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# Blended tube feeding prevalence, efficacy, and safety: What does the literature say?

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**ABSTRACT**

**Background and purpose:** For most of human history, physicians used blended whole foods for patients who are unable to eat by mouth. However, by the 1960s and 1970s, advances in enteral nutrition resulted in the gradual displacement of blenderized tube feedings (BTFs) with commercial formulas. There are advantages and disadvantages to commercial formulas and BTFs. The purpose of this article was to review the literature for the incidence of blended tube feeding use and its safety, efficacy, and implications for clinical practice.

**Methods:** A search of the scientific literature in PubMed, CINAHL, Cochrane, ProQuest, and Ovid was conducted using the keywords "blenderized tube feeding" and "blended tube feeding." Articles were divided into two categories: 1) frequency of use and experiences of BTF in patients or caregivers and health care providers and 2) safety/efficacy studies.

**Conclusions:** The literature review shows a rising interest in BTF, with more research on efficacy indicated.

**Implications for practice:** The use of BTF is primarily patient or caregiver driven. Blenderized tube feeding requires oversight by health care providers just as commercial formulas. Health care providers should be aware of the use of BTF and the effect it can have on different patient populations regarding content, cost, safety, and efficacy in the clinical and home settings.

**Keywords:** Blenderized tube feeding; commercial formulas; enteral nutrition; efficacy.

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## Introduction

For most of human history, physicians used blended whole foods for patients unable to eat by mouth. Papyrus records dating over 3,500 years reveal that patients received rectal feedings of beef, wine, eggs, wheat, and barley broths (Chernoff, 2006; Harkness, 2002). As late as 1881, US president James Garfield survived on rectal feedings for 79 days after an assassination attempt (Campbell, 2006). Efforts to feed patients through the upper gastrointestinal (GI) tract began in the 12th century but resulted in poor outcomes (McCamish, Bounous, & Geraghty, 1997). Advances in surgical techniques and medical products enabled the widespread use of enteral nutrition (EN) in the 1900s (Chernoff, 2006; Harkness, 2002). Initially, hospitals prepared blended foods introduced through nasogastric tubes (Campbell, 2006). However, by the 1960s and 1970s, advances in EN resulted in the gradual displacement of blenderized tube feedings (BTFs) with commercial formulas (CFs) (Chernoff, 2006). Commercial formulas offered the advantages of delivering a sterile product with a known nutrient composition by pumping through smaller bore tubes. Hospitals concerned about microbial overload and labor-intensive BTFs of an uncertain nutrient composition gradually established policies against their use (Chernoff, 2006). However, not all physicians were supportive. Barron and Fallis (1953) asserted that no formula was superior to feeding whole foods and demonstrated the successful use of their own BTF in gastric and jejunal feedings. Furthermore, BTF has persisted as the primary feeding substrate in tube-fed patients where CF is not available (Frizzi, Ray, & Raff, 2005; Odigie et al., 2011). Despite the advantages and widespread availability of CF and the concerns of BTF, interest and use of whole food tube feeding has reemerged (Coad et al., 2017; Klein & Morris, 2007; Mortensen, 2006).

## Purpose

Blenderized tube feeding is simply defined as tube feedings made from whole foods (Fussell, 2003). In

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addition to the concerns of high microbial load, uncertain nutrient composition, and potential to clog feeding tubes, preparation of BTF is time consuming, and costs are not typically covered by medical plans (Borghi, Araujo, Vieira, DeSousa, & Waitzberg, 2013; Jalali, Sabzghabaee, & Badri, 2009; Sullivan et al., 2001). Patients who use BTF may encounter resistance from the medical community when seeking treatment. Those who use or are interested in BTF may choose to "go it alone" without the oversight of health care providers (HCPs). Some reports indicate that BTF does not support adequate growth and poses the risk of infection. Other published work suggests that BTF concerns are overstated; whole food blends may be preferable to CFs in selected patients, making the scant published work equivocal. The purpose of this article was to review the existing literature for estimated BTF use and safety and efficacy and to provide implications for clinical practice.

## Methods

A search of the scientific literature in PubMed, Cochrane, CINAHL, Ovid, and ProQuest was conducted using the keywords "blenderized tube feeding" and "blended tube feeding." Article references were also searched for relevant articles. Inclusion criteria were English language and less than 10 years since publication. The search generated 14 articles, and 10 met inclusion criteria for this review. Articles were divided into two categories: 1) frequency of use and experiences of BTF in patients or caregivers and HCPs and 2) safety/efficacy. Articles are summarized in Tables 1 and 2.

## Results of frequency of use and experiences of blenderized tube feeding in patients or caregivers and health care providers

The literature search produced five surveys on BTF use: three studies surveyed EN-fed adults and/or children or their caregivers (Epp, Lammert, Vallumsetla, Hurt, & Mundi, 2017; Hurt et al., 2015; Johnson, Spurlock, Epp, Hurt, & Mundi, 2017), and two studies surveyed registered dietitians on the use of BTF in clinical practice (Armstrong, Buchanan, Duncan, Ross, & Gerasimidis, 2016; Johnson, Spurlock, & Pierce, 2015), summarized in Table 1. Epp et al. (2017) posted a self-administered survey on the Oley Foundation website targeting patients on home enteral nutrition (HEN). The Oley Foundation is a national nonprofit organization supporting patients on home intravenous nutrition. Two hundred sixteen patients completed the survey, representing approximately 5.8% of the registered EN Oley members (3,748) and less than 2% of the estimated population of EN patients in the United States (>150,000). Although the survey sample is not likely representative of the entire EN-fed population, participants were less likely to experience weight loss on BTF compared with CF-fed patients (Epp et al., 2017).

Johnson et al. (2017) found similar results in a survey of parents of tube-fed children. Half of the parents who completed the online survey used full or partial BTF. Primary reasons parents did not use BTF included lack of knowledge and time constraints. Primary reasons for choosing BTF included a desire to provide a "natural" feeding, reduce tube feeding intolerance, or improve oral intake. Furthermore, parents indicated that BTF reduced GI problems and supported growth goals compared with CF-fed children (Johnson et al., 2017). These outcomes are similar to the survey by Hurt et al. (2015) of adult patients on HEN. However, a consistent and worrisome finding from the surveys by Johnson et al. (2017) and Hurt et al. (2015) is that less than half of the respondents rely on HCPs for BTF oversight (49% and 16%, respectively).

Two studies surveying the use/attitudes of BTF by registered dietitians/nutritionists (RDNs) working in pediatric populations are summarized in Table 1. Armstrong et al. (2016) reported that the majority of RDNs in the United Kingdom had experience with BTF, but half were not supportive of the feeding. The latter position is aligned with policies of the British Dietetic Association (2015) and the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (Braegger et al., 2010). However, these RDNs indicated that they would be more likely to support BTF if evidence-based guidelines were available or use BTF to supplement CF feeding. Primary reasons RDNs were reluctant to support BTF included concerns about nutritional inadequacy, tube blockages, and increased risk of infection. However, RDN perceptions of these potential problems were significantly higher than actual observations in clinical practice ($p < .001$). Furthermore, high caregiver involvement and reduced reflux and vomiting were the main perceived and observed benefits in BTF children (Armstrong et al., 2016). By contrast, Johnson et al. (2015) found that the majority of US pediatric RDNs use and recommended BTF primarily because of parent request to reduce tube feeding intolerance or inability to obtain CF. Similarly, these pediatric RDNs expressed concerns about infection, lack of follow-up with families, and unknown nutrient composition of BTF (Johnson et al., 2015).

## Results of safety and efficacy of blenderized tube feeding

The literature search produced five publications on the safety/efficacy of BTF. Vieira, Santos, Bottoni, and Morais (2016) analyzed the microbial load and macronutrient content provided to 66 adults on HEN in Brazil where CF costs are not typically covered. Nutrition status was assessed by mid-upper arm circumference and triceps skinfolds to assess nutrition status. In this sample, half received CF and half used BTF. All patients received counseling from dietitians, but feeding compliance was not evaluated. Blenderized tube feeding analysis found

**Table 1. Studies exploring estimated use of BTF in patient surveys and HCP surveys**

| | Study | Type | Sample Size | Main Findings |
|---|---|---|---|---|
| Patient surveys | Johnson et al. (2017) | Cross-sectional descriptive survey of families of tube-fed children in an online nutrition support group (United States) | *N* = 430 | 50.5% used full or partial BTF |
| | | | Average age of children = 4.8 years | 62% made own BTF recipes |
| | | | Average number of years on EN = 3.5 | 75% parents reported that BTF provided ¾ of total nutrition |
| | | | | 49.3% of parents using BTF refer to HCPs for oversight |
| | Epp et al. (2017) | Cross-sectional descriptive survey of HEN patients and/or families of HEN patients using an international EN support website | *N* = 216 | 89.6% of pediatric patients |
| | | | 57.8% children | 65.9% of adult patients used full or partial BTF |
| | | | 42.2% adults | |
| | Hurt et al. (2015) | Cross-sectional survey of adults on HEN followed in an outpatient clinic | *N* = 54 | 55.5% used full or partial BTF |
| | | | | Used BTF because |
| | | | | "More natural" (43%) |
| | | | | Promote eating with family (33%) |
| | | | | Better tolerance (31%) |
| | | | | 80% found that BTF helped maintain the body weight goal |
| HCP surveys | Armstrong et al. (2016) | Cross-sectional descriptive survey of British pediatric RDNs | *N* = 77 | 55.8% had experience with BTF |
| | | | | 54% would not use or would advise against BTF |
| | | | | RDNs more likely to support BTF with |
| | | | | EBP guidelines (74%) |
| | | | | To supplement CF feeding (56%) |
| | Johnson et al. (2015) | Cross-sectional descriptive survey of US pediatric RDNs | *N* = 243 | 57.6% use and recommend BTF |
| | | | | 13.9% did not use or recommend BTF |
| | | | | 28.4% wanted more information on BTF |
| | | | | 76.9% reported overall positive outcomes with BTF |

*Note: BTF = blenderized tube feeding; CF = commercial formula; EN = enteral nutrition; HCP = health care provider; HEN = home enteral nutrition; RDN = registered dietitian/nutritionist.*

**Table 2. Safety/efficacy of blended tube feeding**

| Study | Type | Sample Size | Variables | Main Findings |
|---|---|---|---|---|
| Vieira et al. (2016) | Cross-sectional, prospective | *N* = 66 adult patients on HEN in Brazil | Anthropometrics: triceps skinfolds and mid-upper-arm circumference | BTF had 50% less macronutrient value compared with CF |
| | | 50% used BTF | EN analysis for nutritional and microbiological qualities | Undernutrition reported as follows: |
| | | 50% used CF | | 64% in the BTF group |
| | | | | 48% in the CF group |
| Samela et al. (2016) | Retrospective, observational | *N* = 10 children followed in an intestinal rehab medical center weaned from PN but on elemental or semielemental CF | Stool frequency, consistency, and volume; weight | 90% children successfully transitioned to a CF product that contained real food |
| | | | | 100% of transitioned children experienced |
| | | | | Improved stooling |
| | | | | Age appropriate weight gains at 6-month and 1-year follow-up |
| Gallagher et al. (2015) | Prospective, 6-month feasibility study | *N* = 16 convenience samples of pediatric outpatients followed in a Canadian hospital | Gastrointestinal symptom questionnaires; feeding problem assessment | 76% successfully transitioned to BTF |
| | | | | 60% found that BTF was more time consuming |
| | | | | 47% found that BTF was more expensive |
| | | | | 93% of parents reported positive outcomes |
| | | | | 1.5 times more calories were required to sustain weight/growth on BTF compared with CF |
| Pentiuk et al. (2011) | Single-center, prospective, observational study of CF tube-fed children transitioned to BTF | *N* = 34 children after fundoplication with tube feeding intolerance | Anthropometric variables; symptoms of tube feeding tolerance; caregiver satisfaction | 84% reported immediate and sustained reductions in tube feeding intolerance |
| | | Median age = 34.2 months | | 57% using BTF reported increased oral acceptance of food with no reductions in oral intake |

(*continued*)

**Table 2. Safety/efficacy of blended tube feeding, *continued***

| Study | Type | Sample Size | Variables | Main Findings |
|---|---|---|---|---|
| Santos and Morais (2010) | Prospective, observational | *N* = 30 Brazilian children on HEN fed with either milk-based or soup-based BTF | Anthropometric variables; macronutrient analysis of milk-based and soup-based BTF preparations | The prevalence of underweight declined from 30% (9/30) to 20% (6/30), but stunting increased from 30% (9/30) to 53% (16/30)<br>Only 70% of milk-based BTF and 50% of soup-based BTF provided prescribed nutrition |

*Note: BTF = blenderized tube feeding; CF = commercial formula; EN = enteral nutrition; HEN = home enteral nutrition; PN = parenteral nutrition.*

that the samples provided 50% less energy and macronutrient values than prescribed and had higher water content (Vieira et al., 2016). Blenderized tube feedings are more viscous and may require additional water to prevent the clogged tube—diluting the nutrition value of the original BTF recipe. This likely explains why BTF patients received half of the prescribed nutrition needs. The prevalence of undernutrition was high in both groups but higher in the BTF group. Other variables that contribute to malnutrition including age, diagnosis, nutritional status, socioeconomic conditions, and physical activity were not assessed. A larger sample size is required to measure those associations. Microbial load was highest in the BTF preparations, but the impact on patient outcomes was not assessed (Vieira et al., 2016).

Samela, Mokha, Emerick, and Davidovics (2016) attempted to transition 10 children followed in intestinal failure (IF) rehabilitation to a CF product that contained real foods. Six of 10 children had a history of necrotizing enterocolitis, two had gastroschisis, and two had intestinal atresias. Nine had a gastrostomy tube, and one had a jejunostomy tube. All patients were on elemental or semielemental (hydrolyzed) CF products. Although no single CF product is recommended for IF, physicians typically select hydrolyzed products that provide 20–24 calories per ounce. However, they are unpalatable, expensive, have high osmolality, and lack complex nutrients including fiber. Nine children (median age 30 months) were successfully transitioned to the CF product that contained real foods in an average of 67.3 days (range, 2–322 days; M = 18 days). Only one child (gastrostomy fed) was not able to transition to the real food product. Parents reported improved stooling patterns in all nine children. Supplemental fibers required when the children received elemental formula were not needed after the transition. All children maintained age appropriate weights at 6- and 12-month follow-up visits. Samela et al. (2016) concluded that children with IF may successfully transition from a hydrolyzed product to a CF with real food ingredients if they have 30–40 cm of small bowel, at least two-thirds of continuous bowel, and a functional ileocecal valve (Samela et al., 2016).

In a single-center prospective feasibility study, a convenience sample of 16 children in a Canadian hospital were transitioned from a CF tube feeding to a BTF (Gallagher et al., 2015). Those enrolled had to be medically stable, aged 1–16 years, have a gastrostomy tube >12 French, and receive 75% or more of calories from CF tube feeding. Caregivers completed a GI symptom questionnaire, a stool scale, and a feeding problem assessment questionnaire. Families also completed satisfaction and time/cost studies. Registered dietitians/nutritionists provided extensive education during the transition period and follow-up through 6 months. The majority were successfully transitioned to BTF. The remaining subjects either dropped out because of distance for follow-up, were not able to reach the goal of 75% feeding from BTF, or transitioned to oral feeding. Parent perception of the BTF was overwhelmingly positive, although more than half indicated that it was more time consuming and almost half believed that it was more expensive than CF feeding. Significant reduction in emesis ($p = .016$) and improved stool scale score ($p = .015$) were reported. Patient need for motility agents and antacids decreased on BTF but did not reach statistical significance. There was no change for laxative use. However, 50% more calories were needed to sustain weight and growth goals with BTF compared with CF feeding (Gallagher et al., 2015).

Pentiuk, O'Flaherty, Santoro, Willging, and Kaul (2011) transitioned 34 US children with tube feeding intolerance to BTF in a single-center observational study. An RDN evaluated each child, developed the BTF recipe based on individual needs, and provided instruction and oversight to families. Children unable to tolerate 100% BTF at baseline were transitioned over time, with a 50% CF night infusion and BTF boluses during the day until 100% BTF was reached. Blenderized tube feeding sustained growth

trajectories of all children, and an overwhelming majority reported immediate and sustained reductions in gagging, retching, and vomiting. Parents also reported the reduced incidence of constipation. Oral intake improved in patients attempting to wean from the tube, and no child had a reduced oral intake (Pentiuk et al., 2011).

Santos and Morais (2010) analyzed BTF preparations of 30 children on HEN in Brazil. These children used one of two recipes—milk-based and soup-based BTFs. Analysis of the recipes as administered revealed that neither provided prescribed nutrient needs. Anthropometric variables at enrollment were compared with measures made at the time of the study. The prevalence of underweight decreased from baseline to post-assessment. However, stunting increased but did not reach statistical significance ($p$ = .511) (Santos & Morais, 2010). All 30 children in the study were nonambulatory, and 27 were on mechanical ventilation. Their energy requirements were likely much less than estimated, which explains why the BTF did not negatively affect the children's weights.

## Implications for practice

This review of the limited published work on BTF has numerous implications. The use of BTF may be more widespread than appreciated by the medical community where CF is the standard tube feeding. Surveys of patients and RDNs indicate that BTF is primarily patient or caregiver driven by a desire to provide whole foods, reduce tube feeding intolerance, and improve oral intake. Industry is responding with BTF product development and CF product reformulation. As patient interest in unprocessed foods increases, the demand for whole food enteral products and homemade BTF is likely to increase.

In addition, BTF requires oversight by trained HCPs (preferably RDNs), although all providers should screen tube-fed patients for interest or the use of BTF. In a Polish multicenter observational study, Klek et al. (2014) compared anthropometric, biochemical, health care costs, hospital admissions, and length of stay (LOS) variables in HEN adults and children fed BTF for 12 months followed by CF feeding for 12 months. They found significant reductions in the number of hospital admissions, LOS, and health care costs during the CF feeding period. However, these outcomes could not be attributed to the type of feeding because close EN monitoring by the home health care team occurred only during the CF feeding period. It is likely that the patient care provided by the home health team rather than the type of tube feeding was responsible for the positive outcomes (Klek et al., 2014). Medical facilities may need to reevaluate policies on BTF to provide training for HCPs and support for patients and families interested in or using blended foods for tube feeding. Surveys summarized in the article found that less than half of patients or caregivers rely on HCPs for feeding oversight, yet more than two-thirds prepared their own BTF solutions using a variety of resources. Blenderized tube feeding advice from nonmedical sources cannot account for individual patient needs, lack continuity of care, and provide inconsistent information. Successful BTF outcomes in the pediatric population studies by Samela et al. (2016); Gallagher et al. (2015); and Pentiuk et al. (2011) are likely due to judicious patient selection and continued monitoring. BTF evaluation and sustained oversight is particularly important in pediatric populations because children have less nutrient reserves and greater nutrient needs per kilogram body weight compared with adults. Frank nutrient deficiencies are documented in BTF-fed children who were not followed by RDNs (Bobo, 2016).

In addition, the concerns about BTF variability, microbial load, and costs may be overstated (Borghi et al., 2013; Klek et al., 2014; Santos & Morais, 2010). Although BTF is not standardized, CF is monotonous and lacks phytochemicals and whole food constituents that confer benefits to the gut microbiome and body. Several studies reviewed here attributed improved GI function to diversity of whole food feeding. Patient and caregiver surveys reported that BTF supported growth and weight goals (Epp et al., 2017; Hurt et al., 2015; Johnson et al., 2017) in contrast to the study by Vieira et al. (2016). UK dietitians Armstrong et al. (2016) were resistant to BTF because of concerns about inadequate nutrient provision and infection risk, but they did not observe a higher incidence of these in clinical practice. Furthermore, although higher microbial loads were found in the BTF compared with CF in the studies by Klek et al. (2014); Santos and Morais (2010); and Vieira et al. (2016), there was no evidence that patients in these studies experienced a higher incidence of infection.

Finally, costs of BTF should be assessed in the context of patient care (Gallagher et al., 2015; Johnson et al., 2017; Samela et al., 2016). This review found that costs associated with tube feeding may actually be less with BTF owing to reduced needs for medications, less costly formulas, and access to CF.

Some patients experience the benefits of BTF when only part of the feeding is provided by whole foods. Several parents of children with tube feeding intolerance reported that adding baby foods to their child's CF improved tube feeding intolerance (Johnson et al., 2017). In a retrospective cohort study of neonates with bowel resection and tube feeding intolerance at Children's Hospital of Illinois ($N$ = 18), adding green beans to their infant formula improved stool consistency in every infant. Sixty-one percent were able to wean from parenteral nutrition (Drenckpohl et al., 2013). Samela et al. (2016) and

Sousa, Ferreira, and Schieferdecker (2014) also propose that combining BTF with CF would mitigate the drawbacks of each.

## Conclusions

All HCPs should be prepared to screen BTF candidates. Blenderized tube feeding–fed patients must be aged at least 6 months with a tube diameter of ≥14 French (Bobo, 2016). They should be medically stable on an HEN regimen with a mature gastrostomy site (Bobo, 2016). Patients must not be volume intolerant, as BTF typically requires a higher volume than CF to deliver equal energy and nutrition. Patients must not have metabolic disorders or multiple food allergies that prohibit whole food feeding. Patients and caregiver motivation and resources must be considered. Blenderized tube feeding is labor intensive and requires additional food storage space and equipment not covered in medical plans. Access to RDNs for BTF recipe and patient evaluation at baseline and regular follow-up intervals is imperative. Blenderized tube feeding–trained nutrition support teams can mitigate potential concerns of BTF including bacterial overload and inadequate nutrient provision identified in the studies (Klek et al., 2014; Santos & Morais, 2010; Vieira et al., 2016).

Interest and use of BTF is reemerging as a viable feeding substrate for selected patient populations. Health care providers should be trained to screen all enterally fed patients and caregivers for use or interest in BTF and refer to trained RDNs or feeding teams for evaluation and oversight.

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