RESEARCH PAPER

Using Data Analytics to Monitor and Improve Clinical Nutrition Outcomes in Saudi Hospitals: A Systematic Review

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ABSTRACT

Purpose:
This systematic review sought to identify, appraise and synthesize evidence on the approach of data analytics to monitor and improve clinical practice and outcomes of nutrition in Saudi hospital settings.

Methods:
Eligible studies were original primary research studies conducted at Saudi hospitals or hospital-affiliated clinics from January 2015 to 15 May 2025, published in English, and comprising a data-driven or analytic approach to the study of clinical nutrition. Studies also had to report at least one nutrition, clinical, process, implementation, or economic outcome. Databases searched were PubMed, Scopus, Web of Science, and Google Scholar with the last search conducted on 15 May 2025. Risk of bias was judged according to the Joanna Briggs Institute (JBI) critical appraisal tools appropriate to each design, including cross-sectional, diagnostic accuracy, qualitative, and economic evaluation studies. Due to heterogeneity with respect to designs, populations, tools, and outcomes, the results were synthesized narratively.

Results:
Twelve studies were included, involving 1,231 patient participants and 571 healthcare professional participants, with a total sample size of 1,802 participants. The burden of malnutrition in hospitals was very high and differed according to population and criteria, as the malnutrition rate ranged between 18.1% among adult surgical admissions and 76.6% malnutrition or risk among hospitalized older adults assessed by the Mini Nutritional Assessment–Short Form (MNA-SF). Among stroke survivors, 47.1% met the Global Leadership Initiative on Malnutrition (GLIM) criteria for malnutrition. In mechanically ventilated intensive care unit (ICU) patients, malnutrition at admission was 44%, and underfeeding was more than 90%. Diagnostic and validation evidence showed that GLIM had an area under the curve (AUC) of 0.819, with a 95% confidence interval (CI) of 0.734–0.905, compared with the Subjective Global Assessment (SGA) in stroke survivors (Alshammari et al., 2025), while the Saudi modified Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) was highly sensitive at 94.3% but had low specificity at 13.2%. Evidence on practice and implementation emphasized variable structures of services and recurrent barriers such as resistance from other healthcare practitioners, limited resources, and communication issues. Overall, risk of bias was often influenced by cross-sectional study designs, single centers, and self-reported measures.

Conclusion:
Evidence from Saudi hospitals on analytics in clinical nutrition currently is strong for descriptive and diagnostic analytics (prevalence measurement, audits, and tool validation), and limited for evaluation of EHR-embedded analytics interventions (e.g., dashboards/alerts) and improved patient outcomes. Strengthening standardized screening and documentation, alignment of multidisciplinary workflow to measurable indicators and implementation effectiveness studies are priorities to translate analytics from measure to sustained improvement in nutrition care and outcomes.

Keywords: Clinical nutrition; Data analytics; Malnutrition; Saudi hospitals; Systematic review; Nutritional screening; GLIM criteria; Implementation science

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Chapter One Background and Objectives

Malnutrition is an important and often underrecognized clinical issue in the inpatient setting. According to the World Health Organization (2024), malnutrition is characterized by a deficiency, excess, or imbalance in a person's intake of energy and nutrients and includes undernutrition, micronutrient-related malnutrition, and overweight/obesity. Among hospitalized patients, malnutrition is clinically significant because it is associated with adverse outcomes such as impaired immune function, delayed wound healing, reduced functional status, higher rates of complications, longer length of hospital stay, increased readmissions, and increased mortality. Systematic reviews of adult inpatients consistently show associations between malnutrition and clinical outcomes such as infections, pressure injuries (pressure ulcers), and longer hospital length of stay, creating major burdens for health systems (AHRQ, 2022).

Within the hospital environment, disease-related malnutrition is of particular relevance, as acute or chronic disease can result in reduced food intake, increased metabolic demands, and inflammatory responses that accelerate muscle breakdown and functional decline. Consequently, patients' nutritional risk and status may worsen during hospitalization if screening, assessment, and nutrition interventions are not implemented in a timely and consistent manner.

Patients become malnourished due to several reasons, often at the same time. Reduced dietary intake—as a result of poor appetite, nausea, pain, dysphagia, or impaired consciousness—and increased nutritional requirements as a result of infection, trauma, surgery, or cancer are primary mechanisms. Additional factors are impaired digestion or absorption, prolonged fasting, and interrupted feeding associated with procedures and clinical workflows. Older people, people with multiple illnesses, and people with functional limitation are particularly vulnerable. These mechanisms help to understand why malnutrition can be established even when the availability of food in the environment is sufficient; therefore, reliable risk identification and timely nutritional intervention are important rather than waiting for observable weight loss alone (White et al., 2012; Cederholm et al., 2019).

Anemia is one of the important clinical and laboratory manifestations that may indicate nutrition-related deficiency or disease-related deterioration. It can be classified according to red blood cell indices into microcytic anemia, normocytic anemia, and macrocytic anemia. Microcytic anemia is commonly linked to iron deficiency and may present with fatigue, pallor, dizziness, weakness, shortness of breath, brittle nails, poor wound healing, and reduced exercise tolerance. Macrocytic anemia may be related to vitamin B12 or folate deficiency and may present with fatigue, glossitis, poor appetite, and neurological symptoms such as numbness or tingling in vitamin B12 deficiency. Normocytic anemia may be associated with chronic disease, inflammation, renal disease, or acute blood loss. The needed tests include complete blood count, hemoglobin level, hematocrit, mean corpuscular volume, serum ferritin, serum iron, transferrin saturation, vitamin B12, folate, and inflammatory markers such as C-reactive protein when needed. Hemoglobin level is a central test for anemia assessment; anemia is commonly considered when hemoglobin is below 13 g/dL in adult men, below 12 g/dL in non-pregnant adult women, and below 11 g/dL in pregnant women, although interpretation should consider age, sex, pregnancy, altitude, smoking status, and local laboratory standards (WHO, 2024; Turner et al., 2023). The WHO guideline focuses on the use of hemoglobin concentrations to assess anemia in individuals and populations.

In Saudi Arabia, available evidence suggests that malnutrition in hospitals and the associated risk are still prevalent, but surveillance data from hospitalization are scarce. A study of hospitalized older people reported a substantial prevalence of malnutrition and analyzed related factors and outcomes such as length of stay and mortality (Alzahrani & Alamri, 2017). In addition, anemia is also clinically relevant in Saudi hospital populations. Arbaeen and Iqbal (2022) reported that the overall prevalence of anemia among hospital attendees in Makkah was 38.7%, with mild, moderate, and severe anemia reported among affected patients. Microcytic anemia was one of the reported types, which is clinically relevant because it is commonly linked to iron deficiency. This supports the importance of including hemoglobin level and other related laboratory indicators when assessing nutrition-related problems in hospital settings. Recent literature remains very much focused on gaps in good national estimates; an article on Frontiers in Nutrition, for example, discusses the lack of available national data on inpatient malnutrition rates as well as summarizing single-center research which reports prevalence up to around one third, especially among older inpatients, with links to longer time in hospital and an increased risk of death (Ajabnoor et al., 2023). Collectively, this supports the need to promote better early identification and standardization of management pathways for malnutrition within different Saudi hospital settings and particularly deserving groups, such as older adults and patients undergoing major medical or surgical care.

Concurrently, healthcare delivery is receiving an increasing influence through digital transformation and the clinical data capture process in healthcare delivery. The electronic health record (EHR) is the digital version of a patient's history of medical information, including integration of clinical data, medications, laboratory results, radiology reports, and other key components needed to provide the patient with care. Saudi hospitals have invested much in the adoption of EHR, and studies on the implementation have provided descriptions of the extent of EHR

adoption and the practical barriers and enablers in Saudi healthcare settings (Aldosari et al., 2022; Aljohani et al., 2022). This digital infrastructure is fundamental in developing nutrition-related decision support, since many variables relevant to malnutrition risk (e.g. diagnoses, inflammation markers, diet orders, intake documentation, weight trends, and processes of care) are already contained within routine hospital flows of data.

Data analytics in healthcare are usually thought of as progressing through descriptive analytics (describing the current state), diagnostic analytics (finding causal factors) to predictive analytics (finding out what will happen) and prescriptive analytics (finding out what to do about it). In the context of malnutrition in hospitals, the analytical methods can be used to improve the detection, monitoring and response. For example, structured screening data could include screening coverage and time to referral, longitudinal weight and intake trends can be used to identify nutritional deterioration, and prediction models can be built using screening data to identify patients at high risk of being missed by manual processes. More recently, research continues to show that models that use routinely collected patient record data can predict the risk of malnutrition and support intervention at earlier stages in clinical workflows when embedded into patient care (Jin et al., 2022).

Several standardized tools are good examples of how nutrition risk identification can be operationalized in clinical systems. The Malnutrition Universal Screening Tool (MUST) is a five-step instrument based on the identification of adults who are malnourished, at risk of malnutrition, or obese, and incorporates linked management guidance (BAPEN, 2003). In pediatrics, a validated screening method for identifying nutritional risk is the Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP), which is used in hospitalized children. Saudi research has progressed in this area by developing and testing a Saudi modified STAMP and evaluating the validity of both the original and modified tools in hospitalized pediatric children (AlQahtani et al., 2024). These local validation efforts represent an increased focus on standardized nutrition risk processes and the basis of EHR-enabled screening and monitoring.

Despite these improvements, there are still major implementation challenges in Saudi hospitals that make focused synthesis especially timely. Studies on the practice of nutrition support and availability of services in Saudi Arabia show variability in the process, resources, and multidisciplinary coordination, all of which affect whether malnutrition is detected in a timely manner and whether it is uniformly treated (Ajabnoor et al., 2023). Furthermore, recent work in Saudi Arabia has assessed adherence to nutrition support guidelines or protocols and identified barriers that constrain the consistency of implementation between hospitals, thus highlighting the need for system-level solutions to support reliable practices at the point-of-care level (Zaher et al., 2025). From an informatics point of view, these gaps are relevant because the benefits of analytics not only depend on model performance or the design of dashboards, but also on uptake in the real world, integration into work processes, training of staff, and governance of standardized documentation.

Existing reviews increase the importance of pursuing a systematic review on analytics in clinical nutrition, particularly in Saudi Arabia. Janssen and colleagues (2024) synthesized the world's literature on artificial intelligence in malnutrition and noted that there are still many models that have not yet become part of routine clinical practice, which reflects a continued translation gap between research and bedside practice (Janssen et al., 2024). However, global reviews do not address Saudi-specific questions of what analytics tools are currently being used in Saudi hospitals, how they are being integrated in local EHR environments, and what outcomes have been reported. On the other hand, Saudi-focused studies and syntheses tend to focus on burden, screening, or service delivery without a comprehensive evaluation of analytics-focused tools, such as EHR-based alerts or dashboards, automated screening, or predictive models, and their impacts on nutrition processes and patient outcomes. This makes a distinct evidence gap at the juncture of clinical nutrition, health informatics, and Saudi hospital quality improvement.

Accordingly, the objective of this systematic review is to identify, appraise, and synthesize evidence of the use of data analytics for monitoring and improving clinical nutrition outcomes in Saudi hospitals. The review will examine the types of analytics-enabled tools that have been implemented, the types of nutrition process and patient outcomes they affect, including screening completion, referral timeliness, nutrition status indicators, hemoglobin level where reported, length of stay, complications, readmissions, and mortality, and what types of implementation characteristics and data sources are reported. By bringing together this evidence, the purpose of this review is to bring support to Saudi hospitals and policymakers in strengthening pathways to nutrition care as aligned with national priorities in improving healthcare through digital and data-driven approaches.

Research Gap

Despite emerging literature on malnutrition management, digital health, and healthcare analytics, the intersection of these domains within clinical nutrition in Saudi Arabia remains insufficiently synthesized. Existing reviews primarily focus either on malnutrition-related analytics and artificial intelligence applications in international settings, or on local nutrition support practices without examining analytics-enabled implementation and outcomes in Saudi hospitals. Consequently, there is limited consolidated evidence on the use of analytics-driven tools—such as electronic health record (EHR)-based alerts, risk prediction models, automated referral mechanisms, and performance dashboards—and on how these tools influence nutrition care processes and patient outcomes within the Saudi hospital context.

This evidence gap limits informed decision-making by clinicians, hospital administrators, and policymakers because it remains unclear which analytics tools are currently used, how they are integrated into clinical workflows, what data sources they rely on, and how they affect key metrics such as screening completion, timeliness of intervention, length of stay, and recovery-related outcomes. This systematic review addresses the gap by synthesizing the available evidence on the implementation and impact of data analytics in clinical nutrition in Saudi hospitals, with particular attention to both process indicators and patient-centered outcomes.

Research Significance

1. For clinicians (dietitians, physicians, nurses), it provides critically appraised evidence on the application of data analytics in clinical nutrition, to support better-informed decisions and integration of effective tools into clinical practice. Hospital administrators and quality teams can incorporate the findings into strategic planning, technology investment and protocol development, particularly in the improvement of process and clinical outcomes such as screening rates, complications and LOS.
2. National health policymakers can use the synthesized evidence to inform national strategies, guidelines, and EHR standards in line with the Vision 2030 of the Ministry of Health regarding the improvement of healthcare quality and digital transformation. Future studies will be informed of these results, which will highlight gaps in the evidence base, such as cost effectiveness, patient-reported outcomes and long-term sustainability, so that researchers and academics know where to focus.
3. Ultimately, patients are the major beneficiaries. By leading to the implementation of effective data-driven strategies, the review can contribute to malnutrition-related complications, quicker recovery and an overall better quality of life. In sum, this review aims to catalyze evidence-based improvements in clinical nutrition in Saudi Arabia using data analytics as a strategy.

Aim and Objectives

The primary aim of this review is to systematically identify, appraise, and synthesize the available evidence on the application and impact of data analytics in monitoring and improving clinical nutrition outcomes within hospital settings in Saudi Arabia.

- **Objectives of the research**

  This systematic review will:
  - Identify and characterize the data analytic tools (e.g. risk-stratification models, automated screening alerts, audit-and-feedback dashboards, and predictive algorithms) used in Saudi hospitals to inform clinical nutrition care for inpatient and/or outpatient populations.
  - Evaluate and report the impacts of these tools on:
    - Nutritional outcomes: including energy/protein intake adequacy and markers of nutritional status and prevalence of malnutrition
    - Clinical outcomes: including length of stay (LOS), readmission rates, mortality and nutrition complication.
    - Process outcomes: including time to nutritional assessment, screening completion rates, dietitian consultation missing, as well as adherence to care protocols.
  - Identify the data sources related to better outcomes (e.g., EHRs, lab databases, patient surveys, etc.) and implementation characteristics (e.g., screening criteria, dashboard metrics, alert parameters, clinical integration, staffing).
  - Reporting any identified evidence gaps and limitations of reporting within included studies to help inform future research priorities, in the context of the Saudi clinical and digital health systems.

Chapter Two: Methods

2.1 Review question(s)

The main aim of this review is to summarize the available evidence on the use and effect of data analytics on clinical nutrition practice and outcomes within the Saudi healthcare system. The PICO (Population, Intervention, Comparison, Outcome) framework was used to construct the review question (Table 1).

Table 1. PICO framework for the review question

PICO element	Description
Population (P)	Hospitalized patients within Saudi healthcare facilities
Intervention (I)	Data analytics (e.g., audits, prevalence studies, evaluation of screening/intervention instruments)
Comparison (C)	Settings where such systems are not used

Outcomes (O)	Clinical nutrition practice and patient outcomes

2.2 Study design

This study used a systematic review design to identify, appraise, and synthesize available primary research related to data analytics and clinical nutrition outcomes in Saudi hospital settings. This study design was selected because it allows a comprehensive and transparent summary of the current evidence base. By using a systematic methodology, this review aims to reduce bias and improve the reliability of the findings. This review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The PRISMA flow diagram was used to summarize the study selection process, indicating the number of records identified, screened, assessed for eligibility, and included in the review.

2.3 Information sources

A comprehensive and systematic search of electronic databases relevant to clinical nutrition and health informatics are conducted to maximize retrieval of eligible studies. Searches are limited to English-language publications due to feasibility of screening and data extraction. No restrictions are applied based on publication status. The databases searched included PubMed, Scopus, Web of Science, and Google Scholar.

All electronic databases are searched from Jan 2015 to May 2025. The year 2015 was selected as the starting point to reflect the latest decade of research and the acceleration of the development and integration of data analytics and digital health technologies into clinical practice.

2.4 Search strategy

A systematic search strategy was developed using a combination of keywords and, where applicable, controlled vocabulary, such as Medical Subject Headings (MeSH) in PubMed. Terms covered three concepts: (1) data analytics/health informatics/quality measurement, (2) clinical nutrition/malnutrition/nutrition care, and (3) Saudi Arabia. Keywords were combined using AND/OR and adapted to each database. Searches were limited to English-language publications from January 2015 to 15 May 2025.

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Database	Search keywords/phrases/strings including Boolean operators
PubMed	(analytic* OR "data analy*" OR audit* OR "quality improvement" OR prevalence OR dashboard* OR "health informatics" OR "electronic health record*" OR "electronic health record" OR EHR) AND ("clinical nutrition" OR nutrition OR malnutrition OR undernutrition OR "nutrition screening" OR "nutrition assessment" OR "nutrition support" OR dietitian* OR dietetic*) AND ("Saudi Arabia" OR KSA OR "Kingdom of Saudi Arabia")0000000000000000
Scopus	((analytic* OR “data analy*” OR audit* OR “quality improvement” OR prevalence OR dashboard* OR “health informatics” OR “electronic health record*” OR EHR) AND (“clinical nutrition” OR malnutrition OR “nutrition screening” OR “nutrition assessment” OR “nutrition support” OR dietitian* OR dietetic*) AND (“Saudi Arabia” OR KSA OR “Kingdom of Saudi Arabia”))
Web of Science	((analytic* OR “data analy*” OR audit* OR “quality improvement” OR prevalence OR dashboard* OR “health informatics” OR “electronic health record*” OR EHR) AND (“clinical nutrition” OR malnutrition OR “nutrition screening” OR “nutrition assessment” OR “nutrition support” OR dietitian* OR dietetic*) AND (“Saudi Arabia” OR KSA OR “Kingdom of Saudi Arabia”))
Google Scholar	("Saudi Arabia" OR KSA OR "Kingdom of Saudi Arabia") AND ("clinical nutrition" OR nutrition OR malnutrition OR undernutrition OR "nutrition screening" OR "nutrition assessment" OR "nutrition support" OR dietitian OR dietetic) AND ("data analytics" OR analytics OR audit OR "quality improvement" OR dashboard OR "health informatics" OR "electronic health record" OR EHR OR prevalence)

Table 1 summarizes systematic database searches performed for this review, namely the databases searched, the core search strings used, the timeframe of the search (January of 2015 to May of 2025, and the numbers of records retrieved and included. The search strategy includes a combination of free text keywords and controlled vocabulary terms [e.g., Medical Subject Headings [MeSH] in PubMed] that represented the three major concepts in the review: data analytics, clinical nutrition/malnutrition and Saudi Arabia. Search syntax was tailored to individual databases and Boolean operators (AND/OR) were used to combine concepts.

2.5 Eligibility criteria and selection process

Inclusion Criteria:

Studies are eligible if they have the following characteristics:

- Population: patients (adult or pediatric) in hospitals or hospital-clinics in KSA.

- Clinical nutrition; data-driven approach to an element of clinical nutrition. This comprises studies reporting the prevalence of malnutrition, validation of screening tools, audit of nutrition support practice (enteral/parenteral) or economic evaluations of nutrition services.
- Study Design: Primary research studies including observational studies (e.g. cross-sectional, cohort), case-control studies, and qualitative studies.
- Timeframe: Studies published between January 1st, 2015 and May 15th, 2025.
- Outcome: Reported at least one outcome related to nutritional status, nutrition practice or implications of data analysis i.e. prevalence rates, validity metrics, barriers identified, implications for costs.
- Language: English

Exclusion Criteria:

Studies are excluded if they were:

- Not conducted in the Kingdom of Saudi Arabia (KSA).
- Not located in the hospital or a clinic attached to the hospital.
- Review articles, editorials, commentaries, abstracts of full text conference presentations, or case reports
- Studies without reporting original data or performing a systematic analysis of collected data.
- Published before 2015.
- Not Published in English

Selection Process

The study selection process included two stages:

1. All records identified from the database searches were exported to EndNote reference management software, where duplicate records were identified and removed. One reviewer, the author, screened titles and abstracts against the eligibility criteria, and clearly irrelevant records were excluded.
2. Full texts of potentially relevant studies were retrieved and assessed against the eligibility criteria. One reviewer (the author) completed full-text screening, with reasons for exclusion recorded in the screening log. Borderline cases were re-checked and the eligibility criteria were re-applied before final inclusion. The selection process is presented in the PRISMA flow diagram.

2.6 Assessment of quality and risk of bias

The methodological quality and risk of bias of the included studies were evaluated by the author using standardized critical appraisal tools from the Joanna Briggs Institute (JBI). JBI tools were selected because they provide study-design-specific checklists suitable for reviews that include diverse methodologies, such as cross-sectional, prevalence, qualitative, diagnostic/validation, and economic evaluation studies, which aligns with the expected heterogeneity of the included literature. Alternative appraisal tools exist, such as CASP for qualitative studies, QUADAS-2 for diagnostic accuracy studies, and the Newcastle–Ottawa Scale for observational studies; however, JBI was used to ensure a consistent appraisal approach across multiple study designs. For prevalence studies, the JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data was used. For analytical cross-sectional studies, the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used. For validation studies, the JBI Critical Appraisal Checklist for Diagnostic Test Accuracy Studies was used, with minor adaptations where appropriate to reflect validation outcomes. For qualitative research, the JBI Critical Appraisal Checklist for Qualitative Research was used. For economic evaluations, the JBI Critical Appraisal Checklist for Economic Evaluations was used.

2.7 Data extraction

A standard data extraction form is used. The reviewer extracts data using this form to ensure accuracy and consistency. Data extracted from each included study are summarized using a standardized data extraction form (Appendix C). Extracted items include study characteristics (e.g., author, year, design, region, and setting), participant characteristics (e.g., sample size and age group), the clinical nutrition topic/intervention assessed, the data analytics and analysis methods used, and the main findings relevant to the review question (including any reported clinical, economic, or implementation-related outcomes). Authors are contacted when key data are missing or unclear.

2.8 Data Items

Primary Outcomes Sought:

The key endpoints for which data were sought were those directly related to the monitoring and understanding of the clinical nutrition status and practices:

1. Prevalence of Malnutrition: The proportion of patients found to be malnourished by using a variety of tools (e.g. MNA, GLIM criteria).
2. Validity of Screening Tools: Metrics such as sensitivity, specificity, positive predictive value of tools such as STAMP or GLIM against a reference standard and negative predictive value.
3. Adherence to Nutrition Support Guidelines: Percentage of patients who received appropriate enteral or parenteral nutrition, based on established protocols.

4. Identification of Barriers and Facilitators: Qualitative information about healthcare professionals' perception of barriers to optimal nutrition provision.
5. Economic Outcomes: Economic analyses concerning parenteral nutrition services or interventions by pharmacists.

Other Variables Sought:

To put data in context, data on the following variables were also extracted:

- Participant characteristics (age, gender).
- Clinical environment (type of hospital, ward/ICU).
- Specific patients (e.g. critically ill, diabetic, post-stroke).

No assumptions were made concerning missing information. If data for a specific outcome or variable were not reported, it was entered on the data extraction form as "not reported".

2.9 Data synthesis and analysis

Because heterogeneity was expected across study designs, populations, interventions/exposures, and outcome measures, statistical meta-analysis was not undertaken. Findings were synthesized narratively, following established guidance for narrative synthesis (Popay et al., 2006). The narrative synthesis was organized thematically by grouping studies according to the main focus of the evidence, including malnutrition prevalence in different patient populations, application/validation of nutrition screening tools, barriers to and practices in enteral/parenteral nutrition, and economic/workforce issues in nutrition services. Where qualitative findings were reported, they were summarized using a thematic approach, including coding relevant findings, developing descriptive themes, and identifying higher-order analytical themes where appropriate (Thomas & Harden, 2008). Quantitative outcomes such as malnutrition prevalence were summarized descriptively by reporting study-level estimates, confidence intervals where available, and presenting ranges, and medians where appropriate, by population/setting rather than pooling results. This approach supports comparison across studies and helps identify patterns, consistencies, inconsistencies, and potential reasons for variation across the evidence base (Popay et al., 2006; Thomas & Harden, 2008).

2.10 Quality appraisal, risk of bias, reporting bias, and certainty of evidence

The methodological quality and risk of bias of included studies are assessed using the relevant Joanna Briggs Institute (JBI) critical appraisal checklist for each study design. Appraisal is completed by one reviewer (the author), and decisions are recorded in a standardized format.

Potential reporting bias (including publication bias and selective outcome reporting) may threaten the validity of systematic review findings because the availability and reporting of results can depend on the direction or statistical significance of study results (Page et al., 2024). Where a sufficient number of comparable studies (as a rule of thumb, ≥10) report the same outcome and provide effect estimates, funnel plot methods may be explored to assess small-study effects; however, these methods have important limitations and are often uninformative when heterogeneity is substantial (Sterne et al., 2011; Page et al., 2024). When feasible, selective outcome reporting is examined by comparing published reports against available study protocols or trial registry entries (Dwan et al., 2011).

Certainty in the evidence is judged within each synthesis theme by considering the risk of bias of contributing studies, the consistency of findings, the directness and precision of the evidence, and the likelihood of publication or non-reporting bias, drawing on GRADE concepts adapted for narrative synthesis where meta-analysis is not performed (Murad et al., 2017). These judgements are used to contextualize interpretation in the discussion rather than assigning a formal certainty grade.

Chapter Three Results

3.1 Study selection

A total of 280 records were found from database searches and supplementary searching via Google Scholar. These included PubMed (n = 60), CINAHL (n = 20), Embase (n = 50), and Google Scholar (n = 150). After removing 78 duplicate records, 202 records remained for title and abstract screening. During this screening stage, 170 records were excluded because they did not meet the eligibility criteria, such as non-hospital setting, non-Saudi context, wrong exposure or outcome, or ineligible publication type. Full texts were requested for 32 studies, of which 2 studies could not be retrieved. The remaining 30 full-text studies were reviewed for eligibility. Of these, 18 were excluded with documented reasons, including not conducted in a Saudi hospital setting (n = 6), wrong outcomes such as no nutrition-related, clinical, process, implementation, or economic outcome (n = 4), wrong exposure such as no data-driven or analytic approach to clinical nutrition (n = 3), not focused on clinical nutrition, malnutrition, nutrition screening, or nutrition support (n = 3), and ineligible publication type, such as review, editorial, or abstract only (n = 2). Ultimately, 12 studies met the inclusion criteria and were included in the review. The process of study selection is described in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow diagram (Figure 1).

Figure 1. PRISMA Diagram for Selection Study

3.2 Study characteristics

Table 2. Characteristics of included studies

Included study	Design	Setting (Saudi Arabia)	Population / sample	Data sources used	"Analytics-enabled" elements	Main outcomes reported
Ajabnoor et al., 2023	National cross-sectional survey	Multi-region (respondents; majority Western region)	HCP respondents: n=114 (physicians 38, dietitians 62, pharmacists 14)	Online questionnaire	Descriptive benchmarks; between groups comparisons; Regression on confidence scores	NST Presence Screening practices guideline familiarity confidence (EN/PN) Predictors of confidence
Alamri et al., 2025 (Surgery malnutrition prevalence)	Prospective observational cross-sectional	King Abdulaziz Medical City (MNGHA), Riyadh	Adult surgical-ward admissions >48h: n=282	Patient assessments on admission	Risk-factor modeling (using logistic regression); classification (using GLIM stages)	Malnutrition prevalence (GLIM), distribution of the stage, risk factors (OR/aOR)
Alamri & Simbawa, 2024 (Handgrip screening)	Observational cross-sectional	King Abdulaziz University Hospital	Consecutive hospitalized older adults: n=135	Bedside measures + chart labs	Screening performance (ROC/AUC) Multivariable regression for predictors of low HGS	Malnutrition Prevalence (MNA-SF) HGS sensitivity/specificity/AUC Predictors of Low HGS (OR)
Alkhaldy et al., 2020 (NCP implementation)	Quantitative cross-sectional survey	Six MOH hospitals, Jeddah	Practicing dietitians: n=56	Questionnaire	Descriptive implementation measures (awareness, training, standardization, barriers)	NCP awareness/training, NCP standardization (IDNT/ICF-D vs hospital NCP) Perceived challenges
Alomi et al., 2019 (TPN costing)	Costing / economic evaluation (simulation + local costing)	King Salman Hospital, Riyadh (MOH)	TPN recipients/orders over simulated period: 112 patients; 1631 orders	MOH cost database + modeled workflow	Costing for TPN services (direct, overhead, per day/per order)	Cost per day/per order TPN service and estimated expenditure by based on age
Alqahtani et al., 2024 (Saudi-modified STAMP)	Cross-sectional diagnostic validation	Prince Sultan Military Medical City, Riyadh	Hospitalized children: n=307	Anthropometrics + STAMP tools	Sensitivity/specificity/PPV/NPV comparisons; concurrent validity vs. reference standards	High risk prevalence (oSTAMP vs SmSTAMP), screening validity parameters vs anthropometrics
Alshammari et al., 2025 (GLIM validation	Cross-sectional diagnostic validation	Riyadh (stroke survivor	Stroke survivors: n=104	Anthropometrics + GLIM + SGA +	ROC/AUC with CI; Kappa agreement; Evaluation of	Malnutrition prevalence (GLIM vs SGA), Area

in stroke survivors)		cohort; ethics approval noted)		NRS-2002	Diagnostic Performance	under the curve, Sensitivity, Specificity, PPV, NPV, k
Alyumni et al., 2023 (dietitians' EN practices—qualitative)	Qualitative (focus groups)	Riyadh	Registered dietitians: n=24 over 5 focus groups	Transcribed focus groups	Practice patterns & barriers and needs (thematic analysis)	Themes for EN practice variation; obstacles and needs (protocols, role clarity and follow up)
Alzahrani & Alamri, 2017 (elderly inpatient malnutrition prevalence)	Cross-sectional + outcome follow-up (readmission/mortality)	King Abdulaziz University Hospital, Jeddah	Consecutive elderly inpatients: n=248	Bedside screening + chart labs + follow-up outcomes	Logistic regression (OR with CI) Predictors Descriptive differences in outcomes	Malnutrition prevalence (MNA-SF), LOS/ readmission/ mortality comparisons, predictors of malnutrition
Zaher et al., 2020 (JPEN pilot underfeeding study; Saudi ICU)	Prospective observational pilot	King Fahad Hospital, Medina	Mechanically ventilated ICU adults: n=43	Prospective monitoring of EN intake 6 days	Undernutrition of HF in weight growth regression of time to EN regressions intake ventilation outcomes	ICU malnutrition prevalence (NRS-2002) Energy/protein delivery Early vs late differences in EN Ventilation association
Zaher, 2022 (EN barrier survey)	National cross-sectional survey	Adult ICUs & PICUs nationwide	HCP respondents: n=244	Online survey (24 barrier items)	Barrier scoring (Likert); Comparison adult ICU vs. PICU regression on total barrier score	Highest rated barriers Adult vs. picu differences predictors of perceived barriers
Zaher et al., 2025 (dietitians' adherence to NS guidelines/ protocols)	Cross-sectional survey	Nationwide (dietitians in Saudi hospitals)	Dietitians: n=133 (PN sub-analysis n=44)	Online questionnaire	Adherence scoring (EN/PN) Barrier frequency Regression models for predictors	Use of guideline, adherence distributions (EN/PN), barriers, predictors of adherence

3.3 Risk of bias in studies

Risk of bias was assessed using the critical appraisal tools developed by Joanne Briggs Institute (JBI) by selecting the check list based on the type and design of the studies (Analytical Cross-Sectional Studies for most of the prevalence/survey studies, Diagnostic Test Accuracy studies for STAMP, GLIM validation and the handgrip screening performance study, Qualitative Research for focus group and Economic Evaluations for TPN costing).

Overall, risk of bias was most often contributing to poor risk of bias due to single receiver center sampling (limited external validity), convenience sampling for national survey (selection bias), self-reported practices (measurement bias/social desirability) and lack of adjustment for confounding in cross-sectional designs.

Table 3. Risk of bias summary for included studies (JBI-aligned judgement)

Study	JBI tool fit	Key risk-of-bias considerations (design-specific)	Overall RoB (review judgment)
Ajabnoor 2023	Analytical cross-sectional	Convenience sampling, self report survey for practice; small amount of objective verification of hospital processes; profession mix, uneven regional distribution (majority Western).	Moderate
Alamri 2025 (surgery)	Analytical cross-sectional	Single tertiary center, inclusion of all eligible surgical admissions during period to minimize selection bias Standardized GLIM process described Multivariable model used but residual confounding likely	Moderate
Alamri 2024 (handgrip)	Diagnostic test accuracy	Consecutive cohort strengthens selection MNA-SF Used as reference ROC/AUC reported with CI however specificity is poor and malnutrition cases low (n=19), imprecision and possible effects of spectrum change!	Moderate–High
Alkhaldy 2020 (NCP)	Analytical cross-sectional	MOH only hospitals in 1 city Questionnaire was adapted and noted as not validated (risk of measurement bias) Outcomes descriptive (no control for confounding necessary for most endpoints)	Moderate
Alomi 2019 (TPN costing)	Economic evaluation	Modelled/ Simulated costing over a defined hospital workflow; little sensitivity analysis detail; generalizability limited (single hospital, year specific prices; recognized variability of prices)	Moderate
Alqahtani 2024 (STAMP)	Diagnostic test accuracy	Single hospital pediatric setting; reference standards are anthropometrics and oSTAMP (dual reference approach is more complex); very poor specificity so high false positive.	Moderate–High
Alshammari 2025 (GLIM vs SGA)	Diagnostic test accuracy	Clear inclusion/exclusion with flow SGA as reference AUC with CI and predictive values reported Still single cohort with possible spectrum bias (stroke survivors follow-up population)	Moderate
Alyumni 2023 (qualitative)	Qualitative	Purposive for better relevance; online focus groups; analysis as described with independent coding; transferability is restricted to dietitians in Riyadh; self-report practice.	Moderate
Alzahrani 2017 (elderly inpatient)	Analytical cross-sectional	Consecutive admissions within 48h improves selection Standard MNA-SF Logistic regression with OR/CI Some inconsistencies/typos in reporting plus single center design.	Moderate
Zaher 2020 (ICU underfeeding)	Analytical cross-sectional / cohort-like pilot	Single ICU and small sample Prospective intake monitoring strengthens measurement Regression presented using correlations/betas without full uncertainty intervals Outcomes available only for subset (ventilation analyses in 30 patients)	Moderate–High
Zaher 2022 (barriers)	Analytical cross-sectional	Online recruitment via social media + chain referral Can skew sample Barriers are perceptions rather than observed practice Comparisons and regression reported but limited objective corroboration	Moderate

Zaher 2025 (guideline adherence)	Analytical cross-sectional	convenience/ chain referral Adherence self-reported Regression models explain little variance PN model using smaller subsample (n=44)	Moderate

3.4 Results of individual studies

Malnutrition prevalence and associated factors

The included quantitative studies report material inpatient malnutrition burdens, but the estimates are subject to huge variability because of different case mix compositions and diagnostic methods.

Table 4. Malnutrition prevalence and associated factors

Study	Malnutrition definition/tool	Key prevalence results	Effect estimates with precision (as reported or calculated)
Alzahrani 2017	MNA-SF (malnourished <8; at risk 8–11)	Malnourished 72/248 (29.0%); at risk 118/248 (47.6%); "poor nutritional status" (malnourished+at risk) 76.6%	Prevalence CI (Wilson, calculated): malnourished 29.0% (95% CI 23.7–35.0); malnourished+at risk 76.6% (95% CI 71.0–81.5) (calculated from counts reported).
Alamri 2025 (surgery)	GLIM (malnutrition present vs absent)	Malnutrition 51/282 (18.1%); Stage 1 9.6%, Stage 2 8.5%	Prevalence CI (Wilson, calculated): 18.1% (95% CI 14.0–23.0) (calculated from counts reported).
Alshammari 2025 (stroke survivors)	GLIM vs SGA reference	Malnutrition prevalence: GLIM 47.1% vs SGA 51.9%	GLIM prevalence CI (Wilson, calculated from 49/104): 47.1% (95% CI 37.8–56.6).
Zaher 2020 ICU pilot	NRS-2002 ≥3 considered malnourished	Malnourished on ICU admission: 19/43 (44%)	Prevalence CI (Wilson, calculated): 44.2% (95% CI 30.4–58.9).
Alamri 2024 (older adults, inpatient)	MNA-SF	Malnourished 19/135 (14.1%); at risk 50/135 (37%); normal 66/135 (48.9%)	Prevalence CI (Wilson, calculated): malnourished 14.1% (95% CI 9.2–20.9) (calculated from counts reported).

Risk factor modeling

In elderly inpatients (Alzahrani 2017), predictors of being "at risk or malnourished" included BMI (OR 0.146, 95% CI 0.071–0.287), calf circumference (OR 1.837, 95% CI 1.132–3.072), mobility (OR 0.056, 95% CI 0.010–0.346), and food intake (OR 0.077, 95% CI 0.027–0.219) in logistic regression.

In surgical admissions (Alamri 2025), multivariable regression found BMI inversely associated with malnutrition (aOR 0.774, 95% CI 0.71–0.84) and ischemic heart disease (PCI/CABG) associated with increased odds (aOR 4.836, 95% CI 1.46–16.01).

Table 5. Screening and diagnostic analytics for nutrition risk/malnutrition

Study	Index test	Reference standard	Key diagnostic performance results	Precision / notes
Alshammari 2025	GLIM criteria	SGA	AUC 0.819 (95% CI 0.734–0.905); sensitivity 78.2%; specificity 85.7%; PPV 86.0%; NPV 77.8%; κ 0.635	AUC reported with CI; Se/Sp/PPV/NPV presented without CIs.
Alqahtani 2024	Saudi-modified STAMP vs original	oSTAMP and anthropometrics (per authors)	S-mSTAMP vs oSTAMP: sensitivity 94.3%, specificity 13.2%, PPV 64.8%, NPV 57.7%, accuracy 0.654, agreement 0.089	High sensitivity with very low specificity indicates many false positives; CIs not reported for these metrics in the excerpted results.
Alamri 2024	Handgrip strength cutoffs (EWGSOP2: <27 kg men; <16 kg women)	MNA-SF	Detect "malnourished or at risk": men cutoff 27 kg sensitivity 93.75%, specificity 22.6%, AUC 70.8% (95% CI 58.44–83.16); women cutoff 16 kg sensitivity 86.5%, specificity 19.3%,	AUC presented with CI. Very low specificity suggests HGS alone is not suitable as a stand-alone tool.

			AUC 59.9% (95% CI 46.39–73.49)	

Outcomes of processes for nutrition support practice and quality monitoring

- **Multi-profession practice mapping (Ajabnoor 2023):** In a nationally representative sample of 114 hospitals, only 44.7 percent reported the existence of an actively functioning multidisciplinary nutrition support team (NST), and only 48.2 percent reported routine malnutrition screening in their institutions. The screening instruments that were found to be used were the NRS - 2002 and the MUST, while about one-third of the respondents did not know which tool was used. Wilson confidence intervals, based on published frequencies, produced 44.7 per cent (95 per cent confidence interval (CI)35.9-53.9) for the presence of NST and 48.2 per cent (95 per cent CI39.3-57.3) for routine screening.
- **Confidence and training signal (Ajabnoor 2023):** Confidence within the provision of EN differed between professional disciplines and dietitian's mean confidence was the highest (8.66 (1.63)). Physicians had a lower mean confidence rating (7.74 (+-1.82) and pharmacists the lowest (3.86 (+-2.24) (p = 0.001). Regression analysis showed that EN confidence was linked to nutritional qualification (v =0.202), facility type (v =0.210), profession (v =-0.308) and year of experience (v =0.220.(
- **Dietitians' adherence to NS guidelines/protocols (Zaher 2025):** Dietitians rated their adherence to NS guidelines/protocols high; the median score was 5.00. "Always" responses for EN policy items varied from 62.6 to 68.4 percent for policy items in domains such as nutrient assessment, initiation/advancement, formula selection, and complication management. Reported barriers included a lack of resources (26.2%%), poor communication (23.5%); resistance from other professionals was frequently experienced ("sometimes" by 60.9%): Regression re-emphasized the importance of hospital size as a predictor of adherence (e.g., beta equal to 0.355, p equal to 0.001 for screening/assessment/referral adherence).
- **Nutrition Care Process standardization (Alkhaldy, 2020):** Among 56 dietitians working in the MOH, Jeddah, Saudi Arabia, 98.2% reported being familiar with Nutrition Care Process (NCP) whereas, only 26.8% have received formal training related to NCP. While the majority claimed adherence to NCP guidelines in their department (73.2% of respondents), only 12.5% used international standardised framework (ICF- D or IDNT), 62.5% used their own hospital's NCP and 12.5% didn't use the NCP. Documentation of the ADIME framework was the most major challenge cited (23.2 per cent).

ICU enteral nutrition delivery analytics and barriers

- **Prospectively monitored underfeeding (Zaher 2020):** In 43 ventilated ICU patients, the prevalence of underfeeding was greater than 90%. Median cumulative energy intake over 6 days were 39 percent of prescribed energy requirements and 31 percent of prescribed protein requirements. Early EN starters had significantly greater cumulative energy/protein intake (p 1 reported as .00). Regression analyses showed a negative link between time of EN initiation and cumulative energy intake (R=-0.523; p=.00) and cumulative protein intake (R=-0.531; p=.00). Higher NRS 2002 scores were associated with less time free of invasive ventilation (R=-0.369; p=0.045).
- **Perceived barriers at national level (Zaher 2022):** Out of 244 ICU/PICU health care professionals, the barriers which received the highest ratings were "delay in physician ordering EN initiation" (mean 3.33 +- 1.32) and "waiting for dietitians to assess patients" (3.22 +-1.20). Certain barriers varied between adult ICU and PICU settings, for example, failure to progress feeds (p = 0.006) and feeds held too long prior to procedures (p = 0.021) were both reported by nurses.
- **Qualitative practice variation and implementation needs (Alyumni 2023)**: Five focus groups of 24 dietitians identified twelve themes relating to current EN practices. Key obstacles identified were lack of evidence-based guidelines/protocols, ambiguity of the role of diet and communication, lack of follow up after discharge, and issues in formula availability/preparation. These obstructions were coupled with corresponding needs for national guidelines and roles clarification.

Economic outcomes

- In a TPN cost estimation study (Alomi 2019) a total of 112 patients and 1,631 TPN orders were analysed in a modelled workflow. Estimated costs of TPN services per day were reported to be $863.74 (neonatal), $691.30 (adult), and $618.16 (pediatric).
- The study included direct active ingredient prices as well as more general cost categories (direct and overhead), but did not include uncertainty intervals.

3.4 Results of syntheses

Synthesis themes and contributing evidence

Malnutrition prevalence surveillance is feasible and generates actionable risk stratification but there is great variation in estimates. Within the spectrum of adult hospital contexts, the prevalence of malnutrition was as high as 14.1% (older adult inpatients, MNA-SF) and as low as 47.1% (stroke survivors, GLIM) and is not indicative of a single national rate, but rather they represent different populations and tools. Contributing studies were

predominantly single-center studies or single-cohort studies and their risk of bias was generally moderate (selection/measurement limitations), limiting the ability to generalize studies.

Diagnostic/screening analytics reveal a consistent pattern as high sensitivity and weak specificity in some of the tools/thresholds where implemented on a broad scale. GLIM vs SGA in stroke survivors had good AUC (0.819 with 95% CI) and good agreement (κ=0.635) By contrast, the specificities of the Saudi modified STAMP and handgrip thresholds had very low specificities (S(-mSTAMP vs. oSTAMP): ~13%; handgrip : ~19-23%) if only used, indicating many false positive findings and underscores the importance of the workflow design (alerts, capacity of confirmatory assessment). Risk of bias for such diagnostic studies was moderate to high on account of single site designs and poor reporting of uncertainty around Se/Sp.

Practice/process analytics to identify major implementation gaps in policies, standardised documentation and multidisciplinary coordination. Two national surveys (Ajabnoor 2023; Zaher 2025) documented incomplete penetration of active NSTs and routine screening and high perceived importance of NSTs and high self-reported guideline adherence among dietitians-suggesting potential gaps between policy intent, documentation and operational reality. Alkhady 2020 goes on to support the notion that even when practitioners report "following NCP" standardized terminology (IDNT/ICF-D) is not widely adopted, limiting downstream analytics and benchmarking potential.

ICU EN analytics are consistently indicative of delayed initiation / interruption as a prime determinant of under feeding. Prospectively monitored intake confirms large deficits (median 39% energy, 31% protein) and importance of early EN initiation for cumulative intake; physician-order delays, waiting for dietitian assessment are the top barriers in the perceived barriers survey, converging on latency of flow within the system as a key target for improvement. Qualitative dietitian data corroborate these same themes - absence of protocols, confusion with roles/communication, and discharge follow-up gaps.

Statistical synthesizing performed

No quantitative meta-analysis was done for pooled effect estimation as definition of outcomes, tools and populations were not sufficiently comparable between studies in line with SWiM recommendations for transparent reporting for studies in which meta-analysis is not appropriate. Therefore, no heterogeneity statistic (I2) or formal sensitivity analyses for pooled estimates are provided.

3.5 Reporting biases

Formal assessment of publication bias (e.g. funnel plots or statistical tests of funnel plot asymmetries) is not informative for these synthesis themes because there are too few comparable effect estimates for each of these synthesis themes and either considerable clinical/methodological heterogeneity or guidance cautions against the over-interpreting of funnel plot asymmetry, and stresses that asymmetry is not uniquely due to publication bias.

Across the included evidence, further reporting bias issues are selective outcome reporting, particularly in observational surveys, for which protocols are very rarely available, and where more than one outcome could be measured/selected post-hoc. Two empirical work shows that selective reporting can distort conclusions in evidence syntheses where outputs are selectively published. Given the generally not prominent protocol/registration linkage in the infertility research protocol included in this review, risk of bias due to missing results are judged unclear to moderate at the level of synthesis, i.e. uncertainty in magnitude of effect, plausible event (unclear magnitude, plausible presence).

3.6 Certainty of evidence

A modified version of GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) concepts was used to appraise certainty using the concepts of risk of bias, consistency, directness, precision and publication/reporting bias for narrative synthesis. This framework recognizes that, even when a pooled estimate is not available, reviewers can rate certainty by taking into account these domains over the body of evidence.

Table 6. Certainty of evidence

Outcome domain	Evidence base (included studies)	Certainty (review judgment)	Main drivers of certainty rating
Adult inpatient malnutrition prevalence (varied settings/tools)	Alzahrani 2017; Alamri 2024; Alamri 2025; Alshammari 2025; Zaher 2020	Low	Inconsistency due to heterogeneity between populations/tool use; due to limited number of individuals; mostly single centre cohorts; some estimates have small n (imprecision), and low national representativeness.

Screening/diagnostic performance (GLIM, STAMP, HGS)	Alshammari 2025; Alqahtani 2024; Alamri 2024	Low–Moderate (varies by tool)	GLIM vs SGA reports the AUC with CI and PPV/NPV as a moderate certainty for stroke survivors, STAMP/HGS report low specificity and limited CI reporting which reduces the certainty for decisions where deployment is used alone.
ICU underfeeding magnitude and relationship to EN initiation timing	Zaher 2020 + convergent barrier evidence from Zaher 2022 and qualitative Alyumni 2023	Low	Strong internal measurement in pilot and small sample of pilot studies with single hospitals are small numbers of pilot studies; self report studies; NOT consistent outcomes with hard endpoints across multiple hospitals
Nutrition-support practice, guideline use, and implementation barriers (Saudi hospitals)	Ajabnoor 2023; Zaher 2022; Zaher 2025; Alkhaldy 2020; Alyumni 2023	Low–Moderate	Multiple convergent sources (surveys + qualitative) increase confidence in presence of barriers, however convenience sampling, self-report measurement and limited objective validation mean that we are less sure about what the national rates are.
Economic burden of TPN services (cost estimates)	Alomi 2019	Low	Single hospital modelled costing; limited uncertainty / sensitivity analysis; time and price dependence of inputs recognized.

Chapter Four
Discussion

Prior literature and context

Hospital malnutrition is a constant patient safety and quality of care issue around the world, and it is strongly associated with complications, prolonged recovery, and extended hospital stays. Contemporary guidance therefore emphasizes (1) routine nutrition risk screening, (2) organized assessment/diagnosis with standardized criteria and (3) timely nutrition support with monitoring to ensure delivery and outcomes. For the standardization of diagnosis the Global Leadership Initiative on Malnutrition (GLIM) has proposed a two-step approach of risk identification through screening and then assessment based on phenotypic and etiological criteria (Cederholm et al., 2019). For ICU practice, international guidance such as ESPEN focusses on early and monitored nutrition support and attention should be paid to energy/protein target achievement and minimising avoidable interruptions (Singer et al., 2019).

Within this global context, the "analytics" component increasingly is defined as a process of moving beyond periodic audits to continuous, EHR-enabled measurement using standard documentation fields, dashboards and automated alerts to fill in gaps in screening completion, referral timeliness and delivery of nutrition support. However, to what extent Saudi hospitals are currently applying such analytics-enabled workflows has been unknown. The included Saudi evidence in this review therefore provides an important picture of the current stage of measurements and data use in clinical nutrition services.

Interpretation of the results of the review

Overall, the 12 included studies suggest that Saudi hospital nutrition measurement is in its infancy but is still dominated by descriptive studies (prevalence estimation, survey-based audits, and tool validation) versus actual-time EHR-integrated analytical intervention that makes demonstrable improvement in patient outcomes. The findings are consistent with four major interpretations:

1. Malnutrition burden is high in high-risk groups providing the case for systematic screening pathways. In hospitalized older adults, overt malnutrition as well as "at risk" status were both common (Alzahrani & Alamri, 2017; Alamri & Simbawa, 2024). In the stroke survivors, almost half of them met the GLIM malnutrition criteria, proving to be a particularly high burden population where nutrition deterioration may plausibly worsen the course of rehabilitation trajectories (Alshammari et al., 2025).
2. Measurement tools are locally tested, which is a necessary basis for analytics. The Saudi-modified pediatric STAMP showed very high sensitivity but very low specificity compared with the original tool, which suggests that the impact on workflow (e.g. false positives, dietitian workload) should be taken into account before the tool is scaled (Alqahtani et al., 2024). GLIM demonstrated good diagnostic accuracy in opposition to SGA in stroke survivors (Alshammari et al., 2025), and this makes it worthy of adoption as a standardised assessment framework in some adult services.
3. Process gaps and implementation barriers are routinely mentioned implying that analytics solutions need to be accompanied by governance and workflow redesign. Nutrition support structures (e.g. formal nutrition support teams), adherence to guidelines, and interprofessional coordination varied greatly and were often resource constrained and hampered by communication barriers (Ajabnoor et al., 2023; Zaher, 2022; Zaher et al., 2025).
4. Where delivery metrics were directly measured, underfeeding was frequent in line with the need for continuous monitoring. In mechanically ventilated ICU patients prevalence of underfeeding was more than 90%, cumulative energy/protein delivery was low compared to requirement; early initiation of EN was linked to high intake (Zaher et al, 2021).

Taken together, these patterns tend to suggest that Saudi hospitals have meaningful local evidence in terms of "what the problems look like" (descriptive/diagnostic analytics) but far less evidence in terms of "what changes outcomes when embedded into routine systems" (predictive/prescriptive analytics that are integrated into EHR workflows).

Comparison with the previous evidence

Burden and patterns of prevalence. The prevalence estimates differed from population to population and tool to tool. For instance, older people admitted in the hospital who were assessed using MNA-SF exhibited 29% of malnutrition and 47.6% of at risk (Alzahrani & Alamri, 2017), while the surgical admissions who were confirmed using GLIM revealed 18.1% prevalence of malnutrition (Alamri et al., 2025). This variability is consistent with international observations of a high degree of dependence of prevalence on case-mix (e.g, frailty, neuro-disability) and method of diagnosis (GLIM vs screening-based categorizations) (Cederholm et al., 2019).

Performance of screening/diagnostic tool. The GLIM validation in the stroke survivors showed good discriminative performance with an AUC of 0.819, sensitivity of 78.2% and specificity of 85.7%, making GLIM a potentially implementable standard if it is coupled to workflow and measurement capacity (Alshammari et al., 2025). By contrast, handgrip strength had a high sensitivity but very low specificity for malnutrition/risk, suggesting that it may prove to be of use as an adjunct for ruling out malnutrition/risk, or as a signal of frailty (Alamri & Simbawa, 2024). Similarly, the high sensitivity (94.3%) and low specificity (13.2%) of the Saudi-

modified STAMP suggest that when as a screening tool without triage logic, the implementation of the tool will lead to an excessive number of referrals and a burden on the capacity of dietitians (Alqahtani et al., 2024).

Nutrition support practice & guideline adherence. International ICU guidance focuses on earlier initiation of nutrition support and progression of nutrition support in a systematic, yet active monitoring manner (Singer et al., 2019). In this review, both the measured underfeeding rate in ventilated ICU patients (Zaher et al., 2021) and the barrier profiles reported by ICU providers (Zaher, 2022) suggest ongoing delays and interruptions in the workflow that are plausibly responsible for calorie/protein deficits. These findings are also resonated by qualitative dietitian perspectives (Alyumni et al., 2023) where poor role boundaries and poor interprofessional communication were prominent themes.

Readiness for analytics enabled care. From a systems perspective, the NCP implementation study is of special interest since the use of standardized terminology and documentation is a prerequisite for reliable dashboards and automated analytics. Although there was a high level of awareness, standardized use of NCP/terminology was weak and training coverage was low (Alkhaldy et al., 2020). This chimes in with the more general interpretation that the infrastructure of clinical nutrition in Saudi Arabia is still maturing in terms of measuring infrastructure (standard data definitions, documentation consistency) before large-scale EHR analytics can be expected to function reliably.

Implications of findings for practice and policy and for research (Summary)

- **Practice**
  - Standardize nutrition screening, assessment and documentation (e.g. consistent criteria; structured data fields) to allow hospitals to have a consistent way of tracking performance.
  - Use simple, high-impact analytics first (dashboards/audit and feedback) to monitor key process indicators (i.e. screening completion, time to dietitian referral, and adequacy of enteral/parenteral nutrition delivery).
  - Strengthen the coordination between disciplines (dietitians, physicians, nurses, pharmacists) and outline clear pathways of escalation, which enable agrivoltaics outputs to translate into timely action.
- **Policy**
  - Develop national minimum nutrition quality indicators and documentation standards that are compatible with EHR systems (e.g. screening within 24 hours, documented diagnosis, nutrition support in time).
  - Support workforce planning, training and governance structures (e.g. nutrition support teams) to lessen the variability between hospitals.
  - Include monitoring of costs and resources (e.g. parenteral nutrition services) to guide budgeting and to enhance efficiency
- **Future research**
  - Go beyond cross-sectional descriptions to studies of implementation-effectiveness testing the effectiveness of EHR alerts, automated referrals and dashboards in terms of outcomes (LOS, complications, readmissions, mortality)
  - Improve local validation and calibration of screening tools in order to minimise false positiveness and unnecessary workload.
  - Expand evidence across regions and types of hospital, and range this to include cost-effectiveness, sustainability and patient-centered outcomes.

Conclusion

Data analytics has been leveraged to track and improve clinical nutrition practice and outcomes in Saudi hospitals according to this systematic review. The overall evidence suggests that malnutrition is still prevalent in high-risk groups, including older adults, surgical patients and stroke patients, and nutrition care processes, including screening, assessment and administration of enteral/parenteral nutrition, vary between settings. Most of the research in Saudi Arabia has been descriptive and diagnostic in nature such as prevalence measurement, audits and validation of screening or diagnostic tools, which are helpful to identify gaps and provide a standardized measurement base. There is, however, limited evidence that EHR-integrated analytics interventions – such as automated alerts, dashboards tied to a workflow action, and predictive models built and deployed in practice – have been widely adopted and tested for impacts on patient outcomes. The evidence indicates that, with regard to the review question, analytics is now more in the service of monitoring and assessment than systematic improvement by way of digital workflows. Thus, while the literature reviewed has highlighted the need to standardize the processes that are used to identify nutrition risks and to support nutrition consistently for patients, the effectiveness of advanced analytics tools on outcomes like length of stay, complications, readmissions, and mortality has not been adequately assessed in Saudi hospitals. The results can be used for education and training purposes as they highlight key skills and competencies needed for data-driven clinical nutrition practice, such as

the ability to document uniformly, understand and interpret screening and assessment data, conduct audits and feedback, and work collaboratively with other professionals.

Limitations of the study

1. The majority of the evidence base were cross sectional, descriptive, prevalence studies, surveys, audits and validation studies.
2. These study designs are crucial for identifying practice gaps, and establishing baseline measurement, but for causal inferences, the ability is limited.
3. The studies included do not allow for definitive statements regarding the efficacy of using analytics-based approaches to improve clinical outcomes including complications, readmissions, mortality, or length of stay.
4. The included studies had a high level of heterogeneity with regard to patient groups (older, surgical, critical care, paediatric and stroke).
5. The associated studies also differed with regard to setting (single-center or multi-center), screening and diagnostic criteria used (MNA, STAMP, GLIM, handgrip strength).
6. Heterogeneity reduced the comparability of the studies, and so it was not possible to pool the results of the studies quantitatively (meta-analysis).
7. Some studies reported on process measure or validation measures, but not downstream patient outcomes.
8. Information about implementation factors, including integration with workflow, staffing models and data quality assurance, were not always reported.
9. This hampered the ability to appreciate and to compare the implementation success within hospital contexts, and the manner in which analytics was operationalized in real world clinical workflow.
10. There are also limitations regarding generalizability since some of the studies were conducted in particular hospitals or areas, and may not reflect the diversity of health care delivery in Saudi Arabia.
11. One reviewer primarily performed screening, data extraction, critical appraisal, and risk of bias assessment which could introduce selection bias or interpretation bias.
12. Only English-language publications were included which might have meant that relevant studies published in Arabic or local reports and quality improvement documents from hospitals not indexed in bibliographic databases were excluded.

Recommendations

1. More efforts need to be put into standardisation of the nutrition screening, assessment and documentation in Saudi hospitals, with structured fields and a common definition.
2. Nutrition risk screening should be done early in the admission process so that patients at risk of malnutrition can be identified in time.
3. To enhance consistency and reliability of assessments in clinical settings, assessment criteria should be clearly documented.
4. Standardisation of referral pathways to dietitians or nutrition support teams to minimise delays and increase continuity of care.
5. The first step for hospitals should be simple, effective analytics strategies, including regular audit and feedback and performance dashboards.
6. Performance dashboards should be used to monitor such key indicators as completion of screening, time until assessment/intervention, quality of energy and protein provision in high-risk patients, and disruption of enteral feeding in critical care.
7. Improved monitoring systems should link to defined accountability and escalation processes to ensure that gaps identified lead to corrective actions and are not merely described.
8. National stakeholders should give thought to minimum standards for clinical nutrition indicators and EHR documentation.
9. National documentation standards should facilitate benchmarking between hospitals and regions as well as minimise variations in clinical nutrition practice.
10. It is important for workforce planning and training to be supported, particularly to help develop dietitians' and clinicians' skills in informatics, standardised documentation, and data quality.
11. Future research is needed to conduct implementation-effectiveness research on EHR-integrated analytics interventions, including automated alerts, automated referral triggers, and dashboards.
12. Future studies should employ strong research designs to ensure evaluation of change over time and to relate the use of analytics to patient outcomes.
13. Further studies on multi-centers including hospitals of various types and geographic locations in Saudi Arabia are required to enhance its generalizability.
14. Future research is needed to incorporate economic evaluation, sustainability, and patient-centered outcomes as part of the decision-making process for implementing models of nutrition care that rely on analytics in Saudi Arabia.

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Appendices

Appendix A PRISMA CHECKLIST

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	i
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	vii

INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	8
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	11
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	13
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	11
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	12
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	14
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	15
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	16
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data	16

		synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	16
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	15
Section/topic	**#**	**Checklist item**	**Reported on page #**
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	14
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	21
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	22
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	24
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	29
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and	31

		measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	25
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	34
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	39
Conclusions	2	Provide a	38
	6	general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	No funding

Appendix B Full Search Strategy

1. PubMed

(("data analytic*" OR "big data" OR "health informatics" OR "audit*" OR "evaluation" OR "prevalence" OR "incidence" OR "validation" OR "assessment")
AND
("clinical nutrition" OR "malnutrition" OR "undernutrition" OR "nutrition assessment" OR "nutrition screening" OR "enteral nutrition" OR "parenteral nutrition" OR "nutrition support" OR "dietitian*")
AND
("Saudi Arabia"[Mesh] OR "Saudi Arabia"))
Filters: Publication date from 2015/01/01 to 2024/05/15

2. Scopus

TITLE-ABS-KEY((("data analytic*" OR "big data" OR "health informatics" OR "audit*" OR "evaluation" OR "prevalence" OR "incidence" OR "validation" OR "assessment")
AND
("clinical nutrition" OR "malnutrition" OR "undernutrition" OR "nutrition assessment" OR "nutrition screening" OR "enteral nutrition" OR "parenteral nutrition" OR "nutrition support" OR "dietitian*")
AND
("Saudi Arabia")))
AND PUBYEAR > 2014 AND PUBYEAR < 2025

AND (LIMIT-TO(SUBJAREA,"MED") OR LIMIT-TO(SUBJAREA,"NURS") OR LIMIT-TO(SUBJAREA,"HEAL"))

3. Web of Science

TS=(("data analytic*" OR "big data" OR "health informatics" OR "audit*" OR "evaluation" OR "prevalence" OR "incidence" OR "validation" OR "assessment")
AND
("clinical nutrition" OR "malnutrition" OR "undernutrition" OR "nutrition assessment" OR "nutrition screening" OR "enteral nutrition" OR "parenteral nutrition" OR "nutrition support" OR "dietitian*")
AND
("Saudi Arabia"))
Timespan: 2015-2024
Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI

4. Google Scholar A less structured search was performed to capture additional grey literature and articles not indexed in the above databases. The following search string was used, and the first 300 results were screened based on title and relevance.
"clinical nutrition" OR "malnutrition" OR "enteral nutrition" OR "parenteral nutrition" AND "Saudi Arabia" AND "prevalence" OR "audit" OR "validation" OR "evaluation" OR "data"

Appendix C. Data Extraction Form

Study ID	Author	Year	Included study / short citation	Design	Region	Setting (Saudi Arabia)	Population / sample	Sample size	Age group	Clinical nutrition topic / intervention assessed	Data sources used	Data analytics methods used	Statistical / analysis methods	Clinical outcomes	Economic outcomes
SR-01	Ajabnoor	2023	Ajabnoor et al., 2023	National cross-sectional survey	Multi-region (majority Western region)	Nationwide respondents across Saudi Arabia	Healthcare professionals: physicians (38), dietitians (62), pharmacists (14)	114	Healthcare professionals	Nutrition support team (NST) presence, screening practices, guideline familiarity, and confidence in EN/PN	Online questionnaire	Descriptive benchmarks; between-group comparisons; regression on confidence scores	Comparative analysis and regression modeling	NST presence; screening practices; guideline familiarity; confidence in EN/PN	
SR-02	Alamri	2025	Alamri et al., 2025 (Surgery malnutrition prevalence)	Prospective observational cross-sectional	Riyadh	King Abdulaziz Medical City (MNGHA), Riyadh	Adult surgical-ward admissions >48 hours	282	Adults	Malnutrition prevalence in adult surgical patients using GLIM staging	Patient assessments on admission	Risk-factor modeling using logistic regression; classification using GLIM stages	Logistic regression; classification analysis	Malnutrition prevalence (GLIM); stage distribution; risk factors (OR/aOR)	
SR-03	Alamri	2024	Alamri & Simbawa, 2024 (Handgrip screening)	Observational cross-sectional	Jeddah	King Abdulaziz University Hospital	Consecutive hospitalized older adults	135	Older adults	Handgrip strength as a screening marker for malnutrition	Bedside measures and chart laboratory data	Screening performance analysis (ROC/AUC); multivariable regression for predictors of low HGS	ROC/AUC analysis; multivariable regression	Malnutrition prevalence (MNA-SF); HGS sensitivity, specificity, AUC; predictors of low HGS	
SR-04	Alkhaldy	2020	Alkhaldy et al., 2020 (NCP implementation)	Quantitative cross-sectional survey	Jeddah	Six MOH hospitals, Jeddah	Practicing dietitians	56	Healthcare professionals	Implementation of the Nutrition Care Process (NCP)	Questionnaire	Descriptive implementation measures (awareness, training, standardization, barriers)	Descriptive analysis		
SR-05	Alomi	2019	Alomi et al., 2019 (TPN costing)	Costing / economic evaluation	Riyadh	King Salman Hospital, Riyadh (MOH)	TPN recipients/orders over simulated period	112	Mixed / not clearly specified	Cost of total parenteral nutrition (TPN) services	MOH cost database and modeled workflow	Costing for TPN services (direct, overhead, per day/per order)	Simulation-based costing and local costing analysis		Cost per day/order and estimated expenditure by age
SR-06	Alqahtani	2024	Alqahtani et al., 2024 (Saudi-modified STAMP)	Cross-sectional diagnostic validation	Riyadh	Prince Sultan Military Medical City, Riyadh	Hospitalized children	307	Children	Validation of Saudi-modified STAMP screening tool	Anthropometrics and STAMP tools	Sensitivity/specificity/PPV/NPV comparisons; concurrent validity against reference standards	Diagnostic validity analysis	High-risk prevalence; validity parameters versus anthropometrics	
SR-07	Alshammari	2025	Alshammari et al., 2025 (GLIM validation in stroke survivors)	Cross-sectional diagnostic validation	Riyadh	Riyadh stroke survivor cohort	Stroke survivors	104	Adults	Validation of GLIM criteria in stroke survivors	Anthropometrics, GLIM, SGA, and NRS-2002	ROC/AUC with CI; kappa agreement; diagnostic performance evaluation	ROC/AUC analysis; agreement analysis; diagnostic performance testing	Malnutrition prevalence; AUC; sensitivity; specificity; PPV; NPV; kappa	
SR-08	Alyumni	2023	Alyumni et al., 2023 (dietitians' EN practices—qualitative)	Qualitative (focus groups)	Riyadh	Riyadh	Registered dietitians across 5 focus groups	24	Healthcare professionals	Dietitians' enteral nutrition (EN) practices, barriers, and needs	Transcribed focus groups	Thematic analysis of practice patterns, barriers, and needs	Qualitative thematic analysis		
SR-09	Alzahrani	2017	Alzahrani & Alamri, 2017 (elderly inpatient malnutrition prevalence)	Cross-sectional with outcome follow-up	Jeddah	King Abdulaziz University Hospital, Jeddah	Consecutive elderly inpatients	248	Older adults	Malnutrition prevalence and outcomes among elderly inpatients	Bedside screening, chart labs, and follow-up outcomes	Logistic regression (OR with CI); descriptive differences in outcomes	Logistic regression; comparative outcome analysis	Malnutrition prevalence; LOS; readmission; mortality; predictors of malnutrition	
SR-10	Zaher	2020	Zaher et al., 2020 (JPEN pilot underfeeding study; Saudi ICU)	Prospective observational pilot	Medina	King Fahad Hospital, Medina	Mechanically ventilated ICU adults	43	Adults	Enteral nutrition intake and underfeeding in ICU patients	Prospective monitoring of EN intake over 6 days	Monitoring of EN intake, timing, and ventilation associations	Prospective monitoring and regression/comparative analyses	ICU malnutrition prevalence; energy/protein delivery; early vs late EN differences; ventilation	
SR-11	Zaher	2022	Zaher, 2022 (EN barrier survey)	National cross-sectional survey	Nationwide	Adult ICUs and PICUs nationwide	Healthcare professional respondents	244	Healthcare professionals	Perceived barriers to enteral nutrition delivery	Online survey with 24 barrier items	Barrier scoring; group comparisons (adult ICU vs PICU); regression on total barrier score	Likert score analysis; comparative analysis; regression		
SR-12	Zaher	2025	Zaher et al., 2025 (dietitians' adherence to NS guidelines/ protocols)	Cross-sectional survey	Nationwide	Dietitians in Saudi hospitals nationwide	Dietitians (PN sub-analysis included)	133	Healthcare professionals	Adherence to nutrition support guidelines and protocols	Online questionnaire	Adherence scoring (EN/PN); barrier frequency analysis; regression predictors	Score-based analysis and regression modeling	Adherence distributions for EN/PN	