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Dietary assessment methods for measurement of oral intake in acute care and critically ill hospitalised patients: a scoping review

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Abstract

Quantification of oral intake within the hospital setting is required to guide nutrition care. Multiple dietary assessment methods are available, yet details regarding their application in the acute care setting are scarce. This scoping review, conducted in accordance with JBI methodology, describes dietary assessment methods used to measure oral intake in acute and critical care hospital patients. The search was run across four databases to identify primary research conducted in adult acute or critical care settings from 1st of January 2000-15th March 2023 which quantified oral diet with any dietary assessment method. In total, 155 articles were included, predominantly from the acute care setting ($n = 153$, 99%). Studies were mainly single-centre ($n = 138$, 88%) and of observational design ($n = 135$, 87%). Estimated plate waste ($n = 59$, 38%) and food records ($n = 43$, 28%) were the most frequent assessment methods with energy and protein the main nutrients quantified ($n = 81$, 52%). Validation was completed in 23 (15%) studies, with the majority of these using a reference method reliant on estimation ($n = 17$, 74%). A quarter of studies ($n = 39$) quantified completion (either as complete versus incomplete or degree of completeness) and four studies (2.5%) explored factors influencing completion. Findings indicate a lack of high-quality evidence to guide selection and application of existing dietary assessment methods to quantify oral intake with a particular absence of evidence in the critical care setting. Further validation of existing tools and identification of factors influencing completion is needed to guide the optimal approach to quantification of oral intake in both research and clinical contexts.

Keywords: **acute care: critical illness: Dietary assessment tools: nutrition: oral diet**

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Introduction

Malnutrition is both a cause and consequence of ill health and is a significant issue in healthcare settings worldwide[1]. Adequate provision of nutrition is an accepted component of the prevention and treatment of malnutrition yet insufficient food intake has been estimated to occur in 47–76% of patients admitted to an acute care setting[2,3]. It has been hypothesised that certain populations, including acute and critically ill patients, are at an increased risk of suboptimal intake due to the presence of additional disease-related barriers such as fatigue, weakness and altered appetite[4,5]. Recent studies indicate significant nutrition deficits both within the intensive care unit (ICU) and on transfer to the acute care ward in patients consuming an oral diet[6,7].

The causes of suboptimal food intake in the acute and critical care setting are complex and multi-faceted, involving patient and system factors[1,8]. Patient characteristics including age, length of stay, appetite, clinical symptoms and prescription of therapeutic diets have all been associated with reduced food intake[8–10]. Compounding this are system factors associated with the

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hospital environment including mealtime interruptions, inadequate feeding assistance, dissatisfaction with meals, and restrictive mealtimes[1,8,11].

The relationship between malnutrition, suboptimal food intake and related increased morbidity and mortality has led to an emphasis on nutritional monitoring within contemporary healthcare safety and quality standards[12–14]. Yet accurate measurement of oral intake, a core component of monitoring, remains a significant challenge. Multiple tools including food records, ready reckoners and plate waste diagrams have been developed to quantify intake in an acute care setting but concerns regarding accuracy persist[15]. Knowledge deficits, time pressures and competing priorities for healthcare staff responsible for completing these tools, combined with missing data and impaired patient recall, have been found to result in inaccuracies and compromise completion[16–18]. Errors in the quantification of oral intake may impact research quality, as well as adversely affect timely escalation of care, malnutrition identification and prioritisation of healthcare resources in the clinical setting[15]. Despite the perceived importance of accurately measuring oral intake, there has been no systematic exploration of dietary assessment methods that are used to measure oral intake in the acute and critical care setting.

The primary objective of this scoping review was to map and describe dietary assessment methods used to measure oral intake in acute and critical care hospital settings. Secondary objectives were to:

1. Describe the characteristics of the dietary assessment methods used;
2. Report the number of studies, the dietary assessment methods used and the population within which validation processes were completed;
3. Document factors reported to influence completion of the dietary assessment methods;
4. Identify existing evidence gaps and future research priorities aimed at developing accurate but feasible dietary assessment methods for the measurement of oral intake in acute care and critically ill hospital patients.

Methods

Protocol and registration

This scoping review was conducted in accordance with the JBI Manual for Evidence Synthesis and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[19,20]. The protocol was registered a priori on Open Science framework on 6 May 2022; available from https://osf.io/k6m7y. In accordance with JBI process, minor amendments were made to the protocol as the review progressed (listed in Supplementary Table 1, Appendix I).

Eligibility criteria

Original primary research including observational and experimental designs published in English from any geographical location from 1st of January 2000-15th of March 2023 were considered for inclusion. Date restrictions were applied to produce a feasible search result representing modern practice. Sources of evidence were included if they met the following criteria:

Eligibility

Population. Included adults (≥ 18 years) consuming an oral diet. Consumption of an oral diet was defined as ingestion of any oral food or fluids via the mouth with exception of fluid only diets.

Context. Completed in the acute care setting, including critical care but excluding maternity, pre-operative assessment, day-surgery, inpatient rehabilitation or outpatient services.

Concept. Reported on the application of a dietary assessment method to quantify oral diet and included at a minimum calculation of energy intake. Calculation of energy intake was defined as quantification of energy intake from all macronutrients (kilocalorie); studies that included a global estimate of meal consumption were included even though intake was not reported in kilocalories on the basis that such estimates provide an indicator of dietary intake adequacy.

Exclusion. All forms of grey literature were excluded; the original protocol included theses, but due to the size of the final search, a decision was made to also exclude these sources. Additionally, studies were excluded if they:

- quantified intake retrospectively prior to acute hospital admission;
- enrolled patients receiving exclusive enteral or parenteral nutrition with no concomitant consumption of oral diet or included patients receiving oral intake and/or enteral or parenteral with no distinction made regarding quantification of oral intake;
- reported on malnutrition screening tools where dietary intake was estimated as a component of screening;
- included a mixed population where results were not presented separately for acute care and/or critically ill patients; or
- were based on secondary reporting of data. Where multiple published studies reported the same data only the data from the original primary study was included.

Supplementary Appendices II and III Table 2 further outline the eligibility criteria and key definitions used in this review.

Information sources and search

The search strategy was conducted in accordance with the JBI Manual for Evidence Synthesis[19]. Following the development and piloting of the search strategy within Medical Literature Analysis and Retrieval System (MEDLINE) via OVID and Cumulative Index of Nursing and Allied Health Literature (CINAHL) via EBSCO, the final search was conducted in consultation with a trained research librarian across four databases: MEDLINE Epub, ahead of print, in process, in-data-review and other non-indexed citations, daily and versions; Excerpta Medica Database (Embase Classic+Embase) (OVID 1947 to date); Emcare (OVID 1995 to date); and Cumulative Index of Nursing and Allied Health Literature (EBSCOhost1937 to date). The search strategy for MEDLINE can be found in

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Supplementary Appendix IV. The final search was conducted on 15 March 2023. Systematic, scoping and narrative reviews were reviewed only to identify additional primary studies eligible for inclusion in the review.

Selection of sources of evidence

Search results were exported to EndNote (version 20.2.1) and a single author (C.F.) removed duplicates and articles that did not meet the inclusion criteria according to the article title, as per pre-defined criteria (Supplementary Appendix V). Remaining articles were exported to Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia, available at www.covidence.org. Prior to commencing formal screening processes, piloting of title and abstract screening was completed by four reviewers on ten randomly selected articles (C.E.F., O.A.T., J.N.A., I.M.H.). Title and abstract screening were independently completed by two reviewers (C.E.F., I.M.H. or L.M.) with discrepancies resolved by consensus. Articles deemed eligible for full text review were screened independently by two reviewers (C.E.F. and either I.M.H. or L.M.) and conflicts resolved by a third reviewer (O.A.T. and/or E.R.).

Data charting process

A data charting tool was developed and piloted on two articles by three reviewers (C.E.F, O.A.T, L.M.) (supplementary Appendix VI). Data was independently charted by two reviewers (C.E.F and L.M.) with discrepancies resolved via consensus by a third reviewer (O.A.T and/or E.J.R). Details of modifications made to the tool during data charting are listed in Supplementary Appendix VII.

Data items

Article characteristics including location, study design, population, characteristics of the dietary assessment method (method of assessment, format of data collection instruments (automated versus interviewer administered 24 h recalls, paper versus electronic food record and estimated plate waste forms), person responsible for applying the tool and nutrient/s quantified), validation (if completed including reference method and nutrient/s quantified) and factors influencing completion were extracted (supplementary Appendix VI).

Critical appraisal of individual sources of evidence

In line with the JBI Manual of Evidence critical appraisal of the evidence was not completed.

Synthesis of results

Findings for acute care and critically ill patients are reported together. Publication details and information pertaining to validity are presented in a tabular format. Information on the frequency of each dietary assessment method was reported in the literature, and the nutrient/s measured are presented graphically. A narrative summary accompanies the results summarizing the findings in relation to the scoping reviews aims. Where possible, findings are summarised using number (n) and percentage (%).

Results

Selection of sources of evidence

The search identified 12422 articles with an additional ten articles identified from screening reference lists of reviews. Following removal of duplicates, 6161 articles underwent title and abstract screening and 670 underwent full-text screening with 155 articles included in the review (Figure 1).

Characteristics of sources of evidence

Study characteristics are presented in Table 3 (supplementary Appendix VIII). The majority of studies were completed in an acute care setting ($n = 153$, 99%) with only two (1%) including patients admitted to an ICU[12,21–174]. The largest number of studies originated from Australia ($n = 25$, 16%), followed by Denmark ($n = 20$, 13%) and the UK ($n = 18$, 12%)[12,25–27,37,45–47,49–51,53,58,62–64,67,70,72,73,85,87–90,92,93,96,101,105–111,113,114,116–119,122,126,127,130,132–135,147,156,157,159,161,162,166–168,170,172,173]. Most were single-centre ($n = 138$, 88%) and predominantly observational designs ($n = 135$, 87%), with cross sectional being the most common design overall ($n = 79$, 51%). A total of fifteen studies (10%) were randomised controlled trials[26,31,45,48,59,62,68,74,107,132,137,142,143,155,164]. The sample size was reported in 150 studies (97%) and ranged from 9 to 1012 participants with the remaining five papers reporting the number of meals or meal trays rather than number of participants[72,82,147,157,166].

Synthesis of results

Which dietary assessment methods are used to measure oral intake and how have they been applied within acute and critical care hospital patients?

Estimated plate waste ($n = 59$, 38%), followed by food records ($n = 43$, 28%) and then 24 h recall ($n = 23$, 15%), were the most frequently reported assessment methods with the remaining studies using a variety of approaches to quantification (Figure 2)[12,21–174]. Estimated plate waste was predominantly collected using paper-based forms ($n = 40$, 68%), with six studies (10%) using an electronic form and the remaining studies providing inadequate detail to enable classification of the recording approach ($n = 13$, 22%)[12,22,25,28–30,32,35–38,41,54,56,70–72,75–80,82–84,86,87,95,97–101,103,106,111–113,118,121,124,127,128,131,134,138,141,143,147,152,153,157,160,165–168,174]. Similarly, food records were mainly completed using paper-based forms ($n = 30$, 70%) with two (5%) studies reporting on the use of an electronic form and eleven (25%) studies providing insufficient data to enable classification[23,24,27,31,37,42,44,45,48–50,53,57–59,62,65–68,73,85,88,91,104,105,107–110,114,119,122,126,129,136,144–146,155,162,171,174]. Within studies that used a 24 h recall to quantify dietary intake, recall was primarily collected using an interviewer-administered approach ($n = 20$, 87%), with one (4%) study using a self-administered computer-guided recall and the remaining two (9%) studies

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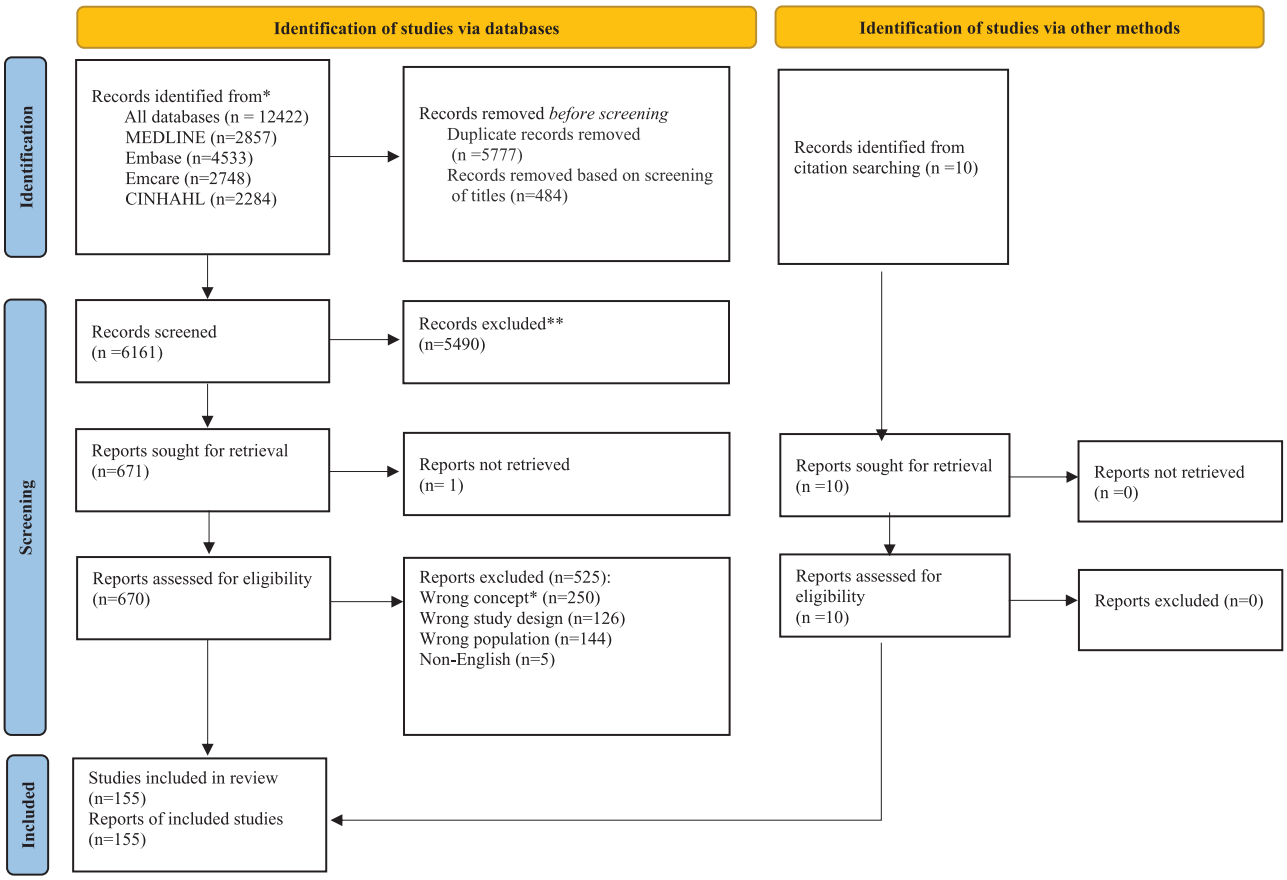

*Wrong concept refers to studies that included patients who were not receiving an oral diet and/or failed to quantify dietary intake or provide adequate detail about the dietary assessment method applied to quantify intake.

Fig. 1. PRISMA diagram

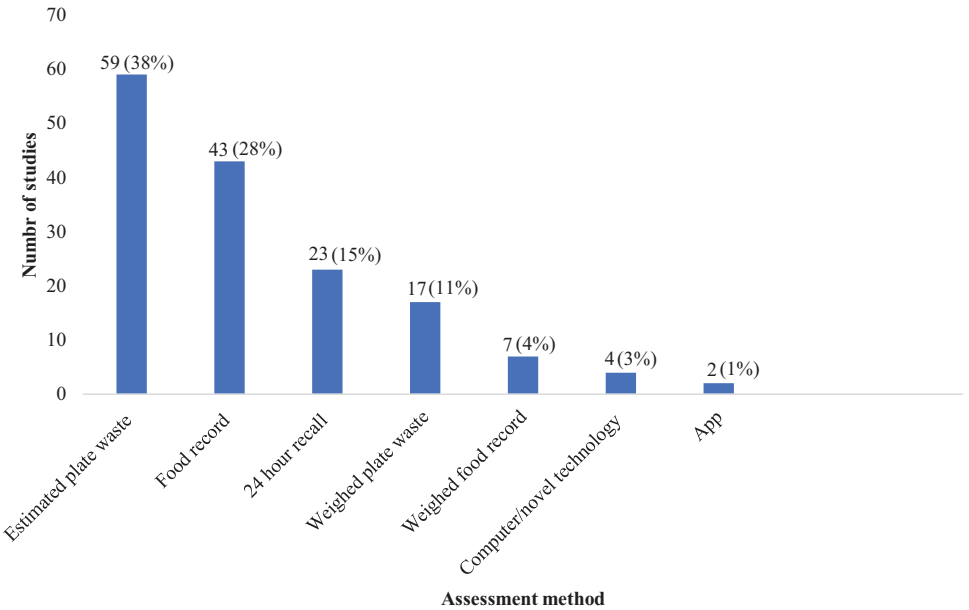

Fig. 2. Dietary assessment methods used to quantify intake in the acute care setting

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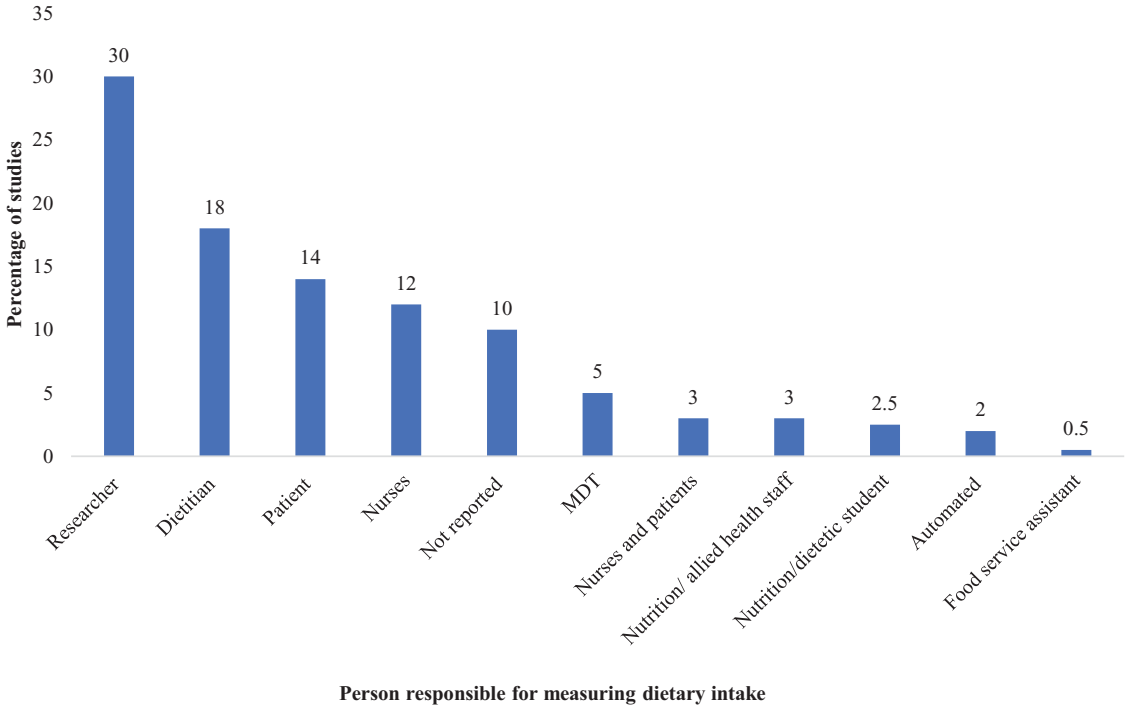

Fig. 3. Profession responsible for applying the dietary assessment method

providing inadequate detail to enable classification[21,26,33,34,40,52,69,74,90,92,102,115,120,130,139,142,148,149,151,164,169,172]. In total, six studies (4%) investigated novel technologies with 4 (2%) studies using either artificial intelligence or software programs to automate dietary intake estimation, and the remaining two (1%) studies investigated the use of mobile/tablet applications[94,116,117,123,125,135]. Application of the dietary assessment method was completed by a range of individuals with researchers and dietitians being the most common professional groups (Figure 3)[12,21,23,25,26,37,39,40,43,46,50,52,56,62,63,68,69,73,74,76,80,81,85–87,89,92,95,99,100,102,103,106,111,112,115,118–121,130,132–134,137–139,141–149,151,154,156–161,163–168,170,171,175]. The majority of studies ($n = 94$, 60%) did not specify the type of oral diet that was quantified; where this was specified, regular texture ($n = 31$, 19%) was the most commonly quantified diet type[27,28,36,46,50,51,54,64,77,81,87,102,103,105,107–109,116,128,130,132,139,142,150,159,160,165,172,174]. Energy and protein ($n = 81$, 52%) were the main nutrients quantified[12,17,25–28,30,31,38,39,41,43,44,46,49–51,59–64,67,69,72,73,76–78,82,85,86,90,91,93,94,96,97,100,101,105–110,115–117,121,122,125–127,130,131,134–139,143,146–148,150,153,154,156,158,162,164,165,167,170,172,173]. Micronutrients were quantified in eighteen studies (12%) in combination with energy and protein or all macronutrients (Figure 4)[21,40,52,53,66,74,81,87,92,102,113,120,141,142,145,149,151,161].

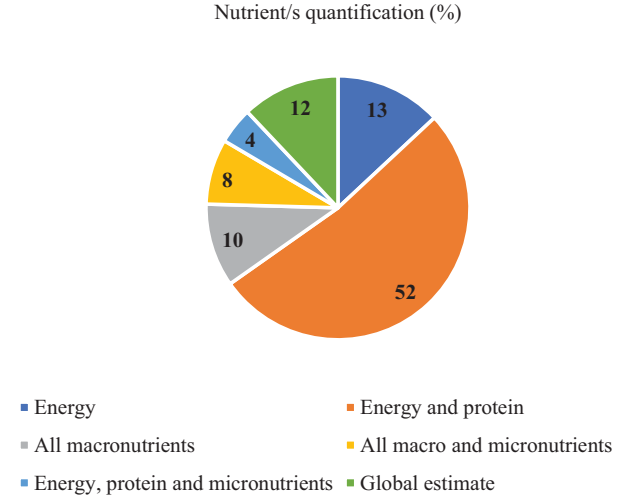

Fig. 4. Percentage of tools quantifying different nutrient/s of interest

Which dietary assessment methods have undergone a validation process and in which populations were these conducted?

In total, twenty-three (15%) studies reported on validation of the reported method in comparison to another dietary assessment method in the acute setting (criterion validity) (Table 1)[24,28,30,36,41,44,53,54,72,82,87,94,98,117,122,123,125,135,140,147,153,160,174]. Estimated plate waste was the most common dietary assessment method which underwent validation, with fifteen (60%) of the twenty-three studies reporting on the validity of this method in comparison with a reference tool. In total 15 (65%) studies reported using an objective (weighed) method as the reference method. However, intake was only weighed pre- and post-consumption in six (26%) studies with the other nine (39%) studies calculating intake on the basis of comparison of a standard portion to the weight of the food remaining after consumption[24,30,36,41,53,54,72,82,87,117,122,147,153,160,174]. The remaining eight (35%) studies assessed validity in comparison with reference methods reliant on estimation of consumption including estimated food records ($n = 1$, 4%), estimated plate waste ($n = 5$, 22%) or 24 h recalls ($n = 2$, 4%)[28,44,94,98,123,125,135,140]. Researchers ($n = 13$, 56%) and

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Table 1. Validation processes

Author, year	Dietary assessment methods compared	Person responsible for completion	Reference method	Person responsible for completing reference method	Nutrients measured
Amaral, 2022[24]	Food record	Patient	Weighed plate waste	Nutrition students	Percentage of meal consumed
Berrut, 2002[28]	Meal portion method (estimated plate waste)	Nursing staff	Meal portion method (estimated plate waste)	Dietitian	Energy and protein
Bjornsdottir, 2013[30]	Plate diagram (estimated plate waste)	Nursing staff	Weighed plate waste[1]	Researchers	Energy and protein
Budiningsari, 2016[36]	Pictorial dietary assessment tool (estimated plate waste)	Health care staff (dietitians, nurses and serving assistants)	Weighed plate waste[1]	Researchers	Energy, protein, carbohydrate and fat
Budiningsari, 2018[174]	Pictorial dietary assessment tool (estimated plate waste)	Health care staff (dietitians, nurses and serving assistants)	Weighed plate waste[1]	Researchers	Energy and protein
	Modified Comstock method (estimated plate waste)	Health care staff (dietitians, nurses and serving assistants)			
Dekker, 2019[41]	Rate a plate (estimated plate waste)	Researchers and nutrition assistants	Phase 1: Weighed food records	Researchers and nutrition assistants	Energy and protein
			Phase 2: Digital photography (estimated plate waste)	Researchers and nutrition assistants	
Doordujin, 2016[44]	At Your Request food (individual food intake estimated from ordering data) (automated)	Automated	Food recall	Researcher	Energy and protein
Gariballa, 2006[53]	Food record	Patients	Weighed food records	Researcher	Energy, protein, carbohydrate, fat and fibre
Ghisolfi, 2014[54]	Calorie Intake Tool (estimated plate waste)	Nurses	Weighed plate waste	Dietitians	Energy
Husted, 2017[72]	Meal portion method (estimated plate waste)	Nurses	Weighed plate waste	Dietitians	Energy and protein
	Plate method (estimated plate waste)	Nurses			
	Reduced plate method (estimated plate waste)	Nurses			
Kawasaki, 2019[82]	Estimated plate waste	Nurses	Weighed plate waste[1]	Researchers	Energy and protein
Kowanko, 2000[87]	Estimated plate waste	Researchers	Weighed plate waste[1]	Dietitians	Energy, protein and micronutrients
Long 2023[94]	R-Dietitian (mobile app)	Patient	24 h recall	Dietitians	Energy and protein
McCulough, 2018[98]	My Meal Intake tool (estimated plate waste)	Patients	Estimated plate waste	Dietitians	Percentage of meal consumed
Ofei,2019[117]	Dietary intake monitoring system (automated)	Automated	Weighed food record[1]	Researchers	Energy and protein
Palmer, 2014[122]	Food record	Nurses	Weighed food record[1]	Researchers	Energy and protein
Papathanil, 2021[123]	Automated AI system (automated)	Automated	Estimated plate waste	Dietitians and trained medical students	All macronutrients
	Estimated plate waste	Nursing staff			
Paulsen, 2018[125]	App (automated)	Patients	Digital photography (estimated plate waste)	Researchers	Energy and protein

Table 1. (*Continued*)

Author, year	Dietary assessment methods compared	Person responsible for completion	Reference method	Person responsible for completing reference method	Nutrients measured
Roberts, 2021[135]	Electronic food service system (automated)	Patients	Estimated plate waste	Researchers	Energy and protein
Saueressig, 2022[140]	Food intake visual scale (estimated plate waste)	Patients and researcher	Food record	Patients	Energy, protein, carbohydrate and fat
Tan, 2021[147]	Meal intake points (estimated plate waste)	Researchers	Weighed plate waste[1]	Researchers	Energy and protein
Tulloch, 2019[153]	My meal intake tool (estimated plate waste)	Food service workers	Weighed plate waste[1]	Researchers	Energy and protein
Winzer, 2018[160]	Post meal digital photography method (estimated plate waste)	Researchers	Weighed food record	Researchers	Grams of food consumed
	Pre- and post-meal digital photography method (estimated plate waste)	Researchers			

[1] Refers to a modified approach to weighed food records and plate waste where the weight of standard serves was used with intake calculated as the difference between these weights and the weight of food remaining on the plate after consumption

dietitians ($n = 6$, 26%) were predominantly responsible for applying the reference method with validity assessed in the majority of studies ($n = 14$, 61%) via comparison of energy and protein estimates[28,30,36,44,53,54,72,82,87,94,98,117,122,125,135,147,153,160,174]. Most studies compared nutrient estimates via comparison of either one or two meals ($n = 10$, 43%)[17,24,28,30,36,72,82,87,123,147]. The remaining studies looked at average intake from either a single day of intake data ($n = 6$, 26%) or multiple days of intake data ($n = 7$, 30%)[41,44,53,54,94,98,117,122,125,135,140,153,160].

What are the reported reasons for non-completion and were any strategies to enhance completion of the reported dietary assessment methods reported?

A quarter ($n = 39$, 25%) of studies reported completion rates for the dietary assessment method of interest[27,30,41,43–46,50,56,61,67,73,82,88,89,91,93,95,97,98,101,107,111,116,122,124,125,127,129,131,134–136,140,144,151,163,170,139]. Definitions of completion varied with twenty-five (63%) reporting this as the number of participants with complete dietary intake data and the remaining studies ($n = 14$, 36%) defining this as the number of complete dietary intake registrations recorded using the assessment method of interest. In total, four studies (2.5%) reported on factors influencing completion of the dietary assessment method with three (2%) studies looking at patient-related factors, and the remaining study ($n = 1$, 0.5%) exploring the influence of staff training on rates of missing data[98,122,125,135]. Patients reported symptom burden/ illness, ease of use, technological familiarity and confidence, and tool design as factors influencing completion[98,125,135]. Design characteristics identified as aiding completion included provision of detailed instructions, addition of word cues to aid with quantification, incorporation of realistic visual diagrams and provision of free text space to record food consumed between meals[98]. Staff training was identified in one study as influencing completion with higher rates of missing data observed in food records completed by nursing staff as part of routine care compared with weighed food records completed by dietitians[122].

Discussion

This is the first scoping review summarising the literature on dietary assessment methods used to quantify oral intake in adult inpatients within acute and critical care settings. The literature on this topic was broad, with 155 studies completed over the last decade across a range of geographic locations. Studies were mainly single centre with only a small number of randomised controlled trials. Two key themes emerged from the literature: (1) a lack of high-quality evidence and validation of tools in the acute care setting (including ICU) and (2) concern regarding validation processes, and lack of consensus on completion definitions combined with insufficient evaluation of factors influencing completion of dietary assessment methods.

Across all studies, the most common methods used to quantify dietary intake were estimated plate waste and food records[12,22–25,27–32,35–38,41,42,44,45,48–50,53,54,56–59,62,65–68,70–73,75–80,82–84,86–88,91,95,97–101,103–114,118,119,121,122,124,126–129,131,134,136,138,140,143–147,152,153,155,157,158,160,162,165–168,171,173]. Traditional paper-based tools were the most common methods used to capture data across all

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studies that reported the use of food records and estimated plate waste. However, validation of these methods within the reported studies was limited and there was an absence of literature in critical care. Methods reliant on estimation, such as food records and estimated plate waste, provide a practical approach to the quantification of intake at the bedside. Compared with approaches such as weighed food records, which have typically been used in research settings, such tools are quick and low cost, representing a feasible approach to intake quantification; however, they are also prone to bias[176]. Patient recall, inaccurate portion size estimation and high rates of missing or inadequate data have been found to compromise the accuracy of these tools[16,177,178]. Moreover, there is also a lack of standardisation with food record forms, typically varying by site and plate waste recorded using a range of different scales and approaches to estimation (whole meal versus meal component method)[178–180]. This absence of standardisation has implications for the generalisability of study findings, making interpretation of the existing literature challenging.

Missing or incomplete data is known to be an important factor influencing measurement accuracy. Given the significance of this source of error, an understanding of completion rates is essential. Yet this review found limited measurement of completion reported, with only a quarter of studies quantifying this and a lack of consensus on how to define 'completion'[27,30,41,43,46,50,56,61,67,73,82,88,89,91,93,95,97,98,101,105,107,111,116,122,124,125,127,129,131,134,136,140,144,151,163,171]. Moreover, only four studies evaluated characteristics influencing completion, with the majority focusing on completion from a patient perspective[98,122,125,135]. Factors identified by patients as influencing completion included technological literacy and confidence, nutrition education, tool design, incorporation of real-time feedback and feeling too unwell[98,125,135]. Previous studies in long term care and rehabilitation in contrast have highlighted the importance of speed, level of effort, diet type and attitudes and knowledge of healthcare staff as influencing completion; however, whether the same factors apply in an acute care setting remains unknown[181,182]. Additionally, staff training was identified as influencing completion, with higher rates of missing data occurring when food records were completed by nursing staff as part of routine care without prior training in comparison with weighed food records completed by dietitians[122]. Monitoring of dietary intake in the clinical setting is reliant on healthcare staff and patients who may lack prior nutrition training. Accordingly, there is a clear need for the development of tools which are feasible and incorporate appropriate training and support of patients and staff to enable accurate quantification of dietary intake within an acute and critical care setting.

Existing guidelines emphasise the importance of using validated tools when measuring dietary intake with attention also paid to the quality of validation completed[176]. Yet, of the fifteen studies which reported validating the tool of interest in comparison with an objective reference method (weighed food records or plate waste), only six of these studies actually calculated intake on the basis of weights of food measured pre- and post-consumption[24,41,53,54,72,160]. The remaining nine studies calculated intake on the basis of the difference between standard portions and the weight of food remaining post-consumption, such an approach has the potential to introduce bias compromising the criterion validity of the reference method[30,36,82,87,117,122,147,153,174,176]. Several studies also attempted validation using methods which are not considered as accepted reference methods, including estimated food records and plate waste[28,44,94,98,123,125,135,140]. Comparing a new tool to an existing tool with similar characteristics increases the likelihood of correlated error arising due to inherent bias present in both the assessment and reference method[176]. Additionally, the majority of studies reporting on validation processes used short time frames, predominantly comparing nutrient estimates from individual meals raising questions about the ability of such tools to accurately capture intra-individual variations in nutrient intake, vital in both a clinical and research context[17,24,28,36,72,82,87,98,123,147].

Substantial gaps in our understanding of the optimal way to quantify oral intake in the acute and critical care settings remain, with several priority research areas emerging from this review. Interest in the role of nutrition across the continuum of care and evidence of significant nutritional deficits in critically ill patients receiving an oral diet has resulted in increasing attention being paid towards methodologies used to quantify intake this patient cohort[6,7,170]. Yet this review found an absence of literature in critically ill patients with only two studies completed in either the ICU or the post-ICU phase[170,171]. Further research is urgently needed in the critical care setting to evaluate which dietary assessment methods are capable of accurately quantifying oral intake at the bedside, both within the ICU and following transfer to the ward, in critically ill adults. The role of technology to aid with dietary intake quantification in an acute care setting remains relatively unexplored and is another area for future development, with only six studies reporting on the application of such solutions[94,116,117,123,125,135]. Given the recent adoption of technology in some hospital food service systems, future research focusing on the integration of food intake monitoring within these systems is warranted[183]. Specifically, implementation of electronic bedside menu (eBMOS) systems presents a promising innovation to engage patients in their nutrition care and enable real-time monitoring of intake. Such systems allow patients, their caregivers or healthcare staff to enter intake data at the bedside, with automated calculation of nutrient intake[184]. However, existing research to date has focused on aspects such as food waste, costs and ordering satisfaction with limited investigation of the capabilities and validity of these technologies with respect to dietary intake quantification[184]. Additionally, whilst other technological innovations such as mobile applications have shown promise in other settings, the applicability of such findings in the acute care setting remains unclear[185,186]. It is plausible that factors influencing the application, acceptability and completion of novel technologies are influenced by characteristics specific to an acute care setting, for example, higher patient symptom burden, varying levels of staff and patient technological literacy or increased time pressures on healthcare staff. Additional research is required to explore whether technological innovations can overcome inherent limitations of traditional tools to improve quantification of oral intake and to determine factors which influence completion unique to an acute care setting.

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Strengths and limitations

This is the first review to describe the dietary assessment methods used to quantify oral intake in acute and critical care settings and provides valuable information to inform clinicians and researchers working in this field. Strengths of this scoping review include the rigorous methodology, including prospective registration of the protocol, completion of the review in accordance with the JBI Manual for Scoping Reviews and development of the search in consultation with an experienced research librarian. Another strength of the review is its breadth, with 155 studies included. Limitations include the restriction of this review to primary research articles published in English resulting in exclusion of potentially relevant literature. Exclusion of grey literature and studies enrolling patients receiving supplementary enteral or parenteral nutrtition in combination with an oral diet, which is common practice in acute and critical care settings, may have compromised the comprehensiveness of this review. Moreover, details regarding the characteristics of each dietary assessment method were frequently limited within the identified literature. Consequently, we are unable to extract data on whether assessment methods were used as part of a dedicated research project versus as part of routine clinical practice which has implications for the generalisability of the findings presented here. Detailed reporting of dietary assessment method characteristics should be a consideration for further research.

Conclusion

Traditional paper-based methods remain the most common approach for the quantification of oral diet in an acute setting despite significant concerns existing regarding their accuracy. Overall, this review found a lack of high-quality evidence regarding the optimal approach to dietary intake quantification with a particular absence of literature in the critical care setting. Evidence regarding factors influencing completion of dietary assessment methods and the validity of existing tools is lacking. Further high-quality research is urgently needed to inform clinician decision making and enable selection of the most appropriate tool for quantification of oral diet in both a research and clinical context.

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Competing interests

None.

Authorship

Conceptualisation was carried out by C.E.F, E.J.R, C.L.H. and O.A.T.; methodology was carried out by C.E.F, C.L.H, L.C, E.J.R. and O.A.T.; literature search was carried out by C.E.F, E.J.R. and O.A.T.; article screening and data extraction was carried out by C.E.F, O.A.T, J.N.A, L.M. and I.M.H.; writing original draft preparation was carried out by C.E.F.; writing-review and editing was carried out by C.E.F, O.A.T, C.L.H, E.J.R and L.S.C. All authors contributed to the review of the article have read and agreed to the published version of this manuscript.

Supplementary material

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References

1. Cass AR, Charlton KE (2022) Prevalence of hospital-acquired malnutrition and modifiable determinants of nutritional deterioration during inpatient admissions: A systematic review of the evidence. *J Hum Nutr Diet* **35**, 1043–1058.
2. Schindler K, Themessl-Huber M, Hiesmayr M, *et al.* (2016) To eat or not to eat? Indicators for reduced food intake in 91,245 patients hospitalized on nutritionDays 2006-2014 in 56 countries worldwide: a descriptive analysis. *Am J Clin Nutr* **104**, 1393–1402.
3. Thibault R, Chikhi M, Clerc A, *et al.* (2011) Assessment of food intake in hospitalised patients: a 10-year comparative study of a prospective hospital survey. *Clin Nutr* **30**, 289–296.
4. Choi J, Hoffman LA, Schulz R, *et al.* (2014) Self-reported physical symptoms in intensive care unit (ICU) survivors: pilot exploration over four months post-ICU discharge. *J Pain Symptom Manage* **47** 257–270.
5. Merriweather JL, Salisbury LG, Walsh TS, *et al.* (2016) Nutritional care after critical illness: a qualitative study of patients' experiences. *J Hum Nutr Diet* **29**, 127–136.
6. Ridley EJ, Chapple L-aS, Chapman MJ. (2020) Nutrition intake in the post-ICU hospitalization period. *Curr Opin Clin Nutr Metab Care* **23**.
7. Ridley EJ, Parke RL, Davies AR, *et al.* (2019) What happens to nutrition intake in the post-intensive care unit hospitalization period? An observational cohort study in critically ill adults. *JPEN J Parenter Enteral Nutr* **43**, 88–95.
8. Curtis LJ, Valaitis R, Laur C, *et al.* (2018) Low food intake in hospital: patient, institutional, and clinical factors. *Appl Physiol Nutr Metab* **43**, 1239–1246.
9. Keller H, Allard J, Vesnaver E, *et al.* (2015) Barriers to food intake in acute care hospitals: a report of the Canadian Malnutrition Task Force. *J Hum Nutr Diet* **28**, 546–557.
10. Böhne SEJ, Hiesmayr M, Sulz I, *et al.* (2022) Recent and current low food intake – prevalence and associated factors in hospital patients from different medical specialities. *Eur J Clin Nutr* **76**, 1440–1448.
11. Naithani S, Whelan K, Thomas J, *et al.* (2008) Hospital inpatients' experiences of access to food: a qualitative interview and observational study. *Health Expect* **11**, 294–303.
12. Agarwal E, Ferguson M, Banks M, *et al.* (2013) Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: Results from the Nutrition Care Day Survey 2010. *Clin Nutr ESPEN* **32**, 737–745.

13. Curtis LJ, Bernier P, Jeejeebhoy K, *et al.* (2017) Costs of hospital malnutrition. *Clin Nutr* **36**, 1391–1396.
14. Valaitis R, Laur C, Keller H, *et al.* (2017) Need for the Integrated Nutrition Pathway for Acute Care (INPAC): gaps in current nutrition care in five Canadian hospitals. *BMC Nutr* **3**, 60.
15. Dao MC, Subar AF, Warthon-Medina M, *et al.* (2019) Dietary assessment toolkits: an overview. *Public Health Nutr* **22**, 404–418.
16. Førli L, Oppedal B, Skjelle K, *et al.* (1998) Validation of a self-administered form for recording food intake in hospital patients. *Eur J Clin Nutr* **52**, 929–933.
17. Budiningsari D, Shahar S, Abdul Manaf Z, *et al.* (2018) Needs assessment for patients food intake monitoring among Indonesian healthcare professionals. *Int Nurs Rev* **65**, 317–326.
18. Amon JN, Tatucu-Babet OA, Hodgson CL, *et al.* Nutrition care processes from intensive care unit admission to inpatient rehabilitation: a retrospective observational study. *Nutr.* 2023, 112061.
19. Peters MDJ, Godfrey C McInerney P, *et al.*Munn Z, Tricco AC, Khalil, H (2020) Chapter 11: Scoping Reviews (2020 version). In: Aromataris E, Munn MZE, editor. *JBI Manual for Evidence Synthesis*: JBI.
20. Tricco AC, Lillie E, Zarin W, *et al.* (2018) PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med* **169**, 467–473.
21. Alkan SB, Artac M, Rakicioglu N (2018) The relationship between nutritional status and handgrip strength in adult cancer patients: a cross-sectional study. *Support Care Cancer* **26**, 2441–2451.
22. Allard JP, Keller H, Teterina A, *et al.* (2015) Factors associated with nutritional decline in hospitalised medical and surgical patients admitted for 7 d or more: a prospective cohort study. *BJN* **114**, 1612–1622.
23. Allepaerts S, Buckinx F, Bruyere O, *et al.* (2020) Clinical impact of nutritional status and energy balance in elderly hospitalized patients. *J Nutr Health Ageing* **24**, 1073–1079.
24. Amaral YG, Penaforte FR, Araujo LB, *et al.* (2022) Can hospitalized patients adequately estimate their own food intake? A cross-sectional pilot study. *Rev Nutr* **35**, 1–13.
25. Barrington V, Maunder K, Kelaart A (2018) Engaging the patient: improving dietary intake and meal experience through bedside terminal meal ordering for oncology patients. *J Hum Nutr Diet* **31**, 803–809.
26. Bauer JD, Isenring E, Waterhouse M (2013) The effectiveness of a specialised oral nutrition supplement on outcomes in patients with chronic wounds: a pragmatic randomised study. *J Hum Nutr Diet* **26**, 452–458.
27. Beermann T, Mortensen MN, Skadhauge LB, *et al.* (2016) Protein and energy intake improved by breakfast intervention in hospital. *Clin Nutr ESPEN* **13**, e23–e27.
28. Berrut G, Favreau AM, Dizo E, *et al.* (2002) Estimation of calorie and protein intake in aged patients: validation of a method based on meal portions consumed. *J Gerontol A Biol Sci Med Sci* **57**, M52–M56.
29. Birmingham CL, Hlynsky J, Whiteside L, *et al.* (2005) Caloric requirement for refeeding inpatients with anorexia nervosa: The contribution of anxiety exercise, and cigarette smoking. *Eat Weight Disord* **10**, e6–e9.
30. Bjornsdottir R, Oskarsdottir ES, Thordardottir FaR, *et al.* (2013) Validation of a plate diagram sheet for estimation of energy and protein intake in hospitalized patients. *Clin Nutr* **32**, 746–751.
31. Blanc-Bisson C, Dechamps A, Gouspillou G, *et al.* (2008) A randomized controlled trial on early physiotherapy intervention versus usual care in acute care unit for elderly: potential benefits in light of dietary intakes. *J Nutr Health Ageing* **12**, 395–399.
32. Bourdel-Marchasson I, Vincent S, Germain C, *et al.* (2004) Delirium symptoms and low dietary intake in older inpatients are independent predictors of institutionalization: a 1-year prospective population-based study. *J Gerontol A Biol Sci Med Sci* **59**, 350–354.
33. Boutata FZ, Bencharif M, Abdessemed D (2022) Hospital nuton: dietary intake characteristics among adults with NCDs (Algeria, 2020). *Revista Espanola de Nutricion Humana y Dietetica* **26**, 114–126.
34. Braga Azambuja F, Beghetto MG, de Assis MC, *et al.* (2015) Food intake reported versus nursing records: is there agreement in surgical patients? *Nutr Hosp* **31**, 2735–2739.
35. Briguglio M, Crespi T, Langella F, *et al.* (2022) Perioperative anesthesia and acute smell alterations in spine surgery: A "sniffing impairment" influencing refeeding? *Front Surg* **9**, 785676.
36. Budiningsari D, Shahar S, Abdul Manaf Z, *et al.* (2016) A simple dietary assessment tool to monitor food intake of hospitalized adult patients. *J Multidiscip Healthc* **9**, 311–322.
37. Burden ST, Bodey S, Bradburn YJ, *et al.* (2001) Validation of a nutrition screening tool: testing the reliability and validity. *J Hum Nutr Diet* **14**, 269–275.
38. Calleja Fernandez A, Pintor de la Maza B, Vidal Casariego A, *et al.* (2015) Food intake and nutritional status influence outcomes in hospitalized hematology-oncology patients. *Nutr Hosp* **31**, 2598–2605.
39. Calleja-Fernandez A, Velasco-Gimeno C, Vidal-Casariego A, *et al.* (2017) Impact of kitchen organization on oral intake of malnourished inpatients: A two-center study. *Endocrinologia, diabetes y nutricion* **64**, 409–416.
40. Celik ZM, Islamoglu AH, Sabuncular G, *et al.* (2021) Evaluation of malnutrition risk of inpatients in a research and training hospital: A cross-sectional study. *Clin Nutr ESPEN* **41**, 261–267.
41. Dekker IM, Langius JAE, Stelten S, *et al.* (2019) Validity of the "Rate-a-Plate" method to estimate energy and protein intake in acutely ill, hospitalized patients. *Nutr Clin Pract* **35**, 959–966.
42. De Luis DA, Izaola O, Cuellar L, *et al.* (2006) Nutritional assessment: Predictive variables at hospital admission related with length of stay. *Ann Nutr Metab* **50**, 394–398.
43. Dijxhoorn DN, van den Berg MGA, Kievit W, *et al.* (2018) A novel in-hospital meal service improves protein and energy intake. *Clin Nutr* **37**, 2238–2245.
44. Doorduijn AS, van Gameren Y, Vasse E, *et al.* (2016) At Your Request(R) room service dining improves patient satisfaction, maintains nutritional status, and offers opportunities to improve intake. *Clin Nutr* **35**, 1174–1180.
45. Duncan DG, Beck SJ, Hood K, *et al.* (2006) Using dietetic assistants to improve the outcome of hip fracture: a randomised controlled trial of nutritional support in an acute trauma ward. *Age Ageing* **35**, 148–153.
46. Dynesen AW, Snitkjaer P, Andreasen LS, *et al.* Eat what you want and when you want. Effect of a free choice menu on the energy and protein intake of geriatric medical patients. *Clin Nutr ESPEN.* 2021,**46**, 288–296.
47. Edwards JS, Hartwell HJ. (2004) A comparison of energy intake between eating positions in a NHS hospital–a pilot study. *Appetite* **43**, 323–325.
48. Eneroth M, Olsson U, Thorngren K (2005) Insufficient fluid and energy intake in hospitalised patients with hip fracture. A prospective randomised study of 80 patients. *Clin Nutr* **24**, 297–303.

https://doi.org/10.1017/S0954422423000288 Published online by Cambridge University Press

49. Francis K, Swan K, Rose T, *et al.* (2021) The use and impact of a supported aphasia-friendly photo menu tool on iPads in the inpatient hospital setting: a pilot study. *Aphasiology* **35**, 148–168.
50. Frederiksen AKS, Beck AM, Luiking YC, *et al.* (2022) Protein intake in hospitalized older patients after hip fracture: Pilot feasibility study evaluating ESPEN guidelines for geriatrics. *Clin Nutr* **42**, 148–159.
51. Freil M, Nielsen MA, Biltz C, *et al.* (2006) Reorganization of a hospital catering system increases food intake in patients with inadequate intake. *Scand J Food Nutr* **50**, 83–88.
52. Gallegos D, Hannan-Jones M, Tran QC, *et al.* (2019) Characteristics of dietary intake among adult patients in hospitals in a lower middle-income country in Southeast Asia. *Nutr Diet* **76**, 321–327.
53. Gariballa SE, Forster SJ. (2008) Dietary intake of older patients in hospital and at home: the validity of patient kept food diaries. *J Nutr Health Aging* **12**, 102–106.
54. Ghisolfi A, Dupuy C, Gines-Farano A, *et al.* (2014) Validation of a new tool: lonh. *J Nutr Health Aging* **18**, 857–860.
55. Goeminne PC, De Wit EH, Burtin C, *et al.* (2012) Higher food intake and appreciation with a new food delivery system in a Belgian hospital. Meals on Wheels, a bedside meal approach: a prospective cohort trial. *Appetite* **59**, 108–116.
56. Goisser S, Schrader E, Singler K, *et al.* (2015) Low post-operative dietary intake is associated with worse functional course in geriatric patients up to 6 months after hip fracture. *BJN* **113**, 1940–1950.
57. Hamai Y, Yoshiya T, Hihara J, *et al.* (2019) Traditional Japanese herbal medicine rikkunshito increases food intake and plasma acylated ghrelin levels in patients with esophageal cancer treated by cisplatin-based chemotherapy. *J Throac Dis* **11**, 2470–2478.
58. Hansen MF, Nielsen MA, Biltz C, *et al.* (2008) Catering in a large hospital - Does serving from a buffet system meet the patients' needs? *Clin Nutr* **27**, 666–669.
59. Hegerova P, Dedkova Z, Sobotka L. (2015) Early nutritional support and physiotherapy improved long-term self-sufficiency in acutely ill older patients. *Nutr* **31**, 166–170.
60. Henry CJK, Woo J, Lightowler HJ, *et al.* (2002) Brief communication: energy and protein intake in a sample of hospitalized elderly in Hong Kong. *Int J Food Sci Nutr* **53**, 475–480.
61. Henry CJK, Woo J, Lightowler HJ, *et al.* (2003) Use of natural food flavours to increase food and nutrient intakes in hospitalized elderly in Hong Kong. *Int J Food Sci Nutr* **54**, 321–327.
62. Hickson M, Bulpitt C, Nunes M, *et al.* (2004) Does additional feeding support provided by health care assistants improve nutritional status and outcome in acutely ill older in-patients? —a randomised control trial. *Clin Nutr* **23**, 69–77.
63. Hickson M, Connolly A, Whelan K (2011) Impact of protected mealtimes on ward mealtime environment, patient experience and nutrient intake in hospitalised patients. *J Hum Nutr Diet* **24**, 370–374.
64. Hickson M, Fearnley L, Thomas J, *et al.* (2007) Does a new steam meal catering system meet patient requirements in hospital? *J Hum Nutr Diet* **20**, 476–485.
65. Hirose K, Tran TP, Yamamoto S (2021) Decreasing Salt in Hospital Meals Reduced Energy Intake in Elderly Japanese Inpatients. *J Nutr Sci Vitaminol (Tokyo)* **67**, 105–110.
66. Hoekstra JC, Goosen JH, de Wolf GS, *et al.* (2011) Effectiveness of multidisciplinary nutritional care on nutritional intake, nutritional status and quality of life in patients with hip fractures: a controlled prospective cohort study. *Clin Nutr* **30**, 455–461.
67. Holst M, Beermann T, Mortensen MN, *et al.* (2017) Optimizing protein and energy intake in hospitals by improving individualized meal serving, hosting and the eating environment. *Nutr* **34**, 14–20.
68. Hou W, Li J, Lu J, *et al.* (2013) Effect of a carbohydrate-containing late-evening snack on energy metabolism and fasting substrate utilization in adults with acute-on-chronic liver failure due to Hepatitis B. *Eur J Clin Nutr* **67**, 1251–1256.
69. Hu W, Jiang H, Chen W, *et al.* (2011) Malnutrition in hospitalized people living with HIV/AIDS: evidence from a cross-sectional study from Chengdu, China. *Asia Pac J Clin Nutr* **20**, 544–550.
70. Huang C, Dutkowski K, Fuller A, *et al.* (2015) Evaluation of a pilot volunteer feeding assistance program: Influences on the dietary intakes of elderly hospitalised patients and lessons learnt. *J Nutr Health Ageing* **19**, 206–210.
71. Humphreys J, de la Maza P, Hirsch S, *et al.* (2002) Muscle strength as a predictor of loss of functional status in hospitalized patients. *Nutr* **18**, 616–620.
72. Husted MM, Fournaise A, Matzen L, *et al.* (2017) How to measure energy and protein intake in a geriatric department – A comparison of three visual methods. *Clin Nutr ESPEN* **17**, 110–113.
73. Huxtable S, Palmer M (2013) The efficacy of protected mealtimes in reducing mealtime interruptions and improving mealtime assistance in adult inpatients in an Australian hospital. *Eur J Clin Nutr* **67**, 904–910.
74. Huynh DT, Devitt AA, Paule CL, *et al.* (2015) Effects of oral nutritional supplementation in the management of malnutrition in hospital and post-hospital discharged patients in India: a randomised, open-label, controlled trial. *J Hum Nutr Diet* **28**, 331–343.
75. Ingadottir AR, Bjorgvinsdottir EB, Beck AM, *et al.* (2019) Effect of two different nutritional supplements on postprandial glucose response and energy- and protein intake in hospitalised patients with COPD: A randomised cross-over study. *Clin Nutr* **39**, 1085–1091.
76. Ingadottir AR, Beck AM, Baldwin C, *et al.* (2020) Association of energy and protein intake with length of stay, readmission and mortality in hospitalised patients with chronic obstructive pulmonary disease. *BJN* **119**, 543–551.
77. Ingadottir AR, Hilmisdottir HB, Ramel A, *et al.* (2015) Energy- and protein intake of surgical patients after the implementation of energy dense hospital menus. *Clin Nutr ESPEN* **10**, e107–e111.
78. Inoue T, Misu S, Tanaka T, *et al.* (2019) Inadequate Postoperative Energy Intake Relative to Total Energy Requirements Diminishes Acute Phase Functional Recovery From Hip Fracture. *Arch Phys Med Rehabil* **100**, 32–8.
79. Jeejeebhoy KN, Keller H, Gramlich L, *et al.* (2015) Nutritional assessment: comparison of clinical assessment and objective variables for the prediction of length of hospital stay and readmission. *AJCN* **101**, 956–965.
80. Kandiah J, Stinnett L, Lutton D (2006) Visual plate waste in hospitalized patients: length of stay and diet order. *J Am Diet Assoc* **106**, 1663–1666.
81. Kawano R, Ishida M, Kimura E, *et al.* (2015) Pilot intervention study of a low-salt diet with monomagnesium di-L-glutamate as an umami seasoning in psychiatric inpatients. *Psychogeriatrics* **15**, 38–42.
82. Kawasaki Y, Akamatsu R, Tamaura Y, *et al.* (2019) Differences in the validity of a visual estimation method for determining patients' meal intake between various meal types and supplied food items. *Clin Nutr* **38**, 213–219.
83. Keller HH, Xu Y, Dubin JA, *et al.* (2018) Improving the standard of nutrition care in hospital: Mealtime barriers

https://doi.org/10.1017/S0954422423000288 Published online by Cambridge University Press

reduced with implementation of the Integrated Nutrition Pathway for Acute Care. *Clin Nutr ESPEN* **28**, 74–79.
84. Keller H, Allard JP, Laporte M, *et al.* (2015) Predictors of dietitian consult on medical and surgical wards. *Clin Nutr* **34**, 1141–1145.
85. Kondrup J, Johansen N, Plum LM, *et al.* (2002) Incidence of nutritional risk and causes of inadequate nutritional care in hospitals. *Clin Nutr* **21**, 461–468.
86. Kong JP, Baharom B, Jamhuri N, *et al.* (2019) Adequacy of energy and protein intake among hospitalized patients on therapeutic diet in government hospitals: A preliminary study. *Nutr Food Sci* **50**, 903–902.
87. Kowanko I, Simon S, Wood J (2001) Energy and nutrient intake of patients in acute care. *J ClinNurs* **10**, 51–57.
88. Larsen CS, Toubro S (2007) The effect of conventional v. a la carte menu on energy and macronutrient intake among hospitalized cardiology patients. *BJN* **98**, 351–357.
89. Lassen KO, Kruse F, Bjerrum M, *et al.* (2004) Nutritional care of Danish medical inpatients: effect on dietary intake and the occupational groups' perspectives of intervention. *Nutr J* **3**, 12.
90. Lee E, Singleton J, Murphy A, *et al.* (2023) The impact of providing flexible meals on patients' nutritional intake, fasting times and cost when admitted to a trauma unit. *J Hum Nutr Diet* **36**, 1234–1241.
91. Leistra E, Willeboordse F, Visser M, *et al.* (2011) Predictors for achieving protein and energy requirements in undernourished hospital patients. *Clin Nutr* **30**, 484–489.
92. Liang L, Thomas J, Miller M, *et al.* (2008) Nutritional issues in older adults with wounds in a clinical setting. *J Multidiscip Healthc* **1**, 63–71.
93. Lindman A, Rasmussen HB, Andersen NF. (2013) Food caregivers influence on nutritional intake among admitted haematological cancer patients - a prospective study. *Eur J Oncol Nurs* **17**, 827–834.
94. Long Z, Huang S, Zhang J, *et al.* (2022) A Digital Smartphone-Based Self-administered Tool (R+ Dietitian) for Nutritional Risk Screening and Dietary Assessment in Hospitalized Patients With Cancer: Evaluation and Diagnostic Accuracy Study. *JMIR Form Res* **6**, e40316.
95. Makhlouf A-M, Kossovsky MP, Gurba F, *et al.* (2019) Severity of pain is associated with insufficient energy coverage in hospitalised patients: A cross-sectional study. *Clin Nutr* **38**, 753–758.
96. Manning F, Harris K, Duncan R, *et al.* (2012) Additional feeding assistance improves the energy and protein intakes of hospitalised elderly patients. A health services evaluation. *Appetite* **59**, 471–477.
97. McCray S, Maunder K, Barsha L, *et al.* (2018) Room service in a public hospital improves nutritional intake and increases patient satisfaction while decreasing food waste and cost. *J Hum Nutr Diet* **31**, 734–741.
98. McCullough J, Keller H. (2018) The My Meal Intake Tool (M-MIT): Validity of a Patient Self- Assessment for Food and Fluid Intake at a Single Meal. *J Nutr Health Aging* **22**, 30–37.
99. Meng Q-H, Wang J-H, Yu H-W, *et al.* (2010) Resting energy expenditure and substrate metabolism in Chinese patients with acute or chronic hepatitis B or liver cirrhosis. *Intern Med J.* **49**, 2085–2091.
100. Mikus RP, Vicic V, Dahmane R (2016) The assessment of energy and protein needs coverage in hospitalized patients. *Zdr Varst* **55**, 126–133.
101. Miller MD, Bannerman E, Daniels LA, *et al.* (2006) Lower limb fracture, cognitive impairment and risk of subsequent malnutrition: A prospective evaluation of dietary energy and protein intake on an orthopaedic ward. *Eur J Clin Nutr* **60**, 853–861.
102. Miyoba N, Ogada I, Mulenga J (2018) Dietary adequacy of adult surgical orthopaedic patients admitted to a teaching hospital in Zambia; a hospital-based cross-sectional study. *BMC Nutr* **4**, 37.
103. Modic MB, Kozak A, Siedlecki SL, *et al.* (2011) Do we know what our patients with diabetes are eating in the hospital? *Diabetes Spectr* **24**, 100–106.
104. Morgan Yordy B, Roberts S, Taggart HM (2017) Quality improvement in clinical nutrition: screening and mealtime protection for the hospitalized patient. *J Adv Nurs* **31**, 149–156.
105. Mortensen MN, Larsen AK, Skadhauge LB, *et al.* (2019) Protein and energy intake improved by in-between meals: An intervention study in hospitalized patients. *Clin Nutr ESPEN* **30**, 113–118.
106. Mudge AM, Ross LJ, Young AM, *et al.* (2011) Helping understand nutritional gaps in the elderly (HUNGER): a prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. *Clin Nutr* **30**, 320–325.
107. Munk T, Beck AM, Holst M, *et al.* (2014) Positive effect of protein-supplemented hospital food on protein intake in patients at nutritional risk: a randomised controlled trial. *J Hum Nutr Diet* **27**, 122–132.
108. Munk T, Bruun N, Nielsen MA, *et al.* (2017) From evidence to clinical practice: positive effect of implementing a protein-enriched hospital menu in conjunction with individualized dietary counseling. *Nutr Clin Pract* **32**, 420–426.
109. Munk T, Seidelin W, Rosenbom E, *et al.* (2013) A 24-h a la carte food service as support for patients at nutritional risk: a pilot study. *J Hum Nutr Diet* **26**, 268–275.
110. Musters SCW, van Noort HHJ, Bakker CA, *et al.* (2022) Impact of a surgical ward breakfast buffet on nutritional intake in postoperative patients: A prospective cohort pilot study. *PLoS ONE* **17**, e0267087.
111. Naughton C, Simon R, White TJ, *et al.* (2021) Mealtime and patient factors associated with meal completion in hospitalised older patients: An exploratory observation study. *J Clin Nurs* **30**, 2935–2947.
112. Navarro DA, Boaz M, Krause I, *et al.* (2016) Improved meal presentation increases food intake and decreases readmission rate in hospitalized patients. *Clin Nutr* **35**, 1153–1158.
113. Neaves B, Bell JJ, McCray S. (2021) Impact of room service on nutritional intake, plate and production waste, meal quality and patient satisfaction and meal costs: A single site pre-post evaluation. *Nutr Diet* **79**, 187–196.
114. Nematy M, Hickson M, Brynes AE, *et al.* (2006) Vulnerable patients with a fractured neck of femur: nutritional status and support in hospital. *J Hum Nutr Diet* **19**, 209–218.
115. Norshariza J, Farrah S, Zaidah M, *et al.* (2017) Prevalence of Malnutrition among hospitalised adult cancer patients at the National Cancer Institute, Putrajaya, Malaysia. *Mal J Nutr* **23**, 161–174.
116. Ofei KT, Holst M, Rasmussen HH, *et al.* (2015) Effect of meal portion size choice on plate waste generation among patients with different nutritional status. An investigation using Dietary Intake Monitoring System (DIMS). *Appetite* **91**, 157–164.
117. Ofei KT, Mikkelsen BE, Scheller RA. (2019) Validation of a novel image-weighed technique for monitoring food intake and estimation of portion size in hospital settings: a pilot study. *Public Health Nutr* **22**, 1203–1208.

https://doi.org/10.1017/S0954422423000288 Published online by Cambridge University Press

118. Oldknow H, Williamson K, Williams E, *et al.* (2019) Dietary intake of people with dementia on acute hospital wards. *Nurs Older People* **31**, 16–21.
119. Osborne T, Edgar D, Gittings P, *et al.* (2022) A prospective pilot study of the energy balance profiles in acute non-severe burn patients. *Burns* **48**, 184–190.
120. Ozturk Arikbuka M, Yucecan S, Karaagaoglu E (2013) Assessment of nutritional status and its association with length of hospital stay and food consumption in elderly cardiovascular patients. *Turkiye Klinikleri Journal of Medical Sciences* **33**, 1236–1244.
121. Paillaud E, Caillet P, Campillo B, *et al.* (2006) Increased risk of alteration of nutritional status in hospitalized elderly patients with advanced cancer. *J Nutr Health Aging* **10**, 91–95.
122. Palmer M, Miller K, Noble S (2015) The accuracy of food intake charts completed by nursing staff as part of usual care when no additional training in completing intake tools is provided. *Clin Nutr* **34**, 761–766.
123. Papathanail I, Bruhlmann J, Vasiloglou MF, *et al.* (2021) Evaluation of a novel artificial intelligence system to monitor and assess energy and macronutrient intake in hospitalised older patients. *Nutrients* **13**, 4539.
124. Papier I, Sagi-Dain L, Chermesh I, *et al.* (2022) Absence of oral nutritional support in low food intake inpatients is associated with an increased risk of hospital-acquired pressure injury. *Clinical nutrition ESPEN* **51**, 190–198.
125. Paulsen MM, Hagen MLL, Frøyen MH, *et al.* (2018) A dietary assessment app for hospitalized patients at nutritional risk: development and evaluation of the MyFood app. *JMIR Mhealth Uhealth* **6**, e175.
126. Pedersen PU (2005) Nutritional care: the effectiveness of actively involving older patients. *J Clin Nurs* **14**, 247–255.
127. Porter J, Collins J (2022) Nutritional intake and foodservice satisfaction of adults receiving specialist inpatient mental health services. *Nutr Diet* **79**, 411–418.
128. Pourhassan M, Sieske L, Janssen G, *et al.* (2020) The impact of acute changes of inflammation on appetite and food intake among older hospitalised patients. *BJN* **124**, 1069–1075.
129. Prockmann S, Ruschel Freitas AH, Goncalves Ferreira M, *et al.* (2015) Evaluation of diet acceptance by patients with haematological cancer during chemotherapeutic treatment *Nutr Hosp* **32**, 779–784.
130. Pullen K, Collins R, Stone T, *et al.* (2018) Are energy and protein requirements met in hospital? *J Hum Nutr Diet* **31**, 178–187.
131. Raffoul W, Far MS, Cayeux M-C, *et al.* (2006) Nutritional status and food intake in nine patients with chronic low-limb ulcers and pressure ulcers: importance of oral supplements. *Nutr* **22**, 82–88.
132. Roberts M, Potter J, McColl J, *et al.* (2003) Can prescription of sip-feed supplements increase energy intake in hospitalised older people with medical problems? *BJN* **90**, 425–429.
133. Roberts H, Pilgrim A, Jameson K, *et al.* (2017) The impact of trained volunteer mealtime assistants on the dietary intake of older female in-patients: The Southampton Mealtime Assistance Study. *J Nutr Health Ageing* **21**, 320–328.
134. Roberts S, Williams LT, Sladdin I, *et al.* (2019) Improving nutrition care, delivery, and intakes among hospitalised patients: a mixed methods, integrated knowledge translation study. *Nutrients* **11**, 1417–1426.
135. Roberts S, Chaboyer W, Hopper Z, *et al.* (2021) Using technology to promote patient engagement in nutrition care: a feasibility study. *Nutrients* **13**, 314–328.
136. Rosenberger C, Rechsteiner M, Dietsche R, *et al.* (2019) Energy and protein intake in 330 geriatric orthopaedic patients: Are the current nutrition guidelines applicable? *Clin Nutr ESPEN* **29**, 86–91.
137. Rufenacht U, Ruhlin M, Wegmann M, *et al.* (2010) Nutritional counseling improves quality of life and nutrient intake in hospitalized undernourished patients. *Nutr* **26**, 53–60.
138. Sanson G, Bertocchi L, Dal Bo E, *et al.* (2018) Identifying reliable predictors of protein-energy malnutrition in hospitalized frail older adults: A prospective longitudinal study. *Int J Nurs Stud* **82**, 40–48.
139. Sathiaraj E, Priya K, Chakraborthy S, *et al.* (2019) Patient-centered foodservice model improves body weight, nutritional intake and patient satisfaction in patients undergoing cancer treatment. *Nutr Cancer* **71**, 418–423.
140. Saueressig C, Ferreira PK, Glasenapp JH, *et al.* (2022) Food Intake Visual Scale-A practical tool for assessing the dietary intake of hospitalized patients with decompensated cirrhosis. *Nutr Clin Pract* **38**, 187–198.
141. Shahar S, Chee KY, Chik WCPW. (2002) Food intakes and preferences of hospitalised geriatric patients. *BMC Geriatr* **2**, 1–6.
142. Soric T, Mavar M, Rumbak I (2019) The effects of the dietary approaches to stop hypertension (DASH) diet on metabolic syndrome in hospitalized schizophrenic patients: A randomized controlled trial. *Nutrients* **11**, 2950.
143. Starke J, Schneider H, Alteheld B, *et al.* (2011) Short-term individual nutritional care as part of routine clinical setting improves outcome and quality of life in malnourished medical patients. *Clin Nutr* **30**, 194–201.
144. Steiber AL, Weatherspoon LJ, Handu D (2002) Clinical and dietary indicators associated with uremic status in hospitalized dialysis patients. *J Ren Nutr* **12**, 49–54.
145. Sundvall P, Gronberg A, Hulthen L, *et al.* (2005) Energy and nutrient intake in patients with chronic obstructive pulmonary disease hospitalized owing to an acute exacerbation. *SJN* **49**, 116–121.
146. Susetyowati S, Djarwoto B, Faza F (2017) Nutrition screening tools as predictor of malnutrition for hemodialysis patients in Dr. Sardjito Hospital in Yogyakarta, Indonesia. *Saudi J Kidney Dis Transpl* **28**, 1307–1313.
147. Tan J, Lau KM, Ross L, *et al.* (2021) Development of a new tool to monitor and identify inadequate oral intake in hospital. *Nutr Diet* **78**, 296–304.
148. Tan SK, Loh YH, Choong HL, *et al.* (2016) Subjective global assessment for nutritional assessment of hospitalized patients requiring haemodialysis: A prospective cohort study. *Nephrol* **21**, 944–949.
149. Tavares MM, Matos L, Amaral TF (2007) Insufficient voluntary intake of nutrients and energy in hospitalized patients. *Nutr Hosp* **22**, 584–589.
150. Theron M, O'Halloran S (2021) Patients in public hospitals received insufficient food to meet daily protein and energy requirements: Cape Town Metropole, South Africa. *South Afr J Clin Nutr* **4**, 133–141.
151. Trollebo MA, Skeie E, Revheim I, *et al.* (2022) Comparison of nutritional risk screening with NRS2002 and the GLIM diagnostic criteria for malnutrition in hospitalized patients. *Scientific reports* **12**, 19743.
152. Tonosaki A (2012) Impact of walking ability and physical condition on fatigue and anxiety in hematopoietic stem cell transplantation recipients immediately before hospital discharge. *Eur J Oncol Nurs* **16**, 26–33.
153. Tulloch H, Cook S, Nasser R, *et al.* (2019) Food service workers: reliable assessors of food intake in hospitalized patients. *Can J Diet Pract Res* **80**, 30–33.

https://doi.org/10.1017/S0954422423000288 Published online by Cambridge University Press

154. van Bokhorst-de van der Schueren MAE, Roosemalen MM, Weijs PJM, *et al.* (2012) High waste contributes to low food intake in hospitalized patients. *Nutr Clin Pract* **27**, 274–280.
155. Vermeeren MAP, Wouters EFM, Geraerts-Keeris AJW, *et al.* (2004) Nutritional support in patients with chronic obstructive pulmonary disease during hospitalization for an acute exacerbation; a randomized controlled feasibility trial. *Clin Nutr* **23**, 1184–1192.
156. Walton K, Williams P, Bracks J, *et al.* (2008) A volunteer feeding assistance program can improve dietary intakes of elderly patients - A pilot study. *Appetite* **51**, 244–248.
157. Ward J, Batt E (2013) Removing salt sachets from ward meal-trays does not affect patients' nutritional intake. *JRenCare* **39**, 103–107.
158. Weijzen MEG, Kouw IWK, Geerlings P, *et al.* (2020) During hospitalization, older patients at risk for malnutrition consume <0.65 grams of protein per kilogram body weight per day. *Nutr Clin Pract* **35**, 655–663.
159. Wilson A, Evans S, Frost G (2000) A comparison of the amount of food served and consumed according to meal service system. *J Hum Nutr Diet* **13**, 271–275.
160. Winzer E, Luger M, Schindler K (2018) Using digital photography in a clinical setting: a valid, accurate, and applicable method to assess food intake. *Eur J Clin Nutr*,**72**, 879–887.
161. Wright L, Cotter D, Hickson M, *et al.* (2005) Comparison of energy and protein intakes of older people consuming a texture modified diet with a normal hospital diet. *J Hum Nutr Diet* **18**, 213–219.
162. Wright L, Cotter D, Hickson M (2008) The effectiveness of targeted feeding assistance to improve the nutritional intake of elderly dysphagic patients in hospital. *J Hum Nutr Diet* **21**, 555–562.
163. Van Wymelbeke V, Jiang T, Pfitzenmeyer P (2009) Change in taste preference in undernourished elderly hospitalized subjects during periods of infection and convalescence. *J Nutr Health Aging* **13**, 40–45.
164. Yang P-H, Lin M-C, Liu Y-Y, *et al.* (2019) Effect of nutritional intervention programs on nutritional status and readmission rate in malnourished older adults with pneumonia: a randomized control trial. *Int J Environ Res Public Health* **16**, 4758–4770.
165. Yoshida T, Shoji S, Shiraishi Y, *et al.* (2020) Hospital meal intake in acute heart failure patients and its association with long-term outcomes. *Open Heart* **7**, 001248.
166. Young A, Allia A, Jolliffe L, *et al.* (2016) Assisted or Protected Mealtimes? Exploring the impact of hospital mealtime practices on meal intake. *J Adv Nurs* **72**, 1616–1625.
167. Young AM, Banks MD, Mudge AM (2018) Improving nutrition care and intake for older hospital patients through system-level dietary and mealtime interventions. *Clin Nutr ESPEN* **24**, 140–147.
168. Young AM, Kidston S, Banks MD, *et al.* (2013) Malnutrition screening tools: comparison against two validated nutrition assessment methods in older medical inpatients. *Nutr* **29**, 101–106.
169. Zisberg A, Shadmi E, Gur-Yaish N, *et al.* (2015) Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. *J Am Geriatr Soc* **63**, 55–62.
170. Chapple LS, Deane AM, Heyland DK, *et al.* (2016) Energy and protein deficits throughout hospitalization in patients admitted with a traumatic brain injury. *Clin Nutr* **35**, 1315–1322.
171. Samadi M, Zeinali F, Habibi N, *et al.* (2016) Intake of Dietary Supplements and Malnutrition in Patients in Intensive Care Unit. *Int J Prev Med* **7**, 90.
172. Beavan S, Baker R, Sadler H, *et al.* (2019) Improving the nutritional intake of hospital patients: how far have we come? A re-audit. *J Hum Nutr Diet* **32**, 372–384.
173. Holst M, Sondergaard LN, Bendtsen MD, *et al.* (2016) Functional training and timed nutrition intervention in infectious medical patients. *Eur J Clin Nutr* **70**, 1039–1045.
174. Budiningsari D, Shahar S, Abdul Manaf Z, *et al.* (2017) Evaluation of Pictorial Dietary Assessment Tool for Hospitalized Patients with Diabetes: Cost, Accuracy, and User Satisfaction Analysis. *Nutrients* **10**.
175. Samadi M, Zeinali F, Habibi N, *et al.* (2016) Intake of dietary supplements and malnutrition in patients in intensive care unit. *Int J Prev Med* **7**, 90.
176. Cade JE, Warthon-Medina M, Albar S, *et al.* (2017) DIET@NET: Best Practice Guidelines for dietary assessment in health research. *BMC Med* **15**, 202.
177. Heighington-Wansbrough AJ, Gemming L (2022) Dietary intake in hospitals: A systematic literature review of the validity of the visual estimation method to assess food consumption and energy and protein intake. *Clin Nutr ESPEN* **52**, 296–316.
178. Bartkowiak L, Jones J, Bannerman E (2015) Evaluation of food record charts used within the hospital setting to estimate energy and protein intakes. *Clin Nutr ESPEN* **10**, e184–e185.
179. Cartlidge M, Fujiwara T, Richardson RA (2009) Are food record charts useful components of nutritional assessment? *J Hum Nutr Diet* **22**, 256-.
180. Williams P, Walton K (2011) Plate waste in hospitals and strategies for change. *Eur J Clin Nutr* **6**, e235–e241.
181. Pfisterer KJ, Boger J, Wong A (2019) Prototyping the automated food imaging and nutrient intake tracking system: modified participatory iterative design sprint. *JMIR Hum Factors* **6**, e13017.
182. Kawasaki Y, Kojima Y, Akamatsu R (2016) Barriers to accurately measuring patients' dietary intake in hospitals using the visual estimation method. *Int J Health Care Qual Assur* **29**, 835–845.
183. NS Osman, N Nor, MS Sharif, SBA Hamid, S Rahamat (2021) Hospital food service strategies to improve food intakes among inpatients: a systematic review. *Nutrients* **13**, 3649–3674
184. MacKenzie-Shalders R, Maunder K, So D, *et al.* (2020) Impact of electronic bedside meal ordering systems on dietary intake, patients satisfaction, plate waste and costs: A systematic literature review. *Nutrition & Dietetics* **77**, 103–111.
185. Boushey CJ, Spoden M, Zhu FM, *et al.* (2017) New mobile methods for dietary assessment: review of image-assisted and image-based dietary assessment methods. *Proc Nutr Soc* **76**, 283–294.
186. Eldridge AL, Piernas C, Illner AK, *et al.* (2018) Evaluation of new technology-based tools for dietary intake assessment-An ILSI Europe Dietary Intake and Exposure Task Force evaluation. *Nutrients* **11**, 55–79.
187. Roberts S, Marshall AP, Gonzalez R, *et al.* (2017) Technology to engage hospitalised patients in their nutrition care: a qualitative study of usability and patient perceptions of an electronic foodservice system. *J Hum Nutr Diet* **30**, 563–573.
188. Ingadottir AR, Beck AM, Baldwin C, *et al.* (2018) Association of energy and protein intakes with length of stay, readmission and mortality in hospitalised patients with chronic obstructive pulmonary disease. *BJN* **119**, 543–551.

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