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Associations between Enteral Nutrition and Acute Respiratory Infection among Patients in New York Metropolitan Region Pediatric Long Term Care Facilities

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Abstract

Background—Pediatric long-term care facilities (pLTCF) serve a complicated and resource-intensive patient population with high usage of nutrition support. However, the relationship between nutrition support and outcomes among pLTCF residents is not well understood. We described this relationship in three metropolitan New York pLTCF and a subsample of infants from one of these facilities with a specialized unit for feeding disorders.

Methods—In this prospective cohort study, we used logistic regression to assess relationships between enteral nutrition (EN), and acute respiratory infections (ARI) among residents ($n=720$, 50% male, mean enrollment age=5.5 years, mean number comorbidities=2.1) and the infant subsample ($n=208$, 50% male, mean number comorbidities=2.0). We then tested these associations in multivariable models controlling for number of comorbidities and number of infections.

Results—Many residents received nutrition via percutaneous (59%) or nasogastric (15%) feeding tubes. In univariate analyses, residents receiving EN had more comorbidities. In multivariable analyses, EN was associated with ARI (Incidence rate ratio=1.65, $p<.001$). Among infants less than one year of age at the facility with a specialized unit, greater risk of ARI was associated only

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with percutaneous (Incidence rate ratio=1.94, $p<.01$) feeding. EN was associated with lower odds of being discharged home (OR=0.45, $p<.01$).

Conclusion—The prevalence of EN, complexity of cases, and necessity of long-term EN make nutrition support important in pLTCFs. Differences in EN types and adverse outcomes in the infant subsample suggest different care is necessary for this subpopulation. Results provide context for improving quality of care and clinician/caregiver education for this population.

Pediatric long term care facilities (pLTCF) primarily serve children who need extensive assistance with activities of daily living.¹ Residents of pLTCFs have substantial, specialized health care needs; chronic comorbid conditions associated with medical fragility; severe functional limitations; and require frequent, ongoing health care use.² They often have respiratory, nutritional, and/or neuromuscular disorders.¹ With ongoing advances in critical care for infants and children, survival rates of premature infants and children with birth defects and genetic disorders continue to improve.³ Likewise, improved treatment of acute illnesses has increased survival as well as disability.⁴ Although estimates suggest that children with chronic comorbid conditions represent less than 1% of the population and those who reside in pLTCF make up a smaller fraction, this growing and resource-intense healthcare sector has been found to account for disproportionate healthcare costs.^{2,5–8}

Many children with chronic comorbid conditions require the support of medical technology to maximize their functioning.² A 2011 retrospective analysis of data from four US children's hospitals indicated that 56% of children who received complex care coordination services had gastrostomy tubes.⁹ Children with chronic comorbid conditions requiring technology assistance, including feeding tubes, incur 3.5 times the costs of other children with chronic comorbid conditions.⁵ Enteral nutrition (EN, i.e., nasal or percutaneous tube feeding) is, therefore, an important component of pLTCF care; however, the prevalence of EN and potential adverse impacts of EN in this unique population has not yet been well described in the literature.

Some pLTCF also admit children who need close observation, medication administration, rehabilitation and/or family education for shorter term stays; many residents are premature infants with acute nutrition needs.¹ Some of these infants cannot feed safely or efficiently due to inability to suck, swallow, or coordinate breathing with swallowing.¹⁰ Clinical indications for EN in both very premature as well as medically complex infants¹¹ and reported relationships between extra-uterine growth restriction and neurodevelopmental impairment have driven recent interest in optimizing EN in this population,¹² but there is wide variation and lack of consensus for nourishment strategies.¹³

A recent retrospective cohort study found that of 15,642 children having a gastrostomy tube placed, 8.6% had an emergency department visit and 3.9% were readmitted within 30 days of discharge; infection, mechanical complication, and replacement were the primary gastrostomy-related reasons for these visits.¹⁴ Children in pLTCF are at particularly high risk for healthcare-associated infections due to their underlying conditions; mechanical supports; and multiple contacts with medical providers, family members, and other children with chronic comorbid conditions.¹⁵ We performed an epidemiologic study of infections in residents in three pLTCFs in the New York City metropolitan area and found use of EN

ranged from 77–85% of residents.¹⁶ Percutaneous feeding tubes (PFTs), but not nasogastric feeding tubes (NGFTs), were an independent predictor of acute respiratory infection.¹⁶

In this exploratory study, we present a more detailed analysis focused on nutrition support to provide a better understanding the relationship between nutrition support and adverse outcomes among residents in pLTCFs. In addition to a more detailed description of the clinical characteristics and outcomes for residents receiving EN, we also separately examined a sub-sample of infants, many of whom received nutrition support for different reasons than the full sample. We aimed to: 1) describe the use of EN and clinical characteristics of children at pLTCFs receiving EN; 2) describe the use of enteral nutrition and clinical characteristics among residents less than 1 year of age in one of the facilities with a specialized unit for infants with feeding difficulties; and 3) identify relationships between feeding type and outcomes including infections, hospitalization, and discharge home in both the whole sample and the infant subsample.

Methods

We conducted a prospective cohort study of residents at three pLTCF from September 2012 to December 2015 as part of an intervention study to reduce healthcare-associated infections, the Keep it Clean for Kids (KICK) Project (R01HS021470).^{15,17} The three pLTCF were independent facilities located in the NYC metropolitan area, ranging in size from 54 to 137 beds, with therapeutic, medical, and school services on-site. This study was approved by the BLINDED Institutional Review Board and the ethics boards of the pLTCFs with approval for waiver of written documentation of consent.

Sample

Analyses included all residents during 2012–2015 except for those admitted for respite care only. Sub-analyses comparing PFT, NGFT, and no EN in infants included residents less than one year old at the time of enrollment from a single facility.

Residents were enrolled from one of three pLTCF in the New York metropolitan region, including 54-bed, 97-bed, and 137-bed facilities. Each of these pLTCF are stand-alone facilities and only provide care for pediatric residents. On average, 30% (range 22–44%) of residents had tracheostomies and 7% (range 5–10%) were mechanically ventilated. About 25% of residents are hospitalized at least once each year. Overall, 70% (range 58–86%) of residents in these facilities have a neurological disorder and 50% (range 36–65%) have a respiratory disorder. The three pLTCFs provide similar care, each with in house physicians, nursing staff, dietitians, and therapists including physical, occupational, music, and art therapies.

Variables of interest

Dependent variables—We measured three dependent variables: acute respiratory infection, infection-related hospitalization, and discharge home.

Acute respiratory infection: Infections were defined based on clinical diagnosis by a physician or nurse practitioner. Study staff conducted ongoing medical record reviews to

collect data related to clinician diagnosis, signs and symptoms, and diagnostic testing related to infections. Acute respiratory infections included both viral and non-viral acute upper respiratory infections as well as pneumonia, pharyngitis, and sinusitis.

Infection-related hospitalization: Hospital admissions related to infection were defined as transfers to acute care for greater than 24 hours with the indication of an infection diagnosed at the pLTCF. This information was collected from medical record reviews conducted by study staff.

Discharge home: Discharge disposition was obtained from the medical records by the study staff. Home was defined as the legal guardian's residence. Discharge home was based on a resident's last discharge and their status at the study's conclusion, i.e., if a resident was discharged home and then readmitted the resident was not considered to be discharged home.

Independent variable—In these analyses, nutrition support was the independent variable. We defined EN to include any tube feeding (i.e., nasal or percutaneous tube feeding). Few residents enrolled during the study period had total parenteral nutrition (n=2); these residents were excluded from analyses. Residents rarely received oral feeding in addition to EN, therefore it was not considered in analyses. For sub-analyses, we compared EN via NGFT (including nasogastric and nasojejunal feeding tubes) and PFT (including all types of gastrostomy, jejunostomy, or other feeding enterostomy). Eight residents were documented as having both PFT and NGFT at admission. For this study, they were included with residents having PFT.

Covariates—We included patient characteristics and comorbidities as covariates in our analyses. Patient demographics and comorbidities were collected from medical records at enrollment, including information about medical devices. Comorbidities were based on the admitting diagnoses for each resident, and included the presence of one or more neurological (e.g., cerebral palsy, epilepsy), respiratory (e.g., bronchopulmonary dysplasia, respiratory failure), cardiovascular (e.g., congenital heart disease, hypertension), gastrointestinal (e.g., short bowel disease, feeding disorder), metabolic (e.g., mitochondrial disease), or immune disorder (e.g., HIV/AIDS). In previous research, our team found that the number of chronic comorbid conditions rather than the type of condition was predictive of ARI.¹⁶ Comorbidities were summed by type for each resident (i.e., a resident with a neurological disorder and a respiratory disorder has two comorbidities independent of how many individual neurological and respiratory disorders the resident may have); this variable was called number of comorbidity types throughout the manuscript. Number of infections was a count of infections each patient was diagnosed with, including infections of the respiratory tract, conjunctivitis/otitis, skin and soft tissue, urinary tract, gastrointestinal, and bloodstream.

Analyses

Descriptive statistics were used to characterize the study sample of all residents and subsample of infants. We assessed relationships between EN, clinical characteristics and

infections in the entire study sample using binomial logistic regression. We assessed relationships among NGFT, PFT, clinical characteristics and infections among the subsample of infants using multinomial logistic regression. For all analyses involving rates, Poisson regression was used. To better understand the independent influence of EN among residents and types of EN among infants, we also tested these associations while controlling for clinically relevant covariates, including number of comorbidities and number of infections, in multivariable models. Statistical significance was set *a priori* at 0.05. Analyses were conducted SAS version 9.3 (SAS Institute, Cary, NC).

Results

Of 720 pLTCF residents enrolled in the study, 59% had a PFT and 15% had a NGFT. Among residents over 1 year of age, only 25 (5%) received feeding via NGFT. Residents receiving any EN were older and had resided in the facilities for longer; they also had more comorbidity types, more gastrointestinal disorders, and, specifically, more feeding disorders. Residents receiving EN had more infections, and fewer residents receiving EN were discharged home. Nutrition, comorbidity types, discharge disposition, and infections in residents who did and did not receive EN are described in Table 1.

Among the 208 infants in the subsample, frequency of feeding type varied for different disorders. Specifically, infants with feeding disorders had higher odds of being fed via NGFT. Infants fed via PFT had more infections, and fewer infants with PFT were discharged home. Nutrition, comorbidity types, discharge disposition, and infections in infants with NGFT, PFT, or no feeding tube are described in Table 2.

Associations between feeding type and outcomes of interest were measured in all residents and the subsample of infants, controlling for number of comorbidity types. As gender and age were not significant in the bivariable models, they were not included in the multivariable models. These results are described in Table 3. Residents with EN had a higher rate of acute respiratory infection compared to residents without EN when controlling for number of comorbidity types. Residents with EN were significantly less likely to be discharged home as compared to residents without EN when controlling for number of comorbidity types. However, residents with EN were not significantly more likely to be hospitalized for an infection, controlling for number of comorbidity types.

Among the infants, only those with a PFT had an increased rate of acute respiratory tract infections compared to those without EN when adjusting for number of comorbidity types. Neither infants with an NGFT nor infants with a PFT had a statistically significantly increased rate of hospitalizations for infection when compared to infants without EN, nor were they significantly less likely to be discharged home, controlling for number of comorbidity types.

Discussion

Seventy percent of pLTCF residents in our sample received EN and the frequency of EN via PFT (59%) among our sample is consistent with the frequency of gastrostomy (56%) reported in a nationwide study of health resource use among children with chronic comorbid

conditions.⁹ That residents receiving EN had, on average, more types of comorbidities suggests that these residents were more complicated, which is consistent with their lower odds of being discharged home when controlling for number of comorbidity types. The prevalence of EN, complexity of cases, and necessity of long-term EN underscore the importance of nutrition support and clinical experts to manage it properly for this population.

Our finding that the pLTCF residents in this study who received EN had more acute respiratory infection and pneumonia is consistent with a study of respiratory infection among a sample of children with profound intellectual and multiple disability in day care centers, 42% with gastrostomy, which found that feeding difficulty and gastrostomy both increased risk of acute respiratory infection.¹⁸ The greater number of mean number of infections per patient among the patients receiving EN may be partially explained by other types of infections, including skin infections at the insertion site. Superficial skin infections have been related to gastrostomy in pediatric acute care settings, with rates ranging from 7–25%.^{14,19,20} Future research should examine the prevalence of EN-related skin infections in pLTCF.

Although 68% of the infants in our subsample received any type of EN, PFT was less frequent than in our overall sample (37% vs. 59%). This may be because some infants are admitted to a pLTCF for short-term intensive feeding. Our findings that many more infants with NGFT had feeding disorder related gastrointestinal comorbidities is consistent with our observation that infants with different feeding tube types are admitted to pLTCF for different reasons and therefore need different care.

This is the first study to report respiratory infection rates in relation to EN among infants in a pLTCF. The finding that even when controlling for number of comorbidities, the incidence rate of acute respiratory infection, including pneumonia, was significantly higher for infants with PFT, contradicts common wisdom associating NGFT with an increased incidence of pneumonia relative to PFTs. The number of infants with NGFT and no EN experiencing pneumonia were very similar (2 cases in each condition) compared with 7 cases in infants with PFT, suggesting that NGFTs may not be a risk factor for pneumonia compared to PFT in this population. There is limited research comparing acute respiratory infection among patients with NGFT and PFT in pediatric population. A retrospective cohort study of children 0–14 years old at a single children's hospital revealed similar rates of pneumonia among patients with long-term (>3 months) use of PFT or NGFT, but that complications (excluding pneumonia and food refusal) were almost twice as common among patients with PFT (80%) than NGFT (46%).²¹

Limitations of the current study include its observational nature—causality cannot be inferred from these analyses. Further, the results may not be generalizable to pLTCF in other regions. We only collected information about NGFT or PFT at enrollment into the study. Therefore, it is possible that some residents who received EN at enrollment had tubes removed during the study period and others who initially did not receive EN had feeding tubes inserted during the study period. Further, this precluded any assessment of nutrition adequacy. We did not have information about indications for EN or, more specifically, for

the choice of PFT or NGFT for individual residents. Finally, due to the small number of residents over the age of 1 year who were fed via NGFT, we were not able to compare adverse outcomes between NGFT and PFT in the full sample.

Future research should examine nutrition adequacy and mechanical EN complications in pLTCHs. Nutrition support care is especially important for children with chronic comorbid conditions because frequent reassessment of estimated energy requirement is necessary due to growth and disease progression²² and because many experience feeding difficulties, malnutrition, and inadequate micronutrient intake.²³ In pediatric intensive care units, perceived intolerance, high gastric residual volumes, nausea and vomiting, fasting around procedures, hemodynamic instability, and feeding tube problems have been cited as reasons for cessation or holding of tube feeds.^{24–26} Due to the complexity of nutrition support required by this population, future research should also describe the role of registered dietitians and other nutrition experts in pLTCH.

Our findings suggest that care providers in pLTCH should monitor residents receiving EN for respiratory infections and take appropriate precaution to prevent them. Additional testing is necessary to identify pathophysiological pathways that explain the link between EN and respiratory infection as well as specific risk factors and intervention targets; however, as EN and PFT are typically non-modifiable risk factors, prevention is crucial. Nutrition support care providers can play an important role in reducing infection by engaging in evidence-based practices and by educating key stakeholders. Residents fed via EN, as well as staff and visitors, should receive vaccinations for respiratory viruses. Additional preventive clinical practices (e.g., attention to secretions, engagement in movement and activity) and policies (e.g., prohibiting ill staff or visitors, enacting transmission reduction protocols) should be followed when caring for residents with EN.

Conclusions

Our description of nutrition support in pLTCH indicates that most residents, including infants, receive EN and that EN is associated with acute respiratory infection. Among infants, PFT were associated with greater risk of acute respiratory infection. Furthermore, EN was associated with lower odds of being discharged home in the whole sample. The results presented here provide a context for improving quality of care as well as clinician and caregiver education for this challenging and growing patient population.

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Table 1

Characteristics of residents with and without enteral feeding tubes at 3 pediatric long term care facilities, 2012–2015, and unadjusted comparisons

	Residents receiving EN ¹ N = 526 (73%)	Residents not receiving EN N = 194 (27%)	OR/IRR ²	P-value
Age at enrollment, mean years (range)	5.2 (0.02–22.3)	5.8 (0.02–26.2)	0.98	0.23
Sex, male	254 (48)	107 (55)	0.76	0.10
Number of comorbidities, mean (range)	2.3 (0–5)	1.6 (0–4)	2.01	<0.001
Respiratory Disorder	291 (55)	70 (36)	2.19	<0.001
Neurologic Disorder	398 (76)	107 (55)	2.53	<0.001
Gastrointestinal Disorder	350 (67)	76 (39)	3.09	<0.001
Feeding Disorder	139 (26)	28 (14)	2.13	<0.001
Dysfunctional Suck/Swallow	12 (2)	0 (0)	–	–
Short Bowel Disease	17 (3)	4 (2)	1.57	0.42
Failure to Thrive	57 (11)	8 (4)	2.80	0.008
Length of Enrollment, mean days (range)	606.2 (1–1217)	398.1 (4–1217)	1.001	<0.001
Rate of Infection Related Hospital Admissions, per 1,000 resident-days	1.01	0.67	1.50 ^a	0.007
Discharged Home ³	154 (29)	99 (51)	0.40	<0.001
Number of Infections, mean (range)	3.42 (0–32)	1.33 (0–17)	1.21	<0.001
ARI ⁴ (Y/N)	298 (57)	55 (28)	3.30	<0.001
Rate of ARI, per 1,000 resident-days	3.57	2.02	1.77 ^a	<0.001
Pneumonia (Y/N)	109 (21)	13 (7)	3.64	<0.001
Number of Pneumonia, mean (range)	0.33 (0–8)	0.11 (0–4)	2.01	<0.001

¹EN includes both nasal (including nasogastric and nasojejunal feeding tubes) and percutaneous feeding tubes (including all types of gastrostomy, jejunostomy, or other feeding enterostomy)

²Odds ratio (OR) was determined by logistic regression. Incidence rate ratio (IRR) was determined by Poisson regression.

³Based on last discharge only, does not include residents who were discharged home and subsequently returned to the same facility

⁴ARI = acute respiratory infection

^aIncidence rate ratio (IRR) reported for Poisson regression with continuous outcome

Table 2

Characteristics of infants less than one year of age with nasogastric, percutaneous and no feeding tubes at a single pediatric long term care facility with specialized unit for infants, 2012–2015, and unadjusted comparisons

	Infants with NGFTs ¹ N = 65 (31%)	Infants with PFTs ² N = 76 (37%)	Infants without a feeding tube N = 67 (32%)	p-value ³
Age at enrollment, mean (range) in years	0.32 (0.05–0.90)	0.38 (0.02–0.99)	0.32 (0.02–0.92)	0.17
Sex, male	27 (42)	38 (50)	38 (56)	0.22
Number of comorbidities, mean (range)	1.95 (0–4)	2.14 (1–4)	1.82 (0–4)	0.12
Respiratory Disorder	28 (43)	45 (59)	36 (54)	0.16
Neurologic Disorder	22 (34)	35 (46)	24 (36)	0.27
Gastrointestinal Disorder	50 (77)	52 (68)	36 (54)	0.02
Feeding Disorder	42 (65)	31 (41)	21 (31)	<0.001
Dysfunctional Suck/Swallow	2 (3)	1 (1)	0 (0)	-
Short Bowel Disease	2 (3)	6 (8)	3 (4)	0.44
Failure to Thrive	8 (12)	8 (11)	2 (3)	0.17
Length of Enrollment, mean days (range)	78 (4–1190)	240 (1–1217)	168 (4–1217)	0.009
Rate of Infection Related Hospital Admissions, per 1,000 resident-days	1.18	1.15	0.89 ^a	0.77
Discharged Home ⁴	44 (68)	36 (47)	44 (66)	0.02
Number of Infections, mean (range)	0.46 (0–4)	1.58 (0–9)	0.67 (0–6)	0.002
ARI ⁵ (Y/N)	11 (17)	24 (32)	14 (21)	0.11
Rate of ARI, per 1,000 resident-days	2.56	4.17	2.05 ^a	0.004
Pneumonia (Y/N)	2 (3)	7 (9)	2 (3)	0.19
Number of Pneumonia, mean (range)	0.03 (0–1)	0.11 (0–2)	0.04 (0–2)	0.28

¹ NGFT = nasogastric feeding tube (including nasogastric and nasojejunal feeding tubes) and percutaneous feeding tubes

² PFT = Percutaneous feeding tube = (including all types of gastrostomy, jejunostomy, or other feeding enterostomy)

³ Based on logistic regression for all variables except Rate of Infection Related Hospital Admissions and Rate of ARI which were based on Poisson regression.

⁴ Based on last discharge only, does not include residents who were discharged home and subsequently returned to the same facility

⁵ ARI = acute respiratory infection

^a Incidence rate ratio (IRR) reported for Poisson regression with continuous outcome

Table 3

Comparison of acute respiratory, hospitalization, and home discharge outcomes by type of feeding, in all residents and infants at a single pediatric long term care facility with specialized unit.

	IRR ^a /OR ^b (95% CI)	p-value
<i>All patients, comparison between Enteral Nutrition (EN)¹ and no EN</i>		
Rate of ARI⁴	1.65^a (1.39, 1.97)	<.001
Discharged home	0.61^b (0.42, 0.89)	<.01
Rate of hospitalization ⁵	1.17 ^a (0.68, 1.27)	0.65
<i>Infants, comparison among NGFT², PFT³, and no EN</i>		
Rate of ARI		
NGFT v. no EN	1.19 ^a (0.60, 2.36)	.621
PFT v. no EN	1.94^a (1.21, 3.11)	0.006
Discharged home		
NGFT v. no EN	1.04 ^b (0.50, 2.18)	.90
PFT v. no EN	0.57 ^b (0.28, 1.14)	.11
Rate of hospitalization		
NGFT v. no EN	1.47 ^a (0.53, 4.09)	.46
PFT v. no EN	0.75 ^a (0.32, 1.77)	.52

Notes: Bold indicates statistically significant result. Multivariable regression was conducted while controlling for number of comorbidity types. For discharged home and rate of hospitalization outcomes, we also controlled for number of infections.

¹EN includes both nasal (including nasogastric and nasojejunal feeding tubes) and percutaneous feeding tubes (including all types of gastrostomy, jejunostomy, or other feeding enterostomy)

^aIncidence rate ratio (IRR) reported for poisson regression with continuous outcome

^bOdds ratio (OR) reported for binomial logistic regression

²NGFT = nasogastric feeding tube (including nasogastric and nasojejunal feeding tubes)

³PFT = Percutaneous feeding tube (including all types of gastrostomy, jejunostomy, or other feeding enterostomy)

⁴ARI = acute respiratory infection, including pneumonia

⁵Based on last discharge only, does not include residents who were discharged home and subsequently returned to the same facility