RESEARCH ARTICLE

Care Variations and Outcomes for Children Hospitalized With Bacterial Tracheostomy-Associated Respiratory Infections

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ABSTRACT

OBJECTIVES: Identify hospital-level care variations and association with length of stay (LOS) and hospital revisit in children with tracheostomies hospitalized for bacterial respiratory tract infections (bRTIs).

METHODS: A multicenter, retrospective cohort study that used the Pediatric Health Information System database between 2007 and 2014 of patients with tracheostomies aged ≤18 years with a primary diagnosis of bRTI (eg, tracheitis) or a primary diagnosis of a bRTI symptom (eg, cough) and a secondary diagnosis of bRTI. Primary outcomes were LOS and 30-day all-cause revisit rates. Secondary outcomes included hospital-level diagnostic testing and anti-*Pseudomonas* antibiotic use. We used mixed-effects negative binomial (for LOS) and logistic (for revisit) regression to explore the relationship between hospital-level diagnostic test utilization and the outcomes.

RESULTS: Data representing 4137 unique patients with a median age of 3 years (interquartile range: 1–9 years) were included. Median LOS was 4 days (interquartile range: 3–8 days), and the 30-day revisit rate was 24.9%. Use of diagnostic testing and empirical anti-*Pseudomonas* antibiotics varied significantly among hospitals (all *P* values <.001). After adjusting for patient and hospital characteristics, compared with low test utilization hospitals, there were no differences in 30-day all-cause revisit rates in moderate (adjusted odds ratio: 1.19; 95% confidence interval [CI]: 0.93–1.52) or high (adjusted odds ratio: 1.07; 95% CI: 0.82–1.39) utilization hospitals. LOS in hospitals with moderate (% difference: −0.8%; 95% CI: −14.4–14.9%) or high (% difference: 13.9%; 95% CI: −0.7–30.6%) test utilization was not significantly longer.

CONCLUSIONS: Given that care variations were not associated with outcomes, future research should focus on standardizing diagnosis and treatment of bRTIs and readmission prevention in this population.

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In the United States, children with tracheostomies account for >$2.6 billion in estimated hospital charges each year.[1,2] Of the 4000 pediatric tracheostomies placed each year,[3,4] in-hospital post-tracheotomy mortality rates are 7% to 10%[4,5] and 6-month all-cause hospital readmission rates are as high as 60%.[6] Because tracheostomies bypass the respiratory tract's normal immunologic protection, children with tracheostomies have an increased risk of bacterial respiratory tract infections (bRTIs) requiring repeated hospitalizations and antibiotic courses. A retrospective study identified bacterial pneumonia as the most common reason for which pediatric patients with tracheostomies were admitted to the hospital, accounting for >2000 admissions and $100 million in 2009.[1] In addition to bacterial pneumonia, children with tracheostomies are at risk of aspiration pneumonia and bacterial tracheitis. Although individual hospitals may have clinical pathways for inpatient care, unlike pediatric community-acquired pneumonia[7] or adult ventilator-associated pneumonia,[8] there are no national guidelines for diagnosis or treatment of suspected bRTI in tracheostomized children.[9–12] Furthermore, the contribution of chronic bacterial colonization and viral coinfection may make differentiation between the heterogeneous respiratory infections challenging.

Although studies in children hospitalized for community-acquired bacterial pneumonia have shown wide variations in diagnostic test use and outcomes,[13,14] care variation and outcomes in children with tracheostomies admitted with bRTI are unknown. The objective of the current study is to identify hospital-level diagnostic and treatment variations in the care of children with tracheostomies hospitalized at children's hospitals for bRTI and to assess associations between hospital level-care variations, length of stay (LOS), and 30-day all-cause revisit rates.

METHODS

Study Design/Data Source

This is a multicenter retrospective cohort study that used administrative data from the Pediatric Health Information System (PHIS) database between 2007 and 2014. The PHIS database contains inpatient, emergency department, ambulatory surgery, and observation unit resource utilization data from 48 not-for-profit, tertiary care pediatric hospitals in the United States. Deidentified data are subjected to a number of reliability and validity checks before inclusion in the database.[15] For the period studied, 45 hospitals contributed data and were evaluated for inclusion. The study was reviewed by the Children's Hospital Los Angeles Institutional Review Board and was granted an exemption per the Code of Federal Regulations (45 CFR 46.101[b][4]).

Patient Selection

We included any patient aged 0 to 18 years with an International Classification of Diseases, Ninth Revision (ICD-9), code consistent with tracheostomy status (V44.0, V55.0, 519.00, 519.01, 519.02, and 519.09)[1,4,16] who had the following: (1) an ICD-9 code consistent with a primary discharge diagnosis of bRTI (those previously validated for bacterial community-acquired pneumonia,[13,17] as well as aspiration pneumonia [507.0, 507.8] and acute tracheitis [464.1x]) or (2) a primary discharge diagnosis of a symptom of a bRTI (eg, tachypnea) with a secondary diagnosis of a bRTI.

We excluded any patient hospitalized >30 days because this finding represented a population outlier before applying any exclusion criteria (median: 7 days; interquartile range [IQR]: 4–14 days). We excluded any patient transferred from an outside hospital, given our interest in test utilization and LOS upon hospital admission. We also excluded any patient who did not receive antibiotics on hospital day 0 or 1 due to the likelihood that these patients did not have a bRTI as their primary reason for admission. One hospital was excluded for not reporting test utilization data. To decrease potential bias that might be introduced by recurrent bRTI admissions represented in the PHIS database, we selected 1 unique hospitalization per patient at random for inclusion (median number of admissions: 1; IQR: 1–2). The final sample included 8369 encounters from 44 hospitals and 4137 unique patients for possible inclusion.

Outcomes

Primary outcomes were LOS and 30-day all-cause revisit rates. We defined LOS as total number of hospital days at midnight. We defined a 30-day revisit as any inpatient, observation unit, or emergency department visit within 30 days of discharge from the index admission. Secondary outcomes included hospital-level diagnostic testing, identified by Clinical Transaction Classification codes in the PHIS database, such as laboratory tests (complete blood count [CBC], respiratory culture, blood culture, electrolytes, blood gas, viral testing, C-reactive protein [CRP], erythrocyte sedimentation rate [ESR]) and chest radiographs. In examining respiratory cultures, many sites did not code specifically for respiratory cultures. We attempted to resolve this missing information by contacting several participating hospitals about their practices, but given the variability in respiratory culture coding across participating hospitals, we categorized codes for respiratory, unspecified, other source, or subcultures all as respiratory cultures. In addition to diagnostic testing, we also analyzed the use of antibiotics targeting *Pseudomonas aeruginosa* (Supplemental Table 4) on hospital day 0 or 1, receipt of mechanical ventilation, and ICU admission at any time during the hospitalization. Of the 44 hospitals providing data, for each specific item between 41 and 44 hospitals each submitted data.

Covariates

Covariates of interest included age at admission, sex, race (categorized as white, black, or other), Hispanic ethnicity, and insurance (categorized as public, private, or other). We used Feudtner et al's[18] definition of complex chronic conditions (CCC; version 1) to describe significant medical comorbidities in the patient population. We defined gastrostomy tube status through the presence of an ICD-9 procedure code (43.1x and 97.02) or diagnosis code (v44.1, v55.1, and 536.4x).[19] We defined ventilator dependency by the presence of an ICD-9 code of V46.1x at discharge. To compare disease severity across different All Patient Refined Diagnostic Related Groups (APR-DRG) classifications, we used

the National Association of Children's Hospitals and Related Institutions' Pediatric LOS weight, which is a normalized value of a patient's expected LOS given their principal APR-DRG and severity of illness. Similar to the case mix index, this allows us to compare hospital-level patient severity across multiple different APR-DRG classifications.

Statistical Methods

Descriptive statistics for demographic variables included means and SDs for normally distributed continuous data, medians and IQRs for nonnormally distributed continuous data, and proportions for categorical data. To assess hospital-level care variations in diagnostic testing, antibiotic use, mechanical ventilation, and ICU use, observed proportions of use were computed by hospital. Hospital-level proportions were adjusted by using mixed-effects logistic regression; patient-level use as the dependent variable was adjusted for patient-level covariates (age, sex, race, Hispanic ethnicity, type of insurance) and hospital-level covariates (average daily census, geographic region, average patient severity). Hospital-level random intercepts were specified. Model-predicted adjusted proportions were estimated for each hospital, representing the average use of each item for hospitals with the same patient- and hospital-level characteristics.

For each hospital, a measure of the overall use of diagnostic testing (CBC, respiratory culture, blood culture, electrolytes, blood gas, viral testing, CRP, ESR, and chest radiographs) relative to other hospitals was computed in the following manner: for each test, relative hospital-level use (calculated as the proportion of patients in that hospital's cohort receiving each test) was evaluated by using mixed-effects logistic regression, with hospital-level random intercepts estimating the deviation of each hospital from the average use over hospitals. Hospital-level test statistics were computed as the estimated random intercept divided by the SE; the statistics were ranked over all hospitals, with ranks representing relative use (from lowest to highest) of the diagnostic test. Overall utilization for each hospital was then calculated as the sum of ranks over all diagnostic tests. To standardize this for hospitals not reporting all 9 elements, we calculated the average rank for those reported and multiplied by 9.

To assess the associations of overall hospital-level diagnostic test utilization with patient outcomes (LOS and 30-day all-cause revisits), categories of low, moderate, and high resource utilization were defined by tertiles of the summed rank measure. Primary patient-level outcomes evaluated were hospital LOS (by using mixed-effects negative binomial regression) and 30-day all-cause revisits (by using mixed-effects logistic regression). Hospital-level random intercepts were specified. The associations of tertiles of hospital-level utilization with these outcomes were estimated and tested in unadjusted models and in models adjusted for patient age, sex, race, Hispanic ethnicity, type of insurance, hospital region, and average daily census. The 30-day all-cause revisit analysis additionally adjusted for hospital average pediatric disease severity. By using the low utilization tertile as the reference group, associations were summarized as adjusted odds ratios (aORs) with 95% confidence intervals (CIs) for 30-day revisits and as percentage differences in means for LOS. The association between hospital-level use of antibiotics for *P aeruginosa* and these outcomes was evaluated with these same patient outcomes in similar mixed-effects logistic regression models. All analyses were conducted by using Stata statistical software, version 13 (StataCorp LP, College Station, TX).

RESULTS

For the 4137 discharges included, the median age on admission was 3 years (IQR: 1–9 years). Patients were primarily male (57.4%; $n = 2375$), white (53.5%; $n = 2214$), and receiving public insurance (71.7%; $n = 2965$). The population had a high level of technology dependence, with 75% ($n = 3103$) having gastrostomy tubes and 32.4% ($n = 1342$) with ventilator dependence. Nearly 52% ($n = 2134$) received mechanical ventilation at some point during their hospitalization and 37% ($n = 1530$) of patients were admitted to an ICU (Table 1). Median LOS for the cohort was 4 days (IQR: 3–8 days). In-hospital mortality for the study cohort was 0.7% ($n = 28$). Of the 4137 discharges, 24.9% ($n = 1030$) had a hospital revisit within 30 days, with 68.6% ($n = 707$) admitted to inpatient status, 6% ($n = 62$) admitted to observation status, and 25.3% ($n = 261$) admitted to the emergency department. There was no association between hospital-level LOS and revisit rates (Spearman's $r = -0.22$, $P = .15$). Primary discharge diagnoses were bacterial pneumonia (43.5%; $n = 1799$), tracheitis (43.3%; $n = 1792$), aspiration pneumonia (8.7%; $n = 360$), and other (4.5%; $n = 186$) (Supplemental Table 5). Patients with a primary diagnosis in the "other" category had higher proportions of cardiovascular or hematologic CCCs, higher rates of mechanical ventilation while hospitalized, and higher ICU utilization (Supplemental Table 5).

Unadjusted and adjusted diagnostic test, antibiotic, ICU, and mechanical ventilation utilization is presented in Table 2. The most frequently used diagnostic tests were chest radiographs, CBCs, and respiratory cultures, whereas the least used resources were ESR, CRP, and viral testing. Utilization varied significantly among hospitals in both the unadjusted and adjusted analyses (all P values for hospital-specific differences $<.001$), with respiratory cultures, blood cultures, and blood gas and viral testing showing the widest variations. Respiratory cultures were obtained in all patients admitted at some hospitals but in $<20\%$ of patients admitted at other hospitals.

After dividing included hospitals into tertiles (low, moderate, and high) on the basis of diagnostic test use, we calculated the mean patient severity for hospitals included in each group. Compared with the lowest tertile, there was no significant difference in patient severity at moderate-tertile (adjusted % difference: −6.9%; 95% CI: −17.1–4.5%) and high-tertile (adjusted % difference: 2.4%; 95% CI: −8.9–15.3%) hospitals.

Hospital-level median LOS varied from 3 to 7 days in the low tertile of diagnostic test use, 2 to 6.5 days in the moderate tertile, and 3.5 to 6 days in the high tertile (Table 3).

TABLE 1 Demographic Characteristics of Pediatric Patients With Tracheostomies Admitted With bRTIs in the Study Population

Variable	Total Sample
N (%)	4137 (100)
Age, median (IQR), y	3 (1–9)
Sex	
Male	2375 (57.4)
Female	1762 (42.6)
Race[a]	
White	2214 (53.5)
Black	906 (21.9)
Other/missing	1042 (25.2)
Hispanic	917 (22.2)
Insurance	
Public	2965 (71.7)
Private	1027 (24.8)
Self-pay, other, missing	145 (3.5)
CCCs	
Total number, median (IQR)	3 (2–4)
Cardiovascular	738 (17.8)
Gastrointestinal	3367 (81.4)
Hematologic	147 (3.6)
Oncologic	99 (2.4)
Metabolic	272 (6.6)
Neuromuscular	2024 (48.9)
Congenital	1324 (32.0)
Renal	300 (7.3)
Respiratory	4137 (100)
Other comorbidities	
Gastrostomy tube	3103 (75.0)
Ventilator dependency	1342 (32.4)
Received mechanical ventilation during hospitalization	2134 (51.6)
Admitted to ICU	1530 (37.0)
Discharge disposition	
Home	3827 (92.5)
Expired	28 (0.7)
Transfer to another unit/hospital, other, missing	282 (6.8)

Data are presented as *n* (%) unless otherwise indicated. $N = 4137$ unique patients.
[a] Race numbers add up to more than the number of patients, as some reported multiple race categories.

When compared with the lowest tertile, average LOS for patients in the middle tertile was not significantly different in adjusted analysis (% difference: −0.8%; 95% CI: −14.4–14.9%). Compared with the lowest tertile, average LOS for patients in the highest tertile was significantly longer in unadjusted analysis (% difference: 16.4%; 95% CI: 2.3–32.4%; $P = .02$) but not in adjusted analysis (% difference: 13.9%; 95% CI: −0.7–30.6%; $P = .06$). Therefore, there was no association between hospital-level diagnostic test utilization and LOS.

Thirty-day all-cause revisit rates varied from 6.2% to 38.5% in the low tertile of diagnostic test use, from 17.7% to 33.3% in the moderate tertile, and from 10.3% to 36.9% in the high tertile (Table 3). On adjusted analyses, when compared with the lowest tertile, 30-day all-cause revisit rates for patients hospitalized at moderate (aOR: 1.19; 95% CI: 0.93–1.52) or high (aOR: 1.07; 95% CI: 0.82–1.39) utilization hospitals were not significantly different. Our subgroup analysis examining emergency department visits and hospital readmissions separately found no difference between both outcomes and degree of diagnostic test use (Table 3). Thus, there was no association between revisit rate and diagnostic test utilization.

In this cohort, hospital-level median rates of empirical antibiotics targeting *P aeruginosa* were 67.3% (IQR: 55.2–82.0%) (Table 2). There were no association between patient severity and hospital use of antibiotics targeting *P aeruginosa* on adjusted analyses (% difference per 10% increase in antibiotic usage: 1.6%; 95% CI: −1.4–4.7%). Increased hospital-level use of antibiotics targeting *P aeruginosa* was associated with significantly longer LOS (adjusted % difference in average LOS per 10% increase in antibiotic usage: 3.4%; 95% CI: 0–7.0%; $P = .05$) (Fig 1). There was no relationship between hospital-level use of anti-*Pseudomonas* antibiotics and 30-day revisit rates (aOR: 0.96 per 10% increase in antibiotic use; 95% CI: 0.91–1.01).

DISCUSSION

Children with tracheostomies hospitalized for treatment of bRTIs have high 30-day all-cause revisit rates with wide variations in care on initial hospital presentation. On admission, most patients received chest radiographs and certain laboratory tests (CBCs, blood cultures, and respiratory cultures), whereas fewer hospitals routinely used markers of inflammation (ESR, CRP). These care variations upon admission did not appreciably change after controlling for patient demographic characteristics, illness severity, and hospital factors. After adjusting for patient demographic characteristics, patient severity, hospital region, and average daily census, we found no statistically significant associations between overall hospital-level admission diagnostic test utilization and 30-day all-cause revisit rates or LOS. Decreasing variation in diagnostic testing may standardize clinical care without increasing LOS or readmission rates.

TABLE 2 Variations in Hospital-Level Resource Utilization and Anti-*Pseudomonas* Antibiotic Use

	Unadjusted Distribution Across Hospitals, % of Patients Receiving		Adjusted Distribution Across Hospitals,[a] % of Patients Receiving	
Resource (number of hospitals)	Median % (IQR)	Range	Median % (IQR)	Range
Chest radiograph (44)	83.8 (76.3–90.2)	60.0–97.9	84.9 (81.0–88.3)	76.4–94.1
Laboratory tests				
CBC (44)	82.4 (76.3–88.4)	17.0–96.6	83.3 (78.3–88.8)	74.9–98.8
Respiratory culture (44)	81.2 (76.8–86.5)	8.3–96.8	78.6 (72.6–82.8)	64.3–92.7
Blood culture (43)	66.7 (50.5–72.2)	0–87.2	63.3 (57.4–69.8)	44.1–84.8
Serum electrolytes (42)	62.6 (41.1–75.4)	0–93.1	55.3 (47.8–61.7)	31.2–77.4
Blood gas (44)	50.3 (38.3–62.8)	9.4–84.7	52.1 (49.1–57.5)	38.6–71.4
Viral testing (41)	23.7 (12.6–35.9)	0–88.2	21.0 (14.2–29.9)	4.3–66.1
CRP (44)	14.3 (5.2–36.2)	0–78.9	17.1 (12.3–21.9)	6.9–33.0
ESR (44)	3.0 (1.3–5.5)	0–13.0	3.1 (2.7–3.6)	2.0–6.1
Antibiotics targeting *Pseudomonas* on hospital day 0 or 1 (44)	67.3 (55.2–82.0)	31.2–90.4	68.9 (66.1–71.9)	55.9–79.2
Patients receiving mechanical ventilation during hospitalization (44)	50.4 (43.2–59.8)	20.7–82.3	49.4 (45.7–53.6)	42.0–69.5
Patients with ICU admission during hospitalization (44)	37.6 (20.5–52.8)	2.0–91.5	36.1 (32.3–40.1)	18.4–58.0

[a] Adjusted for patient age, sex, race, Hispanic ethnicity, type of insurance (public, private, or other), hospital region (Midwest, Northeast, South, or West), average daily census, and average LOS weight.

Our results are consistent with previous studies showing wide variation in hospital-level care in respiratory diseases (eg, community-acquired pneumonia,[13,20] bronchiolitis[21,22]) and other pediatric diseases (eg, tonsillectomy,[23] abscess incision and drainage[24]). The exact reasons for the wide differences in diagnostic testing and other resource use in this population are unclear. As noted, there are no national guidelines for respiratory infections in pediatric patients with

TABLE 3 Associations Between Degree of Hospital-Level Diagnostic Test Use, LOS, and Return Visit Outcomes

	Hospital-Level Resource Utilization (Tertile)					
	Unadjusted Analysis			Adjusted Analysis[a]		
	Low	Moderate	High	Low	Moderate	High
LOS						
Range of hospital-level medians, d	3–7	2–6.5	3.5–6	N/A	N/A	N/A
% difference (95% CI)[b]	Ref	0.2 (−13.8–16.4)	16.4 (2.3–32.4)	Ref	−0.8 (−14.4–14.9)	13.9 (−0.7–30.6)
P	N/A	.98	.02	N/A	.91	.06
30-Day revisit rate						
All-cause revisit rate, %	6.2–38.5	17.7–33.3	10.3–36.9	N/A	N/A	N/A
OR (95% CI)	Ref	1.10 (0.83–1.47)	0.97 (0.72–1.31)	Ref	1.19 (0.93–1.52)	1.07 (0.82–1.39)
P	N/A	.49	.85	N/A	.16	.63
Inpatient/observation readmissions only, %	0–35.9	12.8–25.9	10.3–31.0			
OR (95% CI)	Ref	1.01 (0.72–1.42)	0.88 (0.62–1.25)	Ref	1.08 (0.80–1.45)	0.93 (0.68–1.28)
P	N/A	.97	.48	N/A	.63	.66
ED revisits only, %	0–12.2	0–15.7	0–13.2			
OR (95% CI)	Ref	1.40 (0.77–2.55)	1.35 (0.76–2.39)	Ref	1.46 (0.76–2.78)	1.50 (0.84–2.68)
P	N/A	.27	.30	N/A	.25	.17

Thirty-day revisit outcomes were analyzed by mixed-effects logistic regression, with a random intercept for hospital. LOS outcome was analyzed by mixed-effects negative binomial regression, with a random intercept for hospital. ED, emergency department; N/A, not applicable; OR, odds ratio; Ref, reference.

[a] LOS analyses adjusted for patient age, sex race, Hispanic ethnicity, type of insurance (public, private, or other), hospital region (Midwest, Northeast, South, or West), and average daily census. Thirty-day revisit analysis additionally adjusted for hospital average pediatric LOS weight.

[b] LOS interpreted as the percentage mean difference in outcome (from low resource utilization).

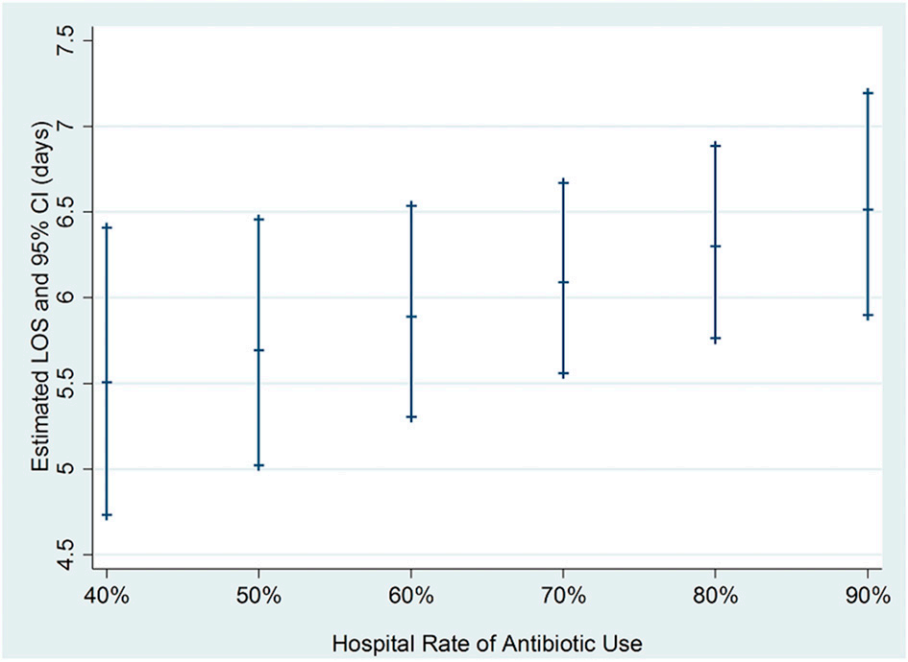

FIGURE 1 Association between hospital-level percentage of patients receiving anti-*Pseudomonas* antibiotics on hospital day 0 or 1 and LOS.

tracheostomies. Furthermore, there are few clinical studies examining tracheostomy-associated respiratory infections, limiting the ability to create evidence-based care guidelines. Finally, the variations in care may be due to patient differences not accounted for in our current study. Our results are consistent with those of previous pediatric studies that showed no correlation between LOS and hospital readmission in community-acquired pneumonia and other common diseases.[13,25–27] This finding suggests that there may be potential to decrease LOS without adversely affecting hospital revisit rates and represents an area for future research. The overall high 30-day revisit rates suggest that there is room for improvement of postdischarge care. There are potential cost savings by decreasing LOS and readmission rates, if the decreased LOS does not lead to higher readmission rates for treatment failures or complications from the index admission. Prospective studies are needed to evaluate the contribution of specific care practices on patient outcomes.

We found high rates of empirical use of antibiotics targeting *P aeruginosa* (adjusted hospital median: 68.9%), but due to a lack of clinical test results from the PHIS database, conclusions are limited. Although receipt of anti-*Pseudomonas* antibiotics is an imperfect measure for a history of *Pseudomonas*-positive cultures, this finding suggests either a present or past history of a positive *P aeruginosa* culture that leads to coverage of this organism during subsequent admissions. The use of broad-spectrum antibiotics may lead to increased development of resistant organisms and suggests an increased role for antimicrobial stewardship programs. Indeed, variations in hospital-level use of empirical anti-*Pseudomonas* antibiotics may be due to the presence of antimicrobial stewardship programs that affect the overall use of these antibiotics. We also found a significant association between the use of antibiotics targeting *P aeruginosa* and longer LOS. The longer LOS may be due to limited enteral alternatives, antibiotic resistance patterns, difficulty obtaining home intravenous antibiotic therapy, hesitance to transition from the intravenous to enteral route, or unmeasured confounders. Future studies should correlate culture results and susceptibilities with appropriate antibiotic utilization.

The current study has several limitations. First, this study had an observational, retrospective design that relied on accurate coding and translation of data from patients admitted at PHIS member children's hospitals. Although we used bacterial pneumonia ICD-9 codes validated in previous work,[17] in children with CCCs they identified correctly 71.8% of provider-confirmed community-acquired pneumonia cases, with a high specificity of 91.4%. Given our inability to confirm diagnoses via chart review, by maximizing specificity we limited the inclusion of patients who may not have met our inclusion criteria. Second, the database only provides administrative billing data and does not include results of tests. There may be some patients treated with antibiotics for positive respiratory cultures that represent chronic colonization and not acute infection. However, we included only patients who received antibiotic therapy and who had a diagnostic code of a bRTI. Third, the data do not include patients hospitalized at community hospitals and may not be representative of all children with tracheostomies admitted with bRTIs. We were not able to capture patient readmission to non-PHIS hospitals; thus, this analysis may underestimate the all-cause

revisit rates at 30 days. However, given the medical complexity of the patient population studied, we believe the number of patients readmitted to non-PHIS hospitals is low. Fourth, although we excluded any lateral (inpatient-to-inpatient) hospital transfers, we may have included patients with tests and medications given by a nonhospital referral source (eg, outpatient clinic, skilled nursing facilities). This possibility, however, would lead to an underestimation of resource utilization. Finally, some resource utilization may be influenced by hospital-level care practices rather than by patient acuity (eg, at some hospitals, most or all patients with tracheostomies are admitted to the ICU); we were not able to account for all potential differences between hospitals given the inherent limitations of the data set.

Despite these limitations, this is the first study to show high hospital-level, 30-day all-cause revisit rates and variable LOS and test utilization in patients with tracheostomies admitted for bRTIs. Because this population accounts for a disproportionately high utilization of health care dollars and resources, the development of evidence-based best practices for the prevention and treatment of respiratory tract infections is crucial to decreasing expenditures and hospital admissions for this vulnerable population. Given the heterogeneity of this patient population, future research should identify patient-level risk factors for prolonged LOS and readmission in children with tracheostomies admitted with bRTIs, controlling for hospital-level factors that may influence test utilization and patient-level outcomes. This information can guide the development of evidence-based guidelines for the diagnosis and management of children with tracheostomies admitted with bRTIs.

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