



Health Outcomes and Quality of Life Indices of Children Receiving Blenderized Feeds via Enteral Tube

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Objective To determine whether clinical and patient-reported outcomes differ in children receiving blenderized diets compared with conventional formula.

Study design We conducted a prospective cohort study of 70 children aged 1-18 years receiving blenderized diets vs conventional formula via feeding tube. We assessed rates of hospitalization and visits to the emergency department (ED) at Boston Children's Hospital in 2017 and Likert scale addressing satisfaction with feeding regimen; Pediatric Gastroesophageal Reflux Disease Symptom and Quality of Life Questionnaire; Pediatric Quality of Life Inventory; and Pediatric Quality of Life Inventory Gastrointestinal Symptoms Scale.

Results Participants receiving blenderized diets ($n = 42$, 60%) did not differ in demographics or comorbid diagnoses from those receiving conventional formula ($n = 28$, 40%). Rates of total visits to the ED (0.8 ± 1.5 vs 1.4 ± 2.7 , $P = .05$), total admissions (0.8 ± 1.2 vs 1.7 ± 2.3 , $P = .01$), and respiratory-related admissions (0.2 ± 0.5 vs 0.6 ± 0.8 , $P = .04$) per year were significantly lower in participants receiving blenderized diets, and respiratory-related visits to the ED trended toward significance (0.1 ± 0.4 vs 0.4 ± 0.8 , $P = .08$). Compared with those receiving conventional formula, participants on blenderized diets reported greater satisfaction ratings (Likert scale 4.3 ± 1.0 vs 3.3 ± 1.2 , $P = .001$), lower symptom (0.7 ± 0.8 vs 1.2 ± 1.1 , $P = .03$), and total (0.8 ± 0.8 vs 1.2 ± 1.0 , $P = .02$) scores on Pediatric Gastroesophageal Reflux Disease Symptom and Quality of Life Questionnaire and greater scores on the Pediatric Quality of Life Inventory Gastrointestinal Symptoms Scale, indicating less nausea and vomiting (64.0 ± 22.6 vs 49.0 ± 37.9 , $P = .02$), abdominal pain (65.0 ± 26.8 vs 56.4 ± 33.9 , $P = .04$), diarrhea (87.9 ± 15.5 vs 73.6 ± 26.3 , $P = .004$), and fewer total symptoms (70.2 ± 16.3 vs 62.3 ± 19.6 , $P = .03$).

Conclusions Blenderized diets are associated with decreased healthcare use, improved symptom scores, and increased patient satisfaction compared with conventional formulas. (*J Pediatr* 2019;211:139-45).

Children with medical complexity are a vulnerable, expensive, and rapidly growing population.¹ Accounting for <1% of the pediatric population, they accumulate one-third of all pediatric medical expenditures, approaching \$50-110 billion dollars annually.^{2,3} Efforts directed at decreasing rates of hospitalization have potential for major cost savings—recent modeling suggests that as little as a 10% reduction in hospital days could translate to \$2.9 billion cost savings nationally.² The primary drivers of cost burden, specifically cardiovascular and pulmonary diseases including pneumonia and aspiration pneumonia,⁴ as well as common comorbidities of asthma and obesity,⁵ can be modified by improving quality of dietary intake. However, optimizing diet quality in medically complex children for the purpose of improving health outcomes has not been addressed systematically.

Many children with medical complexity are fed conventional formulas via gastrostomy tube.^{4,5} Several characteristics of conventional formulas—that they are rich in processed carbohydrate, high in saturated fat, and devoid of fiber, fruits, vegetables, and other foods—have been strongly implicated in the pathogenesis of cardiovascular disease^{6,7} and pulmonary diseases such as chronic obstructive pulmonary disease⁸ and asthma⁹ in adults and neurotypical children. In addition, emulsifiers and other preservatives required for shelf stability may be linked with inflammatory diseases.¹⁰ Despite the increasing evidence implicating individual diet components of conventional formulas to chronic disease in an otherwise-healthy population, the fragile population of medically complex children who receive 100% of their caloric needs in this fashion has been largely ignored.

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ED	Emergency department
GI-PedsQL	Pediatric Quality of Life Inventory Gastrointestinal Symptoms Scale
PedsQL	Pediatric Quality of Life Inventory
PGSQ	Pediatric Gastroesophageal Reflux Disease Symptom and Quality of Life Questionnaire

Blenderized diets, the provision of wide range of pureed table foods such as fruits, vegetables, meat, and legumes via enteral tube, are emerging as popular alternatives to conventional formulas.^{11,12} This movement is largely driven by parental concern of poor dietary quality of conventional formulas and the fundamental urge to share a family mealtime experience with their medically complex children.¹² Despite the widespread popular use,¹¹ these diets have not yet been accepted universally by the medical community. Concerns have been raised about the variability across blenderized diets, potential for nutrient deficiencies and excesses, and lack of data to demonstrate safety and clinical superiority of these data. Therefore, in this prospective, observational cohort study of children with medical complexity, we sought to characterize clinical and patient-reported outcomes of children receiving blenderized diets.

Methods

We prospectively recruited 70 children aged 1-18 years who require enteral feeding support from gastroenterology clinics and gastrointestinal procedure unit from January 2017 to October 2018. Participants were classified in the blenderized diet group if $\geq 50\%$ of their diet was consumed from home-made table food or commercially prepared blenderized diets, eg, Nourish/Liquid Hope, Nutritional Medicinals, LLC, Centerville, Ohio or Real Foods Blends, Real Food Blends, LLC, Chicago, Illinois. Participants were classified as conventional formula if they received the majority of their diet via standard milk-based or elemental formulas. Diet classification was performed based on dietary intake as of December 2017. One participant enrolled in the study while receiving formula for the duration of 2017, then re-enrolled in the study on a blenderized diet. For this patient, healthcare use in 2017 was not included under the blenderized classification. This study was approved by the Boston Children's Hospital institutional review board, and informed consent was obtained from parents or guardians of all study participants, with individual subject assent as appropriate.

Outcomes

Dietary intake data were obtained from detailed food journal and/or interview with registered dietitian, and calculated nutrient composition using Cronometer, a Web-based nutrient database (Cronometer, Inc, Revelstoke, British Columbia, Canada). Vitamin and mineral intake was compared with age- and sex- appropriate dietary reference intake (recommended dietary allowances for B12, folate, calcium, vitamin D, iron, zinc, and adequate intake for manganese).¹³⁻¹⁶ Weight and height were recorded from the most recent outpatient gastroenterology, nutrition, or gastrointestinal procedure unit visits (performed May 2017 through October 2018).

Healthcare use rates at Boston Children's Hospital over the 1-year period of January 1, 2017, to December 31, 2017, were obtained by retrospective chart review. The 1-year duration

was selected to ensure equal lengths of follow-up in both groups and inclusion of all 4 seasons to prevent bias, as admissions typically are greatest in winter. The numbers of hospitalizations and visits to the emergency department (ED) were quantified and classified as respiratory if the primary presenting complaint could be attributed to this category, for example, pneumonia, pneumonitis, or respiratory distress.

A subgroup of patients had 1 year of follow-up on conventional formula and an additional year of follow-up in the year following transition to blends. In this small cohort, using a paired *t* test, we compared admissions and visits to the ED in the year before and after starting the blend in the same patient.

To address quality of life measures, participants' caregivers completed a Likert scale for satisfaction with enteral regimen (1-5, with 5 most satisfied), and 3 validated questionnaires: Pediatric Gastroesophageal Reflux Disease Symptom and Quality of Life Questionnaire (PGSQ), Pediatric Quality of Life Inventory (PedsQL), and the Pediatric Quality of Life Inventory Gastrointestinal Symptoms Scale Gastrointestinal Symptoms Scale (GI-PedsQL).

Statistical Analyses

Data are presented as n (%) or mean \pm SD. Baseline characteristics and nutrient composition were compared using the Fisher exact test (categorical) or the Student *t* test (continuous). Mantel-Haenszel test was used to compare rates of comorbidities by diet type stratified by enteral tube type. For macronutrient composition, we compared variances between the groups using the Levene F test.

We calculated propensity scores from underlying medical comorbidities using logistic regression, with outcome variable of diet category, and exposure of individual comorbidities, to create a covariate for use in regression analysis. For healthcare use rate, we created this propensity score from those comorbidities associated with healthcare use on univariate analysis (cardiac, prematurity, and respiratory). We compared healthcare use rates (number of visits to the ED, respiratory-related visits to the ED, admissions, and respiratory admissions) between the 2 groups (blenderized vs conventional formula) using zero-inflated negative binomial regression model to account for zero inflation and overdispersion, controlling for age and propensity score. We compared quality of life outcomes (Likert scale, PGSQ, PedsQL and GI-PedsQL) using linear regression with covariates of age and propensity score. *P* value $\leq .05$ was set as the threshold for statistical significance. Analyses were performed using SPSS Statistics 24 (IBM Corp, Armonk, New York) or SAS version 9.4 (SAS Institute, Cary, North Carolina).

Results

Patient Characteristics

Forty-two (60%) participants received blenderized diets and 28 (40%) received conventional formula. The groups did not

differ in age, sex, underlying comorbidities, race, parental education, income, or insurance ($P > .09$, **Table I**). The majority of participants receiving blenderized diets were fed via gastrostomy, with a smaller proportion fed postpyloric using a gastrojejunostomy or primary jejunostomy, as shown in **Table I**. Feeding tube type differed significantly compared with those receiving formula ($P = .002$, **Table I**). When diet category was stratified by feeding tube type, comorbidity prevalence did not differ significantly (**Table II**; available at www.jpeds.com). Frequency of bolus and continuous or combination feeding methods are shown in **Table I**.

Table I. Clinical characteristics of study population

Characteristics	Formula (n = 28)	Blenderized (n = 42)	P value
Age, y	5.7 ± 5.0	4.8 ± 3.6	.38
Male	18 (64%)	24 (57%)	.62
Race			
White	19 (68%)	25 (60%)	.09
Black	3 (11%)	0	
More than 1 race	4 (14%)	5 (12%)	
No survey data	2 (7%)	12 (29%)	
Underlying comorbidities			
Neurologic	14 (50%)	29 (69%)	.14
Metabolic	16 (57%)	21 (36%)	.63
Oropharyngeal malformations	14 (50%)	20 (48%)	1.00
Cardiac	14 (50%)	15 (36%)	.32
Prematurity	9 (32%)	17 (41%)	.62
Respiratory	9 (32%)	6 (14%)	.14
Cancer	0	1 (2%)	1.00
Other	9 (32%)	22 (52%)	.14
Tube type			
Gastrostomy (G)	13 (46%)	35 (83%)	.002
G-J	14 (50%)	5 (12%)	
Jejunostomy (J)	1 (4%)	2 (5%)	
Feeding method			
Continuous	15 (54%)	15 (36%)	.09
Bolus	8 (29%)	23 (55%)	
Mixed (continuous/bolus)	5 (18%)	4 (10%)	
Anthropometrics			
Height z score	-1.69 ± 1.69	-1.57 ± 1.18	.74
Weight z score	-1.74 ± 1.89	-1.34 ± 1.29	.34
BMI z score	-0.83 ± 1.79	-0.29 ± 1.09	.16
Parental education			
Some high school	0	0	.23
Graduated from high school/GED	1 (4%)	0	
Some college, all college or vocational	15 (54%)	13 (30%)	
Postcollege graduate courses or degree	10 (36%)	17 (40%)	
No survey data	2 (7%)	12 (29%)	
Household income			
<\$50 000	3 (11%)	4 (10%)	.32
\$50 000-\$100 000	11 (39%)	12 (29%)	
>\$100 000	9 (32%)	14 (33%)	
Prefer not to answer	3 (11%)	0	
No survey data	2 (7%)	12 (29%)	
Insurance			
Private only	7 (25%)	8 (19%)	.20
Government only	7 (25%)	8 (19%)	
International	2 (7%)	0	
Mix of government and private	12 (43%)	26 (62%)	

BMI, body mass index; GED, General Education Development. Results are mean ± SD or n (%).

Nutrient Composition

Of the 28 participants receiving conventional formula, 16 (57%) were prescribed elemental formulas, 10 (36%) standard milk-based formulas, and 2 (7%) more than 1 formula. Of the 42 participants receiving blenderized diets, 17 (40%) use blenderized table foods with conventional formula base, 14 (33%) use commercially prepared blenderized diets (Nourish n = 9, Liquid Hope n = 3, Real Foods Blends n = 2), and 11 (26%) use home-made blenderized diets. A sample home-made blenderized diet recipe is presented in **Table III** (available at www.jpeds.com). For those patients in whom start date of blenderized feeds was documented (n = 32), mean duration of blenderized feeds was 19.4 ± 15.8 months.

Full diet histories were available in 62 participants (n = 36 blenderized, n = 26 formula), and 8 (n = 6 blenderized, n = 2 formula) had limited diet history from which we could not calculate nutrient intake. Dietary fiber intake was significantly greater in blenderized diets (14.6 ± 7.3 vs 4.6 ± 5.1 g/d, $P < .001$). Total energy and macronutrient distribution, as well as variability in each macronutrient component, did not differ between the 2 groups (**Table IV**). Vitamin D intake was lower from blenderized diets compared with formula (64 ± 42 vs 96 ± 57 % of dietary reference intake, $P = .01$). Although the groups differed in folate, iron, and zinc intake, both diets exceeded dietary reference intake (**Table IV**).

Healthcare Use Rates

Using the zero-inflated negative binomial regression model, rates of total ED visits per 1 year (0.8 ± 1.5 vs 1.4 ± 2.7, $P = .05$), total admissions (0.8 ± 1.2 vs 1.7 ± 2.3, $P = .01$), and respiratory admissions (0.2 ± 0.5 vs 0.6 ± 0.8, $P = .04$) were significantly lower in participants receiving blenderized diets, controlling for age and propensity score (**Figure**).

Table IV. Nutrient composition

Nutrients	Formula (n = 26)	Blenderized (n = 36)	P value
Macronutrients			
kcal/kg	74.0 ± 26.0	79.4 ± 32.0	.48
Total kilocalories, kcal	1152 ± 540	1134 ± 469	.89
% cal from carbohydrate	46 ± 6	45 ± 9	.67
% cal from protein	14 ± 5	14 ± 3	.60
% cal from fat	40 ± 5	42 ± 7	.47
Carbohydrate total, g	132 ± 66	122 ± 46	.49
Fiber, g	4.6 ± 5.1	14.6 ± 7.3	<.001
Protein, g/kg/d	2.3 ± 1.0	2.6 ± 1.3	.48
Fat, g/kg/d	3.3 ± 1.1	3.8 ± 1.9	.18
Micronutrients			
B12 (% DRI)	418 ± 197	292 ± 351	.11
Folate (% DRI)	148 ± 68	107 ± 69	.02
D (% DRI)	96 ± 57	64 ± 42	.01
Calcium (% DRI)	126 ± 47	103 ± 49	.07
Iron (% DRI)	227 ± 134	144 ± 83	.009
Manganese (% DRI)	154 ± 148	206 ± 139	.16
Zinc (% DRI)	249 ± 101	159 ± 133	.006

DRI, dietary reference intake. Results are mean ± SD.

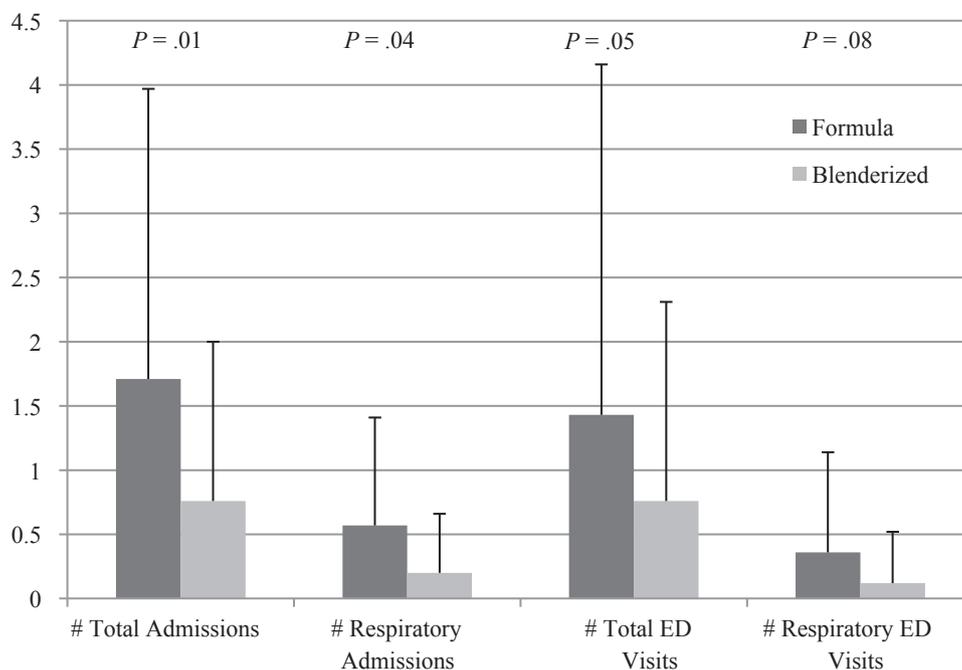


Figure. Healthcare use at Boston Children's Hospital in 2017 by diet type, adjusted for age and propensity score for comorbidities. Dark gray bars indicate conventional formula; light gray bars indicate blenderized feeds.

Respiratory-related visits to the ED were lower, although this did not reach statistical significance (0.1 ± 0.4 vs 0.4 ± 0.8 , $P = .08$). During the 1-year observation period, there were a total of 79 hospitalizations (48 in formula group, 31 in blenderized group) and 71 visits to the ED (40 in formula group, 31 in blenderized group). A total of 32 patients (8 in formula group, 24 in blenderized group) were not admitted during the 1-year period, and 45 (19 in formula group, 26 in blenderized group) never went to the ED during the 1-year period.

Compared with participants receiving postpyloric feeds, participants receiving blenderized diets via gastrostomy had fewer visits to the ED (0.8 ± 1.6 vs 1.6 ± 2.8 , $P = .05$), respiratory-related visits to the ED (0.1 ± 0.4 vs 0.4 ± 0.7 , $P = .04$), total admissions (0.7 ± 1.3 vs 1.9 ± 2.4 , $P = .008$), and respiratory-related admissions (0.2 ± 0.5 vs 0.7 ± 0.9 , $P = .02$) per year, adjusting for age and propensity score.

A subgroup of 22 participants were followed for 1 year before and after starting blends (for a total of 2 complete years of data). Using a paired t test, we found that, with individual patients, total number of total admissions decreased significantly after blenderized feeds were started (1.5 ± 1.7 preblend vs 0.7 ± 1.0 postblend, $P = .05$). Because of the small number of patients and the even smaller number of the subtypes of ED visits and admissions, there was inadequate power to draw conclusions regarding differences in other hospital visits. In this subgroup of patients, there was also no difference in the anthropometrics in the year before and after starting blends ($P > .20$).

Quality of Life Assessments

Fifty-eight participants ($n = 32$ blenderized and $n = 26$ formula) completed a baseline Likert questionnaire addressing satisfaction ratings with feeding regimen. Compared with those receiving conventional formula, participants on blenderized diets reported greater satisfaction ratings (Likert scale 4.3 ± 1.0 vs 3.3 ± 1.2 , $P = .001$, with greater scores indicating greater satisfaction). Moreover, they reported fewer gastroesophageal reflux disease symptoms, as evidenced by lower symptom (0.7 ± 0.8 vs 1.2 ± 1.1 , $P = .007$) and total (0.8 ± 0.8 vs 1.2 ± 1.0 , $P = .02$) scores on the PGSQ. Furthermore, participants on blenderized diets reported greater total scores on the GI-PedsQL indicating overall improved gastrointestinal function (70.2 ± 16.3 vs 62.3 ± 19.6 , $P = .03$). Importantly, GI-PedsQL subscores demonstrated greater scores, indicating less nausea and vomiting (64.0 ± 22.6 vs 49.0 ± 37.9 , $P = .02$), less abdominal pain (65.0 ± 26.8 vs 56.4 ± 33.9 , $P = .04$), less abdominal upset (71.1 ± 26.0 vs 58.9 ± 32.7 , $P = .02$), less diarrhea (87.9 ± 15.5 vs 73.6 ± 26.3 , $P = .004$), less worry about stool (91.5 ± 12.8 vs 81.4 ± 30.0 , $P = .05$), and less limitation to food and drink (46.1 ± 29.6 vs 29 ± 27.6 , $P = .006$) (Table V). The remainder of PGSQ, PedsQL, and GI-PedsQL did not differ between the groups (Table V).

Discussion

Our results demonstrate superior clinical outcomes in children receiving blenderized diets compared with children receiving conventional formula. Specifically, total visits to

Table V. Differences in quality of life measures between participants on formula and blenderized feeds*

	Formula	Blenderized	P value
Likert scale			
Satisfaction with feeding regimen	3.3 ± 1.2 (n = 26)	4.3 ± 1.0 (n = 32)	<.001
PGSQ			
Total symptoms	1.2 ± 1.1 (n = 23)	0.7 ± 0.8 (n = 29)	.007
Every day impact	1.3 ± 1.0 (n = 21)	0.9 ± 0.9 (n = 29)	.06
School items	0.6 ± 1.0 (n = 13)	0.7 ± 0.9 (n = 17)	.83
Total score	1.2 ± 1.0 (n = 23)	0.8 ± 0.8 (n = 29)	.02
PedsQL			
Physical	53.1 ± 30.3 (n = 24)	63.7 ± 31.3 (n = 28)	.31
Psychosocial	62.2 ± 20.1 (n = 23)	63.7 ± 20.1 (n = 28)	.65
Total	58.0 ± 20.4 (n = 24)	63.4 ± 22.5 (n = 28)	.34
GI-PedsQL			
Stomach pain	56.4 ± 33.9 (n = 22)	65.0 ± 26.8 (n = 28)	.04
Stomach upset	58.9 ± 32.7 (n = 22)	71.1 ± 26.0 (n = 26)	.02
Food and drink limits	18.6 ± 27.6 (n = 22)	46.1 ± 29.6 (n = 26)	.006
Trouble swallowing	48.4 ± 29.8 (n = 21)	55.9 ± 27.5 (n = 28)	.45
Heartburn/reflux	63.9 ± 26.5 (n = 22)	67.4 ± 23.9 (n = 28)	.28
Nausea/vomiting	49.0 ± 37.9 (n = 20)	64.0 ± 22.6 (n = 27)	.02
Gas	61.6 ± 31.1 (n = 22)	66.1 ± 14.3 (n = 28)	.19
Constipation	74.5 ± 24.5 (n = 20)	73.7 ± 28.4 (n = 28)	.96
Blood in stool	88.7 ± 20.1 (n = 21)	95.1 ± 13.8 (n = 28)	.19
Diarrhea	73.6 ± 26.3 (n = 21)	87.9 ± 15.5 (n = 28)	.004
Total symptoms	59.7 ± 21.7 (n = 22)	69.7 ± 16.9 (n = 28)	.01
Worry about stool	81.4 ± 30.0 (n = 18)	91.5 ± 12.8 (n = 23)	.05
Worry about abdominal pain	79.6 ± 33.6 (n = 19)	88.1 ± 24.2 (n = 21)	.10
Medications	74.6 ± 17.6 (n = 17)	78.8 ± 25.1 (n = 19)	.48
Communication	36.5 ± 39.1 (n = 20)	39.3 ± 41.3 (n = 23)	.68
Total GI score	62.3 ± 19.6 (n = 22)	70.2 ± 16.3 (n = 28)	.03

GI, gastrointestinal.

Results are mean ± SD.

P value adjusts for age and propensity score.

For Likert, greater scores indicate improved satisfaction (scale 1-5).

For PGSQ, greater scores indicate greater symptom burden.

For PedsQL and GI-PedsQL, greater scores indicate less limitation.

*A subset of questions in the PGSQ, PedsQL, and GI-PedsQL may not be appropriate for all ages and/or developmental abilities.

the ED were reduced by 43%, total admissions by 53%, and respiratory-related admissions by 67%. We observed lower rates of healthcare use with blenderized diets consumed via gastrostomy even when compared with postpyloric feeding regimens, which is a commonly prescribed approach to address feeding intolerance. Despite identical comorbidity profiles and similar degree of reported impairment in functioning, participants receiving blenderized feeds were more likely to be fed via gastric tube, suggesting improved tolerance of feeds. Together, this suggests blenderized diets are a well-tolerated, safe, and relatively low-cost intervention (compared with expensive medications) to improve health outcomes in this population, with potential for significant reduction in healthcare cost.

There are several potential mechanisms that may explain the beneficial effect on health outcomes observed by blenderized diets. The first is increased viscosity.¹⁷ Gastroesophageal reflux disease is common in children with neurologic impairment,¹⁸ which in turn can increase the risk of asthma, chronic cough, and recurrent pneumonia.¹⁸⁻²⁰ Increasing viscosity using half-solid feeds has been shown to reduce regurgitation episodes,²¹ full column gastroesophageal reflux,^{22,23} and number of fever episodes due to aspiration pneumonia in neurologically impaired, gastrostomy-fed adults.²⁴ This may mediate the significant effect observed in our study on respiratory-related health outcomes.

The second potential mechanism for improved health is improved nutrient profile.²⁵ Although our data show similar energy content and macronutrient composition between formula and blenderized diets, the quality of macronutrient composition differs substantially. Specifically, conventional formulas use rapidly digestible carbohydrate sources such as maltodextrin and corn syrup solids, whereas diets with slowly digestible carbohydrates from legumes and whole grains, found in blenderized diets, reduce risk of airway inflammation seen in ventilator-associated tracheobronchitis compared with standard formula.^{26,27} The provision of a diet containing actual fruits and vegetables, rather than simply vitamins as is present in conventional formulas, may reduce airway hyperreactivity²⁸ or reactive airway disease.^{29,30} In addition to a multitude of health benefits, dietary fiber, which is absent in many conventional formulas but emphasized in blenderized diets, acutely decreases airway inflammation.³⁰

Lastly, blenderized feeds provide increased dietary diversity. Gallagher et al demonstrated that this increase in dietary diversity increases intestinal microbial diversity in children transitioning from conventional formula to blenderized diets.²⁵ A diverse intestinal microbiota is associated with decreased risk of asthma,³¹ systemic inflammation,³² and obesity (a risk factor for restrictive lung disease),^{32,33} which is associated with risk of chronic obstructive pulmonary disease—type symptoms and asthma.³⁴ Dietary fiber may be

an important driver of this relationship, as it shapes intestinal microbiome composition, and affects short chain fatty acid production, which in turn directs immune cell differentiation toward nonallergic phenotypes, important for decreasing airway hypersensitivity.³⁵

As reported by Vieira et al, one of the concerns of blenderized feeds is the worry that patients are not receiving complete nutrition.³⁶ In our study, we show that, in fact, patients are receiving identical calorie and micronutrient profiles to formula-fed patients with the exception of vitamin D. Therefore, like many otherwise healthy children on a regular diet, additional vitamin D supplementation may be indicated. Based on this study, providers should be reassured that complete nutrition is clearly possible using blenderized feeds. In contrast to Gallagher et al and Tanchoco et al, who reported that an increase in calories from blenderized diets is required to maintain body weight, we did not observe this effect.^{25,37} This is likely due to differences in underlying patient population, target growth trajectory, or dietary quality affecting metabolism and/or intestinal microbiome composition.

In addition to improved objective health outcomes, our study demonstrates improved patient-reported symptom scores with blenderized diets. We observed lower burden of vomiting, as well as lower symptom and total scores on the PGSQ. This complements the study by Pentiuk et al showing reduced gastrointestinal symptoms of retching in pediatric patients given blenderized feeds after fundoplication and extends the previous observations by Hurt et al in adults and Gallagher et al in children.^{12,25,38} Together, these data support the hypothesis that blenderized diets reduce reflux burden by way of increased viscosity. In addition, we report that participants on blenderized diets had fewer symptoms of diarrhea, less abdominal pain, less abdominal upset, and less worry about stooling, all of which may be explained by the greater fiber content of blenderized feeds. Contrary to findings from Hurt et al, we did not observe a difference in constipation burden, which may reflect differences in underlying characteristics of our patient populations, or our sample size.¹² We also found that parents reported less limitation to food and drink intake with blenderized diets. This may reflect improved gastrointestinal tolerance of dietary components, increased perception of diversity of diet, or increased oral intake, as suggested by Gallagher et al.²⁵ Our study supports that blenderized feeds not only have a beneficial impact on lung health but reduce gastrointestinal symptoms in a medically complex patient population.

Apart from the health benefit, ratings of caregiver satisfaction with feeding regimen ratings were significantly greater with blenderized diets. Parents are able to satisfy the fundamental urge to feed one's child, sharing a mealtime experience with profound effects on family bonding. They may be driven by wanting a more holistic approach to feeding.¹² In addition, parents may be more satisfied with the diet type because they are observing improved clinical outcomes with blenderized diets.

Limitations

Strengths of our data include a prospectively recruited, large cohort of medically complex children in whom we have detailed classification of health outcomes and quality of life. There are several minor limitations. Although study participants were prospectively recruited, we were only able to assess hospitalizations or ED visits within Boston Children's Hospital. Because of the medical complexity of our patients, the majority of our patients receive care at Boston Children's Hospital and require management in a tertiary care facility, and therefore we are likely recording the majority if not all of healthcare use. Although we believe that use of blenderized diets improves health outcomes, we cannot exclude confounding by indication—that patients who are overall doing well are more likely to be prescribed blenderized diets. Similarly, a greater proportion of participants receiving blenderized diets were fed via gastrostomy vs postpyloric feeds. We believe this represents improved tolerance to gastric feeds and may constitute part of the causal pathway by which healthcare use decreases. The similar comorbidity profile including prevalence of pulmonary disease between the groups, even when stratifying by tube type, as well as similar physical and emotional scores on quality of life surveys (other than symptoms that would be expected to improve in response to diets), argue against systematic differences in underlying disease burden. Moreover, all outcomes data were adjusted by propensity score. Generalizability of these data may be impacted by the high education, income level, and rates of insurance coverage observed in this study. Lastly, we captured dietary recall at the time of the study visit, but energy content and macronutrient distribution for both formula and blenderized patients may have varied during the follow-up period, which may have had an impact on hospitalizations and visits to the ED. We would anticipate, however, this would likely bias toward the null hypothesis of no difference between the groups, making this limitation less likely. ■

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Table II. Presence of comorbidities stratified by diet and feeding tube type

Comorbidity categories	Formula (n = 28)			Blenderized (n = 42)			P value
	Gastrostomy (G) (n = 13)	G-J (n = 14)	Jejunostomy (J) (n = 1)	Gastrostomy (G) (n = 35)	G-J (n = 5)	Jejunostomy (J) (n = 2)	
Neurologic	6 (46%)	8 (57%)	0	24 (69%)	3 (60%)	2 (100%)	.20
Metabolic	8 (62%)	8 (57%)	0	19 (54%)	1 (20%)	1 (50%)	.52
Oropharyngeal malformations	5 (38%)	9 (64%)	0	16 (46%)	3 (60%)	1 (50%)	.85
Cardiac	7 (54%)	7 (50%)	0	12 (34%)	2 (40%)	1 (50%)	.46
Prematurity	3 (23%)	6 (43%)	0	15 (43%)	2 (40%)	0	.48
Respiratory	4 (31%)	5 (36%)	0	4 (11%)	2 (40%)	0	.43
Cancer	0	0	0	1 (3%)	0	0	.61
Other	3 (23%)	5 (36%)	1 (100%)	17	4	1 (50%)	.09

G-J, Gastrojejunostomy.

Results are n (% of column).

P value for Mantel–Haenszel test.²

Table III. Sample blenderized diet batch recipe

Ingredients	Amount
Chicken breast, cooked	2 oz
Sweet potato, cooked and mashed	½ cup
Green beans, cooked or canned	½ cup
Mixed tropical fruit	¼ cup
Banana	1 small
Macaroni pasta	123 g
Cream of Wheat, plain	1 oz
Whole milk*	1 cup
Olive oil	1 tbsp

Makes 1060 kcal, 950 mL.

*Can substitute for nondairy milk, such as Ripple milk (Ripple Foods, Emeryville, California).