition (GLIM) taskforce (2019). However, we found that relatively few studies have used criteria aligned with the GLIM criteria to define malnourished patients. Since the GLIM consensus criteria were established relatively recently, it is likely that not enough time has passed for studies to employ these criteria in trials. The few studies identified in our searches that focused on validation of GLIM criteria were excluded for KQ 2 as they did not meet study design criteria for our report (i.e., they were uncontrolled trials).

Even when malnourished patients are identified using validated tools, inconsistent agreement and reliability may be problematic, particularly given the large number of different instruments currently in use. Skipper et al. (2012) performed an SR to assess the validity of available screening tools used to identify patients at-risk of malnutrition.[61] Authors found that available tools only achieved moderate- rather than high-level validity, agreement, and reliability, and that there were large variations in these measures for all tools. Authors attributed the large range in validity and reliability to researchers using different reference standards to validate tools and suggested that use of a single reference standard would narrow the ranges of reliability and validity. Differences in validity of measurement tools likely contributed to variations observed in the SOE for the association of malnutrition with poor clinical outcomes. Use of unvalidated instruments as reference standards was also a common reason for excluding studies from KQ 2.

Regarding hospital-initiated interventions, our findings aligned with prior reviews for the important outcome of mortality, despite large differences in how malnutrition was defined. Two previous systematic reviews, one by Feinberg et al. (2017)[60] and the other by Gomes et al. (2019),[59] examined the efficacy and safety of various nutrition-focused interventions used to treat hospitalized patients. These reviews included studies published prior to 2000 and included trials of patients designated malnourished based on biometrics (e.g., BMI, weight loss, serum

albumin level), severity of disease (e.g., any intensive care unit admission) or clinical judgment. Like our review, these reviews also found that nutrition-focused interventions decreased mortality.

Applicability

As noted, in consultation with our Technical Expert Panel (TEP) and to align with current consensus recommendations for screening and diagnosis, our review was limited to studies that confirmed a diagnosis of malnutrition using commonly available measurement tools. Thus, our findings regarding clinical outcomes and interventions are applicable to other patients with malnutrition determined in this way. However, conversely, it remains unclear to what extent these findings are generalizable across malnourished populations not identified in this way.

Using these criteria to define malnutrition also indirectly led to exclusion of studies assessing more invasive nutritional interventions for hospitalized patients such as parenteral nutrition or enteral nutrition. Studies assessing these interventions initiated treatment based on severity of illness, clinical judgement, or surrogate markers of malnutrition, such as blood serum markers and other biometrics. Thus, our findings only extend to two types of hospital-initiated malnutrition interventions, specialized nutrition care (i.e., consultation with a nutrition specialist and individualized goals) and oral protein/calorie supplementation. Also, while included studies enrolled older patients and patients with a range of underlying clinical conditions, we did not have enough studies to conduct subgroup analysis to determine if the effects of treatment differed depending on patient characteristics.

Limitations and Suggestions for Future Research

Defining Malnutrition

A key challenge for assessing studies of malnutrition is determining how malnutrition should be defined. Although many studies have defined malnutrition using biomarkers (e.g. BMI, weight loss, serum albumin levels) experts have expressed concern that these measures are not reliable indices of malnutrition by themselves.[49] For instance, serum albumin levels often fluctuate in response to physiological stress and other factors unrelated to a patient's nutritional status.[62] Similarly, metrics such as BMI fail to account for variations related to gender, age, race, or body type.[63] Other studies have used severity of disease (e.g. any intensive care admission) as a proxy for or criterion to intervene on malnutrition often without formal diagnostic assessment. Therefore, there is wide variability in how malnutrition has been identified and studied.

The wide range of definitions (and measurement tools) has created challenges for clinical practice and malnutrition research. To address this problem, in 2019, the GLIM taskforce recommended a two-step approach to identifying malnutrition that involves 1) screening for malnutrition using a valid tool, and 2) performing a formal diagnostic assessment for those who screen positive.[16] A formal diagnosis of malnutrition according to GLIM recommendations requires patients to have at least one etiologic factor (reduced food intake, hypercatabolic burden of disease) and one phenotypical factor (non-volitional weight loss, low BMI, low skeletal muscle mass). However, GLIM recommendations have yet to be clinically validated or widely applied in clinical practice or research settings.[19]

Finally, defining malnutrition requires the validation of measurement tools against a gold standard. However, through discussions with our TEP, we recognized that there currently is no universally agreed upon gold standard for malnutrition assessment and measurement. For the purposes of this report, we selected, with input from our TEP and subject matter experts, imaging modalities to quantify and evalute body composition (i.e., muscle and adipose tissues) as the gold standard and SGA as a semi-gold standard for classifying malnutrition. However, use of imaging specifically to assess malnutrition is infrequent and has important limitations, including cost, radiation exposure, and need for serial studies. In addition, at present, none of the current assessment tools (malnutrition measurement tools, the GLIM framework, or imaging modalities) capture micronutrient deficiencies. Development of an accepted gold standard for defining malnutrition is key to supporting future clinical care and research.

Effectiveness of Measurement Tools

This review highlights several important knowledge gaps in the current literature that future research needs to address. One is the relatively small number of studies that used available measurement tools to identify malnutrition. As noted, many studies identified malnutrition based only on biometrical measures, such as serum albumin levels, BMI, and weight, despite consensus that albumin and BMI should not be used to define malnutrition in practice or research. Thus, future studies assessing the impact of malnutrition on outcomes or evaluating malnutrition-focused interventions should use known tools to establish malnutrition status. Future studies would also benefit from stratifying patients by age, gender, and frailty.

Second is the absence of studies meeting inclusion criteria that address KQ 2. The absence of studies addressing the clinical utility (effectiveness) of measurement tools for nutrition screening and diagnostic assessment (KQ 2) does not necessarily imply that these tools are ineffective. However, it reveals the need for appropriately designed studies to better understand the downstream consequences of nutrition screening, including subsequent diagnostic assessment, management, and clinical outcomes is extremely important given that hospitals are mandated to provide nutrition screening for all hospitalized patients within 24 hours of admission.

One way to indirectly address this is to determine if one measure—SGA, imaging modalities, or the new GLIM criteria—better captures clinically important malnutrition. To assess which measure is more effective, one could envision a multi-arm clinical trial that compares multiple tools and techniques. For example, a study could screen hospitalized patients as mandated by the Joint Commission, and further assess at-risk patients with each of these diagnostic assessment tools; results of one diagnostic assessment tool could then be used to randomize patients (i.e., those diagnosed with malnutrition) to nutritional interventions. This would provide better understanding of the clinical course for patients who test negative by various diagnostic assessments and provide insights on potential harms of using specific tools. Furthermore, given significant overlap in the variables utilized in the tools, future research could also support identification of which variables have the greatest impact on sensitivity and specificity in prospective clinical studies.

Malnutrition Interventions

Finally, the studies addressing the efficacy of malnutrition-focused interventions were limited to studies of specialized nutrition care (consultation with a dietitian to set goals for protein and caloric intake) or increased protein/calorie supplementation. These studies had

several shortcomings, including high risk of bias and poor reporting of treatment-related adverse events. Most studies were rated as high risk of bias or had some concerns with outcome-level risks of bias. In most cases, studies failed to report adequate randomization, had unknown allocation concealment, and were unclear if all pre-specified outcomes were reported. Some studies also had high dropout rates (>20 percent) and did not blind outcome assessors. These limitations, along with inconsistencies in the findings for some outcomes and lack of precision for others, downgraded the overall strength of the evidence to low or insufficient for most outcomes. These studies either did not report on harms of treatment or reported on harms in a manner that did not allow us to synthesize the data. Thus, our review does not capture harms associated with the assessed treatments. Specifically, future studies should randomize patients diagnosed with malnutrition (i.e., using a diagnostic assessment tool) to different interventions, such as parenteral and enteral nutrition, conduct subgroup analyses to assess the benefits of nutritional intervention in subpopulations, and document harms associated with treatment.

Implications for Clinical Practice, Education, Research, or Health Policy

Our SR was intended to inform the deliberations of a congressional panel charged with developing quality measures for malnutrition-related hospital readmissions. Such measures would potentially support assigning accountability for the assessment and treatment of malnutrition in hospitalized adults, with an emphasis on the needs of older frail adults. Although our review confirmed that malnutrition is associated with poor outcomes and that specific interventions may be beneficial, it also highlights many challenges of drawing conclusions from this evidence base, starting with fundamental questions regarding how malnutrition should be defined and measured.

Variations in how malnutrition is defined and measured pose a challenge for hospitals seeking to standardize processes for screening, further assessing, and documenting diagnosis of malnutrition. As previously mentioned in the Background section of this review, national survey data indicate that only 38 percent of hospital professionals report using a recognized tool to screen for malnutrition, and only 23 percent report using one for diagnostic assessment in those who screen positive.[7] Another challenge to standardizing these processes is ensuring that the definition or criteria for malnutrition reflected within available measurement tools are consistent with current documentation and coding requirements for malnutrition. For instance, the International Classification of Diseases, 10th edition (ICD-10) coding system has different codes for varying levels of severity of malnutrition that are not always aligned with how malnutrition is defined using GLIM or American Society for Parenteral and Enteral Nutrition (ASPEN) criteria.[64,65]

Further research such as a multi-arm trial that randomizes patients to different measurement tools would allow researchers and practitioners to further understand the clinical utility of each tool, including downstream potential benefits and harms. Similarly, studies that acknowledge the notable overlap in variables utilized amongst these measurement tools may help identify which variables have the greatest sensitivity and specificity, impact on clinical outcomes, and lead to development of a comprehensive tool. For example, some tools may benefit from removing outdated variables, such as BMI. Such research could support the complex and evolving task of disentangling disease (i.e., severity of illness) and nutritional status.

As for malnutrition interventions, no studies were identified specific to the effect of parenteral or enteral nutrition in patients diagnosed with malnutrition, representing a significant

evidence gap in malnourished hospitalized patients. Further research in this area is essential to determine which malnourished patient populations benefit from specific types of interventions. Key guidance for hospitals is needed on how to standardize processes for screening, diagnosing and documenting malnutrition in order to inform development of quality measures and to improve patient outcomes.

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Appendix A. Search Strategy

Search Details and Data Sources

The search strategies for the individual databases were developed, executed, and documented by an experienced EPC librarian and were peer reviewed by an experienced methodologist. We applied the following limits or filters to the database searches:

- Date. The literature search covered January 2000 to June 2021.
- Language. Publications were excluded if they were written in a language other than English.
- Publication status. We searched for published studies.
- Human or organism. The search was limited to human studies.
- Study design. The search was restricted to randomized and non-randomized studies related to Key Question 2 and randomized studies, systematic reviews, and meta-analyses for Key Questions 1 and 3.

We conducted a comprehensive literature search over the course of several months spanning October 2020 – December 2020 (updated March 2021 and again June 2021). Key Questions were searched separately on different dates and there were several searches that included additional terms and expanded concepts. Update searches covering all Key Questions, additional terms, and expanded concepts in all databases were run in March 2021 and again in June 2021. We searched the following databases: EMBASE & MEDLINE (Embase.com) (2000 - 2020) Dates searched October 7, 2020, October 19, 2020, November 20, 2020, November 23, 2020, and December 11, 2020; PubMed in process citations (2000 – 2020) Date searched November 5, 2020.

Search Strategy

This section describes the search strategies.

Embase

1 'cachexia'/de OR 'malnutrition'/de OR cachexi* OR malnourish* OR malnutrition OR nutrition:ti OR underfed OR undernourish* OR undernutrition
2 (malnutrition OR nutrition*) NEAR/3 risk
3 'nutrition* status' OR 'nutrition* store*'
4 'aged hospital patient'/de OR 'hospital patient'/de OR hospitalis* OR hospitaliz* OR icu OR inpatient* OR 'intensive care unit' OR ((hospital* NEAR/5 patient*):ab,ti) OR (hospital* NEAR/5 (admit* OR admission*))
5 (#1 OR #2 OR #3) AND #4
6 #5 AND ([cochrane review]/lim OR [systematic review]/lim OR [meta analysis]/lim OR cochrane OR 'meta analysis' OR 'meta analyses' OR metaanlysis OR metaanalyses OR search* OR systematic:ti)
7 'nutritional screening'/exp/mj OR 'short nutritional assessment questionnaire'/exp OR 'screening'/exp OR screen* OR ‘Malnutrition Screening Tool’ OR MST OR ‘Malnutrition Universal Screening Tool’ OR MUST OR ‘Nutritional Risk Index’ OR NRI OR ‘Nutrition Risk in Critically Ill’ OR NUTRIC OR (nutrition*:ti AND (assess*:ti OR screen*:ti)) OR 'nutrition

risk screening 2002' OR 'nrs2002' OR 'nrs-2002' OR 'short nutritional assessment questionnaire' OR snaq
8 'nutritional assessment'/exp/mj OR 'diagnostic assessment' OR 'subjective global assessment' OR sga OR 'patient generated subjective global assessment' OR 'ps-sga' OR 'mini nutritional assessment' OR mna OR 'and-aspen mcc' OR 'global leadership initiative on malnutrition' OR glim OR 'malnutrition consensus criteria' OR (('academy of nutrition and dietetics' OR 'and') AND ('american society for parenteral and enteral nutrition' OR aspen OR 'a.s.p.e.n.') AND (consensus OR mcc))
9 #5 AND (#7 OR #8)
10 #9 AND ([cochrane review]/lim OR [systematic review]/lim OR [meta analysis]/lim OR cochrane OR 'meta analysis' OR 'meta analyses' OR metaanlysis OR metaanalyses OR search* OR systematic:ti)
11 #9 AND ('randomized controlled trial'/de OR 'randomized controlled trial (topic)'/de OR random*:ab,ti OR nct* OR [randomized controlled trial]/lim)
12 #9 AND ('cohort analysis' OR 'comparative study'/exp OR 'controlled study'/exp OR 'evaluation study'/de OR 'longitudinal study'/de OR 'major clinical study'/de OR 'prospective study'/de OR 'treatment outcome'/de OR 'between groups':ti,ab OR 'case control*':ti,ab OR cohort*:ti,ab OR compar*:ti,ab OR 'control group*':ti,ab OR 'controlled study':ti,ab OR 'controlled trial':ti,ab OR 'double blind':ti,ab OR 'double blinded':ti,ab OR longitudinal:ti,ab OR 'matched controls':ti,ab OR nonrandomiz*:ti,ab OR prospective:ti,ab OR random*:ti,ab OR versus:ti OR vs:ti)
13 #10 OR #11 OR #12
14 #5 AND ('dietary supplement'/exp OR 'drug therapy'/exp OR 'enteric feeding'/exp OR 'parenteral nutrition'/exp OR “drug therap*” OR “nutrition team*” OR ((enteric OR enteral OR parenteral) NEAR/2 (feed* OR nutrition* OR nutrient* OR therap*)) OR “Oral nutrition supplement*” OR pharmacotherap* OR ((diet* OR dietitian* OR nutrition*) NEAR/3 (counsel* OR therap*)))
15 #14 AND ([cochrane review]/lim OR [systematic review]/lim OR [meta analysis]/lim OR cochrane OR 'meta analysis' OR 'meta analyses' OR metaanlysis OR metaanalyses OR search* OR systematic:ti)
16 #14 AND ('randomized controlled trial'/de OR 'randomized controlled trial (topic)'/de OR random*:ab,ti OR nct* OR [randomized controlled trial]/lim)
17 #15 OR #16
18 #6 OR #13 OR #17
19 #18 NOT (adolescen*:ti OR babies:ti OR baby:ti OR child*:ti OR fetal:ti OR foetal:ti OR infan*:ti OR neonat*:ti OR newborn*:ti OR nicu:ti OR nurser*:ti OR paediatric*:ti OR pediatric*:ti OR pubesc* OR pubert*:ti OR 'school age*':ti OR teen*:ti OR toddler*:ti OR young*:ti OR youth*:ti)
20 #19 NOT (abstract:nc OR annual:nc OR 'book'/exp OR 'case study'/exp OR conference:nc OR 'conference abstract':it OR 'conference paper'/exp OR 'conference paper':it OR 'conference proceeding':pt OR 'conference review':it OR congress:nc OR 'editorial'/exp OR editorial:it OR 'erratum'/exp OR letter:it OR 'note'/exp OR note:it OR meeting:nc OR sessions:nc OR 'short survey'/exp OR symposium:nc OR [conference abstract]/lim OR [conference paper]/lim OR [conference review]/lim OR [editorial]/lim OR [letter]/lim OR [note]/lim OR [short survey]/lim OR comment:ti OR book:pt OR 'case report'/de OR 'case report':ti OR 'a case':ti OR 'a patient':ti OR 'year old':ti,ab)

PubMed in process

1 cachexi*[TI] OR malnourish*[TI] OR malnutrition[TI] OR underfed[TI] OR undernourish*[TI] OR undernutrition[TI]
2 “malnutrition risk” OR “nutrition risk” OR “nutritional risk” OR “risk of malnutrition”
3 "nutrition status" OR "nutritional status" OR "nutrition store*"
4 hospitalis* OR hospitaliz* OR icu OR inpatient* OR "intensive care unit" OR "hospital patient*"
5 (#1 OR #2 OR #3) AND #4
6 #5 AND (cochrane OR “meta analysis” OR “meta analyses” OR metaanlysis OR metaanalyses OR search* OR systematic*) AND (inprocess[sb] OR publisher[sb] OR pubmednotmedline[sb])
7 screen* OR “Malnutrition Screening Tool” OR MST OR “Malnutrition Universal Screening Tool” OR MUST OR “Nutritional Risk Index” OR NRI OR “Nutrition Risk in Critically Ill” OR NUTRIC OR “nutrition risk screening 2002” OR “nrs2002” OR “nrs-2002” OR “short nutritional assessment questionnaire” OR snaq
8 “diagnostic assessment” OR “subjective global assessment” OR sga OR “patient generated subjective global assessment” OR “ps-sga” OR “mini nutritional assessment” OR mna OR “and-aspen mcc” OR “global leadership initiative on malnutrition” OR glim OR “malnutrition consensus criteria” OR ((“academy of nutrition and dietetics” OR “and”) AND (“american society for parenteral and enteral nutrition” OR aspen OR “a.s.p.e.n.”) AND (consensus OR mcc)) OR “nutritional assessment” OR “nutrition assessment”
9 #5 AND (#7 OR #8)
10 #9 AND (cochrane OR “meta analysis” OR “meta analyses” OR metaanlysis OR metaanalyses OR search* OR systematic*) AND (inprocess[sb] OR publisher[sb] OR pubmednotmedline[sb])
11 #9 AND (random* OR nct*) AND (inprocess[sb] OR publisher[sb] OR pubmednotmedline[sb])
12 #9 AND (“cohort analysis” OR “between groups” OR “case control*” OR cohort* OR compar* OR “control group*” OR “controlled study” OR “controlled trial” OR “double blind” OR “double blinded” OR longitudinal OR “matched controls” OR nonrandomiz* OR prospective OR random* OR versus[TI] OR vs[TI]) AND (inprocess[SB] OR publisher[SB] OR pubmednotmedline[SB])
13 #10 OR #11 OR #12
14 #5 AND (“drug therap*” OR “nutrition team*” OR “Oral nutrition supplement*” OR pharmacotherap* OR “enteric feed*” OR “enteric nutrition*” OR “enteric nutrient*” OR “enteric therap*” OR “enteral feed*” OR “enteral nutrition*” OR enteral nutrient*” OR “enteral therap*” OR “parenteral feed*” OR “parenteral nutrition*” OR “parenteral nutrient*” OR “parenteral therap*” OR “diet therap* OR “diet counsel*” OR “nutrition counsel* OR nutrition therap*”)
15 #14 AND (random* OR nct*) AND (inprocess[SB] OR publisher[SB] OR pubmednotmedline[SB])
16 #14 AND (cochrane OR “meta analysis” OR “meta analyses” OR metaanlysis OR metaanalyses OR search* OR systematic*) AND (inprocess[SB] OR publisher[SB] OR pubmednotmedline[SB])
17 #15 OR #16
18 #6 OR #13 OR #17

Appendix B. Methods

Inclusion and Exclusion Criteria

As suggested in the Agency for Healthcare Research and Quality (AHRQ) EPC Methods Guide for Comparative Effectiveness Reviews, the inclusion criteria are listed below in separate categories pertaining to publication type, study design, patient characteristics, test characteristics, and reported data.[1]

Publication Criteria

1. **Full-length articles.** The article must be published as a full-length, peer-reviewed study. Abstracts and meeting presentations will not be included because they do not include sufficient details about experimental methods to permit an evaluation of study design and conduct; they may also contain only a subset of measured outcomes.[2,3]Additionally, it is not uncommon for abstracts that are published as part of conference proceedings to have inconsistencies when compared with the final study publication or to describe studies that are never published as full articles.[4-7]
2. **Publication date.** Include: For studies of interventions, particularly studies that report on quality metrics such as readmission the search date range will include studies published from 2010 to present. For studies assessing the diagnostic properties of assessment/screening tools the search date range will include studies published from 2000 to present.
3. **Redundancy.** To avoid double-counting patients, when several reports of the same or overlapping groups of patients are available, only outcome data from the report with the largest number of patients will be included. We will make an exception and include data from a smaller study when it reports data on an outcome that was not provided by the largest report or reports longer followup data for an outcome.
4. **English language.** When a study with an English abstract is published in a foreign language, the abstract will be assessed against the full set of inclusion/exclusion criteria. If the study appears to fit the inclusion criteria, then we will evaluate whether excluding the study may result in language bias (e.g., if the findings differ from other included studies.) If language bias seems unlikely, the study will be excluded. If a study is selected for inclusion, it will be translated and the data extracted into the evidence tables.

Study Design Criteria

1. For KQ 1, included studies must be systematic reviews of relevant study designs (RCTs, prospective cohort trials, or cross-sectional studies) that use a valid assessment tool to identify patients at risk of malnutrition.
2. For KQ 2, we will include randomized or non-randomized comparative trials, including prospective cohort trials that report on intermediate and clinical outcomes. Retrospective studies will not be considered for inclusion for this Key Question as these types of study designs are subject to biases that reduce the reliability of the findings.
3. For KQ 3, we will include randomized trials.

4. For all Key Questions, systematic reviews may also be used as a primary source of data if 3 conditions are met: (1) the review is determined to be at low risk of bias (using Cochrane's ROBIS tool); (2) the included studies would individually meet our inclusion criteria; and (3) our searches did not identify additional, relevant, primary studies that meet our criteria and were not included in the existing review.

Patient Criteria

1. The patient population for Key Question 1 and 2 will include hospitalized adult patients aged 18 years. Key Question 1 will also consider the following subgroups of patients: patients at risk of malnutrition, patients with baseline malnutrition, and patients with no risk of malnutrition. The population for Key Question 3 will only include patients with a diagnosis of protein-energy malnutrition. Studies enrolling individuals with planned admissions (e.g. undergoing nonemergent elective procedures), patients receiving or who have received hospice services, or pregnant women will not be considered for inclusion in this report.

Intervention Criteria

1. For Key Question 2 and 3, studies must report on assessment/screening tools (utilized within the U.S., Australia, New Zealand, Canada, and Europe) initiated within the hospital and designed to measure nutritional status.
2. Studies addressing Key Question 2 or 3 must report on an intervention initiated within the hospital and intended to impact nutritional status (See list of example interventions in Table 1). Studies of interventions that are initiated, managed, or implemented by entities either completely or partially external to the hospital setting; or surgical interventions will be excluded. Examples of excluded interventions include but are not limited to ambulatory clinic followup visits, community-based support resources, regulatory policies, and third-party reimbursement programs.

Setting Criteria

1. Only acute care hospitalization settings. Studies of patients in specialty hospitals (e.g., psychiatric, ophthalmologic, orthopedic, cancer, rehabilitation, long-term acute care) will be excluded.

Data Criteria

1. The study must report data pertaining to one of the clinical outcomes of interest (mortality, length of stay, functional status, activities of daily living, quality of life, readmission, hospital acquired conditions, and discharge disposition). For KQ 2, diagnostic accuracy factors (sensitivity and specificity), treatment and change in nutrition stores will be considered as intermediate outcomes. Studies reporting only on intermediate outcomes of interest and outcomes exclusive to screening or diagnostic performance will be excluded.

Grading the Strength of Evidence

Regardless of whether evidence was synthesized quantitatively or qualitatively, the strength of evidence for each Key Question/body of evidence was assessed for each clinical outcome by using the approach described in the AHRQ Methods Guide. The strength of evidence grades were based on the following factors described in Table B-1.

Table B-1. Factors used to assess strength of evidence

Evidence Category	Definition
Study Limitations	Study limitations takes into account the overall risk of bias rating of all the studies included in the evidence base, and is rated as low, moderate, or high level of study limitations.
Consistency	Consistency of evidence refers to the degree of similarity in the direction of effects or the degree of similarity in the effect sizes (magnitude of effect) across individual studies within an evidence base, and is rated as consistent, inconsistent, or unknow/ not applicable in the case of an evidence base of a single study.
Directness	Direct evidence directly compares interventions of interest in populations of interest and measures patient-oriented outcomes. Evidence can be indirect if the tested intervention differs from the intervention of interest, the study population differs from the population of interest, the outcomes differ from those of primary interest, or treatment comparisons have not been tested in head-to-head comparisons. Directness is rated as direct or indirect.
Precision	Precision is the degree of certainty surrounding an estimate of effect with respect to an outcome, and is primarily assessed by examining the 95% confidence intervals around the summary effect size. CIs within the following ranges indicate non-statistical significance, but are considered precise and should not be downgraded for precision. Further, if a KQ is focused on comparative effectiveness of two interventions estimates within these bounds support findings of equivalence or no difference. • Summary estimates using ratio statistics: Lower CI 0.80 to Upper CI 1.25. • Summary estimates using standardized mean difference: Lower CI -0.2 to Upper CI 0.2. • Summary estimates using raw mean difference: Depends on measure or instrument; default is 20% difference on each side. Estimates outside of these bounds would be considered imprecise and downgraded for imprecision. Precision may also take into account the total number of patients in a systematic review. If the total number of patients included in a systematic review is less than the number of patients generated by a conventional sample size calculation for a single adequately powered trial, reviewers may downgrade for precision. This threshold as the ‘‘optimal information size’’ (OIS). Using GRADE guidance, we considered a sample size of 1,000 or more as sufficiently high for risk estimates and 400 or more as sufficiently high for continuous estimates. • If the optimal information size criterion is not met, rate down for imprecision, unless the sample size is sufficiently large. • If the OIS criterion is met and the 95% CI excludes no effect (i.e. CI around RR excludes 1.0), do not rate down for imprecision. • If OIS criterion is met, and the 95% CI overlaps no effect (i.e. CI includes RR of 1.0) rate down for imprecision if the CI fails to exclude important benefit or important harm.

We did not assess the potential for publication bias as the number of studies was not sufficient (≥10) for most outcomes in Key Question 3 to perform tests, such as Trim and Fill or Funnel Plot. However, we did assess the potential for selective outcome reporting bias by

checking the outcomes reported in the included studies for Key Question 3 against the protocols for the studies provided through Clinicaltrials.gov.

Each body of evidence was assigned an overall strength of evidence grade of high, moderate, low, or insufficient based on the definitions presented in Table B-2.

Table B-2. Definitions of the grades of overall strength of evidence

Grade	Definition
High	We are very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. We believe that the findings are stable (i.e., another study would not change the conclusions).
Moderate	We are moderately confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	We have limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome. No evidence is available, or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Peer Review and Public Commentary

Peer reviewers with expertise in nutrition were invited to provide written comments on the draft report. The AHRQ Task Order Officer and an Evidence-based Practice Center Associate Editor will also provide comments and editorial review. The draft report will be posted on the AHRQ web site for 4 weeks for public comment. A disposition of comments report with authors' responses to all peer and public review comments will be posted after publication of the final CER on the AHRQ public Web site.

Appendix C. Excluded Studies

Table C-1. Studies excluded at full text

Author	Reason for Exclusion
Burgel et al. 2020[8]	Individual study addressing KQ1
Cattani et al. 2020[9]	Not a setting of interest
Habaybeh et al. 2020[10]	Not a setting of interest
Hsueh et al. 2020[11]	Not a study design of interest
Jantharapattana et al. 2020[12]	Not a setting of interest
Lima et al. 2020[13]	Individual study addressing KQ1
Matheson et al. 2020[14]	Not a study design of interest
Torbahn et al. 2020[15]	Population not of interest
Valladares et al. 2020[16]	Not an intervention of interest
Xie et al. 2020[17]	Not a setting of interest
Becker et al. 2019[18]	Not a study design of interest
Gomes et al. 2019[19]	Other exclusion criteria
Lovesley et al. 2019[20]	Not a study design of interest
Padilla et al. 2019[21]	Population not of interest
Rinninella et al. 2019[22]	Population not of interest
Thomas et al. 2019[23]	Not a study design of interest
Yang et al. 2019[24]	Not a setting of interest
Yu et al. 2019[25]	Population not of interest
Malafarina et al. 2018[26]	Not a study design of interest
Ortíz-Reyes et al. 2018[27]	Not a setting of interest
Perman et al. 2018[28]	Population not of interest
Rasmussen et al. 2018[29]	Not an intervention of interest
Re et al. 2018[30]	Not published in English
Shi et al. 2018[31]	Population not of interest
Wyers et al. 2018[32]	Population not of interest
Cano-Torres et al. 2017[33]	Not a setting of interest
Feinberg et al. 2017[34]	Other exclusion criteria
García-Rodríguez et al. 2017[35]	Population not of interest
Sriram et al. 2017[36]	Not an intervention of interest
Aust et al. 2016[37]	Not published in English
Baldwin et al. 2016[38]	Population not of interest
Bally et al. 2016[39]	Other exclusion criteria
Özbilginet al. 2016[40]	Individual study addressing KQ1
Calleja Fernandez et al. 2015[41]	Individual study addressing KQ1
Casals et al. 2015[42]	Not published in English
Da Silva Fink et al. 2015[43]	Not a setting of interest
Rossi et al. 2015[44]	Not a study design of interest
Sun et al. 2015[45]	Not a setting of interest
Tapia et al. 2015[46]	Not a study design of interest
Agarwal et al. 2013[47]	Individual study addressing KQ1
Lomivorotov et al. 2013[48]	Included in SR for KQ1
Milte et al. 2013[49]	Not an outcome of interest
Olveira et al. 2013[50]	Not a study design of interest
Omidvari et al. 2013[51]	Not a study design of interest
Collins et al. 2012[52]	Population not of interest

Author	Reason for Exclusion
Moon et al. 2012[53]	Not an intervention of interest
Neelemaat et al. 2012[54]	Not a study design of interest
Klek et al. 2011[55]	Population not of interest
Klek et al. 2011[56]	Population not of interest
Velasco et al. 2011[57]	Included in SR for KQ1
Neelemaat et al. 2010[58]	Not a study design of interest
Cansado et al. 2009[59]	Not an outcome of interest
Milne et al. 2009[60]	Population not of interest
Baldwin et al. 2008[61]	Population not of interest
Pronio et al. 2008[62]	Not published in English
Koretz et al. 2007[63]	Population not of interest
Vanderkroft et al. 2007[64]	Population not of interest
Alho Letra Martins et al. 2006[65]	Not a study design of interest
De Luis et al. 2006[66]	Not a comparator of interest
Miller et al. 2006[67]	Population not of interest
Kruizenga et al. 2005[68]	Not a study design of interest
Braunschweig et al. 2004[69]	Not a study design of interest
Hickson et al. 2004[70]	Population not of interest
Rypkema et al. 2004[71]	Population not of interest
Kondrup et al. 2003[72]	Not a setting of interest
Potter et al. 2001[73]	Not an intervention of interest

Appendix D. Characteristics of Included Studies

Table D-1. Characteristics of systematic reviews assessing association of malnutrition with outcomes

Author/Year Objective	Databases Searched and Timeframe	Study Selection Criteria	Evidence Base (n of Included Studies) Design of Included Studies	ROB of SR (ROBIS Rating)	Instrument Used for ROB of Included Studies Overall ROB Rating	Meta-Analysis	Qualitative or Narrative Synthesis	GRADE or Similar Analysis
Dijkink et al.2020[74] To review the current knowledge about the pathophysiology, prevalence, and effects of malnutrition in severely injured patients.	PubMed and Embase from inception to May 2019.	**Inclusion:** Full-text studies published in Dutch, English, French, and German without restriction on publication year. Included studies either: (1) described the metabolic response of malnutrition in severely injured trauma patients, or (2) were clinical cohort studies describing the prevalence of malnutrition and its association with clinical outcomes in severely injured trauma patients during hospital admission. **Excluded:** Expert opinions, conference papers and letters to the editor.	13 cohort trials (2 retrospective, 11 prospective); 10 reported on outcomes related to malnutrition	Low	Used MINORS (Methodological Index for Non-randomized Studies) criteria "Generally" low ROB; however, rating tool does not assess if study controlled for confounders.	No	Yes	No

Author/Year Objective	Databases Searched and Timeframe	Study Selection Criteria	Evidence Base (n of Included Studies) Design of Included Studies	ROB of SR (ROBIS Rating)	Instrument Used for ROB of Included Studies Overall ROB Rating	Meta-Analysis	Qualitative or Narrative Synthesis	GRADE or Similar Analysis
Ney et al., 2019[75] A systematic review with the aim of summarizing: the varying definitions of malnutrition across studies, the available evidence for nutritional screening tools (NST) and the ability of NSTs and nutritional assessment tools (NATs) to predict clinical outcomes in patients with cirrhosis.	PubMed (1966-2018), EMBASE (1974-2018) and Web of Science (1990-2018). Bibliographies of the included studies and relevant review papers were searched by hand for any further studies. The final search was completed on February 14, 2018.	**Inclusion:** (a) full-text English language articles, (b) patients with cirrhosis ≥16 years of age, (c) studies assessing clinical outcomes as predicted by NSTs or NATs and/or (d) studies measuring the validity of NSTs for diagnosing malnutrition. **Exclusion:** (a) 25% of patients with hepatocellular carcinoma, (b) studies investigating NATs that were primarily comprised of laboratory-based parameters (ie controlling nutritional status score), (c) studies without formal nutritional assessment/ screening objectives and (d) body mass index (BMI) as the sole marker of nutrition status.	47 cross-sectional; 8 reported outcomes for tools of interest (SGA)	Low	Ottawa Newcastle Assessment Scale (ONS) Moderate ROB; loss to follow-up	Yes, mortality	Yes	No

Author/Year Objective	Databases Searched and Timeframe	Study Selection Criteria	Evidence Base (n of Included Studies) Design of Included Studies	ROB of SR (ROBIS Rating)	Instrument Used for ROB of Included Studies Overall ROB Rating	Meta-Analysis	Qualitative or Narrative Synthesis	GRADE or Similar Analysis
Muscaritoli et al. 2017[76]	Cochrane Central Register of Controlled Trials (CENTRAL), The Cochrane Database of Systematic Reviews (CDSR), Database of Abstracts of Reviews of Effects (DARE), MEDLINE (1946 onwards), and ClinicalTrials.gov.	Prospective cohort studies of adult hospital patients with any disease, during their hospital stay or during follow-up after discharge.	15 studies, 12 prospective cohort studies and 3 database studies	Low	Modified Cochrane Risk of Bias tool, using three out of six original domains (blinding, selective data reporting, selective outcome reporting) and two additional domains (comparability of groups and confounding factors) were used to assess the risk of bias in the included non-randomized studies. All studies rated as High ROB due to lack of comparability of included patients and lack of or not clearly reporting if confounders were controlled.	No	Yes	No

Author/Year Objective	Databases Searched and Timeframe	Study Selection Criteria	Evidence Base (n of Included Studies) Design of Included Studies	ROB of SR (ROBIS Rating)	Instrument Used for ROB of Included Studies Overall ROB Rating	Meta-Analysis	Qualitative or Narrative Synthesis	GRADE or Similar Analysis
Lew et al. 2016[77] To assess the association between malnutrition and clinical outcomes in the ICU.	PubMed, CINAHL, Scopus, and Cochrane Library on August 1, 2014; additionally searched reference lists of the articles that were included in this systematic review were hand searched along with the table of contents of Critical Care Medicine, Journal of Parenteral and Enteral Nutrition, and Nutrition in Clinical Practice from inception to August 2014.	**Inclusion:** Patients >18 years and not pregnant admitted to the ICU who were screened/ assessed for malnutrition using a nutrition screening or assessment tool and whose outcomes were based on the results of nutrition screening or assessment (i.e., not at risk of malnutrition vs at risk of malnutrition or well-nourished vs malnourished). **Exclusion:** Articles that measured the prognostic value of individual biochemical markers or anthropometric measurements, articles that did not report on the prevalence of malnutrition, relevant clinical outcomes, and/or results specific to patients in the ICU. Articles that did not compare the clinical outcomes between at-risk patients and not-at-risk patients for malnutrition and between well-nourished and malnourished patients.	20 prospective cohort trials (of which 15 were used to assess outcomes)	Low	Instrument described in Laupacis et al. 1994 that considered representativeness of patients, sufficient follow-up, blinding of outcome assessors, and controlling for confounders. 6 studies rated as "Low" ROB and 9 rated as "Possible" ROB. The authors of the review only considered studies with Low ROB when drawing conclusions.	No	Yes	No

Author/Year Objective	Databases Searched and Timeframe	Study Selection Criteria	Evidence Base (n of Included Studies) Design of Included Studies	ROB of SR (ROBIS Rating)	Instrument Used for ROB of Included Studies Overall ROB Rating	Meta-Analysis	Qualitative or Narrative Synthesis	GRADE or Similar Analysis
Lin et al. 2016[78]	PubMed, Embase, Web of Science and ScienceDirect from inception to May 2015.	Only studies of adults ≥18 years published in English that (1) assessment of the nutritional status of patients with HF using multidimensional evaluation tools or multidimensional evaluation technologies recommended by ASPEN; (2) assessment of prognostic value parameters [e.g. length of stay (LOS), mortality, hospitalization and complications; (3) available full text; and (4) cohort or cross-sectional studies.	17 trials of which 11 trials were of hospitalized patients Prospective cohort (12); retrospective cohort (5)	Low	Ottawa Newcastle Assessment Scale (ONS) 10 Fair ROB; 7 Good ROB	Yes, only for mortality	Yes	No
Gupta et al. 2011[79]	MEDLINE from inception to December 2010; bibliographies of selected papers.	Only studies published in English, reported data collected in humans with cancer, had nutritional status/assessment/ screening as one of the predictor variables, had LOS as one of the outcome measures, and utilized any of the following study designs (case-control, cohort, cross-sectional, prospective, retrospective, case series, longitudinal, clinical trial, meta-analysis). There were no restrictions in terms of age, ethnicity, or type or stage of cancer.	8 trials of 21 trials reported in association between screening/ assessment tool and LOS (other studies only considered biomarkers	High; review did not assess ROB of included studies **Authors of review did report on key elements, such as study design, confounder analysis.	NR; based on information provided by authors, studies most studies were high ROB due to lack of cofounder analysis.	No	Yes	No

Table D-2. Characteristics of studies and patients included in systematic reviews on association of malnutrition on outcomes

Author/ Year	Number of Patients Length of Follow-up Hospital Setting, n Studies	Patient Age Gender Ethnicity Socioeconomic Status (SES)	Underlying Condition, n Studies Severity of Disease	Nutritional Screening/ Assessment Tool(s)	% Malnourished
Dijkink et al.2020[74]	N=9,167 NR NR	Mean: 61.8, range 27 to 84 % Male: 54.8 NR NR	General trauma patients with severe injuries: 6 studies Geriatric trauma patients with severe injuries: 4 studies Severe injuries	Visceral proteins: 4 studies NRS: 2 studies MNA: 4 studies SGA: 2 study Anthropometric measures: 1 study	All pts: 7 to 76% Geriatric pts: 7 to 62.5% % Geriatric pts at risk: 35.6 to 60%
Ney et al. 2019[75]	N=611 among studies of SGA NR Inpatient	Mean: 52 % Male: 67.2% NR NR	Cirrhosis Model for End Stage Liver Disease (MELD): 14.8 Child-Pugh (CP): 26% CP A, 41.6% was CP B and 32.5% was CP C	SGA: 8 studies	8.0% to 100%
Muscaritoli et al. 2017[76]	N=20,775 NR NR	NR NR NR NR	Various conditions/general medicine: 7 COPD: 3 Heart failure: 4 Pneumonia: 1 NR	SGA: 3 studies NRI: 1 study MNA: 2 studies Weight/weight loss/BMI/ anthropometric: 8 studies MUST: 1 study	NR
Lew et al. 2016[77]	N=4,228 Follow-up: Entire ICU admission period to 1-year post-discharge Medical ICU: 10 studies Surgical ICU: 1 study Medical vs. Surgical Not Reported: 10 studies	Mean: 59 years NR NR NR	Heterogeneous condition: 12 studies Elderly: 3 studies Post-Liver transplant: 2 studies Cardiac patients: 2 studies Acute kidney injury: 1 study APACHE Score: Range 12 to 25	SGA: 10 studies MNA: 2 studies Nutrition Risk Screening–2002: 4 studies MUST: 3 studies MNA-SF: 1 study Prognostic Inflammatory and Nutritional Index (PINI): 1 study Short Nutritional Assessment Questionnaire (SNAQ]): 1 study	Heterogeneous group (11 studies): 37.8% to 78.1% Elderly (1 study): 23.2% to 34.4% Cardiac surgery (1 study): 5.0% to 20.0% Liver transplantation (2 studies): 52.6% Acute kidney injury (1 study): 82.0%

Author/ Year	Number of Patients Length of Follow-up Hospital Setting, n Studies	Patient Age Gender Ethnicity Socioeconomic Status (SES)	Underlying Condition, n Studies Severity of Disease	Nutritional Screening/ Assessment Tool(s)	% Malnourished
Lin et al. 2016[78]	N=4,303 Follow-up (median months): 27, range 6 to 68 NR	Mean 64 years 46% male NR NR	Heart failure (17) Advanced HF: 2 studies Acute decompensated HF: 3 studies Stable HF: 5 studies All types HF: 7 studies	MNA: 5 studies GNRI: 4 studies NRI: 3 studies MNA-SF: 2 studies SCORE: 1 study NRS: 1 study CONUT: 1 study PNI: 1 study Other: 2 studies	General: 16 to 90% By tool: MNA: 16 to 90% GNRI: 22 to 48% NRI: 23 to 90% NRS: 57.3%
Gupta et al. 2011[79]	N=2,153 NR NR	NR NR NR NR	Gastrointestinal cancer (4) Gynecologic cancer (1) Head and neck cancer (1) Multiple myeloma (1) Lymphoma (1) NR	SGA: 6 studies PG-SGA: 2 studies	Moderate to severe MN: 898 (42%)

CI = confidence interval; LOS = length of stay; MNA = mini nutritional assessment; MUST = malnutrition universal screening tool; NO indicates no association identified or no important difference found between malnourished and well-nourished; NR = not reported; NRS-2002 = nutrition risk screening 2002; PG-SGA = patient-generated subjective global assessment; PINI = Prognostic Inflammatory and Nutritional Index; RCT = randomized controlled trial; SD = standard deviation; SE = standard error; SES = socioeconomic status; SGA = subjective global assessment; SNAQ = Short Nutritional Assessment Questionnaire; VP = visceral proteins

Table D-3. Characteristics of studies and patients of effectiveness of interventions for malnutrition

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
Bonilla-Palomas et al. 2016[80] RCT Spain	Assess whether a nutritional intervention of diet optimization, recommendations, and nutritional supplement prescriptions versus standard care in malnourished hospitalized patients with HF benefits morbidity and mortality.	Included patients aged over 18 years who are admitted for acute HF, whether chronic and uncompensated or of new onset, and in a state of malnutrition (score on the MNA <17 points). Excluded pregnant women, patients with chronic renal failure in dialysis, patients already receiving nutritional treatment, patients with concomitant disease who, regardless of HF itself, have a life expectancy of less than 1 year, patients participating in other clinical trials, patients who undergo surgery or percutaneous coronary intervention during their hospital stay to correct the cause of acute HF, and patients whose clinical status means that it is impossible to perform the nutritional assessment as established in the study protocol or who	Treatment (Tx): Physician specialist with assistance by a nutritionist provided diet optimization, specific recommendations, and nutritional supplement prescriptions in cases in which nutritional goals were not reached for patients. Control group (CG): Conventional treatment for HF	Tx: 61 CG: 59 12 months	Age, mean (SD): Tx: 78.6 (7.1); CG: 79.8 (7.0), p=0.38 Female gender, n (%): Tx: 38 (64.4%); CG: 37 (60.7%), p=0.67 Race/Ethnicity: NR SES: NR	MNA score, mean (SD): Tx: 14.4 (2.3); CG: 14.1 (2.6), p=0.41 BMI in kg/m^2, mean (SD): Tx: 25.5 (5.4); CG: 24.7 (5.1), p=0.41	Comorbidities, n (%): COPD: Tx: 11 (18.6%); CG: 7 (11.5%), p=0.27 Decompensated CHF: Tx: 38 (64.4%); CG: 40 (65.6%), p=0.89 Diabetes: Tx: 28 (47.5%); CG: 30 (49.2%), p=0.85 HLD: Tx: 19 (32.2%); CG: 16 (26.2%), p=0.47 HTN: Tx: 41 (69.5%); CG: 49 (80.3%), p=0.17 Charlson comorbidity index, mean (SD): Tx: 3.8 (2.0); CG: 4.0 (2.2), p=0.63

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
		do not provide their consent for such procedures.					
Deutz et al. 2016[81] RCT USA	To evaluate a high-protein ONS containing beta-hydroxybeta-methylbutyrate on post discharge outcomes of nonelective readmission and mortality in malnourished, hospitalized older adults.	Included patients aged >65 years with a recent hospital admission (within 72 h) and a primary diagnosis of CHF, AMI, PNA, or COPD. Patients were required to have a Subjective Global Assessment (SGA) class of B (moderate or suspected malnutrition) or C (severe malnutrition). Excluded patients diabetes mellitus (type 1 or 2) due to product composition not intended for patients with diabetes mellitus; current active or treated cancer, and impaired renal or liver function.	Oral Nutrition Supplement (ONS): High-protein ONS containing beta-hydroxybeta-methylbutyrate Control group (CG): Placebo	ONS: 309 CG: 313 90 days	Age, mean (SD): ONS: 78.1 (8.6); CG: 77.7 (8.2), p=NS Female gender, n (%): ONS: 160 (51.8%); CG: 164 (52.4%), p=NS Race, n (%): Black/African American: ONS: 32 (10.4%); CG: 35 (11.2%), p=NS White: ONS: 273 (88.3%); CG: 267 (85.3%), p=NS Other: ONS: 4 (1.3%); CG: 11 (3.5%), p=NS Government sponsored insurance, n (%): ONS: 276 (89%); CG: 278 (89%), p=NS	SGA category, n (%): SGA-B, mildly-moderately malnourished: ONS: 268 (86.7%); CG: 275 (87.9%), p=NS SGA-C, severely malnourished: ONS: 41 (13.3%); CG: 38 (12.1%), p=NS BMI in kg/m^2, mean (SD): ONS: 24.3 (5.2); CG: 23.9 (5.0), p=NS Body weight in kg, mean (SD): ONS: 67.5 (17.4); CG: 66.2 (16.0), p=NS	Primary admission diagnosis, n (%): AMI: ONS: 25 (8.1%); CG: 30 (9.6%), p=NS COPD: ONS: 105 (34.1%); CG: 109 (34.8%), p=NS HF: ONS: 78 (25.3%); CG: 79 (25.2%), p=NS Pneumonia: ONS: 100 (32.5%); CG: 95 (30.4%), p=NS Charlson comorbidity index, mean (SD): ONS: 2.05 (1.46); CG: 2.12 (1.48), p=NS

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
					Income <$25,000 per year, n (%): Tx: 154 (49%); CG: 130 (42%), p=NS		
Gazzotti et al. 2003[82] RCT Belgium	Evaluate whether daily oral supplementation versus usual care improve LOS for malnourished patients.	Included patients aged 75 or older admitted for acute conditions between November 1999 and end of March 2000 in the geriatric ward of a hospital. Patients were required to have an MNA score between 17 and 23.5, indicating they were at-risk for malnutrition. Excluded patients with a medical condition preventing oral feeding, end-of-life patients, patients with severe dementia (Mini Mental Score -10) [20], patients presenting clinical signs of dehydration or HF, and those suffering from diseases requiring special dietary treatment (kidney or liver failure).	Oral nutrition supplement (ONS): Patients received a sweet or salty sip feed twice daily, totaling 500 kcal and 21 grams of protein daily in addition to usual care. Control group (CG): Usual care	ONS: 39 CG: 41 2 months	Age, mean (SD): ONS: 81.5 (7.6); CG: 78.8 (6.1), p=0.09 Female gender, n (%): ONS: 28 (72%); CG: 33 (80%), p=0.20 Race/Ethnicity: NR SES: NR	MNA score, mean (SD): ONS: 19.9 (2.0); CG: 20.2 (2.4), p=0.62 BMI in kg/m^2, mean (SD): ONS: 24.8 (4.5); CG: 26.9 (5.4), p=0.07 Weight in kg, mean (SD): ONS: 61.7 (13.0); CG: 65.6 (13.7), p=0.20	Underlying Condition: NR

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
Ha et al. 2010[83] Norway	Examine the effect of individualized, nutritional support on weight loss, functional outcomes, and other clinical outcomes.	Included patients aged over 65 between May 2005 and December 2007 admitted with a stroke to a medical acute ward in Norway. All patients were at nutritional risk or undernourished according to a MUST score >0. Excluded patients with a stroke diagnosis that could not be confirmed, was critically ill, had severe dementia, could not be weighed, or if there was a planned discharged within 24 hours after the first visit by the trial assessor.	Intervention (Tx): Individualized, nutrition treatment with a goal to maintain or improve nutritional status according to individual intake and needs. Control (CG): Routine care	Tx: 84 CG: 86 3 months	Age, mean (SD): Tx: 78.5 (7.4); CG: 79.7 (6.8), p=0.34 Female gender, n (%): Tx: 33 (57%); CG: 31 (47%), p=0.27 Race/Ethnicity: NR SES: NR	MUST Classification of Undernourished, n (%): Tx: 5 (8.6%); CG: 3 (4.5%), p=0.47 BMI in kg/m^2, mean (SD): Tx: 24.5 (4.0); CG: 26.2 (4.6), p=0.031 Weight in kg, mean (SD): Tx: 66.3 (13.6); CG: 72.6 (14.8), p=0.015	Diagnosis: NR
Holyday et al. 2011[84] RCT Australia	Assess the impact of nutrition screening and malnutrition care plan intervention on patient outcomes and health costs.	Included patients transferred from the emergency department to an Australian hospital between April and September 2006. Patients were required to have an MNA score greater than 17, with scores between 17 and 23.5 indicating at-risk for malnutrition, and scores less than	Intervention (Tx): Malnutrition care plan involving the modification of hospital meals (texture modification and fortification), prescription of nutrition supplements, flagging for assistance with meals by ward based staff, and	*At-Risk* Tx: 47 CG: 40 6 months *Malnourished* Tx: 12 CG: 20 6 months	*At-Risk* Age, mean (SE): Tx: 83.2 (0.9); CG: 83.1 (1.3), p=0.98 Female gender, n (%): Tx: 23 (57.5%); CG: 32 (68.1%), p=NR Race/Ethnicity: NR	*At-Risk* MNA score, mean (SE): Tx: 20.0 (0.3); CG: 19.8 (0.3), p=0.64 BMI in kg/m^2, mean (SE): Tx: 23.0 (0.8); CG: 24.5 (0.9), p=0.23 Weight in kg, mean (SE):	*At-Risk* Charlson comorbidity index, mean (SE): Tx: 5.8 (0.2); CG: 5.4 (0.2), p=0.26 *Malnourished* Charlson comorbidity

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
		17 indicating malnourished. Excluded patients with an expected LOS less than 72 hours, palliative (not for active treatment) or who were unable to be nutritionally assessed (non-English speaking, severe dementia/ confusion, non-cooperative/refused), already seen by a dietitian during the admission, or enrolled in the study during a previous admission.	education of patients and their carers regarding optimization of nutrition intake and referral to other health professionals for discharge planning. Control (CG): Usual nutrition care		Socioeconomic status: NR *Malnourished* Age, mean (SE): Tx: 86.9 (2.3); CG: 84.4 (1.1), p=0.27 Female gender, n (%): Tx: 11 (55.0%); CG: 3 (25.0%), p=NR Race/Ethnicity: NR SES: NR	Tx: 60.2 (2.4); CG: 65.0 (2.6), p=0.18 *Malnourished* MNA score, mean (SE): Tx: 12.7 (0.7); CG: 13.2 (0.6), p=0.59 BMI in kg/m^2, mean (SE): Tx: 21.2 (1.5); CG: 19.0 (1.2), p=0.28 Weight in kg, mean (SE): Tx: 59.7 (5.4); CG: 52.6 (3.9), p=29	index, mean (SE): Tx: 5.7 (0.4); CG: 5.4 (0.2), p=0.50
Johansen et al. 2004[85] RCT Denmark	To evaluate the effect of a specialized nutritional team versus standard regime on LOS, complications, and quality of life in a random sample of hospitalized patients at nutritional risk.	Included patients were admitted to one of three participating Danish hospitals and screened at nutritional risk according to the NRS-2002 (total score ≥3). Excluded patients had less than 4 days' expected admissions, less than 18 years of age, less than 1 month of expected survival, did not understand the Danish language, previously participated in nutrition trials, were placed next to another	Intervention (Tx): Nutritional care with motivation of patient and staff, adjustment of the nutritional plan by estimation of protein- and energy requirements and ordering food in collaboration with the patient and securement of the supply of food ordered. Control (CG): Standard regime of nutritional care	Tx: 108 CG: 104 28 days	Age, mean (SE): Tx: 62.0 (1.6); CG: 62.4 (1.7), p=NR Female gender, n (%): Tx: 54 (50%); CG: 56 (54%), p=NR Race/Ethnicity: NR SES: NR	NRS-2002 score for nutritional status, mean (SE): Tx: 2.4 (0.08); CG: 2.5 (0.07), p=NR NRS-2002 score for severity of disease, mean (SE): Tx: 1.0 (0.07); CG: 1.0 (0.06), p=NR BMI in kg/m^2, mean (SE): Tx: 21.2 (0.50); CG: 21.8 (0.48), p=NR	Primary admission diagnosis, n (%): Cardiovascular disease: Tx: 7 (6.5%); CG: 4 (3.8%), p=NR GI disorders: Tx: 13 (12.0%); CG: 14 (13.4%), p=NR Neurological disorders: Tx: 6 (5.6%); CG: 6 (5.8%), p=NR Respiratory disease: Tx: 14

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
		participant in the same room, pregnant or lactating healthy women, had psychiatric disorders, were receiving hemodialysis, and who were already receiving, or were planned to receive, a standard parenteral or PEG-tube feeding.				Weight in kg, mean (SE): Tx: 61.5 (1.65); CG: 62.4 (1.51), p=NR	(13.0%); CG: 19 (18.3%), p=NR Internal medicine, other: Tx: 34 (31.5%); CG: 27 (26.0%), p=NR Surgical, other: Tx: 34 (31.4%); CG: 34 (32.7%), p=NR
Munk et al. 2014[86] RCT Denmark, Sweden	Investigate whether a novel food service concept with protein-supplementation in addition to standard food service would increase protein intake, increase energy intake, and impact LOS in hospitalized patients at nutritional risk.	Included patients admitted to a Denmark hospital between October 2011 to February 2012 aged 18 years or older, at nutritional risk (NRS-2002 score ≥3), able to eat orally, had an anticipated length of hospitalization ≥3 days, and had sufficient language proficiency. Excluded patients with dysphagia, food allergy or intolerance, anatomical obstructions preventing oral food intake, patients who exclusively received enteral or parenteral nutrition, and terminally ill.	Intervention (Tx): A targeted food concept consisting of an a la carte menu of small dishes enriched with natural energy-dense ingredients and supplemented with a high-quality protein powder in addition to standard hospital food service. Control Group (CG): Standard hospital food service (buffet style serving system with 3 main meals and 2–3 in-between snacks or ONS)	Tx: 41 CG: 40 7 days	Age, mean (SD): Tx: 75 (10); CG: 74 (11), p=NR Female gender, n (%): Tx: 25 (61.0%); CG: 22 (55.0%), p=NR Race/Ethnicity: NR Socioeconomic status: NR	NRS-2002 total score, mean (SD): Tx: 3.88 (0.95); CG: 3.43 (0.68), p=NR BMI in kg/m^2, mean (SD): Tx: 21 (4); CG: 22 (4), p=NR Weight in kg, mean (SD): Tx: 60 (14); CG: 65 (13), p=NR	Admitting department, n (%): Oncology: Tx: 14 (34.1%); CG: 15 (37.5%), p=NR Orthopedic surgery: Tx: 12 (29.3%); CG: 10 (25.0%), p=NR Urology: Tx: 15 (36.6%); CG: 15 (37.5%), p=NR

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
Rufenacht et al. 2011[87] RCT Switzerland	Study the impact of nutritional therapy on quality of life and food intake.	Included patients from April 2005 to March 2006 admitted with an NRS-2002 score ≥3, estimated LOS ≥10 days, unintended loss of body weight ≥5% of usual weight over the previous 2 months, loss of appetite, and given informed consent to participate. Excluded people with terminal illness, existing enteral or parenteral nutrition, ongoing nutritional counseling or interventions, e.g., intake of ONSs, impaired cognition, and incapability to give consent.	Nutrition therapy (Tx): Patients received individual nutritional counseling and interventions, including oral nutritional supplements, if appropriate. Oral nutrition supplementation group (ONS): Oral nutritional supplements provided in addition to hospital meals without further instruction or counseling.	Tx: 18 ONS: 18 2 months	Age, mean (SD): Tx: 69.2 (12.6); ONS: 70.8 (13.3), p=0.669 Female gender, n (%): Tx: 7 (39%); ONS: 9 (50%), p=NR Race/Ethnicity: NR SES: NR	NRS-2002 score, mean (SD): Tx: 3.8 (0.7); ONS: 3.9 (0.9), p=0.657 SGA score, n (%): SGA-A, well-nourished: Tx: 2 (11%); ONS: 1 (6%), p=NR SGA-B, mildly-moderately malnourished: Tx: 16 (89%); ONS: 17 (94%), p=NR SGA-C, severely malnourished: Tx: 0 (0%); ONS: 0 (0%), p=NR BMI in kg, mean (SD): Tx: 22 (4); ONS: 22 (3.6), p=0.950 Weight in kg, mean (SD): Tx: 64.6 (16.3); ONS: 57.8 (11.4), p=0.304	Primary admission diagnosis, n (%): COPD: Tx: 2 (11%); ONS: 2 (11%), p=NR Malignant tumors: Tx: 7 (39%); ONS: 7 (39%), p=NR Pneumonia: Tx: 3 (17%); ONS: 4 (22%), p=NR Other: Tx: 6 (33%); ONS: 5 (28%), p=NR Case mix index, mean (SD): Tx: 1.453 (0.953); ONS: 1.451 (0.950), p=NR

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
Schuetz et al. 2019[88] RCT Switzerland	Evaluate if protocol-guided individualized nutritional support to reach protein and caloric goals reduces the risk of adverse clinical outcomes in medical inpatients at nutritional risk.	Included patients between April 1, 2014 and February 28, 2018 admitted to one of eight Swiss secondary or tertiary care hospitals aged at least 18 years with an NRS-2002 score ≥3 and expected LOS of more than 4 days. All patients were required to provide informed consent within 48 hours of hospital admission. Excluded patients who were initially admitted to intensive care units or surgical units; unable to ingest oral nutrition; already receiving nutritional support on admission; with a terminal condition; admitted to hospital because of anorexia nervosa, acute pancreatitis, acute liver failure, cystic fibrosis, or stem-cell transplantation; after gastric bypass surgery; with contraindications for nutritional support; and	Intervention (Tx): Nutritional support including establishing individual nutrition targets and creating a strategy to reach nutrition targets within 48 hours of hospital admission. Control Group (CG): Standard hospital food	Tx: 1,015 CG: 1,013 30 days	Age, mean (SD): Tx: 72.4 (14.1); CG: 72.8 (14.1), p=0.56 Female gender, n (%): Tx: 490 (48%); CG: 474 (47%), p=0.50 Race/Ethnicity: NR SES: NR	NRS-2002 score, mean (SD): Tx: 4.05 (0.87); CG: 4.05 (0.88), p=0.0.98 BMI in kg/m^2, mean (SD): Tx: 24.9 (5.4); CG: 24.7 (5.3), p=0.43 Weight in kg, mean (SD): Tx: 70.9 (16.4); CG: 70.9 (16.4), p=0.91	Admitting diagnosis, n (%): Cancer: Tx: 201 (20%); CG: 173 (17%), p=0.11 CVD: Tx: 92 (9%); CG: 113 (11%), p=0.12 Failure to thrive: Tx: 99 (10%); CG: 95 (9%), p=0.77 GI disease: Tx: 50 (5%); CG: 75 (7%), p=0.023 Infection: Tx: 298 (29%); CG: 315 (31%), p=0.39 Metabolic: Tx: 30 (3%); CG: 32 (3%), p=0.79 Neurological disease: Tx: 42 (4%); CG: 53 (5%), p=0.24 Renal disease: Tx: 34 (3%); CG; 34 (3%), p=0.99 Other: Tx: 30 (3%); CG: 25 (2%), p=0.5 Comorbidities, n (%):

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
		previously included in the trial.					CHD: Tx: 287 (28%); CG: 279 (28%), p=0.71 CHF: Tx: 174 (17%); CG: 179 (18%), p=0.75 CKD: Tx: 323 (32%); CG: 318 (31%), p=0.83 COPD: Tx: 147 (14%); CG: 156 (15%), p=0.56 CVA: Tx: 75 (7%); CG: 87 (9%), p=0.32 Dementia: Tx: 39 (4%); CG: 36 (4%), p=0.73 Diabetes: Tx: 215 (21%); CG: 213 (21%), p=0.93 HTN: Tx: 557 (55%); CG: 552 (54%), p=0.86 Malignant disease: Tx: 338 (33%); CG: 329 (32%), p=0.69 Peripheral disease: Tx: 80 (8%); CG: 106 (10%), p=0.044

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
Sharma et al. 2017[89] RCT Australia	Examine the efficacy of providing an early nutrition intervention and its continuation post-discharge in older hospitalized patients.	Include patients ≥60 admitted to the general medicine department of an Australian medical center between November 2014 and June 2016 and confirmed as malnourished by PG-SGA classes B and C. Exclude patients receiving palliative care, patients residing in rural areas, Indigenous Australians and non-English speaking patients and patients unable to give informed consent. Rural patients were excluded due to inadequate funds to travel to rural areas to follow up these participants and Indigenous Australians and non-English speaking subjects were excluded due to lack of funds to seek services of an Aborigine's Liaison Officer/interpreter.	Intervention (Tx): Combination of strategies including oral nutrition supplements (1–2.2 kcal/ml and 0.05–0.12 g of protein/ml), mid-meal snacks and food fortification were employed with consideration given to individual patients' food preferences and dietetic counseling was provided to the patients and care providers to augment energy intake including flagging for assistance with meals by ward based staff if needed. Control Group (CG): Usual care	Tx: 78 CG: 70 3 months	Age, mean (95% CI): Tx: 82.0 (80.0 to 83.9); CG: 81.6 (79.5 to 83.6), p=0.76 Female gender, n (%): Tx: 47 (60.3%); CG: 47 (67.1%), p=0.38 Race/Ethnicity: NR SES: NR	MUST score, mean (95% CI): Tx: 1.8 (1.5 to 2.1); CG: 1.5 (1.1 to 1.8), p=0.12 PG-SGA score, mean (95% CI): Tx: 12.1 (11.0 to 13.2); CG: 13.3 (12.2 to 14.5), p=0.11 BMI in kg/m^2. mean (95% CI): Tx: 20.6 (19.7 to 21.5); CG: 21.8 (20.7 to 22.8), p=0.09 Weight in kg. mean (95% CI): Tx: 55.7 (52.9 to 58.6); CG: 57.6 (54.3 to 60.9), p=0.40	Principal diagnosis at admission, n (%): Cardiovascular: Tx: 14 (18.0%); CG: 8 (11.4%), p=NR CNS: Tx: 6 (7.7%); CG: 3 (4.3%), p=NR Falls: Tx: 13 (16.7%); CG: 10 (14.3%), p=NR Miscellaneous: Tx: 25 (32.1%); CG: 20 (28.6%), p=NR Respiratory: Tx: 20 (25.6%); CG: 29 (41.4%), p=NR Number of co-morbidities, mean (95% CI): Tx: 6.1 (5.5 to 6.6); CG: 6.3 (5.6 to 6.9), p=0.64 Charlson comorbidity index, mean (95% CI): Tx: 2.2 (1.8 to 2.7); CG: 2.3

Author/Year Study Design Country/ Setting	Objective	Patient Inclusion/ Exclusion Criteria	Intervention Control	Number of Patients per Study Arm Follow-up Duration	Age Gender Race/Ethnicity Socioeconomic Status (SES)	Screening Instrument Nutritional Status BMI Weight	Underlying Condition Disease Severity
							(1.9 to 2.8), p=0.82
Starke et al. 2011[90] RCT Switzerland	Evaluate a routinely manageable concept for an improved nutritional care of malnourished in-hospital patients.	Included adult patients admitted to the general medical ward in a Swiss hospital between January 2007 and November 2007 with an NRS-2002 score ≥3. Excluded patients with no informed consent, terminal condition, expected stay <5 days (judged by physician), previous participation in this study, patient on starvation, on parenteral nutrition, and/or being on dialysis.	Intervention (Tx): Individual nutritional care, including a detailed nutritional assessment, individual food supply, fortification of meals with maltodextrin, rapeseed oil, cream and/or protein powder, in-between snacks and oral nutritional supplements. Control (CG): Standard nutritional care, including the prescription of oral nutritional supplements and nutritional therapy prescribed by the physician independently of this study and according to the routine ward management.	Tx: 66 CG: 66 6 months	Age, mean (SD): Tx: 70 (16); CG: 75 (11), p=0.091 Gender: NR Race/Ethnicity: NR SES: NR	NRS-2002 score for nutritional status, mean (SD): Tx: 1.8 (0.6); CG: 1.7 (0.7), p=0.233 NRS-2002 score for severity of disease, mean (SD): Tx: 1.0 (0.3); CG: 0.9 (0.5), p=0.057 BMI in kg/m^2, mean (SD): Tx: 24.6 (5.3); CG: 24.1 (4.9), p=0.527 Weight in kg, mean (SD): Tx: 68.1 (16.9); CG: 66.1 (16.2), p=0.504	Diagnosis: NR

AMI = acute myocardial infarction; BMI = body mass index; CG = control group; CHD = coronary heart disease; CHF = congestive heart failure; CI = confidence interval; CKD = chronic kidney disease; CNS = central nervous system; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; CVD = cardiovascular disease; GI = gastrointestinal; HF = heart failure; HLD = hyperlipidemia; HTN = hypertension; Kg = kilograms; Kg/m^2 = kilograms per meters squared; LOS = length of stay; MNA = mini nutritional assessment; MUST = malnutrition universal screening tool; NR = not reported; NRS-2002 = nutrition risk screening 2002; NS = not significant; NT = nutrition therapy; ONS = oral nutrition supplement; PEG = percutaneous endoscopic gastrostomy; PG-SGA = patient-generated subjective global assessment; PNA = pulmonary nodular amyloidosis; RCT = randomized controlled trial; SD = standard deviation; SE = standard error; SES = socioeconomic status; SGA = subjective global assessment; Tx = Treatment

Appendix E. Risk of Bias

Table E-1. Risk of bias assessment for systematic reviews

	Question	DiJkink 2020	Ney 2019	Muscaritoli 2017	Lew 2016	Lin. 2016	Gupta 2011
Study eligibility criteria	Did the review adhere to predefined objectives and eligibility criteria?	Yes	Yes	Yes	Yes	Yes	Yes
	Were the eligibility criteria appropriate for the review question?	Yes	Yes	Yes	Yes	Yes	Prob Yes
	Were eligibility criteria unambiguous?	Yes	Yes	Yes	Yes	Yes	Yes
	Were all restrictions in eligibility criteria based on study characteristics appropriate (e.g. date, sample size, study quality, outcomes measured)?	Yes	Yes	Yes	Yes	Yes	Yes
	Were any restrictions in eligibility criteria based on sources of information appropriate (e.g. publication status or format, language, availability of data)?	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes	Prob Yes
	Overall Concern	Low	Low	Low	Low	Low	Low
Identification and Selection of Studies	Did the search include an appropriate range of databases/electronic sources for published and unpublished reports?	Yes	Yes	Yes	Yes	Yes	Yes
	Were methods additional to database searching used to identify relevant reports?	Yes	Yes	Yes	Yes	Yes	Yes
	Were the terms and structure of the search strategy likely to retrieve as many eligible studies as possible?	Prob Yes	Yes	Yes	Yes	Yes	Yes
	Were restrictions based on date, publication format, or language appropriate?	Prob Yes	Yes	Yes	Prob Yes	Prob Yes	Prob Yes
	Were efforts made to minimize error in selection of studies?	Prob Yes	Yes	Yes	Yes	Yes	Yes
	Overall Concern	Low	Low	Low	Low	Low	Low
Data Collection and Study Appraisal	Were efforts made to minimize error in data collection?	Yes	Yes	Yes	Yes	Yes	Yes
	Were sufficient study characteristics available for both review authors and readers to be able to interpret the results?	Prob Yes	Yes	Yes	Yes	Yes	Yes
	Were all relevant study results collected for use in the synthesis?	Prob Yes	Yes	Yes	Prob Yes	Yes	Yes
	Was risk of bias (or methodological quality) formally assessed using appropriate criteria?	Prob Yes	Yes	Yes	Yes	Yes	No
	Were efforts made to minimize error in risk of bias assessment?	Yes	Yes	Yes	Yes	Yes	No
	Overall Concern	Low	Low	Low	Low	Low	High
Synthesis and Findings	Did the synthesis include all studies that it should?	Prob Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes

	Question	DiJkink 2020	Ney 2019	Muscaritoli 2017	Lew 2016	Lin. 2016	Gupta 2011
	Were all pre-defined analyses reported or departures explained?	Prob Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Yes
	Was the synthesis appropriate given the nature and similarity in the research questions, study designs and outcomes across included studies?	Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes
	Was between-study variation (heterogeneity) minimal or addressed in the synthesis?	Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes
	Were the findings robust, e.g. as demonstrated through funnel plot or sensitivity analyses?	Prob Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes
	Were biases in primary studies minimal or addressed in the synthesis?	Prob Yes	Prob Yes	Prob Yes	Prob Yes	Yes	Prob Yes
	Overall Concern	Low	Low	Low	Low	Low	Low
Overall Risk of Bias Rating		Low	Low	Low	Low	Low	Low*

*While the authors of this review did not formally assess the ROB of the included individual studies, they did report on critical information that allowed ECRI-Penn to infer the ROB of the studies. Only one of the 8 studies from this review addressing KQ1 controlled for important confounders. Thus, the ROB of most studies was rated ”High”.

Table E-2. Risk of bias for randomized controlled trials (Cochrane ROB 2.0) for studies answering KQ 3

Author	Outcomes	Randomization	Effect of Assignment	Missing Outcome Data	Measurement of Outcome	Selection of Reported Results	Overall RoB
Bonilla-Palomas 2016	Mortality, Readmission	Some Concerns	Low	Low	Low	Some Concerns	Some Concerns
Deutz 2016	Length of Stay, Mortality, Readmission, Activities of Daily Living	Low	Low	Some Concerns	Low	Low	Some Concerns
Gazzotti 2003	Discharge Disposition, Hospital Acquired Conditions, Length of Stay, Mortality, Readmission	Low	Low	Some Concerns	Low	Some Concerns	Some Concerns
Ha 2010	Length of Stay, Mortality	Some Concerns	Some Concerns	Some Concerns	Low	Low	High
Ha 2010	Quality of Life*	Some Concerns	Some Concerns	High	Some Concerns	Low	High
Holyday 2011	Length of Stay, Mortality, Readmission	Some Concerns	Low	Low	Low	High	High
Johansen 2004	Hospital Acquired Conditions, Length of Stay	Low	Low	High	Low	Some Concerns	High
Johansen 2004	Quality of Life*	Low	Low	Low	Some Concerns	Some Concerns	High
Munk 2014	Length of Stay, Mortality	Some Concerns	Low	Low	Low	Low	Some Concerns
Rufenacht 2011	Mortality	Low	Low	Low	Low	Some Concerns	Some Concerns
Rufenacht 2011	Quality of Life*	Low	High	Low	High	Low	High
Schuetz 2019	Activities of Daily Living, Length of Stay, Mortality, Readmissions	Low	Low	Low	Low	Low	Low
Schuetz 2019	Quality of Life*	Low	Low	Low	High	Low	High
Sharma 2017	Discharge Disposition, Hospital Acquired Conditions, Length of Stay	Low	Some Concerns	High	Low	Low	High
Sharma 2017	Quality of Life*	Low	High	Some Concerns	High	Low	High
Sharma 2017	Readmissions**	Low	High	High	Low	Low	High
Starke 2011	Hospital Acquired Conditions, Length of Stay, Mortality, Readmission	Some Concerns	Low	Low	Low	Low	Some Concerns
Starke 2011	Quality of Life*	Some Concerns	Low	High	Low	Low	High

Note: Colors in table are for visual effect and do not provide any additional information.
*Quality of life analyzed separately to account for domains influencing outcome assessment.
**For Sharma et al. 2017 patients received telehealth visits which could have potentially influenced the outcome of readmissions; thus, we rated the readmissions outcome separately from other objective outcomes.

Appendix F. Results From Included Studies

Table F-1. Findings of reported outcomes of systematic reviews assessing the association of malnutrition with outcomes

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
Dijkink et al. 2020[74] Trauma Patients	**VP** (3, n=6,050) Study 1 (Wilson, 2019): OR: 2.22, 95% CI: 1.26 to 3.92 Study 2 (Wilson, 2019): RR: 4.86, CI: 2.66 to 8.87 Study 3 (McClave, 1992): OR: 4.04, p<0.05 **MNA** (1, n=97, Goisser, 2015): WN: 13%, ARM: 21%, MN: 0%, p=0.120 **SGA** (1, n=161 (Goiburu, 2006): RR: 4.0, 95% CI: 1.0 to 15.0	**VP** (3, n=6,050) Study 1 (Wilson, 2019): p=0.024 Study 2 (Wilson, 2019): p<0.001 Study 3 (McClave, 1992): OR: 1.29, p<0.05 **NRS** (1, n=521, Ihle, 2017): ND **MNA** (2, n=396) Study 1 (Goisser, 2015): p=0.388, ND Study 2 (Compan et al. 1999): positive association **SGA** (1, n=161 (Goiburu, 2006): RR: 2.3, 95% CI: 1.2 to 4.7	**VP** (1, n=5,673, Wilson, 2019): 2.0, 95% CI: 1.55 to 2.57	NR	NR	NR	**<u>Sepsis</u>** **VP** (2, n=5673) Study 1 (Wilson, 2019): 1.99, 95% CI: 1.03 to 3.86 Study 2: (McClave, 1992): OR: 2.64, p<0.05 **<u>Infection</u>** **VP** (1, NR, McClave, 1992): OR: 2.26, p<0.05 **<u>AE not described</u>** **VP** (2, n=6,050) Study 1 (Wilson, 2019): positive association Study 2 (Wilson 2019): RR: 1.46, 95% CI: 1.03 to 1.64 **NRS** (2, n=2,163) Study 1 (Ihle, 2017): positive association (p<0.001) Study 2 (Wintermeyer et al. 2019): positive	NR	NR

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
							association (p<0.001) **SGA** (1, n=161, Goiburu, 2006): RR: 2.9, 95% CI: 1.4 to 5.8		
Ney et al. 2019[75]	**SGA Pre-transplant** (3 studies): Alvaras 2005, n=50; Ciocirlan 2017, n=97; Nunes 2017, n=130): RR: 2.40, 95% CI: 1.16 to 4.96 **Post-transplant** (2 studies): Bakshi 2016, n=43; RR: 0.66, 95% CI: 0.10 to 4.55; Pikul 1994, n=68; RR: 5.73, 95% CI: 0.36 to 92.2	**SGA** (2 studies Pikul, 1994, n=30; Stephenson, 2001, n=68): RR: 4.35, 95% CI: 5.42 to 22.69, I^2=93%	NR	NR	NR	NR	NR	NR	NR
Muscaritoli et al. 2017[76] Various Conditions/ General Medicine: 7 COPD: 3 Heart Failure: 4 Pneumonia: 1	NR	NR	5 prospective cohort trials showed positive association b/w MN and increase in readmission. 8 studies showed no independent predictive association of MN for readmission.	NR	NR	NR	NR	NR	NR

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
			NRI (Aziz, 2011, n=1,110, heart failure): OR NRI score: 3.1 (2.34 to 4.22), p<0.0001 **MNA** (Benedik, 2011, n=108, COPD): MN group 67% readmitted within 6 mos; at-risk 39%; well-nourished 39% **BMI** (Mudge, 2011, n=142, older patients): Underweight (BMI <18.5) OR: 12.7, 95% CI: 2.3 to 70.7, p=0.004 **MUST ≥2 vs. 0** (Steer, 2010, 547, COPD): OR: 1.71, 95% CI: 1.04 to 2.83, p=0.034 **Serum albumin:** <2.9 mg/dL or unintentional weight loss (Vecchiarino, 2004, n=213): 49 (23.9%) of all patients readmitted, OR: 2.25, 95% CI: 0.997 to 5.1, p=0.051						

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
Lew et al. 2016[77] Trauma/Acute Care Patients	**SGA:** 2 of 5 studies found an association b/w MN and hosp. mortality: Fontes, 2014, n=185, OR: 8.12, 95% CI: 2.94 to 22.42, p<0.05; Sheean, 2013, n=260, WN: 4.8, MN: 23.0, p<0.01 2 studies non-significant trend (Capossi, 2012, AOR: 2.00, 95% CI: 0.50 to 7.60; Merli, 2010, p=0.10) **MNA:** 2 studies Identified no association (Lomivorotov, 2013, n=1193; Sheean, 2013, n=260) **NRS-2002:** 1 of 2 studies found MN associated with greater hospital mortality (Sheean, 2013, n=260 adjusted p=0.03)	**SGA:** 3 of 5 studies found MN was associated with longer Hosp and ICU LOS: Lomivorotov. 2013, n=1193, 2.00, 95% CI: 1.10 to 3.70, p=0.02; Caporossi, 2012, n=246, Hosp OR: 2.80, 95% CI: 1.50 to 7.70, p<0.01; Merli, 2010, n=38, ICU HR: 0.18, p<0.01, Hosp HR: 0.20, p<0.01 2 studies reported non-significant trend (Sheean, 2013; Sheean, 2010) **MNA:** 2 studies identified no association: Lomivorotov, 2013, n=1193; OR: 1.40, 95% CI: 0.70 to 2.30; Sheean, 2013, n=260, adj p=0.17 Hosp, p=0.07 ICU	**SGA:** 1 study (Fontes, 2014, n=185) found MN was associated with higher incidence of ICU readmission (OR: 2.27, 95% CI: 1.08 to 4.80; p<0.05)	NR	NR	NR	**SGA:** 1 study (Merli, 2010, n=38) found MN independently associated with higher incidence of infection (4.5 vs 0.6 episodes per patient, adjusted, p=0.0001) **MNA:** 1 study (Lomivorotov, 2013, n=1193) found MN independently associated with higher incidence of postoperative complications (adjusted odds ratio, 1.60, 95% CI: 1.10 to 2.20, p<0.01) **NRS-2002:** 1 study (Lomivorotov, 2013, n=1193) identified no association between MN and post-operative complications	**SGA:** 1 study (Merli, 2010, n=38) identified no association between MN and wound healing or graft rejection	**SGA:** 1 study (Sheean, 2013, n=260) found MN was associated with a lower percentage of patients discharged to home (28.6% lower than their well-nourished counterparts; adjusted p value=0.001) **NRS-2002:** 1 study (Sheean, 2013, n=260) found MN associated with lower discharge to home (WN: 74.9%, MN: 53.2%, p=0.01 **MNA-SF:** 1 study (Sheean, 2013, n=260), no association btw MN and discharge home, adj p=0.19

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
	MUST: Tripathy, 2014, n=109, found MN associated with 1-year mortality (adjusted OR: 2.94, 95% CI: 1.10 to 8.00) **MNA-SF:** 1 study (Sheean, 2013, n=260) found MN associated with higher hospital mortality (adj p<0.01)	**NRS-2002:** 1 of 2 studies found malnutrition associated with increased LOS (>2 days; OR: 1.80, 95% CI: 1.10 to 3.30 (Lomivorotov, 2013, n-1193) **MUST:** Lomivorotov, 2013, n-1193 found no association, AOR >2d of ICU stay: 1.20, 95% CI: 0.90 to 2.00, p=0.33 MNA-SF: 1 study (Sheean, 2013, n=260), No association btw MN and LOS, adj p=0.06							
Lin et al. 2016[78] Heart Failure	**MNA:** 4 (Bonilla, 2011, Sargento, 2013, Aggarwal, 2013, Suzuki, 2015, 472): HR: 4.32, 95% CI: 2.30 to 8.11), I^2=0.0% **MNA-SF:** 2 (Yost, 2014, n=162; Sargento et al. 2013, n=50): HR: 3.56, 95% CI: 1.41 to 9.00	**MNA** (Yost, 2014, n=162): ND **MNA-SF** (Yost, 2014, n=162): ND **NRI** (Aziz, 2011 n=1,110): OR: 1.7, 95% CI: 1.58 to 1.9 **NRS** (Tevik, n=131): OR: 2.99, 95% CI: 1.33 to 6.73, confounded with disease severity	NR	NR	NR	NR	**NRS** (Aziz, 2011 n=1,110): p<0.05; higher risk of complication associated with MN	NR	NR

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
	NRI: 3 (Aziz, 2011; Al-Naijer, 2015; Gouya, 2014, n=1,785): HR: 2.08, 95% CI: 1.60 to 2.71 **GNRI:** 3 (Narumi, 2013, Kinugasa 2013, Kaneko, 2015, n=978): HR: 3.11, 95% CI: 1.69 to 5.74), I^2=70%								
Gupta et al. 2011[79] Cancer	NR	LOS was significantly higher in the MN group vs. WN group **SGA** **Gastrointestinal cancer (4):** Wu, 2010, n=505, mean WN: 20.8 days; mean MN: 29.1 days, p=0.001; Wu, 2009, n=751, mean WN: 17.1 days, mean MN: 21.1 days, p=0.07; Wakahara, 2007, n=262, WN: mean 24 days, MN: mean 57 days, p=0.01; Ulander, 1998, n=75, 1994, WN: <8 days, MN: >14 days	NR	NR	NR	NR	NR	NR	NR

Author/Year Type of Patient	Mortality	Length of Stay	30-Day Readmission	Quality of Life	Functional Status	Activities of Daily Living	Hospital Acquired Condition (HAC)	Wound Healing	Discharge Disposition
		Head and neck cancer (1, Shirodkar, 2005, n=266): Median postoperative days=WN: 5 days, MN: 10 days, p<0.001 **Lymphoma** (1, Bauer, 2002, n=71 retrospective): WN: 7.0 days, MN: 13.0 days, p=0.02 **PG-SGA** **Gynecologic cancer** (1, Laky, 2010, n=157): OR: 6.89, 2.48 to 19.2, p<0.01 **Multiple myeloma** (1, n=66, Horsley, 2005, retrospective): WN: 16.9 days, MN: 23 days, p=0.002							

ARM = at-risk of malnutrition; CI = confidence interval; GNRI = Geriatric Nutritional Risk Index; LOS = length of stay; MN = malnourished; MNA = mini nutritional assessment; MNA-SF = MNA-short form; MUST = malnutrition universal screening tool; NO indicates no association identified or no important difference found between malnourished and well-nourished; NR = not reported; NRI = Nutritional Risk Index; NRS-2002 = nutrition risk screening 2002; PG-SGA = patient-generated subjective global assessment; RCT = randomized controlled trial; SD = standard deviation; SE = standard error; SES = socioeconomic status; SGA = subjective global assessment; VP = visceral proteins; WN = well-nourished

Table F-2. Findings of reported outcomes on effectiveness of malnutrition interventions

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
Bonilla-Palomas et al. 2016[80]	1-month mortality, %: Tx: 0.07; CG: 0.11, p=NR 3-month death from any cause, %: Tx: 0.14; CG: 0.26, p=NR 6-month death from any cause, %: Tx: 0.15; CG: 0.36, p=NR 12-month death from any cause, %: Tx: 0.203; CG: 0.475, p=0.003	NR	1-month readmission, %: Tx: 0.00; CG: 0.09, p=NR 3-month readmission, %: Tx: 0.04; CG: 0.22, p=NR 6-month readmission, %: Tx: 0.08; CG: 0.35, p=NR *12-month readmission, %: Tx: 0.114; CG: 0.433, p=0.001	NR	NR	NR	NR	NR
Deutz et al. 2016[81]	30-day mortality, %: ONS: 2.9%; CG: 6.2%, p=0.049 60-day mortality, %: ONS: 4.2%; CG: 8.7%, p=0.020 90-day mortality, %: ONS: 4.8%; CG: 9.7%, p=0.018 The NNT to prevent 1 death, 95% CI: 20.3 (10.9 to 121.4)	LOS in days, mean (SD): ONS: 5.0 (3.2); CG: 5.1 (3.6), p=NS	30-day readmission, %: ONS: 15.0%; CG: 13.9%, p=0.697 60-day readmission, %: ONS: 20.4%; CG: 21.4%, p=0.780 90-day readmission, %: ONS: 25.2%; CG: 25.6%, p=NS	NR	Katz score, median (Q1, Q3): Tx: 6 (6, 6); CG: 6 (6, 6), p=NR	NR	NR	Adverse events: ONS, n (%): 136 (44); CG: 146 (47), p=NS Serious adverse events, n (%): ONS: 92 (30); CG: 82 (26), p=NS

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
Gazzotti et al. 2003[82]	All-cause mortality, n: ONS: 2; CG: 2, p=NR	LOS in days, mean (SD): ONS: 21.2 (10.1); CG: 19.8 (15.1), p=0.19	60-day readmission, n: ONS: 4; CG: 3, p=NR	NR	NR	NR	Discharged Home, %: ONS: 66.7%; CG: 65%, p=NR	Minor side effects, n: ONS: 5; CG: 0, p=NR
Ha et al. 2010[83]	All-cause mortality, n: Tx: 12; CG: 10, p=NR	LOS in days, median (Range): Tx: 12 (2 to 54); CG: 13 (3 to 55), p=NS	NR	Increase in EQ-5D VAS score, Median (Range): Tx: 10 (-80 to 60); CG: 0 (-35 to 70), p=0.009 Patients with an increase in EQ-5D Score: Tx: 71.4%; CG: 37.2%, p=0.003	NR	NR	NR	NR
Holyday et al. 2011[84]	*At Risk* All-cause mortality, n: Tx: 1; CG: 0, p=NR *Malnourished* All-cause mortality, n: Tx: 2; CG:1, p=NR	*At Risk* LOS, excluding deaths, mean (SE): Tx: 13.8 (1.6); CG: 11.0 (1.4), p=0.20 LOS, adjusted for deaths, mean (SE): Tx: 14.5 (1.8); CG: 11.0 (1.4), p-0.097 *Malnourished* LOS, excluding deaths, mean (SE): Tx: 10.6 (1.6); CG: 19.5 (3.0), p=0.013	*At Risk* 1-month readmission, mean (SE): Tx: 0.11 (0.05); CG: 0.10 (0.05), p=0.90 6-month readmission, mean (SE): Tx: 0.37 (0.09); CG: 0.62 (0.12), p=0.11 *Malnourished* 1-month readmission, mean (SE): Tx: 0.00 (0.00); CG: 0.16 (0.09), p=0.083	NR	NR	NR	NR	NR

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
		LOS, adjusted for deaths, mean (SE): Tx: 11.2 (1.5); CG: 19.8 (3.0), p=0.054	6-month readmission, mean (SE): Tx: 0.50 (0.31); CG: 0.63 (0.14), p=0.31					
Johansen et al. 2004[85]	All-cause mortality, n: Tx: 9; CG: 6, p=NR	LOS until 28 days, mean (SD): Tx: 11.2 (0.7); CG: 12.2 (0.7), p=NS	NR	Change in SF-36 quality of life MCS, mean (SE): Tx: 2.2 (2.5); CG: 3.3 (2.0), p=NR Change in SF-36 quality of life PCS, mean (SE): Tx: 2.4 (1.3); CG: 0.2 (1.5), p=NR	NR	Incidence of minor complications, n: Tx: 18; CG: 14, p=NR Incidence of major complications, n: Tx: 5; CG: 0, p=NR	NR	NR
Munk et al. 2014[86]	All-cause mortality, n: Tx: 1; CG: 1, p=NR	LOS from admission to discharge, mean (SD): Tx: 15 (10); CG: 14 (8), p=0.38 LOS, inclusion to discharge, mean (SD): Tx: 10 (8); CG: 10 (8), p=0.73	NR	NR	NR	NR	NR	NR

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
Rufenacht et al. 2011[87]	All-cause mortality, n: Tx: 4; ONS: 1, p=NR	NR	NR	30-day change in EQ-5D VAS score, mean (SD): Tx: 28.5 (20.6); ONS: 17.1 (20.4), p=NR 30-day change in FAACT total score, mean: Tx: 9.7; CG: 10.7, p=NR 60-day change in FAACT total score, mean: Tx: 29.9; CG: 24.0, p=NR	NR	NR	NR	NR
Schuetz et al. 2019[88]	All-cause mortality, n (%): Tx: 73 (7%); CG: 100 (10%), p=0.011	LOS in days, mean (SD): Tx: 9.5 (7.0); CG: 9.6 (6.1), p=0.46	30-day readmission, n (%): Tx: 89 (9%); CG: 91 (9%), p=0.96	EQ-5D index, mean (SD): Tx: 0.75 (0.32); CG: 0.73 (0.34), p=0.018 EQ-5D VAS, mean (SD): Tx: 59 (26); CG: 56 (29), p<0.0001	Barthel index, mean (SD): Tx: 88 (26); CG: 85 (30), p=0.006 Decline in functional status of ≥10%, n (%): Tx: 35 (4%); CG: 55 (6%), p=0.034	Major complications, n (%): Any major complications: Tx: 74 (7%); CG: 76 (8%), p=0.79 Acute kidney failure: Tx: 32 (3%); CG: 31 (3%), p=0.96 GI disease: Tx: 9 (1%); CG: 15 (1%), p=0.19 Major cardiovascular event: Tx: 8 (1%); CG: 7 (1%), p=0.84 Nosocomial infection: Tx: 40 (4%); CG: 39 (4%), p=0.98	NR	All side effects, n (%): Tx: 162 (16%); CG: 145 (14%), p=0.26 Complications due to enteral feeding or parental nutrition: Tx: 5 (<1%); CG: 3 (<1%), p=0.51 GI side effects: Tx: 43 (4%); CG: 40 (4%), p=0.66 Liver or gall bladder dysfunction: Tx: 4 (<1%); CG: 7 (1%), p=0.34

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
						Respiratory failure: Tx: 14 (1%); CG: 13 (1%), p=0.89		Refeeding syndrome: Tx: 86 (8%); CG: 73 (7%), p=0.27 Severe hyperglycemia: Tx: 48 (5%); CG: 46 (5%), p=0.80
Sharma et al. 2017[89]	All-cause mortality, n (%): Tx: 23 (29.5%); CG: 22 (31.0%), p=0.84 In-hospital mortality, n (%): Tx: 7 (9.0%); CG: 1 (1.4%), p=0.09 3 months post-discharge, n: Tx: 14; CG: 12, p=NR	Acute LOS in days, median (IQR): Tx: 5.0 (3.0 to 8.4); CG: 8.8 (4.1 to 13.9), p=0.007 Total LOS, inclusive of hospital at home time, median (IQR): Tx: 5.4 (3.1 to 11.2); CG: 11.4 (5 to 21.6), p=0.01	Total readmissions, n (%): Tx: 46 (59.0%); CG: 46 (64.8%), p=0.47 1-month readmissions, n (%): Tx: 14 (18.0%); CG: 17 (23.9%), p=0.37 3-month readmissions, n (%): Tx: 26 (33.3%); CG: 29 (40.9%), p=0.34 6-month readmissions, n (%): Tx: 37 (47.4%); CG: 35 (50.0%), p=0.82	EQ-5D 5 level index, mean (95% CI): Tx: 0.770 (0.721 to 0.818); CG: 0.740 (0.674 to 0.805), p=0.45 EQ-5D VAS score, mean (95% CI): Tx: 61.2 (56.8 to 65.6); CG: 52.4 (45.2 to 59.7), p=0.03	NR	Proportion of patients with complications, n (%): Tx: 21 (26.9%); CG: 23 (32.4%), p=0.47 Total complications, mean (95% CI): Tx: 0.65 (0.33 to 0.98); CG: 0.73 (0.41 to 1.05), p=0.73 Infective complications, n (%): Tx: 9 (11.5%); CG: 7 (9.9%), p=0.74 Non-infective complications, n (%): Tx: 19 (24.4%); CG: 21 (29.6%), p=0.48	Proportion of patients discharged to residential facility, n (%): Tx: 6 (7.7%); CG: 6 (8.5%), p=0.09	NR

Author/Year	Mortality	Length of Stay	Readmissions	Quality of Life	Activities of Daily Living	Hospital Acquired Condition (HAC)	Discharge Disposition	Adverse Events
Starke et al. 2011[90]	During-study mortality, n: Tx: 2; CG: 5, p=0.440 Mortality during follow-up period, n: Tx: 9; CG: 6, p=0.585	Admission to actual discharge, mean (SD): Tx: 15.7 (9.2); CG: 15.9 (10.7), p=0.843 Admission to possible discharge, mean (SD): Tx: 13.8 (7.1); CG: 14.9 (10.2), p=0.458 Hospital LOS, mean (SD): Tx: 17.0 (10.4); CG: 18.6 (17.1), p=0.913	6-month readmissions, n (%): IG: 17 (27%); CG: 28 (46%), p=0.027	SF-36 MCS, mean (SD): Tx: 50 (11); CG: 51 (11), p=0.640 SF-36 PCS, mean (SD): Tx: 37 (11); CG: 32 (9), p=0.033	NR	Number of patients suffering from in-hospital complications, n: Tx: 4; CG: 13, p=0.035 Total number of complications, n: Cerebrovascular ischemia: Tx: 0; CG: 1, p=NR Decompensated CHF: Tx: 1; CG: 1, p=NR Decubitus: Tx: 0; CG: 1, p=NR Diarrhea: Tx: 0; CG: 1, p=NR MI: Tx: 0; CG: 2, p=NR Septic arthritis: Tx: 0; CG: 1, p=NR Thrombosis: Tx: 0; CG: 1, p=NR UTI: Tx: 1; CG: 5, p=NR Unknown: Tx: 0; IG: 2, p=NR	NR	NR

CG = control group; CHF = congestive heart failure; CI = confidence interval; EQ-5D = EuroQol 5 dimension; FAACT = Functional Assessment of Anorexia/Cachexia Therapy; GI = gastrointestinal; HF = heart failure; HR = hazard ratio; IQR = interquartile range; LOS = length of stay; MCS = mental component summary; MI = myocardial infarction; NNT = number needed to treat; NR = not reported; NS = not significant; ONS = oral nutrition supplement; PCS = physical component summary; Q1 = first quartile; Q3 = third quartile; QoL = quality of life; RR = relative risk; SD = standard deviation; SF-36 = 36 item short form health survey; Tx = treatment; VAS = visual analog scale

*1-month, 3-month, and 6-month data extracted from survival analysis curves using a web-based numerical data extraction tool (WebPlotDigitizer v 4.4) to estimate graphical data. 12-month mortality data matched text data, although, the survival analysis plot portrayed different results than described in text (Treatment 10.2% vs Control Group 36.1%). Data reported are from the survival analysis.

Appendix G. Forest Plots of Additional Analysis

Figure G-1. Effect of hospital-initiated interventions on mortality, all studies

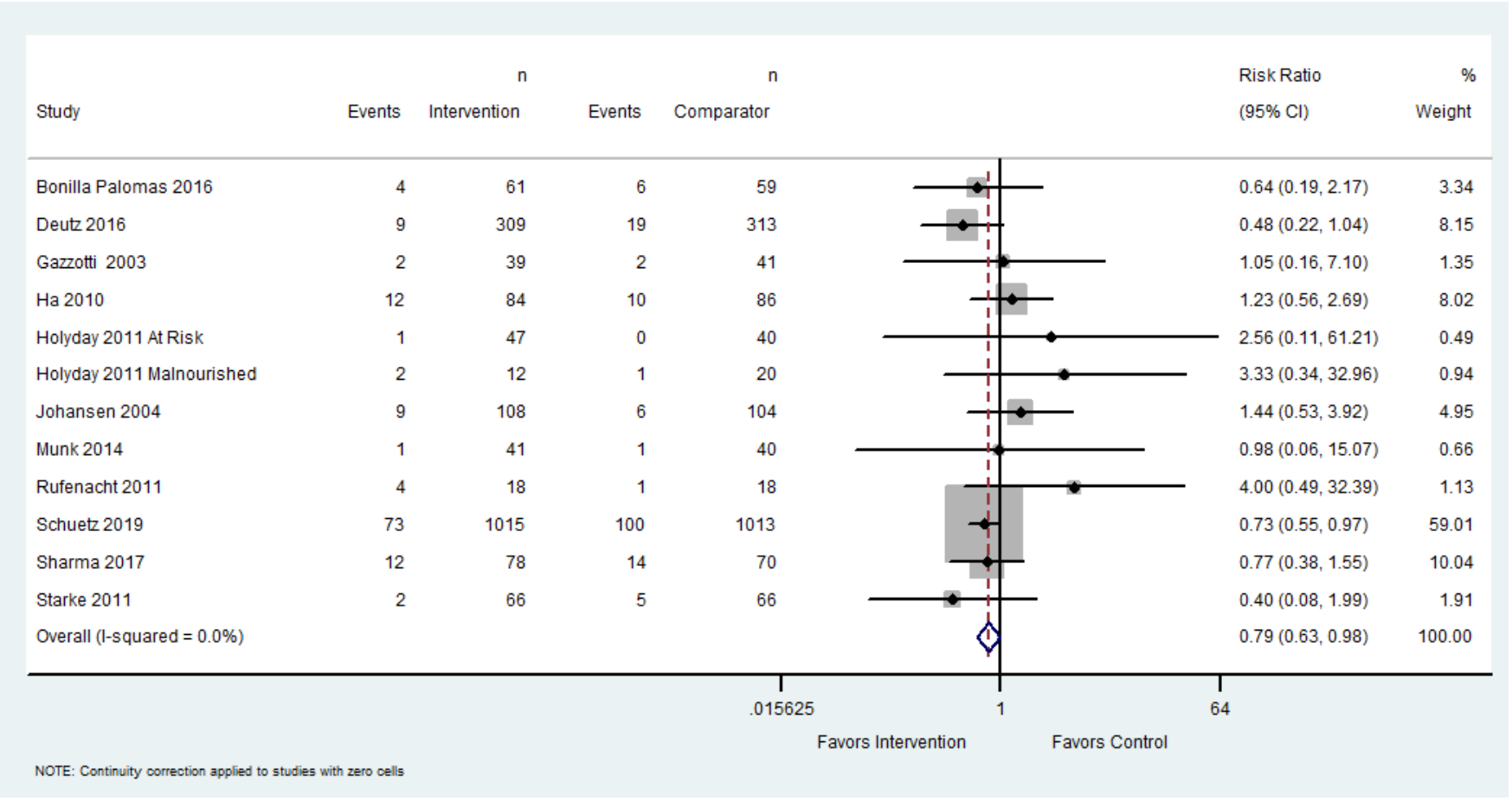


Figure G-2. Effect of hospital-initiated interventions on mortality, subgroup intervention type

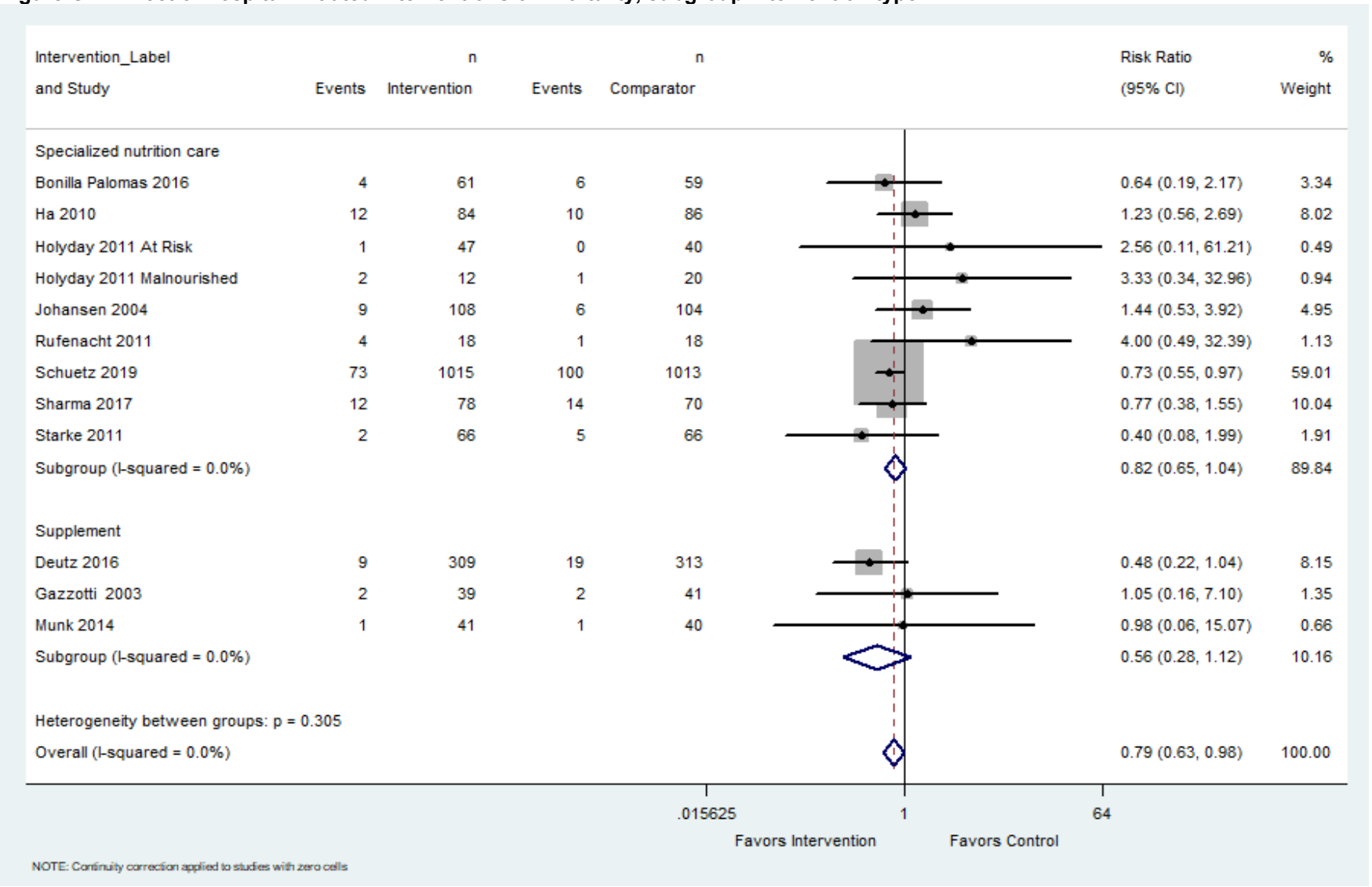


Figure G-3. Effect of hospital-initiated interventions on mortality, subgroup malnutrition status

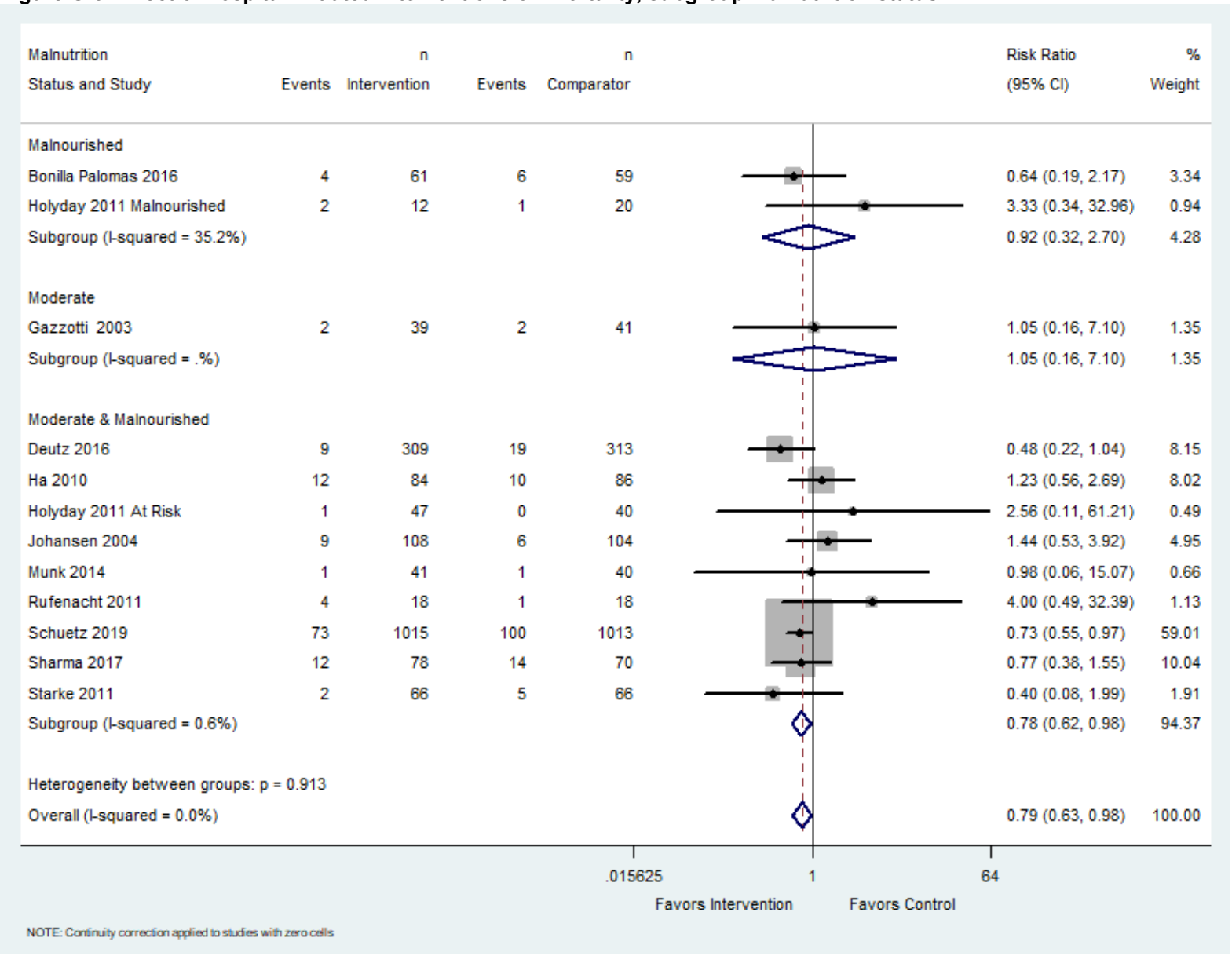


Figure G-4. Effect of hospital-initiated interventions on mortality, subgroup followup time

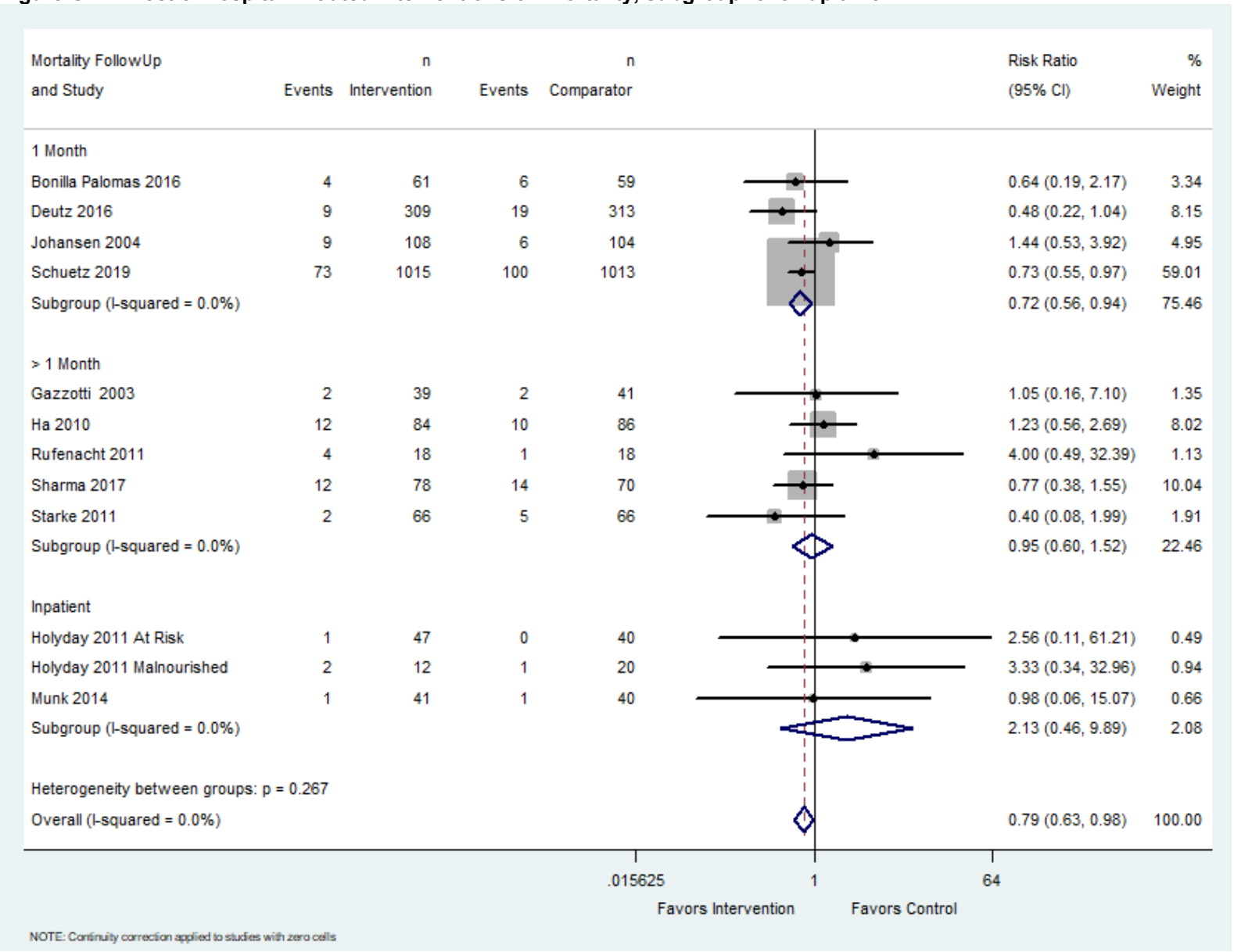


Figure G-5. Effect of hospital-initiated interventions on length of stay, all studies

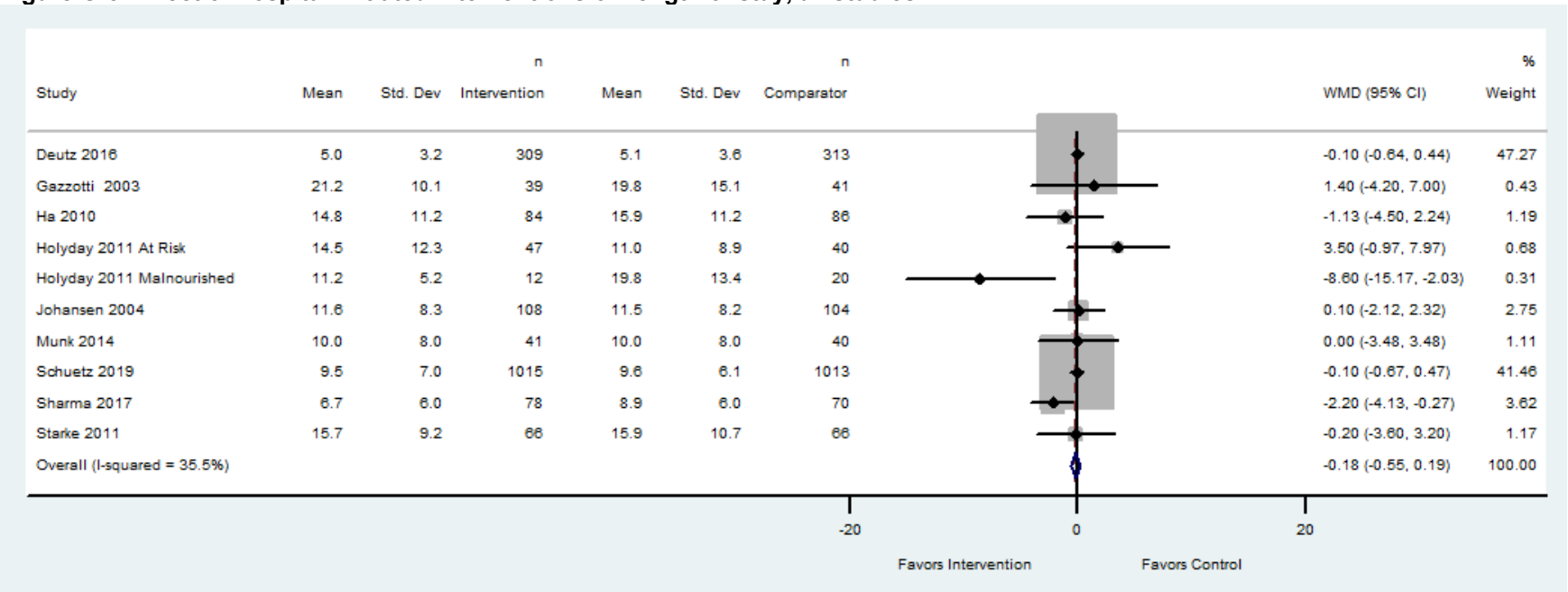


Figure G-6. Effect of hospital-initiated interventions on length of stay, subgroup type of intervention

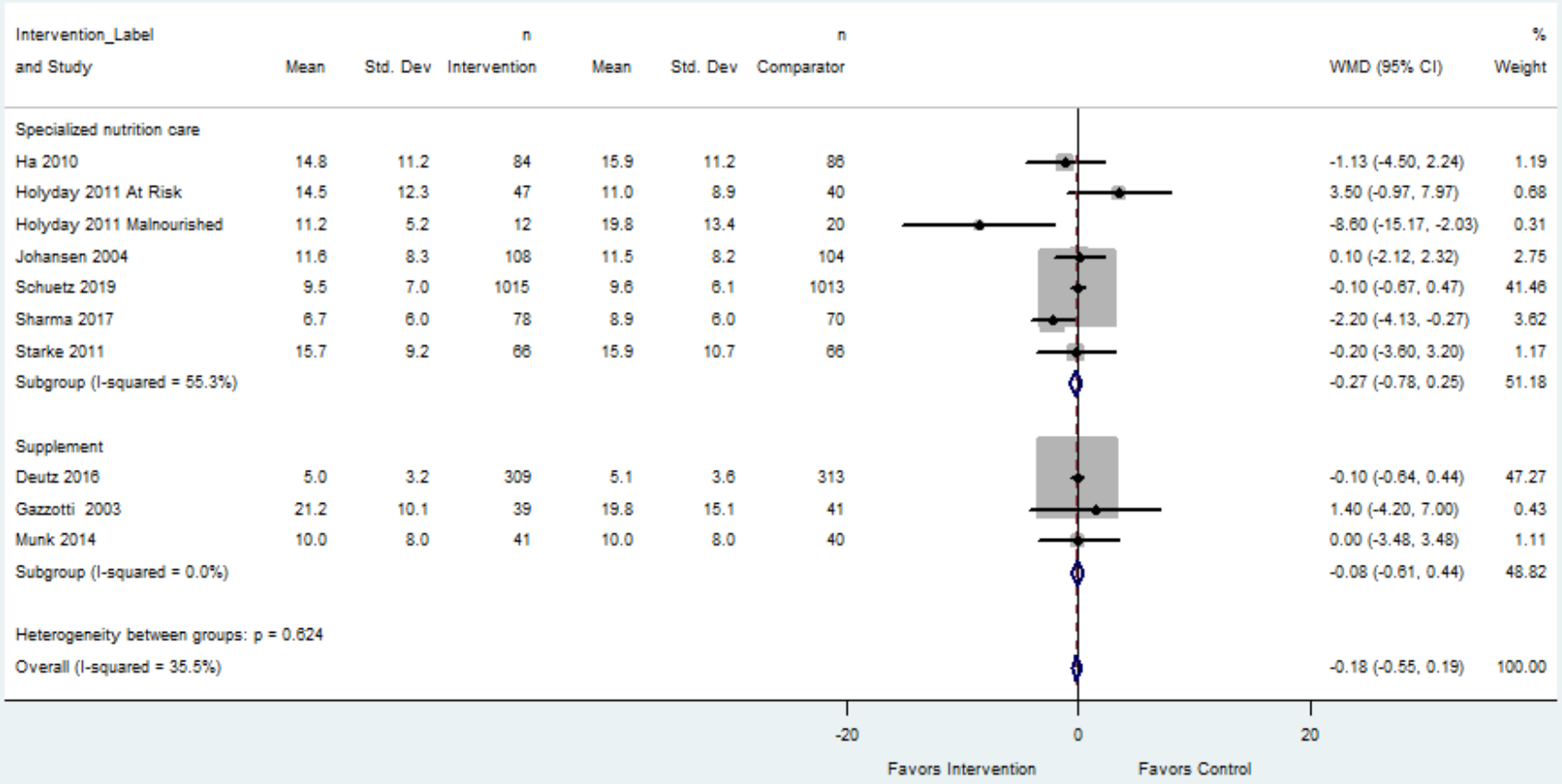


Figure G-7. Effect of hospital-initiated interventions on length of stay, subgroup malnutrition status

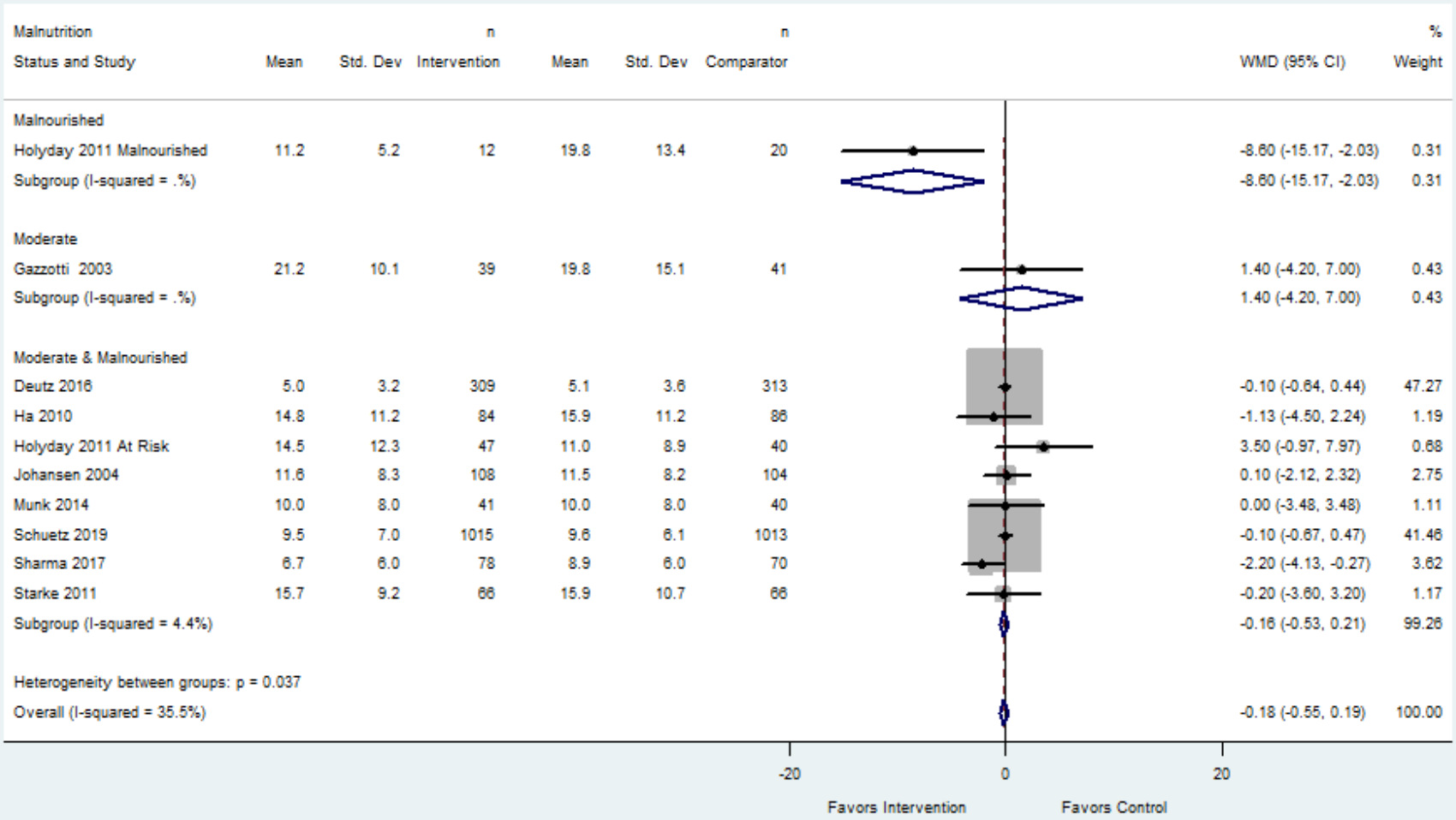
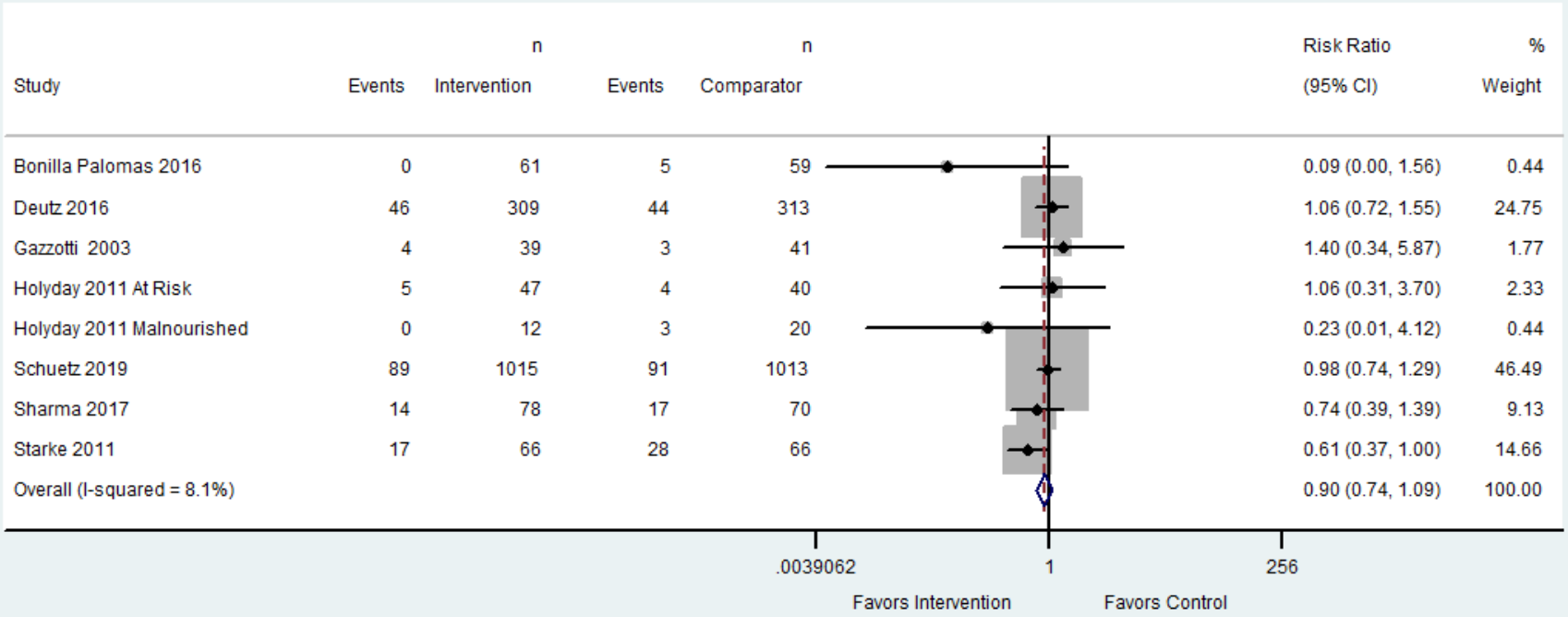


Figure G-8. Effect of hospital-initiated interventions on readmissions, all studies



NOTE: Continuity correction applied to studies with zero cells

Figure G-9. Effect of hospital-initiated interventions on readmissions, subgroup type of intervention

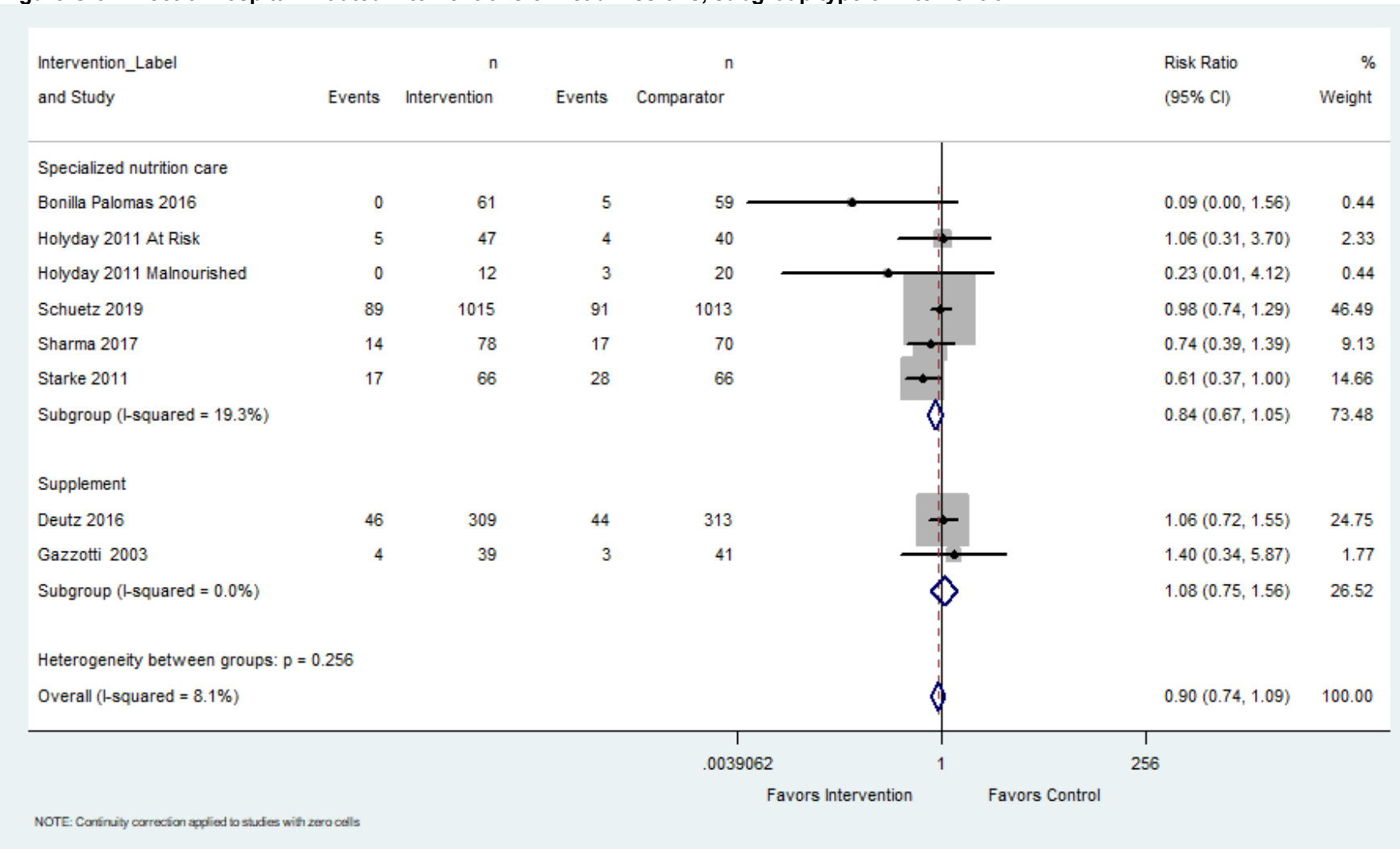


Figure G-10. Effect of hospital-initiated interventions on readmissions, subgroup malnutrition status

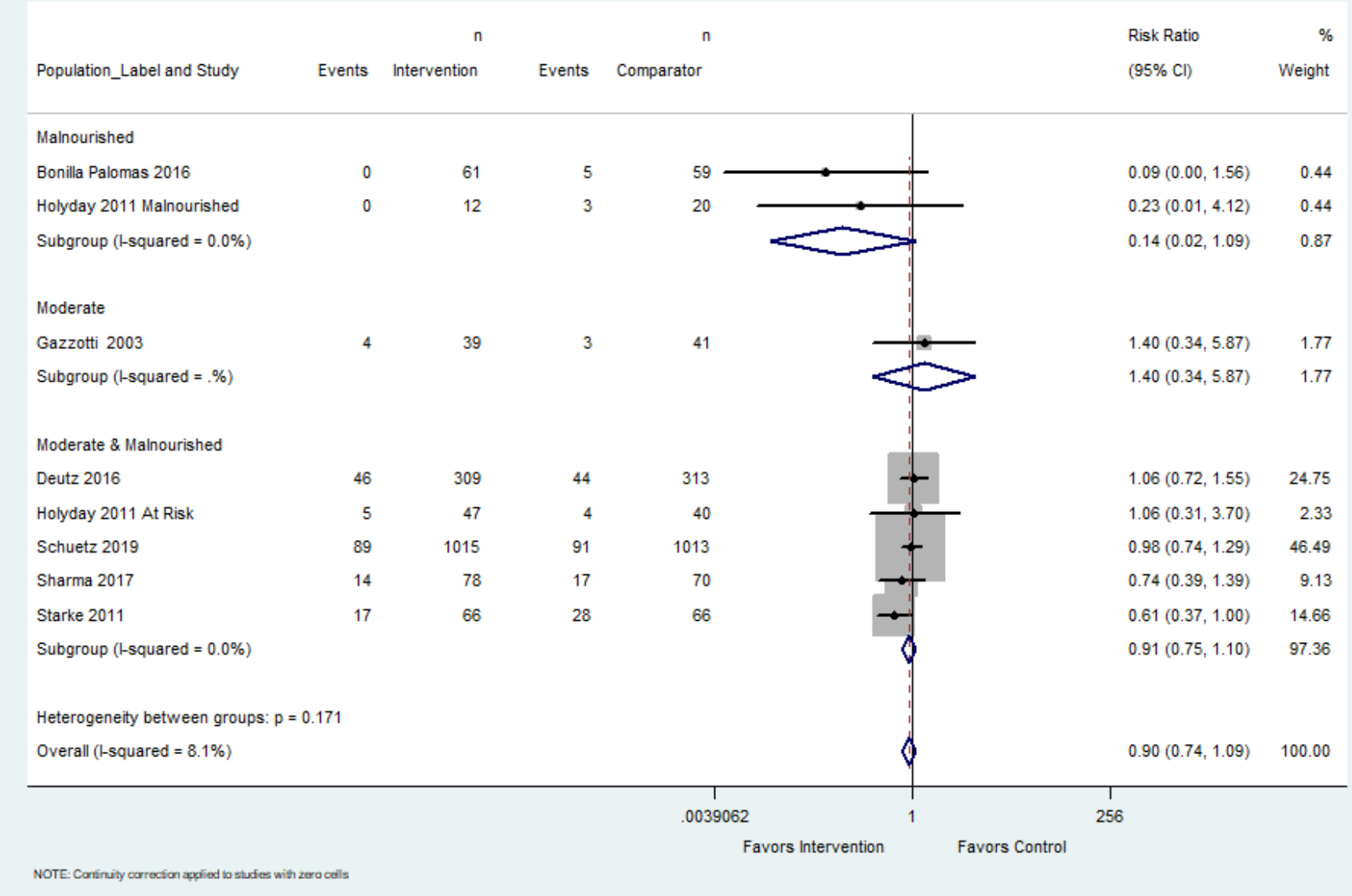


Figure G-11. Effect of hospital-initiated interventions on readmissions, subgroup follow-up time

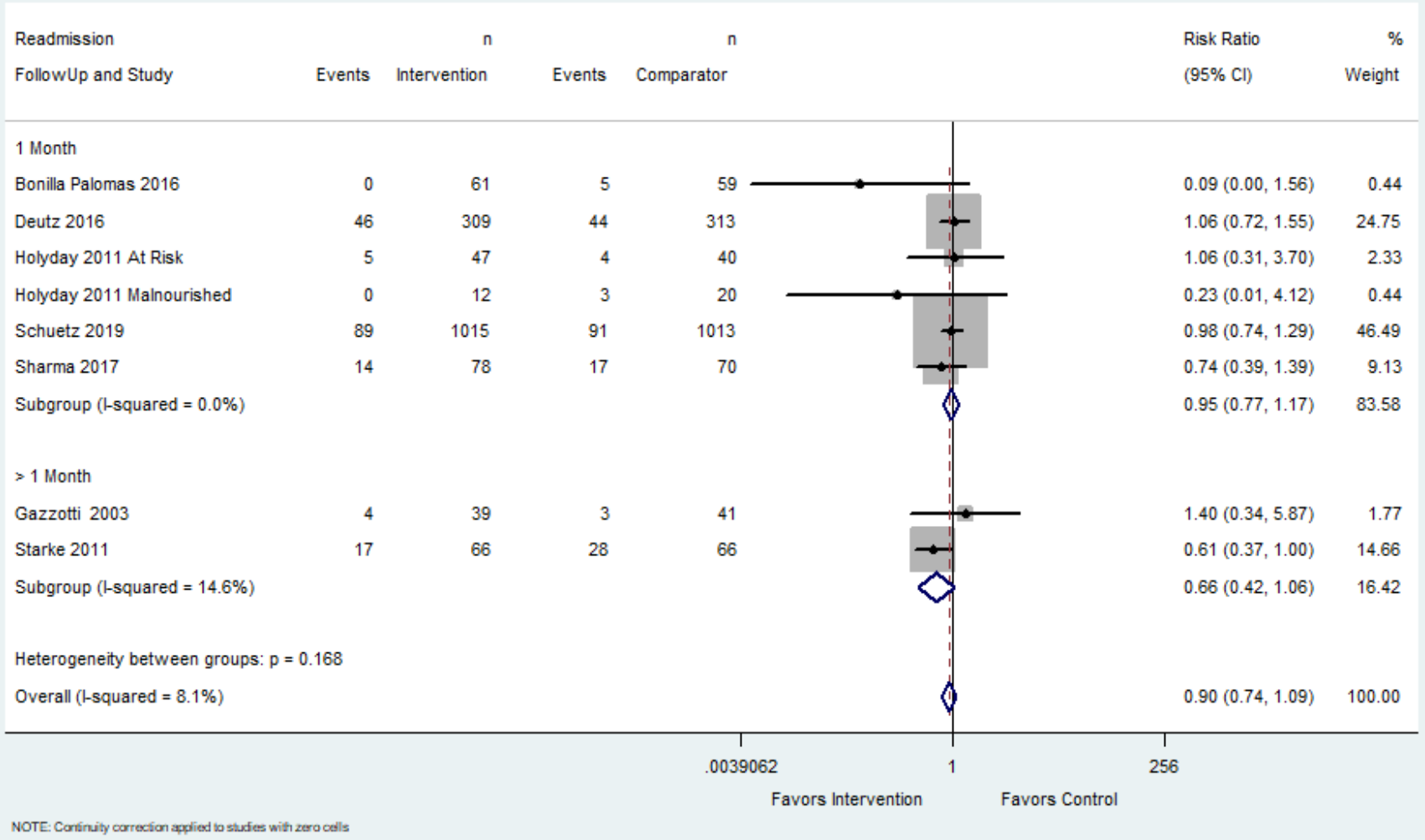


Figure G-12. Effect of hospital-initiated interventions on hospital acquired conditions, all studies

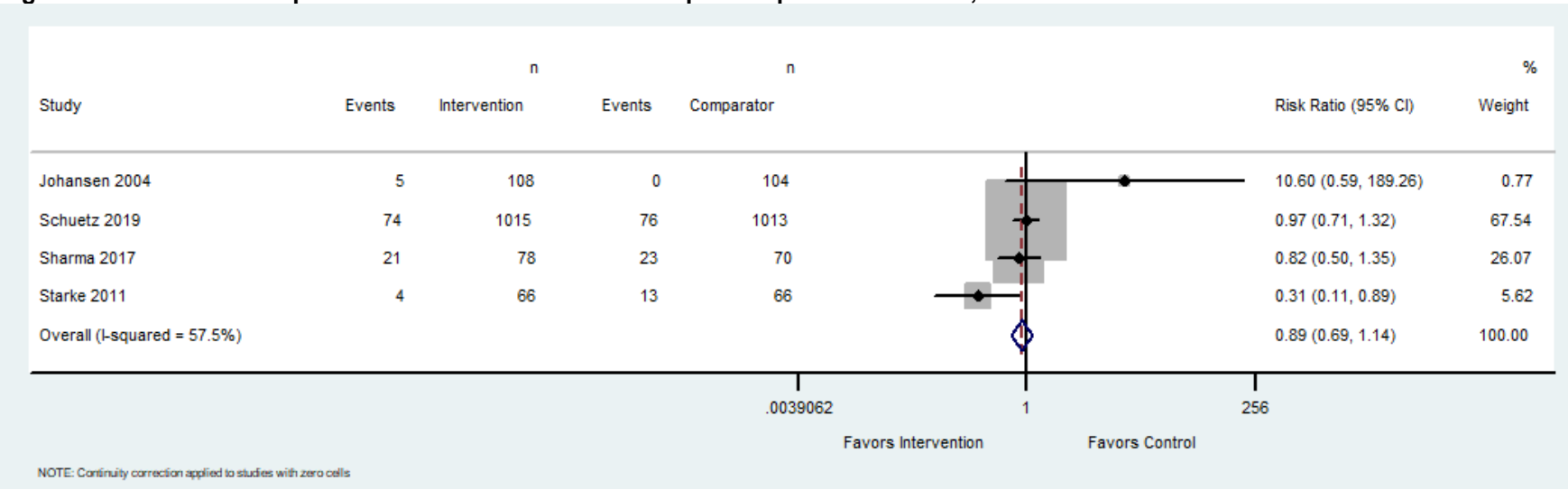
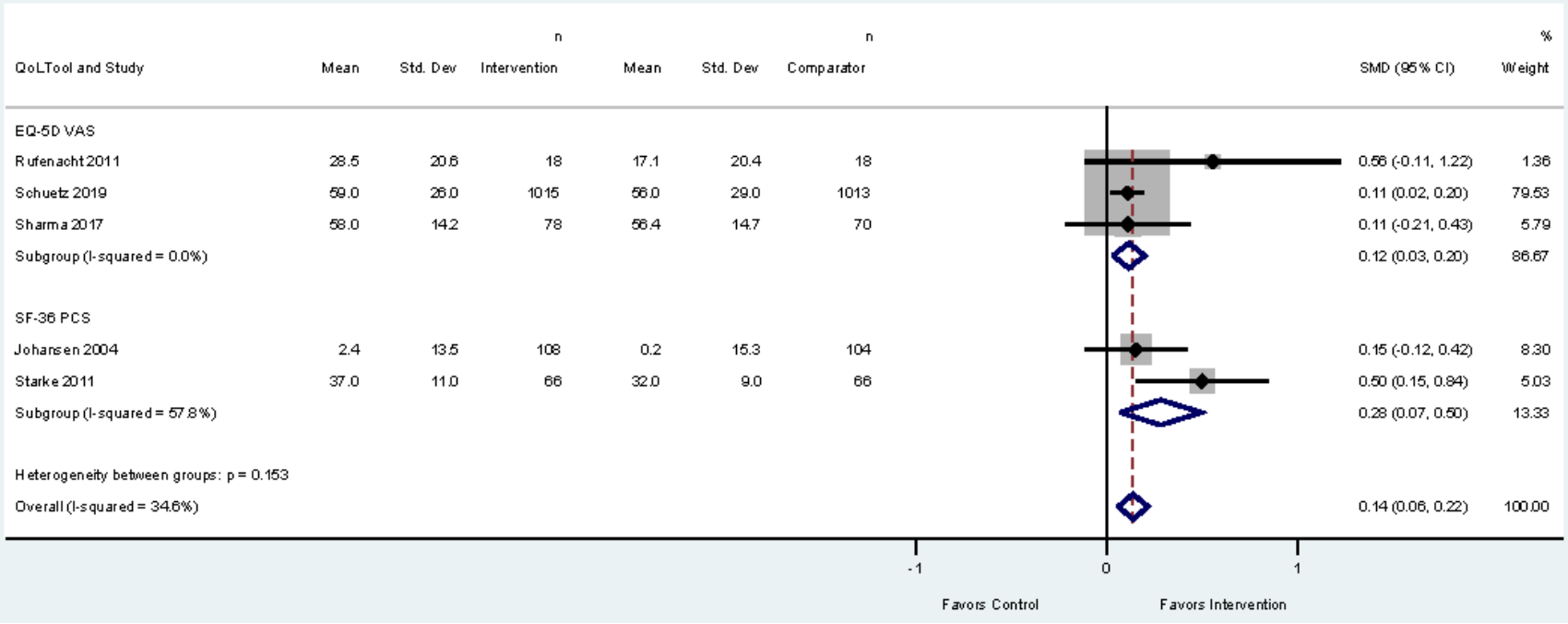


Figure G-13. Effect of hospital-initiated interventions on quality of life, subgroup Quality of Life Measurement Tool



Appendix H. Additional Information for KQ 1

Table H-1. Studies included in systematic reviews

DiJkink 2020	Ney 2019	Muscaritoli 2017	Lew 2016	Lin 2016	Gupta 2011
Wilson et al. 2019[a] Wilson et al. 2019[b] Wintermeyer et al. 2019 Ihle et al. 2017 Müller et al. 2017 Goisser et al. 2015 Chakravarty et al. 2013 Banks et al. 2010 Dhandapani et al. 2007 Goiburu et al. 2006 Compan et al. 1999 McClave et al. 1992 Kaufman et al. 1987	Ciocirlan 2017 Nunes 2017 Bakshi 2016 Gaikwad 2016 Yosry 2014 Alveras 2005 Stephenson 2001 Pikul 1994	Agarwal et al. 2013 Zapatero et al. 2013 Koren-Hakim et al. 2012 Lim et al. 2012 Zapatero et al. 2012 Aziz et al. 2011 Benedik et al. 2011 Mudge et al. 2011 Hamaguchi et al. 2010 Steer et al. 2010 Lobo Tamer et al. 2009 Planas et al. 2004 Vecchiarino et al. 2004 Thomas et al. 2002 Chima et al. 1997	Coltman et al. 2015 Fontes et al. 2014 Tripathy et al. 2014 Chakravarty et al. 2013 Lomivorotov et al. 2013 Sheean et al. 2013 Caporossi et al. 2012 Sheean et al. 2012 van Venrooij et al. 2011 Merli et al. 2010 Peterson et al. 2010 Sheean et al. 2010 Terekeci et al. 2009 de Luis et al. 2008 Guimaraes et al. 2008 Küçükardali et al. 2008 Sungurtekin et al. 2008 Banks et al. 2007 Penie et al. 2005 Schlossmcher et al. 2002	Kaneko et al. 2015 Suzuki et al. 2015 Gastelurrutia et al. 2014 Gouya et al. 2014 Tevik et al. 2014 Yost et al. 2014 Aggarwal et al. 2013 Kinugasa et al. 2013 Narumi et al. 2013 Sargento et al. 2013 Son et al. 2013 Al-Najjar et al. 2012 Aziz et al. 2011 Bonilla-Palomas et al. 2011 Gastelurrutia et al. 2011 Veloso et al. 2006	Laky, 2010 Wu, 2010 Wu, 2009 Wakahara, 2007 Horsley, 2005 Shirodkar, 2005 Bauer, 2002 Ulander, 1998

Table H-2. Individual studies not included in existing SR for KQ 1

Reference	Nutritional Status Tool	Medical Condition
Acehan S. et al. 2020[91]	NRS	Critically ill
Bedock et al. 2020[92]	GLIM	COVID-19
Brascher et al. 2020[93]	NUTRIC	Hospitalized patients
Burgos et al. 2020[94]	NRS	Chronic disease
Dou et al. 2020[95]	NRS	Cancer
Galindo et al. 2020[96]	GLIM	Critically ill
Han et al. 2020[97]	MUST	Hip fracture
Hirose et al. 2020[98]	GNRI	Heart failure
Kaddoura et al. 2020[99]	PG-SGA	Critically ill
Karim et al. 2020[100]	Not reported in abstract	Heart transplant
Karin et al. 2020[101]	PG-SGA, MUST	Cancer
Kootaka et al. 2020[102]	GLIM	CVD
Machado et al. 2020[103]	NUTRIC, NRS	Critically ill
Matsumoto et al. 2020[104]	NRS, GLIM	Critically ill
Maurer et al. 2020[105]	NRS	Critically ill
Pratt et al. 2020[106]	Not reported in abstract	Hospitalized patients
Tao et al. 2020[107]	ESPEN	Older adults
Toledo et al. 2020[108]	NUTRIC	Critically ill
Tonet et al. 2020[109]	MNA-SF	CVD
Trestini I. et al. 2020[110]	NRS	Cancer
Yilmiz et al. 2020[111]	NRS, GLIM	Cancer
Zhao et al. 2020[112]	GNRI	Older adults
Nishi et al. 2019[113]	GNRI	Heart failure
Abd-Elraheem M. et al. 2019[114]	MUST	Hospitalized patients
Almasaudi et al. 2019[115]	MUST	Cancer
Chien et al. 2019[116]	PNI, CONUT, GNRI	CVD
Contreras-Bolovar et al. 2019[117]	SGA	Cancer
Gonzalez et al. 2019[118]	NUTRIC	Critically ill
Gottschall C et al. 2019[119]	MUST	Hospitalized patients
Hirose EY. et al. 2019[120]	SGA	Stem cell transplant
Inoue T et al. 2019[121]	MNA-SF, MUST, GNRI, NRS	Hip fracture
Komici K. et al. 2019[122]	MNA	CVD
Minamisawa M et al. 2019[123]	GNRI	CVD
Muller et al. 2019[124]	NRS	CKD
Ruiz AJ et al. 2019[125]	MST	Cardio-Pulmonary conditions
Sauer et al. 2019[126]	MST	Hospitalized patients
Subwongcharoen S. et al. 2019[127]	SGA	Cancer
Viana MV et al. 2019[128]	NRS	Critically ill
Ceniccola GD. et al. 2018[129]	AND-ASPEN	Critically ill
Chen WZ. et al. 2018[130]	Not reported in abstract	Cancer
Dent E et al. 2018[131]	MNA, MNA-SF	Older adults
Marcadenti A. et al. 2018[132]	NRE-2017; Nurtritional Risk in Emergency	Hospitalized patients
Morris N. et al. 2018[133]	SGA	Hospitalized patients
Ramos R. et al. 2018[134]	NRI	Cancer
Rondel et al. 2018[135]	ESPEN	Hospitalized patients
Borek P. et al. 2017[136]	NRS	CKD
Guerra RS. et al. 2017[137]	SGA	Hospitalized patients

Reference	Nutritional Status Tool	Medical Condition
Inoue T. et al. 2017[138]	MNA-SF	Hip fracture
Kalaiselvan MS et al. 2017[139]	NUTRIC	Critically ill
Kirushnan BB et al. 2017[140]	SGA	Dialysis
Leiva Badosa et al. 2017[141]	MUST, SNAQ	Critically ill
Martucci RB et al. 2017[142]	MNA-SF	Cancer
Pierik VD et al. 2017[143]	SNAQ	Older adults
Potyraa P. et al. 2017[144]	NRS	Cancer
Rabito EI. Et al. 2017[145]	MUST, MST, SNAQ, NRS	Hospitalized patients
Salomon du Mont et al. 2017[146]	NRI	Critically ill
Sharma Y et al. 2017[147]	PG-SGA	Hospitalized patients
Soderstrom L. et al. 2017[148]	MNA	Older adults
Yun T. et al. 2017[149]	SGA	Hospitalized patients
Allard JP et al. 2016[150]	SGA	Hospitalized patients
Bakshi N. et al. 2016[151]	SGA	Liver transplant
Gau BR et al. 2016[152]	MNA	Diabetes
Guerra RS et al. 2016[153]	NRS-2002, MUST, AND/ASPEN, PG-SGA	Hospitalized patients
Gultekin A. et al. 2016[154]	SGA, NRS	Hospitalized patients
Koren-Hakim T. et al. 2916[155]	MNA-SF, MUST, NRS	Hip fracture
Kruizenga H. et al. 2016[156]	SNAQ, MUST	Hospitalized patients
Maasberg S et al. 2016[157]	Not reported in abstract	Cancer
Sanz-Paris A. et al. 2016[158]	ESPEN	Diabetes
Tan SK et al. 2016[159]	SGA	Dialysis
van Wissen J. et al. 2016[160]	MNA	Hip fracture
Coltman A. et al. 2015[161]	SGA, NUTRIC	Critically ill
Cui J. et al. 2015[162]	NRS	COPD
Dent E. et al. 2015[163]	MNA, MNA-SF, GNRI	Older adults
Felder S. et al. 2015[164]	NRS	Critically ill
Grass F. et al. 2015[165]	NRS	Hospitalized patients
Guerra RS et al. 2015[166]	NRS, PG-SGA, MUST	Hospitalized patients
Jeejeebhoy KN et al. 2015[167]	SGA, NRS	Hospitalized patients
Leandro-Merhi VA et al. 2015[168]	NRS, SGA	Cancer
Rodrigues CS et al. 2015[169]	PG-SGA	Cancer
Simpson F & Doig GS. 2015[170]	Not reported in abstract	Critically ill
Sohrabi Z. et al. 2015[171]	SGA	Dialysis
Bell JJ et al. 2014[172]	MNA-SF	Hip fracture
Chermesh I. et al. 2014[173]	MUST	Cardio-Pulmonary conditions
Cui H. et al. 2014[174]	PG-SGA	Cancer
de Mendonoa Soares BL et al. 2014[175]	NRS	Cancer
Huang TH et al. 2014[176]	PG-SGA	Critically ill
Mendes J. et al. 2014[177]	PG-SGA, NRS	Cancer
Schrader E. et al. 2014[178]	MNA	Older adults
Soderstrom L. et al. 2014[179]	MNA	Older adults
Almeida AI et al. 2013[180]	NRS, MUST, SGA	Hospitalized patients
Holst M. et al. 2013[181]	MNA, MUST	Older adults
Lee JS et al. 2013[182]	GNRI	Older adults
Rasheed S & Woods RT. 2013[183]	NRI	Older adults
Ulltang M. et al. 2013[184]	MST, SGA	Hospitalized patients
Zhang SS et al. 2013[185]	SGA	Diabetes

Reference	Nutritional Status Tool	Medical Condition
Charlton K. et al. 2012[186]	MNA	Hospitalized patients
Gamaletsou MN et al. 2012[187]	GNRI	Hospitalized patients
Komlanvi K. et al. 2012[188]	MNA, GNRI	Older adults
Pavic T. et al. 2012[189]	NRS	Hospitalized patients
Teiusanu A. et al. 2012[190]	SGA	Cirrhosis
Chermesh I. et al. 2011[191]	MUST	Hospitalized patients
Karl A. et al. 2011[192]	NRS	Hospitalized patients
Kuseolu Z. et al. 2011[193]	NRS	Hospitalized patients
Hafsteinsdottir TB et al. 2010[194]	MNA	Neurological
Merli M. et al. 2010[195]	SGA	Cirrhosis
Zamora RJ et al. 2010[196]	SGA	Older adults
Fiedler R. et al. 2009[197]	SGA, NRS	Dialysis
Oliveira MR et al. 2009[198]	MNA	Older adults
Ozkalkanli MY et al. 2009[199]	NRS, SGA	Ortho surgery
Bin J. et al. 2008[200]	NRS	Hospitalized patients
Casariego AV & Fernandez MJ 2008[201]	SGA	Hospitalized patients
Henderson S. et al. 2008[202]	MUST	Older adults
Kukardali Y. et al. 2008[203]	NRS	Hospitalized patients
Sungurtekin H. et al. 2008[204]	SGA	Critically ill
Gurreebun F. et al. 2007[205]	SGA	Dialysis
Wakahara T. et al. 2007[206]	SGA	Digestive disease
Kruizenga HM et al. 2006[207]	SNAQ	Hospitalized patients
Kyle UG et al. 2006[208]	NRI, MUST, NRS, SGA	Hospitalized patients
Stratton RJ et al. 2006[209]	MUST	Older adults
Bouillanne O. et al. 2005[210]	GNRI	Older adults
Kagansky N. et al. 2005[211]	MNA	Older adults
Norman K. et al. 2005[212]	SGA	Hospitalized patients
Pepersack T. 2005[213]	Not reported in abstract	Older adults
Thomas DR et al. 2005[214]	Not reported in abstract	Hospitalized patients
Kyle UG et al. 2004[215]	NRI	Hospitalized patients
Pichard C. et al. 2004[216]	SGA	Hospitalized patients
Visvanathan R. et al. 2004[217]	MNA	Older adults
Bauer J. et al. 2002[218]	PG-SGA	Cancer
Persson MD et al. 2002[219]	SGA, MNA	Older adults
Kalantar-Zadeh et al. 2001[220]	SGA	Dialysis
Laws RA et al.[221]	SGA	Dialysis
Santoso JT et al. 2000[222]	Prognostic Nutritional Index	Cancer

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