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Review

Nutrition therapy in patients with moderate to severe traumatic brain injury in the inpatient rehabilitation and subacute setting: A scoping review

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ABSTRACT

Introduction: Patients with moderate to severe traumatic brain injury (TBI) often face prolonged rehabilitation. These individuals experience elevated nutrition needs and barriers to normal eating behaviours, necessitating effective nutrition therapy to enhance rehabilitation and recovery. Existing nutrition research focuses on intensive and acute care settings, with a notable lack of evidence in the rehabilitation and subacute contexts. This scoping review aims to describe evidence on nutrition therapy and outcomes for adult patients with moderate to severe TBI in inpatient rehabilitation and subacute settings and identify gaps to guide future research.

Methods: A systematic scoping review was conducted in accordance with PRISMA guidelines, comprising of a literature search of CINAHL and MEDLINE for studies published between January 2010 and August 2024. Articles were included if they were: quantitative studies in adults (≥16 years) with a moderate to severe TBI, admitted to a rehabilitation or subacute facility, that addressed an aspect of nutrition therapy. Data were extracted on study design, patient characteristics, TBI severity, and nutrition-related results. Data were categorised and synthesised according to the study design, nutrition intervention, and outcomes.

Results: A total of seventeen studies were identified, comprising between 7 to 1701 participants. Among these, nine studies were prospective observational, seven were retrospective observational, and one was a randomised controlled trial. The investigations covered various aspects of nutrition management: ten focused on the route of nutrition delivery, four assessed nutrition status, three evaluated specific nutrient intakes, and one examined eating behaviours (two studies addressed multiple interventions).

Conclusion: Evidence on nutrition management practices for patients with a TBI admitted to a rehabilitation or subacute setting is sparce, with only one interventional study identified, and observational studies predominantly exploring route of nutrition delivery. Further research is essential to delineate optimal nutritional therapies for adults with TBI in rehabilitation and subacute settings to guide clinical care.

Introduction

Traumatic Brain Injury (TBI) refers to an alteration in brain function or structure resulting from an external force. It is a major global health issue, with an estimated 10 million cases of moderate to severe TBI occurring annually worldwide [1]. Patients with moderate to severe TBI typically experience prolonged recovery and require extended inpatient rehabilitation [2]. As such, strategies to optimise recovery in this patient population are urgently needed.

Nutrition has emerged as a critical component of TBI management, with the potential to enhance recovery, as emphasised in the Brain Trauma Foundation's 2016 Guidelines for the Management of Severe TBI [3]. However, delivering optimal nutrition therapy in these patients presents unique challenges. In the acute phase, resting energy

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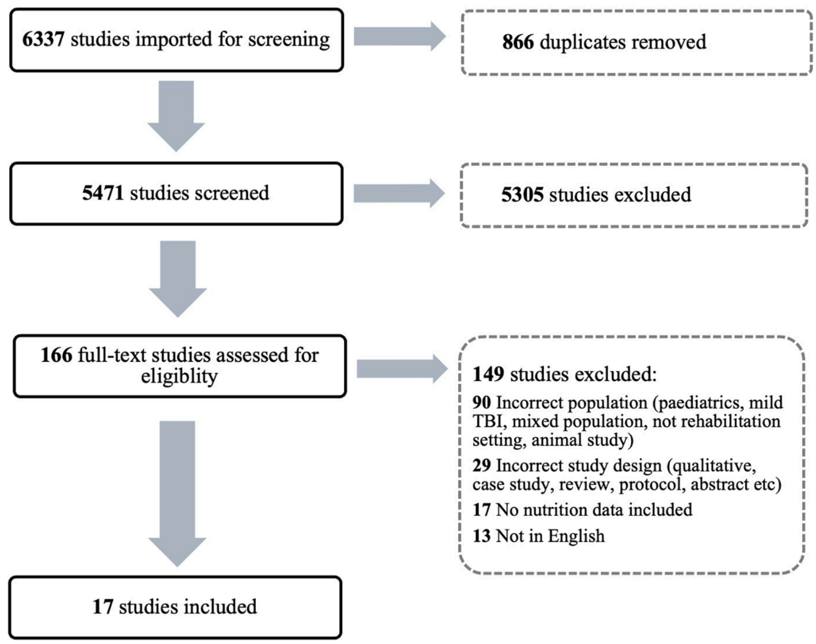

Fig. 1. PRISMA flowchart detailing progression of references through the review process.

expenditure increases by 100 % to 200 % [4,5] and nutrition delivery is suboptimal, leading to significant skeletal muscle loss. These factors are associated with an increased risk of malnutrition, infection, poorer neurological outcome, and higher morbidity and mortality [6,7], impacting recovery.

In the rehabilitation phase, energy expenditure stabilises, with mild increases of 30–60 % compared to baseline levels to support physical therapy [5]. Increased protein requirements remain essential, as significant muscle loss is common during the rehabilitative period [2,8]. Further, a range of barriers to nutrition intake are likely to persist throughout recovery, including dysphagia, and delayed gastric emptying [2,9,10]. Consequentially, malnutrition and sarcopenia are common, impacting 30–50 % of patients in inpatient rehabilitation [11]. Within two months of injury, 68 % of TBI patients exhibit signs of malnutrition [4], and at six months post-injury malnutrition is associated with worse neurological and mortality outcomes [12], and increased healthcare costs [13,14]. As such, nutrition optimisation should occur throughout the recovery phase of illness.

Current guidelines from the international trauma and nutrition societies primarily address nutritional management during the acute phase of TBI [3,15,16], with limited guidance on nutritional strategies in the rehabilitation and subacute phase of recovery. In response to this gap, a systematic scoping review was conducted to describe the literature on nutritional management for TBI patients during these phases. This review aims to synthesise research and identify key themes in the nutrition care of patients recovering from TBI in the rehabilitation and subacute settings.

Materials and methods

Search strategy

A systematic scoping review was conducted in accordance with the methodology detailed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [17]. The aim was to map key concepts and types of evidence, as well as identify research gaps in the field of nutrition for patients with a TBI managed within an inpatient rehabilitation facility or subacute setting. An online search of databases Medical Literature Analysis and Retrieval System Online (MEDLINE) (via Ovid SP), and Cumulative Index to Nursing and Allied Health Literature (CINAHL) (via EBSCOhost) was conducted on 27 August 2021 for original research articles published since January 2010. Studies were limited to those published in the last 10 years to provide an update of the recent literature. The search was updated on the 22 August 2024. The scoping review protocol was not registered nor published to expedite the review process. The search strategy included three strings containing keywords for: (1) patients admitted with a TBI; (2) nutrition; and (3) the critical care, acute care, or subacute care setting. The full search criteria are shown in Supplemental Tables S1-S2. Following the initial search, the inclusion criteria were reviewed to focus only on patients within the rehabilitation or subacute setting.

Inclusion/exclusion criteria

Studies were included if they:

- Were original quantitative research papers (includes randomised trials and observational studies)
- Included adults (aged ≥16 years)
- Included patients with a documented moderate and/or severe TBI as per the studies' chosen definition
- Included patients that were managed within a rehabilitation facility or subacute hospital setting

Studies were excluded if they:

- Were individual case reports, abstracts, reviews, protocols, guidelines or qualitative research papers
- Were in paediatric patients
- Were animal or pre-clinical studies
- Included data in which patients with a TBI were included as part of a mixed cohort whereby TBI specific data could not be extracted or separated from other medical conditions
- Included patients with a mild TBI only (e.g. concussion)

Study selection

Search results from both databases were collated in Endnote (Version X9) and uploaded to Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). Duplicates were removed

Table 1
Details of included studies.

Author	Year of publication	Country of origin	Study design	Study aim	Number of patients	Severity of TBI	Patient characteristics
Aadal, L [27]	2015	Denmark	Prospective Observational Cohort	To describe weight changes, malnutrition, and potential associations in patients with acquired brain injury (ABI) at an inpatient rehabilitation hospital.	Total $n = 76$ TBI $n = 15$	Not specified	Not specified for TBI cohort
Avesani, R [18]	2013	Italy	Retrospective Observational Cohort	To evaluate functional outcomes of patients with TBI and non-traumatic ABI admitted to rehabilitation facilities.	TBI $n = 1469$ TBI severe $n = 651$	Severe TBI (GCS score ≤8)	Mean age = 43.7 Male $n = 516$ (79 %) Female $n = 135$ (21 %)
Avesani, R [19]	2018	Italy	Retrospective Observational Cohort	To compare demographic and clinical characteristics of patients in a vegetative state following severe ABI and assess recovery of consciousness and outcome at rehabilitation discharge.	Total $n = 492$ TBI $n = 184$	Severe ABI (GCS score ≤ 8 within 24 h of onset and a DRS score >21 at admission.	Mean age = 44.7 Male $n = 155$ (84 %) Female $n = 29$ (16 %)
Bremare, A [20]	2016	France	Prospective Observational Cohort	To determine clinical and naso-endoscopic characteristics of swallowing disorders and oropharyngeal dysphagia in severe brain injury in the arousal phase after coma.	Total $n = 11$ TBI $n = 8$	Severe TBI (GCS >8)	Mean age = 40.7 ± 14.6 Male $n = 8$
Dubiel, R [31]	2019	United States of America	Retrospective Observational Cross-Sectional	To determine prevalence of vitamin D deficiency in individuals with TBI undergoing acute inpatient rehabilitation.	Total $n = 369$	Etiological diagnosis of TBI (nil further specified)	Mean age = 43.5 ± 21.0 Female = 33 % Male = 67 %
Fabricius, J [21]	2023	Denmark	Prospective Observational Cohort	To develop a prognostic model and online tool, coined "subacute prognosis of oral nutrition" (SPOON), for complete oral intake in tube-fed subjects with ABI admitted for sub-acute inpatient rehabilitation.	Total $n = 1233$ TBI $n = 223$	ABI severity indicated by FIM score (19) at admission.	Median age = 58 (46–67) Male = 61 % Female = 39 %
Hakiki, B [22]	2020	Italy	Prospective Observational Cohort	To assess concomitance between critical illness polyneuropathy and myopathy (CIPNM) and severe acquired brain injury might influence rehabilitative outcomes - functional autonomy, oral feeding recovery and endotracheal tube weaning.	Total $n = 22$ TBI $n = 64$	Not specified	Not specified for TBI cohort
Horn, S [23]	2015	United States of America	Prospective Observational Cohort	To determine association of enteral nutrition preinjury and injury characteristics and outcomes for patients receiving inpatient rehabilitation after TBI.	Total $n = 1701$	TBI (caused by external force + loss of consciousness, PTA, skull fracture, or objective neurological findings)	Enteral nutrition $n = 145$ Male = 72 % Nil enteral nutrition $n = 1250$ Male = 72 %
Huang, HC [28]	2023	Taiwan	Prospective Observational Cohort	To determine functional improvement with TBI after participating in post-acute care programs.	Total $n = 27$	Not specified	Mean age = 55.8 ± 17.4 Male $n = 14$ (52 %) Female $n = 13$ (48 %)
Huang, ST [24]	2024	Taiwan	Retrospective Observational Cohort	To construct a prognostic model for unsuccessful removal of nasogastric tube.	Total $n = 203$ TBI $n = 43$	Stroke or TBI. GCS was used to assess impaired consciousness.	Not specified for TBI cohort
Kokuwa, R [25]	2021	Japan	Retrospective Observational Case-series	To investigate longitudinal changes in physical and cognitive functions in moderate to severe TBI.	Total $n = 7$	Moderate to severe TBI (GCS scores 3–12)	Not specified
Langdon, C [32]	2021	Spain	Prospective Observational Cross-Sectional	To identify and correlate severity of TBI associated with olfactory dysfunction with cognitive and behavioural profiles.	Total $n = 111$	Severe TBI (GCS ≤ 8)	Mean age = 32.9 Male $n = 78$ Female $n = 33$
Odgaard, L [29]	2020	Denmark	Retrospective Observational Cohort	To determine weight status and risk of overweight up to 1 year after severe TBI as basis for defining nursing-sensitive indicators of fundamental nutritional nursing care in a clinical quality database.	Admission: $n = 424$ Discharge: $n = 360$ 1-year post-injury: $n = 316$	Severe TBI (GCS ≤8 within 48hr after injury or a length of post-traumatic amnesia (PTA) ≥ 15 days	Age = <35 (38.7 %) 35–64 (44.1 %) >65 (17.2 %) Female $n = 94$ (22.4 %)
Pellicane A [8]	2013	United States of America	Prospective Observational Cross Sectional	To compare calorie and protein intake with new SCI versus other diagnoses (new TBI, new stroke, and Parkinson's disease in acute inpatient rehabilitation setting.	Total $n = 78$ TBI $n = 9$	Not specified	Mean age = 53.5 ± 23.4 Male $n = 7$ Female $n = 2$

(continued on next page)

Table 1 (*continued*)

Author	Year of publication	Country of origin	Study design	Study aim	Number of patients	Severity of TBI	Patient characteristics
Prum, G [26]	2023	France	Retrospective Observational Cohort	To compare feeding modalities and level of consciousness in patients with a severe brain injury during re-education and rehabilitation.	Total $n = 33$	Severe (GCS at admission in ICU was at 4.7 ± 1.6)	Mean age = 44.8 Male $n = 27$
Tóth, B [30]	2023	Hungary	Prospective Observational Cohort	To investigate changes in body composition post TBI and stroke and determine whether bioelectrical impedance analysis (BIA could effectively monitor these changes while accounting for demographic and pre-rehabilitation factors.	Total $n = 22$ TBI $n = 11$	Not specified	Mean age = 37 Sex not specified Nutritional Risk Screening scores ≥2
Yan, N [10]	2021	China	Randomised Controlled Trial	To explore effect of an evidence-based bundled care model with dysphagia after severe TBI.	Total $n = 60$	Severe TBI (GCS score ≤8 and confirmed by CT or MRI)	Test group: Age mean = 55.2 ± 5.5 Control group: Age mean = 54.8 ± 6.2

Abbreviations: ABI, acquired brain injury; BIA, bioelectrical impedance analysis; CIPNM, critical illness polyneuropathy and myopathy; CT, computed tomography; DRS, disability rating scale; FIM, functional independence measure; GCS, Glasgow coma score; ICU, intensive care unit; MRI, magnetic resonance imaging; PTA, post-traumatic amnesia; SCI, spinal cord injury; TBI, traumatic brain injury.

automatically by Covidence based on author and title similarity and confirmed by authors (LC, SD, SMD, SK and PW). Title and abstract screening were conducted by at least one of the following authors (LC, MG, SD, SMD, SK or PW) to identify eligible articles based on selection criteria. Full-text screening was conducted independently in duplicate by two different authors (a combination of LC, MG, SD, SMD, SK or PW), with discrepancies resolved by a third independent author not involved in the original decision (LC, MG, SD, SK or PW).

Data extraction and synthesis

Data extraction was completed independently using a pre-defined data extraction tool (SMD, SK or PW). Characteristics extracted from the published reports included author, year of publication, country of origin, study design, and study aim. Furthermore, the number of patients included, TBI severity, patient characteristics (including age and sex), methods/outcome measures, and primary results relevant to nutrition were extracted. Following data extraction, key nutrition themes were determined. Data are presented descriptively, as number (percentage). No assessment of study quality was included, in line with scoping review methodology.

Results

Study selection

The final database searches identified 6337 references, with a total of 17 studies included in the final analysis (**PRISMA Flowchart,** Fig. 1).

Study characteristics

Characteristics of the 17 included studies are detailed in Table 1 and study methods and results are detailed in Table 2. Studies ranged from 7 to 1701 patients (with TBI aetiology). Among these, nine studies were prospective observational, seven were retrospective observational, and one was a randomised controlled trial. Studies were conducted in a range of geographical regions with the most common being the United States ($n = 3$), Italy ($n = 3$) and Denmark ($n = 3$). Whilst the inclusion criteria did not specify the use of the Glasgow Coma Scale (GCS), eleven studies utilised it to determine TBI severity. In contrast, six studies did not use specific criteria for categorising severity.

Nutrition themes

The key nutrition themes presented in the studies of patients with a TBI in the rehabilitation or subacute setting included various aspects of nutrition management: ten focused on the route of nutrition provision; four assessed nutritional status; three assessed specific nutrient provision; and one evaluated the impact of TBI on eating behaviours. Two studies examined more than one nutrition **spell.**

Route of nutrition

Ten studies addressed the theme of route of nutrition delivery [10, 18–26], including presence of swallowing disorders, requirement for percutaneous endoscopic gastrostomy (PEG), and the capacity to return to oral intake [18–22,24–26]. Three were prospective studies [10,20, 23], and seven were retrospective studies [18,19,21,22,24–26]. The prevalence of PEG between admission and discharge was featured in two studies, which noted a 15 % **promotion** in dependency on PEG feeding from admission to rehabilitation compared to discharge [18,19]. Two studies focused on the progression to oral feeding [18,24]. Four studies indicated that TBI aetiology impacted the capacity to achieve sole oral intake, with three studies supporting this [20,22,26], and one study presenting conflicting results [21]. One study specifically examined the impact of critical illness polyneuromyopathy (CIPNM) on Functional Oral Intake Scale (FOIS) [22].

Nutritional status

Four studies focused on the theme of nutrition status, including weight change and malnutrition risk [27–30]. Two were prospective studies [27,30], and two were retrospective studies [28,29]. Malnutrition risk was determined using various screening tools including the Malnutrition Universal Screening Tool (MUST), Mini Nutrition Assessment Tool (MNA), and Bioelectrical Impedance Analysis (BIA). A general trend of weight gain was observed, particularly in overweight and obese patients across all age groups during the rehabilitation period and within the first-year post injury. Older patients were shown to have a greater tendency to become overweight or obese in comparison to younger patients [29].

Nutrients

Three studies examined the provision of specific nutrients on TBI (energy, protein, and micronutrients) [8,23,31]. Two were prospective studies [8,23] and one was a retrospective study [31]. A notable finding was that TBI patients exhibited a high prevalence of vitamin D defi-ciency, although this did not correlate with functional outcomes or

Table 2
Methods and results of included studies.

Author	Methods / outcome measures	Primary results
Route of feeding		
Avesani [18]	Outcome measures included clinical data such as presence of PEG at admission and discharge.	Patients with TBI showed a reduction in PEG dependency from rehabilitation admission ($n = 215$, 39 %) to discharge ($n = 159$, 24 %).
Avesani [19]	Outcome measures included clinical data such as presence of PEG at admission and discharge.	117 TBI patients had a PEG, ($n = 97$ male; $n = 20$ female).
Fabricius [21]	Model developed using clinical data from 1233 adult tube-fed patients admitted for subacute inpatient rehabilitation (2012-present). Outcome measures included time taken to achieve full oral intake without tube-feeding.	60 % TBI patients achieved complete oral intake by discharge. TBI patients had a higher likelihood of achieving complete oral intake compared to other diagnostic groups ($P = 0.0007$). Patients with tracheostomy were less likely to recover oral intake.
Hakiki [22]	Data was collected within 7 days admission and compared at discharge, assessing impact of CIPNM vs. no-CIPNM inclusive of: FOIS score	Traumatic aetiology was confirmed to be associated with the oral feeding restoration ($P = 0.001$).
Huang [24]	Outcome measures were collected including swallowing function (FOIS score) and food types according to IDDSI after 1 month	24 % ($n = 36$) of TBI patients successfully weaned their nasogastric tube (NGT), while 13.2 % ($n = 7$) experienced removal failure.
Kokuwa [25]	Outcome measures included Swallowing disorders using the DSS and ESS. Data was collected monthly until discharge or until study end date.	Significant improvements in DSS and ESS at the time of discharge or at the time the latest measurements were performed, compared with those at admission.
Prum [26]	Swallowing function was assessed at admission and discharge using VFS or FEES. Patients WHIM scores were compared between oral feeding and non-oral feeding groups.	WHIM scores increased in both gastrostomy-fed and oral-fed patients, with a greater increase in Group 2 - exclusive oral feeding ($P < 0.05$). At discharge, 23 patients transitioned to oral feeding, with 10 consuming normal solids and various liquid consistencies. A positive correlation was found between WHIM scores and the FOIS at discharge ($P < 0.01$).
Bremare [20]	Swallowing evaluation which included a functional exam, clinical swallowing test, and naso-endoscopic swallowing test. Initial clinical characteristics who resumed oral feeding compared to patients who did not resume, 3 months after admission to rehabilitation unit.	50% of patients resumed oral feeding at 3 months. Mean time to oral refeeding: 29.2 ±16.8 days post-admission, 113.2±56.5 days post-injury. All oral fed patients were weaned off the tracheostomy, while only one non-oral fed patient was weaned, though the differences were not statistically significant ($P=0.14$).
Yan [10]	Patients with dysphagia post-severe TBI randomised to evidence-based bundled care ($n = 30$), or routing care ($n = 30$). Bundled care: Included swallowing assessments, neuromuscular electrical stimulation, orofacial sensory and exercise training, personalised dietary interventions.	No significant difference in baseline FOIS score between groups ($P > 0.05$). After intervention, FOIS score increased in both groups ($P < 0.001$). Nutritional risk scores in the test group were significantly decreased after intervention compared to control ($P < 0.05$). Total incidence of adverse events in the test group (6.7 % vs. 43.3 %, respectively) was significantly reduced ($P < 0.001$).
Horn [23]	Nutritional support methods during rehabilitation were evaluated, and the association of patient preinjury and injury characteristics were examined via the use and duration of EN support.	EN patients had higher discharge Rasch-transformed FIM motor and cognitive scores ($P = 0.055$ and $P = 0.050$, respectively), and less weight change ($P = 0.075$).
Nutritional status		
Aadal [27]	Weight change (%) and malnutrition risk using the Malnutrition Universal Screening Tool (MUST) at 3 time points relative to injury: T1: Days to rehabilitation admission T2: Days to 4 weeks length of stay T3: Days to rehabilitation discharge	T1: −10 % weight change ($P = 0.191$). T2: −8.5 % weight change ($P = 0.191$). T3: −4.5 % weight change ($P = 0.636$). Malnutrition risk: Low $n = 4$ Medium $n = 4$ High $n = 7$ Weight loss in acute phase then weight gain during rehabilitation. No association between malnutrition risk and injury severity, complications, functional outcomes or length of stay.
Huang [28]	Outcome measures including the Mini Nutrition Assessment (MNA, scored from 0–30) were taken on admission and at discharge from rehabilitation.	MNA admission mean±SD: 7.7 ± 1.6 MNA discharge mean±SD: 9.7 ± 1.4 P value of MNA 0.000* (*$P < 0.05$). Significant improvements were found in MNA ($P < 0.05$).
Odgaard [29]	BMI was calculated to categorise weight status - normal weight, underweight and overweight at 3 time points: subacute rehabilitation admission, discharge and 1-year post injury.	Underweight patients decreased from 12.5 % on admission to 3.2 % 1-year post injury. Overweight and obesity rates increased from 26 % to 44 %. 74.4 % of underweight individuals reached a normal weight by 1-year, and 33.3 % of normal weight individuals became overweight or obese. In those <35 years the prevalence of overweight/ obesity rose from 13.4 % to 35.9 % while in those ≥65 it increased from 48 % to 55.6 %.
Tóth [30]	BIA completed on admission and discharge from rehabilitation: BMI; FMI; SMMI 25–30 kcal/kg/d (mean 1800–2200 kcal) and 1–2 g/kg/d protein content diets were provided to all patients regardless of feeding route (oral, PEG)	Despite prolonged ICU stays, TBI patients maintained stable fat mass, with no significant reduction in FMI (4.7 kg/m^2 at admission vs. 4.8 kg/m^2 at discharge). SMMI significantly increased from 6.1 kg/m^2 at admission to 6.5 kg/m^2 at discharge, indicating an increase in muscle gain during rehabilitation.
Nutrients		
Dubiel [31]	Patients were categorised into three vitamin D groups: deficient (<20 ng/mL), insufficient (20–29.9 ng/mL), and sufficient (≥30 ng/mL). Relationship between vitamin D levels, rehabilitation stays and patient characteristics	62 % of patients were insufficient or deficient in vitamin D at admission to inpatient rehabilitation. Significant difference was found in vitamin D levels based on race/ethnicity ($P = 0.01$), with 57 % of non-Hispanic White patients, 71 % of non-Hispanic Black patients and 79 % of Hispanic patients having insufficient or deficient levels.
Pellicane [8]	Demographic data and weight were collected on admission to an inpatient rehabilitation facility. Calorie (kcal) and protein (g) intake calculations were obtained weekly	Mean calorie intake: 1546.8 ± 352.3 kcal Mean calorie intake per body weight: 20.4 ± 5.3 kcal/kg Mean protein intake: 61.1 ± 12.8 g Mean protein intake per body weight: 0.81±0.18 g/kg
Horn [23]	Nutritional support methods during rehabilitation were	EN with standard or high-protein formula for >25 % of the

(continued on next page)

Table 2 (*continued*)

Author	Methods / outcome measures	Primary results
	evaluated, and the association of patient preinjury and injury characteristics were examined via the use and duration of EN support.	rehabilitation stay was associated with significantly higher discharge FIM subscale scores. High-protein EN given for >25 % of stay was associated with almost 2-lb weight gain from admission to discharge, compared to almost 2 lb weight loss in patients without EN.
Eating behaviours		
Langdon [32]	Motor function using the Functional Instrument Measure and DRS Patients with subjective smell loss underwent evaluation using the Barcelona Smell Test 24 (BAST-24) and gustrometry.	Patients with TBI and olfactory dysfunction showed statistically significant alterations in feeding when compared with patients with TBI without smell loss. Patients with a higher BAST- 24 score in detection, recognition, and identification (and therefore a better sense of smell), had a higher prevalence of abnormal eating behaviour.

Abbreviations: BIA, bioelectrical impedance analysis; BAST-24, Barcelona Smell Test 24; BMI, body mass index; CIPNM, critical illness polyneuropathy and myopathy; CT, computed tomography; EN, enteral nutrition; ESS, eating status scale; DRS, disability rating scale; DDS, dysphagia severity score; FEES, functional endoscopy evaluation of swallowing; FIM, functional independence measure; FMI, fat mass index; FOIS, functional oral intake scale; GCS, Glasgow coma score; ICU, intensive care unit; IDDSI, International Dysphagia Diet Standardisation Initiative; MNA, mini nutrition assessment; MRI, magnetic resonance imaging; MUST, malnutrition universal screening tool; NGT, nasogastric tube; PEG, percutaneous endoscopic gastrostomy; PTA, post-traumatic amnesia; SCI, spinal cord injury; SMMI, skeletal muscle mass index; TBI, traumatic brain injury, VFS, video fluoroscopy; WHIM, Wessex head injury matrix.

length of hospital stay [31]. Two studies reported that high-protein enteral **nutriton** was associated with improved Functional Independence Measure (FIM) scores and weight gain during the rehabilitation period [8,23].

Eating behaviours

One prospective study identified that patients with TBI and olfactory dysfunction showed statistically significant alterations in neuropsychiatric behavioural performances such as feeding when compared with patients with TBI without smell loss [32]. Patients with a better sense of smell had a higher prevalence of abnormal eating behaviour.

Discussion

This scoping review aimed to identify research themes and evidence gaps relating to nutrition management for adults with a moderate to severe TBI admitted to an inpatient rehabilitation facility or subacute setting. Key nutritional themes identified include route of nutrition delivery, nutritional status, specific nutrient provision, and eating behaviours. Few studies examined the direct influence of these nutritional factors on clinical or functional outcomes. Most studies included small sample sizes (<100 patients), lacked assessment of long-term outcomes, and were observational in nature, hindering generalisability and potentially impacting the validity of conclusions. This review highlights the need for well-powered rigorous studies to evaluate the potential impact of nutritional interventions in TBI rehabilitation. Without high quality trials, particularly of an interventional nature, clinical practice is likely to radically differ across healthcare services.

The predominant theme identified in this scoping review was the route of nutrition delivery. Of note, the majority of these studies focused on the progression from enteral nutrition to oral intake. This focus differs to previous reviews on nutrition in TBI patients where patients are largely enterally fed [33], representing a topic of specific interest to the rehabilitation and subacute recovery phase of illness. The observational nature of these studies, and lack of assessment of impact on outcomes limit implementation into clinical care [34].

Conducting nutrition research in TBI patients presents several challenges identified in this scoping review. One key issue is the heterogeneity of TBI, with included patients differing in injury severity, recovery trajectories, and comorbidities, complicating the standardisation of nutritional interventions. Studies within this review often varied in their definitions of TBI severity, with some using GCS scores and others relying on clinical history or imaging data, making it challenging to compare results between studies. Furthermore, the utilisation of tools like GCS in establishing the severity of TBI poses limitations due to being affected by confounding factors such as drug and alcohol use [34]. Additionally, comorbidities such as dysphagia and critical illness polyneuromyopathy further complicate nutrition-focused rehabilitation interventions. Many studies do not stratify results based on these comorbidities, making it difficult to draw conclusions specific to patients with TBI.

Future research in the field of nutrition for patients with TBI should focus on several key areas to address the gaps identified in this systematic review. Longitudinal cohort studies should assess nutrition intake and outcomes over extended periods, ideally capturing changes in nutritional status from acute care through to rehabilitation. Specifically, more studies are needed that not only document caloric and protein intake but also investigate micronutrient intakes. Given the high metabolic demands of TBI patients, future research should focus on the role of nutrition in muscle mass preservation and functional recovery, incorporating functional markers such as muscle strength, mobility improvements, and quality of life to provide a more comprehensive understanding of how nutritional interventions aid rehabilitation. Lastly, studies should explore effective nutrition optimisation strategies and the optimal timing for transitioning from enteral to oral feeding, ensuring that nutrition delivery methods address the metabolic, cognitive, behavioural, and swallowing challenges unique to this population.

Implications for clinical practice

With limited evidence to support clinical practice on nutrition practices for patients with a moderate to severe TBI admitted to an inpatient rehabilitation facility or subacute setting, our author group provides the following overall recommendations to support clinician decision-making at the bedside:

1. Malnutrition risk assessment should occur on admission to an inpatient rehabilitation facility, using a validated nutrition assessment tool such as the Mini Nutrition Assessment.
2. Nutrition status, including weight and body composition, should be monitored regularly throughout the rehabilitation admission, to prevent significant weight loss or gain, or muscle mass loss.
3. For patients admitted to an inpatient rehabilitation facility with a short-term feeding tube (e.g. nasogastric tube), a multi-disciplinary decision should be made regarding the need for a long-term feeding tube (e.g. PEG).
4. As patients transition to oral intake following hospital discharge, the ongoing need for artificial feeding should be reassessed at regular intervals.
5. Oral intake should be regularly quantified and adequate intake (defined as meeting at least 75 % of calorie and protein requirements [35]) should be confirmed prior to removal of nasogastric or PEG feeding tubes.
6. Barriers to oral intake, including dysphagia, olfactory dysfunction, and cognitive and behavioural issues, should be identified and addressed, where possible, by the multidisciplinary team in order to optimise dietary intake.

Conclusion

This scoping review has identified key research themes and significant evidence gaps in nutrition management for patients admitted to inpatient rehabilitation with a moderate-severe TBI. Despite some progress in understanding the nutritional challenges faced by this population, there remains a considerable lack of high-quality evidence, particularly on the role of specific nutrition interventions on long-term outcomes. High-quality studies are needed to better assess the impact of nutrition interventions during rehabilitation.

Ethics statement

Not applicable- review article

CRediT authorship contribution statement

Sarah Dunthorne: Writing – original draft, Formal analysis, Data curation. **Sarah Kirsanovs:** Writing – original draft, Formal analysis, Data curation. **Nikita Wilson-Beddoe:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Marc Campbell:** Writing – review & editing, Supervision, Formal analysis, Data curation, Conceptualization. **Sara Dowling:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Miranda Green:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Lee-anne Chapple:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Paige Wicks:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

None

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Nil to report

Supplementary materials

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