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REVIEW

Nutrition and preparation of blenderized tube feeding in children and adolescents with neurological impairment: A scoping review

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Abstract

Background: The use of homemade tube feeding formula has become increasingly popular for children requiring enteral nutrition. This project aimed to investigate nutrition and preparation of blenderized tube feeding in the field of children and adolescents with neurological impairment.

Methods: A scoping review was performed using established methodologies. In January 2021, we searched PubMed, Embase, CINAHL Complete, the Cochrane Central Register of Controlled Trials, and gray literature to identify relevant articles.

Major findings: Twenty-two papers were included describing the composition of food items, preparation procedures, and food safety. No randomized controlled trials and only a few prospective studies were included. A broad variety of food items from all food groups and many examples of recipes were presented. Most recipes provided 1.0 kcal/ml but tended to contain less energy and nutrients than expected, which could be due to preparation issues, such as sieving and the high viscosity of the blend. Preparation requires a commercial-grade household blender and diligence to ensure thorough household hygiene for adequate food safety.

Conclusions: This review revealed practical experience in the nutrition and preparation aspects of blenderized tube feeding but minimal empirical evidence. Multiple examples of the composition of food items and preparation procedures for blenderized tube feeding were found, but uncertainty regarding the ideal composition or preparation was also exposed. The future of blenderized tube feeding would benefit from clinically tested recipes that

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include an evaluation of nutrients, viscosity, and microbial contamination, as well as the effect of the food's appearance and scent on the target group.

KEYWORDS
blenderized formula, enteral nutrition, neurologic impairment, pediatrics

INTRODUCTION

In recent years, blenderized tube feeding (BTF) using whole foods has become increasingly in demand as an alternative to commercial tube feeding (CTF) products.[1,2] There are multiple incentives for the use of BTF, including intolerance of CTF products or a perception of nutrition benefits from homemade food due to the variety of food items and the option of tailoring BTF to special needs. Psychosocial aspects also have an influence—for instance, the desire to feed one's own child and serve the same foods as the rest of the family eats.[2]

When caregivers consider BTF for enteral nutrition, it is our experience that the child has often received tube feeding for months or years. Clinicians experience an increasing interest from families with tube-fed children and adolescents who wish to be counseled on BTF, including accessible knowledge and advice on this type of tube feeding. This is supported by surveys showing that the demand for BTF often originates from families and is rarely suggested by a dietitian.[3] Feeding difficulties are frequent in children and adolescents with neurological impairment (NI) and cerebral palsy (CP) and can be associated with undernutrition and micronutrient deficiencies. This population is generally tube fed for long periods of time using gastrostomy tubes.[4] NI often includes gastrointestinal symptoms such as reflux, vomiting, and constipation. Two studies revealed a reduction in some of these symptoms when using BTF,[5,6] which may increase the motivation for its use.

The European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), which expressed concerns regarding the nutrition adequacy and safety of BTF, recommends caution when using BTF in children with NI.[4] There are multiple considerations for BTF. Families and caretakers request information and guidance from dietitians on the application of BTF, whereas professionals are concerned about nutrition inadequacy, tube blockages, and increased infection risk.[7] A knowledge gap is evident, necessitating the development of qualified safety guidelines for dietitians and other clinicians to share with families and caretakers if BTF is being considered.

We aimed to investigate aspects of BTF in the field of children and adolescents with NI regarding optimal composition and the practical aspects of food handling in terms of preparation and safety. The objective of this scoping review was to systematically map evidence on NI and BTF and identify knowledge gaps. We address two questions that succinctly summarize our focus: What is the optimal composition of food items to ensure that BTF has adequate nutrition value? What are the ideal procedures for BTF preparation and food safety?

METHODS

The scoping review methodology is suited to identifying the types of available evidence in a given field, pinpointing knowledge gaps, and providing a broad overview of a scientific topic. To ensure a high level of evidence and transparency about how the review was executed, we applied a combination of the *Joanna Briggs Institute Reviewers' Manual*[8] and stages 1–5 of Arksey and O'Malley's[9] original framework throughout the review. Our protocol was drafted using the abovementioned frameworks and the corresponding Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews.[10] The title was registered online (www.joannabriggs.org), and the protocol was published on the Open Science Framework website (https://osf.io).

Nutrition aspects were defined as the optimal energy and nutrient composition, as well as the optimal composition of food items in relation to what is practically manageable when preparing BTF. The research questions were defined to ensure a full perspective on nutrition and preparation of BTF. We defined preparation as all aspects in relation to BTF, such as blending, pureeing, and sieving, as well as physical properties such as viscosity and osmolarity. Food safety was explicitly perceived as food contamination regarding preparation of BTF.

Eligibility criteria

Randomized controlled trials, cohort, and cross-sectional studies, as well as educational papers, practice guidelines, discussions, expert opinions, abstracts, and poster presentations, were included if they focused, or partially focused, on the nutrition aspects, preparation, and food safety of BTF. Reference lists from reviews on BTF that our search yielded were searched for additional relevant papers. Only papers in English or a Scandinavian language were included. We applied inclusion criteria according to population (children and adolescents with NI/CP), concept (BTF), and context (gastrostomy tube home enteral nutrition).[8] Studies with an adult population were included if the information was applicable to children and adolescents with NI/CP. Papers on BTF were excluded if nutrition aspects/preparation/food safety were not covered; other populations besides children and adolescents with NI/CP were studied; puréed, liquidized, or blended foods were not administered through a gastrostomy tube; or the source was commercial, nondietary, or outside the field of clinical nutrition.

Search strategy and selection of sources

In January 2021, a search was undertaken in PubMed, Embase, CINAHL Complete, and the Cochrane Central Register of Controlled Trials. Before that search, these databases were searched for existing reviews on nutrition and preparation of BTF for children and adolescents with NI/CP. No published studies were identified. Two authors independently conducted the searches (A.M.T.R. and G.B.). The specific search strategy was created in collaboration with information specialists. The literature search results were uploaded to a systematic review software program, Covidence (https://www.covidence.org/).

To embrace a broader scope of information, gray literature was included, providing the opportunity to include literature, information, or data from sources ranging from library books to Facebook posts to Tweets on social media.[11] Figure 1 contains a flowchart describing the search and selection of sources, and Figure S1 includes the search terms and search strategy for PubMed and additional information on the gray literature.

A.M.T.R. and G.B. independently screened titles and abstracts before independently screening full texts and deciding on whether the inclusion criteria were met. Disagreements were resolved through discussion or further adjudication by other members of the review team (C.E.H.-H., C.M., and A.P.B.). Reasons for excluding studies were recorded. Journal titles or study authors were anonymized for neither A.M.T.R. nor G.B. Covidence

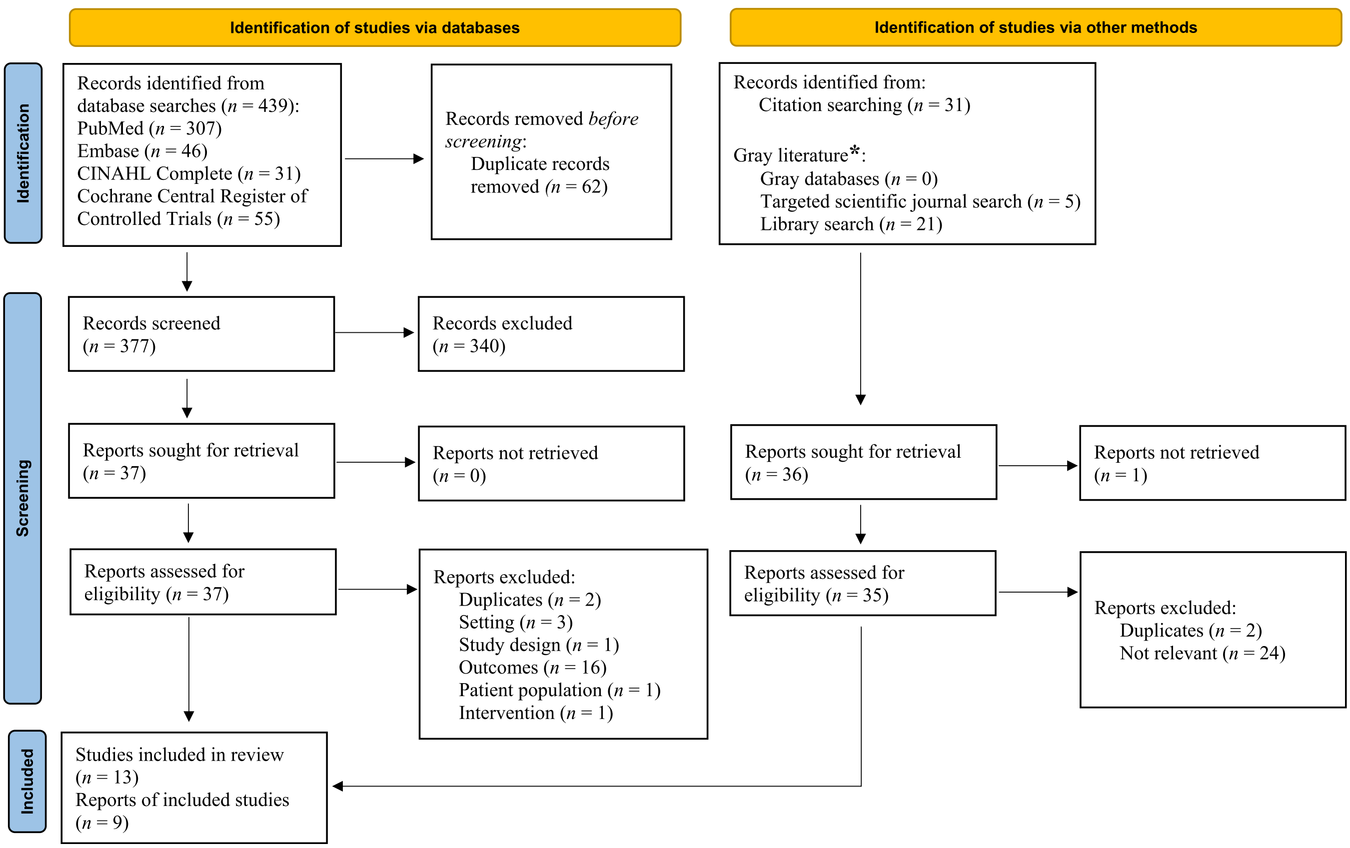

FIGURE 1 Flowchart of search and selection of sources. *Figure S1 contains details on how gray literature was used. Reprinted from Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71

software was used to screen and select papers from the database searches. Results from the gray literature search and reference lists from the database search were manually searched.

Data charting and synthesis of results

To chart data, we developed a form that was tested on three papers to identify unforeseen relevant data and to reduce potential errors or disagreements. A.M.T.R. and G.B. independently charted data from each eligible paper. Disagreements were resolved through discussion or further adjudication by C.E.H.-H., C.M., and A.P.B. Table 1 presents key findings according to research questions, and Tables S1–S3 contain the full set of charted data.

RESULTS

We conducted extensive research on the nutrition and preparation of BTF in children and adolescents with NI. The search and selection of sources included database and gray literature searches; the latter did not generate a single relevant result or any items not already included in the database search. Consequently, only results from the database searches are described below.

After removing 62 duplicates, 377 citations were identified. Based on title and abstract, 340 articles were excluded, resulting in 37 full-text articles to be assessed for eligibility. Of these, 24 were excluded, leaving 13 articles for inclusion. References in reviews identified by the search but excluded according to eligibility criteria resulted in nine articles not already included. In all, 22 articles were considered eligible (Figure 1), with 16 conducted in the US, 1 in Canada, 2 in Europe, 2 in South America, and 1 partly in North America and Asia (Tables S1–S3). All papers were in English and published between 1976 and 2020, 82% of them in the last decade (2010 included). Most studies stated the authors' professions ($n = 19$). Fifteen studies were authored or coauthored by registered dietitians or nutritionists. Only 11 articles explicitly stated the study design or type of article: cross-sectional ($n = 2$), prospective ($n = 2$), retrospective ($n = 2$), case presentation ($n = 1$), practice guidelines ($n = 3$), and educational ($n = 1$). No intervention studies met the inclusion criteria. Most studies did not include any participant information, because of the study design, but merely included an indication of the setting. The settings were primarily pediatric ($n = 16$), but far from all studies included diagnoses ($n = 6$), with NI/CP included to various extents. One article comprised both pediatric and adult settings, and three included an adult setting.

Composition of food items

Nineteen of 22 papers had information on the composition of food items.[5,6,12,14–19,21–30] All papers presented a broad variety of food items from all food groups, just as many examples of recipes were given (Table 1, Table S1).

Macronutrients

Nineteen papers included sources of protein (eg, meat and eggs) and carbohydrate (eg, fruits, vegetables, starch, and various types of sugar) in their recipes. Dietary fiber from grains, cereals, legumes, fruits, or vegetables and sources of fat (eg, oil or milk fat) were described in 18 papers.[5,6,12,14,15,17–19,21–30] Four papers provided examples of vegetable protein (eg, nuts, legumes, and tofu) or milk alternatives (eg, liquid soy or almond products).[17,18,22,30] Types of simple sugars, such as syrup or maltodextrin, were mentioned in the ingredient lists of nine papers.[6,12,14,15,22,23,25,26,30] One paper included dairy- and gluten-free products.[16]

Micronutrients

Nine papers designated the need for multivitamin or mineral supplements,[6,12,17,21,23,25,28–30] whereas one other paper did not prescribe additional vitamins or minerals.[18] Sullivan et al.[26] stated the risk of micronutrient values being lower than expected. Added salt was mentioned in the ingredient lists of nine papers[12,14,18,21,25,27,28,30] and suggested as supplementation in two papers.[6,29]

Fluids

Sixteen papers described added fluids: water, juice, fluid dairy products, and broth.[5,6,12,14,15,17–19,21,23–25,27–30] Four provided information on free water content,[6,17,27,30] three of which described a free water content of 65%–75%,[6,17,30] and Vieira et al.[27] found that the water content of a specific BTF recipe was significantly higher than prescribed values.

Energy content

Energy content was provided in 14 papers,[5,6,12,15–18,21,23,25,26,28–30] and 5 analyzed energy content.[5,14,18,21,26] Others provided retrospectively assessed energy contents,[6,12,23,25,27] and the remaining papers were recommendations on energy content.[15–17,28–30] Six papers included energy content

TABLE 1 Key findings on nutrition and preparation aspects on blenderized tube feeding in children and adolescents with neurological impairment

	Food items[a]				Preparation[b]			Food safety[c]	
		Supplementation							
First author	Composition	Vitamins	Salt	Content	Procedure	Equipment	Viscosity and osmolarity	Administration	Hygiene
Batsis[12]	Meat, yogurt, vegetable, fruit, grains, honey, oil	x	x	1.0 kcal/ml; 3.8 g P/100 ml; Energy %, P15%, C55%, F30%	n/a	n/a	n/a	n/a	n/a
Brown[13]	n/a	n/a	n/a	n/a	Cooked/prepared food blended into a smooth consistency	Blender, sieve	n/a	Blend when serving, use immediately or store in fridge for up to 24 h, and discard reheated leftovers	Equipment rinsed and drained immediately after use
de Sousa[14]	Beef, broth, milk, fruit, maltodextrin, oil	n/a	x	Low match between real and estimated macronutrients	Cooked vegetables before adding other ingredients; liquefied with milk	Blender, sieve	Adequate viscosity	n/a	n/a
Duperret[15]	Meat, milk powder, vegetable, fruit, rice cereal, syrup, oil	n/a	n/a	1.0 kcal/ml; 4.4 g P/100 ml; Energy %, P18%, C42%, F40%	Frozen vegetables can be used without cooking; freeze foods individually and mix/blend after thawing	Blender	When more types of food are mixed and frozen, the thawed mix does not go through the tube easily	Refrigerate or freeze promptly; keep in fridge until feeding; thaw in fridge or microwave	Utensils must be washed in hot soapy water, especially after being used for raw meat or fish
Epp[1]	n/a	n/a	n/a	n/a	Preparation once daily	Blender	Extra fluid may be added to blends before use to prevent clogging	n/a	n/a
Epp[16]	Gluten-free, dairy-free	n/a	n/a	0.9–1.06 kcal/g; max 3 g P/100 kcal; Energy %, F40%–50%	Recipe blended for 3 min	Blender	Viscosity tested with IDDSI flow test	Refrigerate for up to 24 h; administer within 1 h of removal from fridge	General food safety principles
Escuro[17]	Meat or alternative, milk or alternative, vegetable, fruit, grains, oil	(x)	n/a	1000 kcal	n/a	Blender, sieve	n/a	Discard after max 2 h if kept at room temperature	n/a

(Continues)

TABLE 1 (Continued)

	Food items[a]				Preparation[b]			Food safety[c]	
		Supplementation							
First author	Composition	Vitamins	Salt	Content	Procedure	Equipment	Viscosity and osmolarity	Administration	Hygiene
Gallagher[18]	Meat or alternative, milk or alternative, vegetable, fruit, grains, nut butter, oil	no	x	1000–1100 kcal; P 43 g	n/a	Blender	n/a	n/a	n/a
Hron[5]	Chicken, milk, vegetable, fruit, pasta, farina (Cream of Wheat), oil	n/a	n/a	1.1 kcal/ml (calculated)	n/a	n/a	n/a	n/a	n/a
Hron[19]	Chicken, milk, yogurt, vegetable, fruit, pasta, farina (Cream of Wheat), oil	n/a	n/a	n/a	Puréed until smooth; preparation in large batches; defrosted in water bath	Blender	Higher viscosity than in CTF by IDDSI flow test; decrease in viscosity when frozen in large batches	n/a	n/a
Johnson[20]	n/a	n/a	n/a	n/a	n/a	Blender	n/a	Feed should not be administered after >2 h at room temperature	n/a
Johnson[21]	Chicken, milk, vegetable, fruit, dry oats, cod liver oil	(x)	x	1.0 kcal/ml; 3.8 g P/100 ml (calculated); Energy%, P15%, C55%, F30%	Frozen vegetables cooked in microwave; frozen fruit added directly to blend	Blender	n/a	Feed was administered within minutes of preparation	Utensils and blender sanitized in accordance with the FDA 2017 Food Code

TABLE 1 (Continued)

	Food items[a]				Preparation[b]			Food safety[c]	
		Supplementation							
First author	Composition	Vitamins	Salt	Content	Procedure	Equipment	Viscosity and osmolarity	Administration	Hygiene
Jonkers-Schuitema[22]	Meat or alternative, milk powder, starch, sugars, cream, oil	n/a	n/a	Nutrients to meet patient's needs	Food should, if possible, be pasteurized and should be liquid to pass easily through the tube	Sieve	Syrups, sucrose, lactose, and fructose create high osmolarity	Refrigerate immediately after preparation; with continuous drip, containers should not be kept >6 h outside fridge	Prepare under strict hygienic conditions
Kernizan[23]	Chicken/egg, milk/dairy product, vegetable, fruit, grains, honey, oil	x	x	30 kcal/oz; Energy %, P17%, C52%, F31%	Liquids should be placed into the blender before solids; prepare each meal separately or once daily; thaw in fridge for 24 h	Blender	n/a	Discard leftovers after 24 h; serve formula at room temperature; do not store in freezer for >3 months	Utensils washed thoroughly after each use
Milton[24]	Chicken, milk, vegetable, fruit, dry oats, cod liver oil, oil	n/a	n/a	n/a	Cooked vegetables before adding other ingredients; liquefied with milk, water, and oil	Blender	n/a	Kitchen environment must be evaluated	Blender design should allow for complete disassembly of blade and gasket
Pentiuk[6]	Meat, formula/milk/yogurt, vegetable, fruit, infant cereal, cornstarch/sugar, oil	x	x	1.25 kcal/ml; 4.7 g P/100 ml (calculated)	n/a	n/a	n/a	Refrigerated immediately after preparation and discarded after 24 h	n/a
Shils[25]	Beef, egg, milk powder, vegetable, fruit juice, farina, syrup, oil	x	x	1000 kcal	n/a	n/a	n/a	n/a	n/a

(Continues)

TABLE 1 (Continued)

	Food items[a]				Preparation[b]			Food safety[c]	
		Supplementation							
First author	Composition	Vitamins	Salt	Content	Procedure	Equipment	Viscosity and osmolarity	Administration	Hygiene
Sullivan[26]	Chicken, egg, dry milk, vegetable, fruit, rice gruel, bread, sugar, oil	n/a	n/a	66–123 kcal/100 g; measured values tended to be lower than expected	n/a	n/a	Mean viscosity was >43 times higher than in CTF	n/a	n/a
Vieira[27]	Meat, egg, milk, vegetable, legumes, grains, oil	n/a	x	Macronutrients <50% of prescribed values	All ingredients cooked together	Blender, sieve	n/a	n/a	n/a
Walia[28]	Meat, vegetable, fruit, rice, oil	x	x	700 kcal; Energy%, P23%, C45%, F32%	n/a	Blender	n/a	Refrigerate up to 24 h; discard after max 2 h if kept at room temperature	n/a
Weeks[29]	Meat, milk, vegetable, fruit, oatmeal, quinoa, oil	x	x	1000 kcal; 45 g P	n/a	Blender	n/a	n/a	n/a
Zettle[30]	Meat or alternative, dairy or alternative, vegetable, fruit, grains, sugars, oil	(x)	x	1600 kcal; 56 g P (calculated)	Foods blended to a puréed consistency; preparation once daily	Blender	n/a	Feed should not hang for >2 h; unsuited for feeding pumps (risk of bacterial growth and tube clogging)	n/a

Abbreviations: (calculated), calculated by A.M.T.R. and G.B.; C, carbohydrate; CTF, commercial tube feeding; F, fat; FDA, US Food and Drug Administration; IDDSI, International Dysphagia Diet Standardization Initiative; max, maximum; n/a, not applicable; P, protein; x, needed; (x), may be needed.

[a]Table S1 contains details on food items.

[b]Table S2 contains details on preparation.

[c]Table S3 contains details on food safety.

calculated as kilocalories per milliliter, or the energy content was possible to estimate.[5,6,12,15,16,21] Results showed an energy content of about 1.0 kcal/ml. In four of the six papers, it was possible to calculate protein in grams per 100 ml, which varied from 3.8 g/100 ml to 4.7 g/100 ml.[6,12,15,21]

Preparation

Seventeen of the included papers described one or more aspects of preparing the BTF, such as the procedure, the equipment required, and viscosity or osmolarity issues (Table 1, Table S2).[1,13–24,26–30]

Procedure

Twelve papers described the preparation procedures and provided an impression of somewhat generally accepted procedures.[1,13–16,19,21–24,27,30] Fresh fruit and vegetables should be cooked, but frozen items can be either added directly to the blender or thawed and, optionally, cooked.[14,15,21,23,24] Grains, legumes, meat, and eggs must be cooked before blending.[15,23] Ingredients can be liquefied with dairy, nondairy alternatives, or broth.[14,15,23,24] The feed should be blended,[13,16,19,21–24,27,30] and some also recommended additional sieving.[13,14,17,22,27] The order in which food should be added into the blender was not specified,[13,15,21,22,27,30] except by Kernizan et al.,[23] de Sousa et al.,[14] and Milton et al.[24]

Equipment

The recommended equipment included a commercial household blender,[1,14–21,23,24,27–30] and some studies advised using a sieve.[13,14,17,22,27]

Viscosity and osmolarity

de Sousa et al.[14] described adequate viscosity, but five papers reported high viscosity.[1,15,16,19,26] Some indicated that viscosity was higher than in CTF products,[19,26] implying that more water needs to be added to BTF to pass through the tube.[1] Viscosity was tested with 10-ml syringes, with two studies using the International Dysphagia Diet Standardization Initiative's flow test.[16,19] Hron and Rosen[19] described the impact of batch size on viscosity. Only one study reported on the risk of high osmolarity implying a risk of diarrhea when adding syrups, sucrose, lactose, or fructose.[22]

Food safety

Twelve of the 22 papers provided information on food safety (Table 1, Table S3).

Administration

Four papers recommended that BTF should be either administered or refrigerated promptly.[13,16,21,28] For BTF prepared in advance, five papers suggested storage in the refrigerator for no more than 24 h.[6,13,16,23,28] Four papers suggested storage in the freezer to avoid bacterial growth, if preparing BTF >24 h in advance.[15,17,23,28] Two of these papers recommended a maximum freezing time.[15,23] In addition, three papers suggested methods for reheating and/or thawing.[13,15,23] Five papers recommended administering BTF within 2 h, if kept at room temperature.[15,17,20,23,30] Epp et al.[16] preferred administering within 1 h of removal from the refrigerator. Jonkers-Schuitema[22] suggested that maximum hanging time should be no more than 6 h outside the refrigerator, if given as a continuous drip.

Hygiene

Six papers described hygiene procedures in relation to the preparation of BTF.[13,15,16,21,23,24] Apart from the handling of food items, the majority of papers described generally accepted food safety procedures, such as washing hands, equipment, and surfaces, and Johnson et al specifically mentioned cleaning and sanitizing utensils and blenders in accordance with the US Food and Drug Administration (FDA) 2017 Food Code.[21] Furthermore, Milton et al.[24] claimed that blender design should allow for complete disassembly of blades and gaskets, as the latter are a particular source of contamination.

DISCUSSION

There is a great need for validated data on BTF as an alternative to industrially manufactured CTF products. The families of both children and adolescents with NI and clinicians treating these individuals need clearer data than what are presently available. This scoping review extensively analyzed and presented the currently available data on recommendations of food items, preparation, and food safety. As the review did not include any intervention studies and is mostly based on descriptive studies and practice papers, there were not enough data to respond to the aim and questions addressed in the introduction thoroughly.

The scoping review methodology does not require an assessment of the quality of included articles but merely gives a broad overview of a scientific topic.[8] We did not assess the level of quality, which means the quality of the scientific evidence may vary, implying a risk of bias in the extracted data. This scoping review revealed a large variety of nutrition and preparation of BTF for children and adolescents, preferably with NI/CP. Far from all papers included this population, but given that home enteral tube feeding by gastrostomy, gastrointestinal symptoms, and limitations in nutrition status are common in individuals with NI/CP, generalization of our results is justified. We identified several key areas of importance, including heterogeneity of results and a lack of evidence concerning the nutrition and preparation of BTF.

Based on the eligibility criteria, all of the included papers were written by health professionals, primarily registered dietitians. These authors share a concern that BTF may lead to malnutrition, if not adequately assessed, and often appear reluctant to supervise families implementing BTF.[3,7] Even though several papers provided an analysis or assessment of energy content of BTF,[4–6,12,14,18,21,23,25,27] the papers that provided extensive examples of recipes and preparation procedures generally comprised recommendations from experienced registered dietitians.[15–17,28–30] The lack of evidence from practice guidelines raises the dilemma of the value of these recommendations and gives no indication of the underlying basis of the recipes, such as whether the composition of food items favored administration through the tube without clogging or the ability to sustain growth. Thus, this review cannot point out one ideal composition of food items. Most recipes provided approximately 1.0 kcal/ml, independently of whether energy content was calculated or clinically tested.[5,12,15,21] The recommendation for enteral nutrition in children with NI is a standard energy-density formula of 1.0 kcal/ml. If the energy requirement increases or if large volumes are not tolerated, a formula with a high energy density of 1.5 kcal/ml may be preferred.[4] None of the articles on BTF gave an example of a formula with a high energy density, and only one author described a feed of 1.25 kcal/ml.[6]

Consequently, whether BTF can provide adequate energy in individuals requiring a high energy intake is questionable. It was also worrying that BTF often did not seem to provide the energy and macronutrients expected from an estimation of the contents. Several papers discussed the issue of content in BTF with lower values of energy, protein, or micronutrients than required. Sullivan found that nutrient values were lower in general and calorie values were significantly lower than expected.[26] Viera et al.[27] showed that BTF provided 50% less energy and macronutrient values than prescribed, and de Sousa et al.[14] reported lower energy content than estimated. These findings are supported by others not included in this review,[31–33] indicating that this is a major concern. Indications of lower energy content than expected were also seen in the study by Gallagher et al,[18] who showed that an increase of up to 1.5 times in calories was required with BTF compared with CTF to sustain adequate growth. This was supported by Pentiuk et al,[6] whose cohort was given an energy content of 1.25 kcal/ml and initially experienced poor weight gain until the amount of calories was increased. A prospective study by Orel et al.[34] also supports Gallagher et al.[18] in terms of needing larger volumes of BTF to cover adequate energy and suggests supplementing BTF with, for example, medium-chain fatty acids, sugar polymers, and hypercaloric enteral formulas. Orel et al.[34] also suspected that inadequacy of BTF could be related to the preparational scope and difficulty of BTF, which is why parents and caregivers might have improvised when selecting and measuring amounts of the prescribed ingredients. On the other hand, the variation of ingredients and nutrition content that is the likely consequence of preparing BTF made of natural food items may also be a desirable advantage compared with CTF. Only Batsis et al.[12] reported retrospectively that children followed previous growth charts after transition from CTF to BTF with 1.0 kcal/ml. Possible explanations for lower nutrient content may include seasonal availability and access to food items, as well as loss of nutrients during preparation or storage.[31,32] Two studies that reported lower nutrient value than expected indicated that sieving the feed after blending had an adverse impact.[14,27] None of the other studies reported preparational procedures,[6,26] and the ones that did not include sieving were not clinical studies, which means they lacked information on the de facto nutrition content.[1,15,16,23,28–30]

Although this scoping review did not focus on the clinical outcomes of BTF, concerns about inadequate energy content were described, but the possible positive effects of BTF may be addressed as well. Pentiuk et al.[6] showed that transitioning 33 children after fundoplication to BTF gave a >50% reduction in gagging and retching in 73% of participants. This was supported by Hron et al,[5] who showed reduced gastrointestinal symptoms in patients, including reflux and vomiting, implying that improved upper gastrointestinal tolerance may reduce energy needs because of reduced nutrient loss from, eg, vomiting. Thus, improved tolerance and reduced energy loss mean that a lower intake of energy can be sufficient. Hron et al.[5] hypothesized that a possible explanation for the positive influence on tolerance is the increased viscosity of BTF. Hron and Rosen[19] and Sullivan et al.[26] reported the higher viscosity of BTF compared with that of CTF but also addressed the risk of the tube clogging because of the higher viscosity. Epp et al.[1] suggested adding extra fluid to the feed to prevent clogging, and Viera et al.[27] also saw a higher water content being used to reduce viscosity. de Sousa et al.[14] reported that the viscosity was adequate but that there was a low match between the real and estimated amounts of macronutrients. The balance between ease of administration through the tube and the possible dilution of nutrients enhances concerns about nutrition adequacy. The studies that provided examples of the composition of food items with high viscosity should be applied with awareness toward the risk of tube clogging.

Another area of importance concerns food safety. Historically, BTF was replaced by commercial products in the 1970s because they had a lower level of microbial contamination.[2] Even though BTF has advantages, the reemergence of BTF also raises concerns. Health professionals raise microbial safety as a major concern when using BTF.[7,35] The risk of contamination from the environment, poor preparation procedures, poor attention to hygiene, the transfer of the prepared feed to containers, and longer hanging times increases when using BTF.[4,36] Some papers discussed paying attention to hygiene—eg, by thoroughly cleaning utensils.[13,15,16,21–24] Johnson et al.[21] and Milton et al.[24] assessed microbial loads in BTF, which was not the case in other studies providing advice on hygiene procedures, which means that relying on their recommendations is more warranted than relying on papers describing experiences that were not necessarily documented. The preparation procedures for food items are tightly linked to food safety, so greater confidence can be put in the articles that provide more than just experience-based recommendations, highlighting the studies by Johnson et al.[21] and Milton et al.[14] Studies not included —those by Jalali et al.[37] and Sullivan et al.[38]—found that BTF prepared by hospitals was highly contaminated based on standard limits and posed a substantial risk of recipients developing infections. Even though the papers included in this review primarily are researched in North America, other papers originated from other parts of the world. One cannot rule out that different approaches to food handling worldwide may have an impact on papers showing negative outcomes of BTF compared with papers showing the benefits of BTF. When BTF is primarily prepared at home, hospital hygiene procedures might not be feasible or may be of less concern in the home environment. As demand for BTF increases, providing parents with advice is paramount, which means receiving instruction and supervision from registered dietitians or other health professionals remains highly relevant.

Unsurprisingly, all of the included papers showed that health professionals take a physiological approach to BTF but neglect to address the more psychosocial aspects or taking a holistic approach, which may be needed to accommodate families and caretakers who wish to use BTF. None of the articles described using seasoners, and only one mentioned the color and smell of BTF.[14] The only seasoning added was salt, which mainly seemed to serve a physiological purpose. Because both CTF and BTF feeds bypass the tongue, our primary organ of taste, it remains uncertain how much patients are able to taste, but appearance and scent might still play a role, providing a reason to season and present BTF to be as appealing as possible. In addition to the psychosocial aspects of BTF (eg, normalization of mealtimes and the opportunity for parents or caregivers to feel they are nurturing the child),[2] BTF makes it possible to embrace the perception of consuming ordinary food.[35] A more holistic mindset may focus more on presentation and including organic ingredients. None of the included articles addressed using organic foods, even though 82% of them were published after 2009. From a holistic point of view, this was surprising because interest in sustainability and organic products is generally on the rise.[39]

BTF also offers the opportunity to individualize feeds to address food preferences, food allergies, and food sensitivities.[2] Four of the included papers provided examples of vegetable sources for protein and milk,[17,18,22,30] with one paper specifically using gluten- and dairy-free products.[16] The fact that gluten and dairy are used is unexpected because gluten and lactose often occur in very low doses or not at all in CTF, probably for safety reasons due to the risk of allergies. Is it a good idea for BTF to contain gluten and lactose? When using natural food items, it is debatable whether excluding large groups of food items (dairy and grains containing gluten) further increases the risk of BTF containing inadequate nutrition value. This issue may not be of concern because BTF can be individually tailored to specific dietary needs. Individuals with NI are known to struggle with gastrointestinal issues but presumably do not suffer from lactose or gluten intolerance to a greater extent than the general population.

Overall, the data extracted from the included papers provided multiple examples of nutrition aspects and preparation procedures but also revealed uncertainty about the ideal composition and preparation of BTF due to the heterogeneity of the research and outcomes. This underlines that the concerns ESPGHAN raised about using BTF in children with NI are well founded.[4] Consequently, registered dietitians assisting families in implementing BTF must be aware of, for example, the risk of nutrient amounts being lower than expected and the tube clogging. Important issues to consider are whether tube feeding should be CTF or BTF or whether a combination of both would be advantageous to balance nutrition needs and tolerance.

Limitations and strengths of the scoping review process

To achieve a high level of evidence, the review adhered to the scoping review methodology and applied the PRISMA Extension for Scoping Reviews checklist. The evidence level was enhanced by the a priori protocol, and two authors selected and reviewed the studies, in addition to writing the manuscript. Despite focusing on the methodology, limitations may exist. The search for gray literature from the first tier of the taxonomy and the graduation of gray literature was undertaken in accordance with Adams et al,[11] but no literature was included. Results reflecting a more comprehensive approach to BTF may have been revealed if a broader variety of literature had been included, such as blogs by parents or caretakers. Only including papers in English or Scandinavian languages excluded potentially relevant papers in other languages.

CONCLUSION

The aim of this review was to investigate whether it is possible to give evidence-based advice regarding composition, preparation, and food safety of BTF. The 22 papers included in this review revealed information and practical experience regarding nutrition and preparation of BTF for children and adolescents with NI but provided minimal empirical evidence. In Table 1, we have summarized the many, somewhat diverging, published data. Although not all papers included this population, generalization of the results is justified. This review found multiple examples of the composition of food items and preparation procedures for BTF but also identified the uncertainty that exists concerning the ideal composition or preparation of BTF. BTF included dairy products and gluten, as opposed to CTF, which mostly contains milk-derived protein but is low in lactose and free of gluten. Most BTF recipes provided 1.0 kcal/ml but tended to contain lower amounts of energy and nutrients than expected, which could be due to preparation issues, such as sieving, and a higher viscosity in BTF than in CTF. Preparation of BTF requires a commercial-grade household blender and adequate focus on food safety, just as a high level of household hygiene is recommended. A comprehensive overview of recommendations is presented in our paper and may aid families and healthcare professionals interested in BTF.

The physiological approach of health professionals must be weighed against the more holistic approach that families and caretakers can be expected to take. Future BTF advances could include clinically tested recipes and evaluations of nutrient levels, viscosity, and microbial contamination, as well as the effect of the food's appearance and scent. This would support the many examples of the composition of food items revealed from our review that had often been nutritionally analyzed but not tested in trials. Combining the experiences of clinicians, parents, and caretakers is a beneficial approach that can be applied to develop the best possible BTF for individual children or adolescents with NI/CP.

AUTHOR CONTRIBUTIONS

Ghita Brekke, Anne Mette Terp Raun, Alfred P. Born, and Christina E. Hoei-Hansen equally contributed to the conception and design of the research; Christian Mølgaard, Sarah B. Sørensen, Karin Kok, and Jette L. Sørensen contributed to the design of the research; Ghita Brekke and Anne Mette Terp Raun contributed to the acquisition and analysis of the data; Ghita Brekke and Anne Mette Terp Raun contributed to the interpretation of the data; and Ghita Brekke and Anne Mette Terp Raun drafted the manuscript. All authors critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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