


REVIEW ARTICLE

Nutrition

State-of-the-art review of blenderized diets—Status and future directions

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Abstract

This state-of-the-art review was produced by a multidisciplinary team composed of pediatric gastroenterology and nutrition healthcare providers to provide a comprehensive overview of the use of blenderized tube feeds (BTFs). The team developed 12 vital questions to address gaps in the current understanding and practice of using BTFs, then performed a comprehensive search of literature published between 2000 and 2023 using PubMed, MEDLINE, Embase databases, and an individual search of references. There was a scarcity of well-designed randomized clinical trials, and most of the studies were prospective or retrospective observational reports from heterogeneous patient demographics, varieties of BTFs, and medical conditions. Use of BTFs was associated with improved outcomes, including higher satisfaction, reduced gastroesophageal reflux, retching, gagging, constipation, frequency of hospitalization for respiratory disease, and greater diversity of the gut microbiome. However, homemade and commercially manufactured BTFs varied in nutrient composition and physical properties, such as viscosity, which posed challenges related to ease of administration and comparison of clinical outcomes. Therefore, whereas the use of BTFs as an alternative to standard commercial formulas has become increasingly popular, further evidence is warranted to provide guidelines on best practices for usage, monitoring, and comparing clinical outcomes. Pediatric dietitians and clinician practitioners must regularly monitor children receiving BTFs to ensure nutritional adequacy, optimize safe and effective delivery, and promote optimal growth. The team proposed future directions regarding best practices for using BTFs, primarily related to clinical application and nutritional outcomes in children and adolescents.

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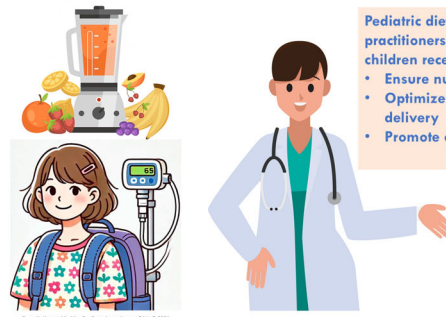
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What is known and evidence-based about blenderized tube feeds (BTF) in children?

Change to BTF from standard commercial formula has been associated with:

- Increased patient and caregiver satisfaction
- Improvement in some intractable gastrointestinal symptoms



Pediatric dietitians and clinician practitioners must regularly monitor children receiving BTFs to:

- Ensure nutritional adequacy
- Optimize safe and effective delivery
- Promote optimal growth

There is a shortage of evidence-based research on BTF use.

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KEYWORDS

blenderized tube feeds, enteral formula consistency, enteral nutrition, home nutrition support, pediatrics

1 | INTRODUCTION/BACKGROUND

The growth in interest and demand for using blenderized tube feeds (BTFs) has outpaced the availability of robust evidence-based literature that adequately informs the efficacy, indications, monitoring, and outcomes of BTFs. Since the turn of the 21st century, there has been an upsurge in interest among patients and caregivers of patients dependent on enteral nutrition support to use more natural and whole-food ingredients blended to create feedings as an alternative to commercially manufactured enteral formulas (CMFs).¹

Historical accounts about the use of blenderized feeds date back to writings from 1500 BC, when ancient Egyptians administered rectal feedings of beef, wine, broth, and other nutrients to treat various bowel disorders and foster good health. Rectal administration of various food substances continued until the early 20th century, when the development of gastric and nasogastric delivery devices² enabled the administration of BTFs. By the 1970s, reliance on home/hospital-prepared blenderized tube feeds (HBTFs) in hospital settings was rapidly replaced by CMFs, which were considered superior based on their more consistent nutrient profiles, lower risk of microbial contamination, and less labor intensive for hospital staff during preparation and administration. However, since the turn of the 21st century, the growing public perception that commercially processed foods are unnatural and unhealthy has fueled an interest in relying on natural foods³ (see Figure 1). Therefore, despite mixed reception by many in the medical community, BTFs are increasingly being used as supplemental or total replacement for CMFs as the sole source of nutrition.^{4,5}

What is Known

- Blenderized tube feeds (BTFs) are becoming increasingly popular as alternatives to commercial enteral formulas.
- Change to BTFs has been associated with increased patient and caregiver satisfaction and improvement in some intractable gastrointestinal symptoms while on standard commercial formulas.

What is New

- The shortage of evidence-based studies demonstrating the efficacy of BTFs is an opportunity for engaging well-designed prospective studies that address the knowledge gaps in indications, mechanisms, monitoring, and clinical outcomes.
- The consistent use of standardized measures when reporting efficacy and outcomes will enable clinical application and generalizability of clinical benefits of BTFs.

BTFs are now available as commercially manufactured blenderized formulas (CBTFs)⁶ (see Table 1).

The transition from CMF to BTFs has been associated with better emotional and social connections between patients and their families, improved regulation of gastrointestinal (GI) symptoms, induction of broader diversity in the gut microbiome, and potentially lower cost as compared to CMF, while being equally efficacious as CMF in supporting growth.^{4,7,8} However, many reports about the

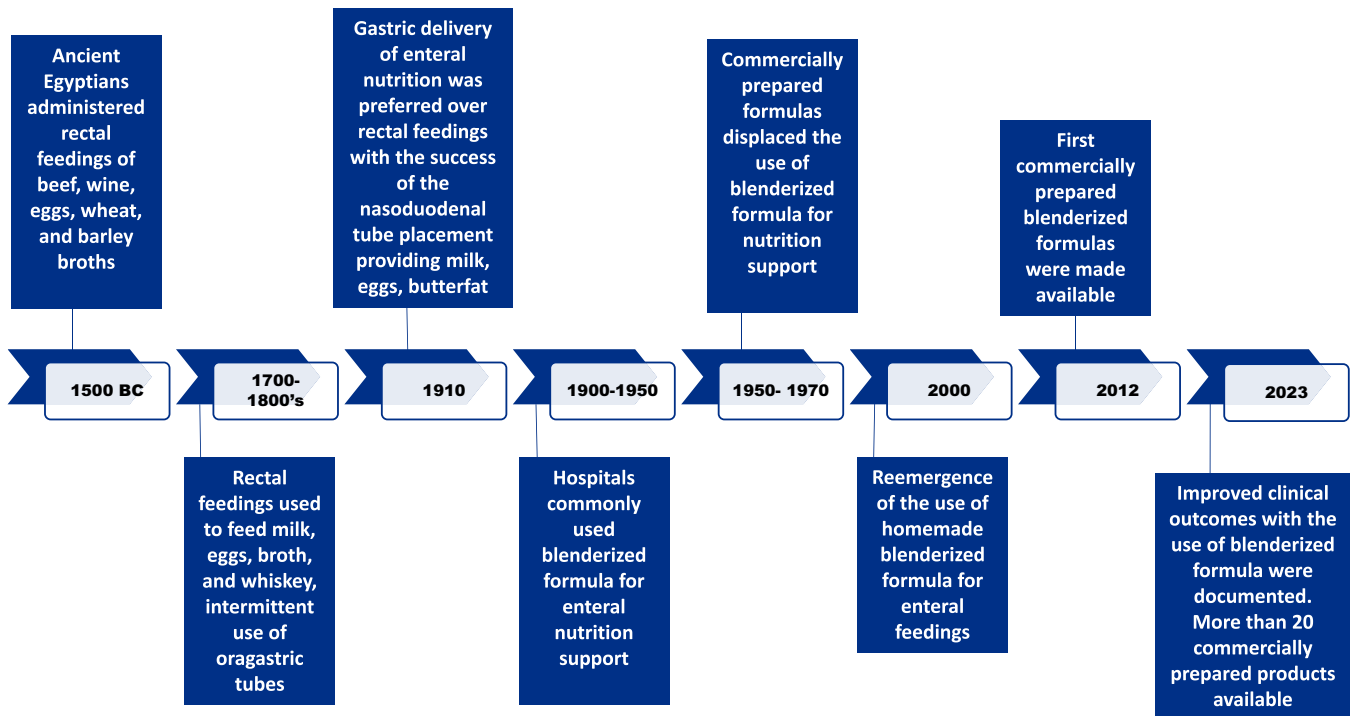


FIGURE 1 History of blenderized formulas.

efficacy of BTFs do not distinguish between HBTFs and CBTFs and lack comparison groups to validate and generalize the benefits. This state-of-the-art review will only address BTFs administered as enteral feeds, that is, directly into the GI tract, bypassing the oral cavity.⁶ This review will discuss BTFs when referring collectively, CBTFs when explicitly referring to commercially manufactured products, and HBTFs when referring to BTFs prepared in the home from natural food ingredients.

2 | METHODS

A multidisciplinary team composed of gastroenterology, hepatology and nutrition healthcare providers experienced with the use of BTFs was created. The team developed 12 vital clinical questions to address gaps in the current understanding and practice of using BTFs in children, adolescents, and young adults. The team also proposed future directions, emphasizing the clinical and growth parameters that must be consistently reported when describing the clinical applications and nutritional outcomes of BTFs in children, adolescents, and young adults. The questions are summarized in Table 2.

2.1 | Sources literature search

We searched PubMed, MEDLINE, and Embase from 2000 to 2023 to identify references published in English that addressed clinical questions. We selected peer-

reviewed articles using the following search terms: liquid diet, blender, blenderized, blended, liquified, or smoothie, combined with nutritional support, diet, or food, and combined with infants, children, and adolescents. Due to the scarcity of well-designed randomized clinical trials, many studies addressing the clinical questions were prospective or retrospective observational reports of clinical outcomes associated with heterogeneous patient populations and medical conditions. Additional references not detected by the literature search terms were identified based on the general knowledge of the literature and by checking references from relevant review articles. Titles and abstracts from the citations were scanned for potential relevance to the clinical questions. The selected studies were grouped according to clinical questions. Some studies had adequate content to address multiple questions. The manuscripts of each identified study were downloaded, and the entire document was examined for relevance to the clinical questions. The study's findings and the team's collective opinions were combined to frame the discussion.

3 | RESULTS

3.1 | What is the definition of a blenderized tube feed?

HBTFs consist of whole foods and purees typically mixed in a blender into a homogenous liquid with a fluid texture

TABLE 1 Nutrient composition of CBTFs.

	Real food blends	Nourish	Liquid hope	Kate farms pediatric blended meals	Compleat pediatric organic chicken garden blend	Compleat pediatric organic plant-based blend	Compleat organic chicken garden blend	Compleat organic plant based blend
Indicated age	>1 year	>1 year	>14 years	1–13 years	1–13 years	1–13 years	>14 years	>14 years
Caloric density (kcal/mL)	1.3	1.1	1.3	1.0	1.2	1.2	1.27	1.27
Osmolality (mOsm/kg water)	Not recorded	553	482	440–560	720	710	740	780
Thickness level (IDDSI)	Moderately to extremely thick	Mild to moderately thick	Mild to moderately thick	Not Recorded	Moderately thick	Moderately thick	Moderately thick	Moderately thick
Protein source	Chicken, turkey, egg, salmon, hemp powder, quinoa, beef, egg, salmon	Mild to moderately thick Organic pea protein, organic whole grain brown rice, organic garbanzo beans, organic green peas, organic sprouted quinoa	Organic pea protein, organic whole grain brown rice, organic garbanzo beans, organic green peas, organic sprouted quinoa, organic almond butter	Organic pea protein	Hydrolyzed pea protein, sweet potato puree, rice protein, chicken	Hydrolyzed pea protein, sweet potato puree, rice protein	Hydrolyzed pea protein, rice protein, chicken	Hydrolyzed pea protein, rice protein
Protein (g/100 mL)	3.4-5.9	3.9	6.5	3.6	4.3	4.3	6.3	6.3
Fat source	Grapeseed oil, sunflower seed, olive oil, flaxseed oil	Olive oil, flaxseed oil	Olive oil, flaxseed oil, almond butter	High linoleic sunflower oil, flaxseed oil, MCT oil	Extra virgin olive oil, canola oil	Extra virgin olive oil, canola oil	Extra virgin olive oil, canola oil	Extra virgin olive oil, canola oil
Fat (g/100 mL)	7.6–8.4	4.8	5.6	4.4	5.3	5.3	5.0	5.0
Carbohydrate source	Fruit, vegetable, oat, rice, quinoa, hemp powder	Legumes, rice, quinoa, vegetable	Fruit, vegetable, brown rice flour	Fruit, vegetable, oat flour	Fruit, vegetable, brown rice flour	Fruit, vegetable, brown rice flour	Fruit, vegetable, brown rice flour	Fruit, vegetable, brown rice flour
Carbohydrate (g/100 mL) (fiber g/100 ml)	9.7–13.5 (0.8-2.5)	14.1 (2)	13.8 (2.5)	11.2 (1.2–1.6)	13.7 (1)	13.7 (1.7)	14.7 (1)	13.7 (2)
Comparison to DRI	No synthetic vitamins and minerals added	3 pouches meet 100% of the DRI for 26 vitamins and minerals for ages 4–8 years	4 pouches meet 100% of DRI for 21 essential vitamins and minerals for ages 18 years and older	950 mL meets or exceeds 100% DRI for protein and 25 key vitamins and	900 mL meets or exceeds 100% DRI for protein and 25 key vitamins and minerals for ages 1–8 years	900 mL meets or exceeds 100% DRI for protein and 25 key vitamins and minerals for ages 1–8 years	1200 mL meets or exceeds 100% DRI for protein and 25 key vitamins and minerals for ages 14 years and older	1200 mL meets or exceeds 100% DRI for protein and 25 key vitamins and minerals for ages 14 years and older

TABLE 1 (Continued)

	Real food blends	Nourish	Liquid hope	Kate farms pediatric blended meals	Compleat pediatric organic chicken garden blend	Compleat pediatric organic plant-based blend	Compleat organic chicken garden blend	Compleat organic plant based blend
Major allergens, lactose	Egg, seafood	None	Tree nuts (almond)	None	None	None	None	None
Free water content	68%–81%	68%	68%	79%–80%	78%–81%	78%–81%	81%	81%

minerals for ages 1–8 years

Abbreviations: CBTF, commercially manufactured blenderized tube feed; DFI, dietary reference intake; IDDSI, International Dysphagia Diet Standardization Initiative; MCT, medium-chain triglyceride.

TABLE 2 Vital questions about definitions, efficacy, and application of BTFs.

1. What is the definition of BTFs?
2. What are the patient and caregiver perspectives of BTFs?
3. What are the clinicians' perspectives on BTFs?
4. What are the potential benefits of BTFs?
5. What is the nutritional adequacy of BTFs?
6. What patient age and populations need review for the appropriateness of BTFs?
7. What factors influence the administration of BTFs?
8. Are there digestive risks of post-pyloric administrations of BTFs?
9. Are BTFs associated with an increased risk of microbial contamination?
10. What are the long-term safety and monitoring concerns related to the use of BTFs?
11. What are the costs of BTFs?
12. What are future directions regarding understanding BTFs?

Abbreviation: BTF, blenderized tube feed.

and consistency that can be administered through an enteral feeding tube as supplemental feeds or the sole source of nutrition. Some families use milk or a CMF as the base and then add blenderized table foods to create their HBTF. CBTFs are commercially manufactured from natural food ingredients and then packaged and labeled as a ready-to-use liquid formula. See Table 1 for examples of CBTFs and their composition.

3.2 | What are the patient and care provider perspectives of blenderized tube feeds?

Patients and caregivers of those who receive BTFs as compared to CMFs for home enteral nutrition report improved quality of life perceptions. Adult patients ($n = 54$) who participated in a cross-sectional survey of patients on home enteral feeds stated that an interest in nutrition composed of more natural foods, a desire to consume similar meals as family members, a dislike of ingredients present in CMFs, and better GI tolerance compared to CMFs were among their primary reasons for implementing HBTFs. The lack of adequate information on how to use or prepare BTF was one of the main reasons for not using BTF as compared to CMF.⁹ Caregivers of children on home enteral nutrition favorably viewed BTFs because nutrition could be personalized based on family and cultural dietary preferences as well as avoiding allergens.^{5,10} Caregivers also felt more empowered and satisfied by the improved parent-child relationship^{7,11–13} that came with direct involvement in preparing the child's nourishment.¹⁴

3.3 | What is the clinicians' perspective on blenderized tube feeds?

Clinicians' overall response rates to surveys are low¹⁵; however, the generally expressed views about BTFs include increased interest but limited knowledge and lack of formal training about the use.¹⁶ A survey conducted among RDs registered and authorized to administer enteral nutrition ($n = 715$, 31% response rate) indicated that 28% of the respondents felt knowledgeable about BTFs. Sources for BTF education were described to be primarily from informal self-directed study, or learning from colleagues or patients.¹⁷ A cross-sectional survey in 2015 that assessed attitudes and experiences with BTFs by pediatric RDs in North America identified through a membership database ($n = 2448$) had 244 (9.9%) respondents, of whom only 58% regularly used or recommended BTFs. The reasons cited for the non-use of BTFs included limited RD time and resources, concerns about increased risk of infection, lack of opportunities for patient follow-up, and facility-related restrictions on preparing HBTFs.¹ Therefore, more work is needed to increase clinicians' awareness and education resources about the indications, use, and monitoring of BTFs.

3.4 | What are the potential benefits of blenderized tube feeds?

3.4.1 | Regulation of GI intolerance symptoms?

Some patients on enteral feeds develop recurring feeding intolerance, postprandial gagging, retching, and dumping symptoms that may be attributable to gastroesophageal reflux (GER) or post-fundoplication increased gastric hypersensitivity, impaired accommodation, and rapid emptying.^{18,19} The various studies conducted thus far have all indicated a positive correlation between change from CMFs to BTFs and improvement in reflux symptoms, gagging, retching, and oral feeding aversions.^{7,11,20,21} It is worth noting, however, that most of these reports have been based on retrospective and uncontrolled observational studies.²² The improved symptoms also allow for faster administration of syringe feedings.

3.4.2 | Response of aerodigestive symptoms to BTFs

Chronic cough, aspiration pneumonia, and frequent hospitalizations for respiratory illnesses may represent aerodigestive manifestations of GER induced by bolus gastrostomy feeds.²³ Hron et al. reviewed the clinical outcomes in 70 medically complex children who transitioned to BTFs ($n = 42$) compared to CMFs ($n = 28$)

and found a significant reduction in the frequency of hospitalizations for respiratory illnesses in association with the transition to BTFs.²⁴ The increased viscosity of BTF compared to CMF was credited for the anti-reflux effects.^{24,25}

3.4.3 | Response of intestinal microbiome to BTFs

Gallagher et al.¹¹ examined the intestinal microbiome in 17 medically complex children before and after transitioning from CMF to HBTFs. They found significantly increased bacterial diversity associated with the change in enteral feeds. Chandrasekar et al.¹² compared the fecal microbiome of children on CMF ($n = 8$) and BTFs ($n = 10$) and found a trend for greater alpha diversity in association with BTFs. Marchesi et al.²⁶ examined the fecal microbiomes of children enterally fed with CMF versus HBTFs compared with their healthy siblings consuming a regular diet. They found that children nourished with HBTFs had microbiomes similar to those of their healthy siblings, in contrast to a uniquely different microbiome among children enterally fed with CMF. Furthermore, HBTF induced a more complex microbiome than CBTFs.²⁷ In contrast, the mechanisms of exclusive enteral nutrition therapy with CMF for disease and symptom remission of Crohn's disease in children involve inducing lower diversity in the gut microbiome.²⁸ Therefore, dietary interventions that enhance or suppress diversity in the gut microbiome may need to be selected based on clinical status and disease.

3.5 | What is the nutritional adequacy of blenderized tube feeds?

CMF and CBTFs (see Table 1) are standardized in their nutrient composition in contrast to HBTFs, which vary in nutrient composition based on recipes and ingredients. Viera et al.²⁹ evaluated the nutrient composition of HBTFs and CBTFs, and reported that HBTFs had lower macronutrients and energy content compared to similar volumes of CBTFs. HBTFs also greatly vary in composition of electrolytes and micronutrients compared to CMFs.³⁰ Consequently, when creating HBTFs reputable resources should be used to provide nutritional balance among food groups, account for adequate fluid, and meet macro- and micronutrient needs.³¹ Energy intakes have been shown to be increased to maintain BMI in both pediatric and adult patients who received BTF in comparison to CMF.^{11,32} This may be related to the thermal effect of using whole food ingredients or a change in digestion due to increased microbiome diversity.¹¹

The nutritive value of BTFs may also be decreased by content of naturally occurring antinutritional factors among the ingredients such as glucosinolates, trypsin

inhibitors, hemagglutinins in legumes, tannins in cereals, and high levels of insoluble fiber that may interfere with the absorption of nutrients.³³ Added herbal extracts, such as mangosteen and quercetin, may cause drug–nutrient interactions with serious health consequences.³⁴ Therefore, the involvement of a dietitian or a clinician with expertise caring for the nutritional needs of medically complex patients is essential for nutritional assessment, nutrient prescription, and monitoring of nutritional outcomes in patients on BTFs.^{6,35}

3.6 | What patient age and populations need review for the appropriateness of blenderized tube feeds?

The American Academy of Pediatrics (AAP) recommends human milk as the sole feed for healthy term infants during the first 6 months of life and that breastfeeding should continue for at least 12 months while weaning foods rich in iron and zinc are introduced.³¹ When human milk is limited or unavailable, the AAP recommends iron-fortified infant formula. The Food and Drug Administration (FDA) guidance document³⁶ stipulates that before marketing, manufacturers of “infant” formulas should follow good clinical practice and conduct well-controlled growth monitoring studies that demonstrate the formula supports normal physical growth and nutrient status. Therefore, BTFs may be used only as supplemental feeds and not as the sole source of nutrition in infants. For children older than the age of 1 year, the choice of enteral formula is guided by their growth status, underlying disease, and GI tolerance.

3.6.1 | Moderate to severe malnutrition

Whole milk has the highest protein quality, digestibility, and bioavailability compared to plant-based protein³⁷ and other protein sources.³⁸ Therefore, in the absence of dairy allergy or intolerance, a cow milk protein-based formula is the preferred source of nourishment for infants and children with severe malnutrition during the initial phases of nutritional rehabilitation.³² HBTFs are variable in nutrient source, composition, and digestibility therefore may not be appropriate for managing severe malnutrition when CMF options are available.³⁹

3.6.2 | Patients with delayed gastric emptying

Gastric emptying is slower after consuming a solid rather than a liquid meal.⁴⁰ Hron et al.⁴¹ compared gastric emptying rates after bolus feeds with CMF ($n = 15$) versus BTF ($n = 32$) in children aged 6 months

to 20 years, using the criteria of 1-h gastric residual volumes $\geq 60\%$ as indicative of delayed gastric emptying. Based on these criteria, they found similar rates of delayed gastric emptying among patients fed BTFs versus CMFs. The patients who received BTF tolerated larger bolus volumes and also had larger residual volumes compared to those given CMF. As with all enteral feeds, signs of intolerance should be assessed.

3.7 | What factors influence the administration of blenderized tube feeds?

The unique viscosity and thickness of BTFs are thought to relate to improved clinical symptoms but are also associated with administration challenges. BTFs have an increased risk for clogging events and incomplete delivery of prescribed feeds when administered using infusion pumps.^{42,43} Therefore, successful administration of BTFs requires attention to viscosity management, the size of delivery tubing, and whether the delivery method is by manual/gravity bolus or infusion by enteral feed infusion pump. A G-tube size that is at least 14 French (Fr) is recommended for BTFs to prevent clogging and ensure safe administration, although there are reports that smaller tube sizes have been used depending on the blend.³⁵ The viscosity and thickness of BTFs vary between and within different HBTFs and CBTFs (see Table 1). BTFs with viscosity levels corresponding with moderately thick, according to the International Dysphagia Diet Standardization Initiative (IDDSI) Syringe Flow Test, are poorly delivered by routine enteral feed infusion pumps.⁴⁴ The IDDSI Syringe Test^{45,46} is a bedside test that standardizes the description and categorization of fluids as “thin liquids,” “slightly thick,” “mildly thick,” and “moderately thick.” Moderately thick fluids may need dilution for ease of administration when using an enteral feeding pump, however overthinning may result in a loss of the clinical benefits imparted by the thicker viscosity and should be done judiciously.⁴⁵ Using O-ring syringes, large bore gravity bags, or reusable tube feeding pouches can assist in administering thicker feeds effectively.³¹

The viscosity and thickness of HBTFs are influenced by the fluid content of the ingredients, immediate use, storage practices such as freezing and then thawing before use, and particle size.⁴⁷ Freeze storage and then thawing before use changes the viscosity and thickness of HBTFs unpredictably, and the effects vary depending on whether the thawed volume was a large batch (>300 mL) or a small aliquot (30 mL).⁴⁷ This storage- and temperature change-induced variation in viscosity and thickness may explain the unpredictable efficacy of HBTFs in regulating some GI symptoms. Achieving a smaller particulate size requires a longer blend time, higher blender wattage,³⁵ or inclusion of a

sieving step. However, sieving reduces the meal's nutritive value through nutrient loss in the non-sieved discarded residue.⁴⁸

3.8 | Are there digestive risks of post-pyloric administration of BTFs?

There is insufficient data to support or oppose the post-pyloric administration of BTFs. However, the requirement for slow continuous administration, reliance on small diameter enteric feeding tubes, and preference for isotonic feeds⁴⁹ make post-pyloric delivery of HBTFs inappropriate. Furthermore, distal jejunal delivery of nutrients activates the "ileal brake," which increases secretion of peptide YY and glucagon-like peptide 1 that have the physiological effect of inhibiting exocrine pancreatic enzyme synthesis⁵⁰ leading to increased risk for maldigestion and malabsorption. Therefore, an elemental-, partially hydrolyzed-, or isotonic formula is preferred for ease of administration, and optimal nutrient digestion and absorption of post-pyloric enteral feeds.⁵¹

3.9 | Are blenderized tube feeds associated with an increased risk of microbial contamination? How can the contamination risks be reduced?

The US Food Code/FDA standards to minimize the risk of food-borne microbial illnesses through commercially manufactured foods require that aerobic bacterial counts not exceed 10^4 colony forming units (CFU) in a single sample or 10^3 CFU in three or more samples of enteral feeds.⁵² Increased risk for microbial contamination was among the reasons for the preference for CMFs and decreased reliance on HBTFs.⁵³ The risk of microbial contamination of HBTFs is higher at warmer ambient temperatures and when the duration of hang time exceeds 2 h (<1 h if the temperature exceeds 90°F).⁵⁴ On the contrary, bolus administration within 20 min, immediately followed by cleaning all the reusable equipment according to the manufacturer's instructions, can keep microbial counts below the contamination threshold even after multiple re-use cycles.⁵⁵ Furthermore, when the preparation of HBTFs adhered to a recipe that utilized pasteurized shelf milk, a canned source of protein, and replaced fresh fruits and vegetables with their frozen versions, the rates of microbial contamination were significantly minimized.⁵⁵ Therefore, the risk for increased microbial contamination of HBTFs may be managed by adhering to safe equipment care practices and utilizing enteral delivery protocols that rely on bolus administration and formula hang-time durations shorter than 2 h, assuming

hot temperatures are avoided. Hang times for CBTFs range based on the manufacturer's guidelines.

3.10 | What are the long-term safety and monitoring concerns related to the use of BTFs?

Enteral nutrition is indicated in children with clinical states associated with severe inability to maintain oral intake at rates sufficient for sustaining average protein–energy balance, growth, and physical activity at rates consistent with good health. Therefore, the concerns are increased risk for inadequate or excess malnutrition and micronutrient deficiencies. Historically, the change to BTFs in children has frequently been parent-initiated.¹ A survey administered to caregivers participating in an online pediatric tube feeding support group revealed that only half of the respondents reported using BTFs and referred to their healthcare providers for recipes and feeding oversight.⁵⁶ Similar findings occurred among adult patients on HBTFs.⁹ Therefore, using HBTFs requires anticipating the potentially increased nutrition-related health risks posed by patients and caregivers who fail to seek or cannot obtain proper supervision. A registered dietitian or equivalent practitioner should perform the initial assessment and long-term monitoring of BTFs at least quarterly or at a cadence relevant to the patient's age and nutrition status.³⁵ Additionally, the introduction of whole foods and fiber may be associated with anastomotic ulcer disease in children with short bowel syndrome associated with the surgical anatomy of ileal-colonic anastomoses. These patients should be monitored for the potentially increased risk of developing bacterial overgrowth and inflammation.^{57,58}

3.11 | What are the costs of BTFs?

Insurance coverage may enable increased affordability for CMFs or CBTFs; however, for patients with no insurance coverage for enteral feeds, the direct costs of HBTFs can be lower than CBTFs and CMFs. Pentiuk et al.⁷ estimated the cost of a day's worth of HBTF prepared using pureed meats, vegetables, and fruits mixed in commercial formula or milk, providing ~942 kcal/day at \$6.20 compared to \$8.00/day for CMF providing equivalent calories. Mezzomo et al.⁸ also compared the cost of HBTFs and CMFs based on \$/2000 kcal and found a difference of \$29.7 versus \$154, indicating significant savings using HBTFs. However, the lower monetary costs of HBTFs compared with CMFs should also be balanced with the potentially higher indirect costs of time and effort required for purchase, preparation, storage, and more meticulous infection avoidance protocols.⁵⁵

4 | FUTURE RESEARCH DIRECTIONS

There is a need for guidance about the classification and determination of the components responsible for the symptom-modulating benefits of BTFs. Future reports and studies are encouraged to address the following limitations that perpetuate knowledge gaps:

1. A significant limitation to generalizing the efficacy of BTFs is the increased heterogeneity in subject demographics, disease severity, and inconsistent use of standardized methods for comparing growth and clinical outcomes, such as growth z-scores and disease severity indices. Therefore, future reports and studies are encouraged to utilize standardized reporting tools, including growth z-scores and disease monitoring tools, such as Pediatric Gastroesophageal Reflux Disease Symptom and Quality of Life Questionnaire, Pediatric Quality of Life Inventory, Pediatric Gastrointestinal Symptom Scale, and Bristol stool scores.
2. Reports and studies about the nutritional efficacy of BTFs should document the involvement of dietitians in nutrition assessment, calorie prescription versus delivery, other sources of nutrition, duration of therapy, and anthropometric monitoring.
3. Comparisons of the nutritional efficacy and outcomes of BTFs should be based on documented isocaloric, isonitrogenous intakes, and site of administration (gastric vs. post-pyloric).
4. Reports and studies examining the efficacy and outcomes of BTFs should distinguish CBTFs from HBTFs, clinical indications, and differentiate gastric from post-pyloric administration.
5. Studies and reports examining the efficacy of BTFs in modulating GI and aerodigestive symptoms are encouraged to report osmolality⁴⁷ and or viscosity scores estimated using the IDDSI method⁴⁵ or an alternative standardized tool (see Table 1).
6. Short bowel syndrome is a disease category with heterogeneous involvement and thus requires carefully designed studies. Therefore, reports and future studies examining the efficacy of BTFs on nutritional outcomes and symptom modulation in patients with short bowel syndrome are encouraged to use the recommended nomenclature of types 1, 2, and 3 short bowel syndrome⁵⁹ to stratify patients. This will help determine whether the postsurgical anatomy should guide the indications and efficacy of BTFs.
7. Advancements in medical devices are used to administer BTFs to improve ease of delivery and accuracy of volumes administered.

5 | CONCLUSIONS

Progress in enteral nutrition support has enabled the successful nourishment of patients at risk of malnutrition because of the inability to consume adequate nutrition orally. BTFs, the original source of enteral nutrition then superseded by CMF, have come full circle and are now increasingly popular in HBTF and CBTF options. Compared with CMF, the reported benefits include similar nutritional efficacy when monitored by a dietitian, improved regulation of GI symptoms, increased psychosocial satisfaction, and lower costs. However, a significant limitation to the generalized use of BTFs remains the lack of evidence-based studies that distinguish objective from perceived benefits. Therefore, there's an opportunity to conduct well-controlled studies that utilize standardized terminology and outcome parameters to guide best practices in using BTFs. There is also a need for increased educational opportunities and resources for dietitians, advanced practice providers, and physicians about using BTFs.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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