RESEARCH ARTICLE

Technology-Dependent Pediatric Inpatients at Children's Versus Nonchildren's Hospitals

Namrata Ahuja, MD,[a,b] Wendy J. Mack, PhD,[c] Christopher J. Russell, MD, MS[a,b]

ABSTRACT

BACKGROUND AND OBJECTIVE: Technology-dependent children (TDC) are admitted to both children's hospitals (CHs) and nonchildren's hospitals (NCHs), where there may be fewer pediatric-specific specialists or resources. Our objective was to compare the characteristics of TDC admitted to CHs versus NCHs.

METHODS: This was a multicenter, retrospective study using the 2012 Kids' Inpatient Database. We included patients aged 0 to 18 years with a tracheostomy, gastrostomy, and/or ventricular shunt. We excluded those who died, were transferred into or out of the hospital, had a length of stay (LOS) that was an extreme outlier, or had missing data for key variables. We compared patient and hospital characteristics across CH versus NCH using χ^2 tests and LOS and cost using generalized linear models.

RESULTS: In the final sample of 64 521 discharges, 55% of discharges of TDC were from NCHs. A larger proportion of those from CHs had higher disease severity (55% vs 49%; $P < .001$) and a major surgical procedure during hospitalization (28% vs 24%; $P < .001$). In an adjusted generalized linear model, the mean LOS was 4 days at both hospital types, but discharge from a CH was associated with a higher adjusted mean cost (\$16 754 vs \$12 023; $P < .001$).

CONCLUSIONS: Because the majority of TDC are hospitalized at NCHs, future research on TDC should incorporate NCH settings. Further studies should investigate if some may benefit from regionalization of care or earlier transfer to a CH.

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Address correspondence to Namrata Ahuja, MD, Division of Hospital Medicine, Children's Hospital Los Angeles, 4650 Sunset Blvd, Mail Stop 94, Los Angeles, CA 90027. E-mail: nahuja@chla.usc.edu

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[a]Division of Hospital Medicine, Children's Hospital Los Angeles, Los Angeles, California; and [b]Departments of Pediatrics and [c]Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California

Children who require inpatient admission are cared for at diverse hospital types, ranging from specialized children's hospitals (CHs) to urban and rural nonchildren's hospitals (NCHs). The majority of pediatric admissions occur at NCHs.[1,2]

There has been movement toward regionalization of pediatric health care for specific patient populations, such as neonatal intensive care[3] and pediatric trauma care.[4–6] Regionalization refers to the directing of patients with specific conditions to specialized hospitals, with the hypothesis being that regional centers of excellence with pediatric-specific medical and ancillary services provide better care.[7] Conversely, regionalization may burden families who live further away from specialty hospitals.[8,9] Parents, providers, and insurers have an interest in identifying children who can receive quality care at closer-to-home NCHs and children who would be better served at a tertiary or quaternary specialty CH.

Children with medical complexity account for a large proportion of pediatric inpatient admissions[10,11]and have a longer length of stay (LOS) and increased costs of hospitalization.[11] Although children with medical complexity often receive care at specialty CHs, a 2006 study showed that 37% of children with ≥1 complex chronic condition (CCC) are hospitalized at NCHs.[11] A large subset of children with medical complexity rely on the use of medical technology such as a gastrostomy tube or tracheostomy to sustain life or improve functioning.[11–13] Often multiple medical specialists and health care professionals, such as pediatric respiratory therapists, may be involved in the care of technology-dependent children (TDC) who are admitted to CHs[12]; however, these resources may not be available at an NCH. Given these differential resources, TDC may be a subgroup that benefits from regionalization of care, and TDC may have better outcomes at specialized CHs.

To our knowledge, no previous studies have compared characteristics of TDC at CHs versus at NCHs and the association of hospital type with outcomes such as LOS or cost. Understanding the differences in baseline characteristics as well as outcomes between these 2 groups will help direct where future research for this population is conducted as well as whether this population, or a portion of it, may benefit from regionalization of care.

METHODS

Data Source and Sample

This was a multicenter, retrospective, cross-sectional study using data from the 2012 Kids' Inpatient Database (KID 2012), which is a national administrative data set with a sample of inpatients from ages 0 to 20 who were discharged in 2012 from all community, nonrehabilitation hospitals in 44 participating states in the United States. It is part of a family of databases that were developed for the Healthcare Cost and Utilization Project (HCUP), which is sponsored by the Agency for Healthcare Research and Quality.[14]

We selected a study sample from KID 2012 (Fig 1) that included any patient aged 0 to 18 with discharge International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes used in Feudtner et al's[15] CCC classification system and previous studies[16–21] consistent with at least 1 of the following technologies: tracheostomy (V44.0, V55.0, 519.0, 519.00, 519.01, 519.02, or 519.09), gastrostomy (with or without jejunostomy; V44.1, V55.1, or 536.4), or ventricular shunt (V45.2, V53.01, 996.2, or 996.63). We focused on these 3 technology types because they are among the most prevalent, in our clinical experience. We excluded those whose final disposition was deceased because LOS was 1 of our outcomes of interest. For our primary analyses, the "Transfer In" and "Transfer Out" indicator provided in KID 2012 was used to exclude discharges of patients who had been transferred into or out of a different acute care hospital than the hospital at discharge, again because LOS was 1 of our outcomes of interest and the database does not report LOS before a transfer. Discharges with a LOS that was an extreme outlier (>18 days), calculated as 3 times the interquartile range (IQR) from the median, were excluded from the sample. Additionally, we excluded discharges of patients who were missing data for key variables (race, sex, median household income, payer, All Patient Refined Diagnosis Related Group Severity of Illness score, and charge).

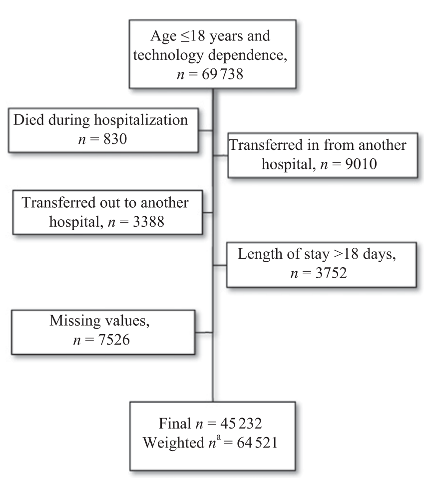

FIGURE 1 Flowchart depicting sample selection and inclusion and exclusion criteria. [a] The sample was weighted by using a weighting variable provided in the KID 2012 to obtain national estimates from the raw data.

This project was deemed exempt by our hospital's institutional review board (per 45 Code of Federal Regulations 46.102[f]).

Hospital Type

The primary predictor was the hospital type of each discharge: CH versus NCH. KID 2012 uses information from the American Hospital Association Annual Survey as well as the National Association of Children's Hospitals and Related Institutions (now known as the Children's Hospital Association) to define CHs, which include freestanding CHs as well as pediatric units within general hospitals.[22] All hospitals not defined as CHs by using KID 2012 were defined as NCHs.

Patient Demographics

Patient demographics studied included age (in years), sex, race (categorized as non-Hispanic white, non-Hispanic African American, Hispanic, and other), median household income for the patient's zip code (categorized in quartiles), payer (categorized as public insurance, private insurance, and other), and the size of the patient's county of residence (categorized as central or fringe counties of a metropolitan area with a population >1 million, counties of a metropolitan area with populations of 50 000–999 999, and micropolitan counties and/or nonmetropolitan counties).

Patient Clinical Characteristics

Patient clinical characteristics studied included type of technology (tracheostomy, gastrostomy, or ventricular shunt), number of technologies, CCCs (as defined by Feutdner et al[15]), and whether a major operating-room procedure occurred during admission (defined [by an indicator provided in KID 2012] as a therapeutic or diagnostic procedure that occurred in an operating room, which could include placement of a tracheostomy, gastrostomy, or ventricular shunt). As a proxy measure for complexity, we used the number of CCCs, and for severity of illness, we used the Hospitalization Resource Intensity Score for Kids (H-RISK), which is calculated by using cost and All Patient Refined Diagnosis Related Group Severity of Illness score.[23] H-RISK scores compare the relative intensity of hospital care for inpatient pediatric populations, with a higher score demonstrating a higher intensity of care. Scores can range from as low as 0.18 (normal newborn) to as high as 91.66 (heart and/or lung transplant).

Hospital Demographics

Hospital demographics studied included hospital region (Northeast, Midwest, South, and West), teaching and urban versus rural status (rural, urban teaching, and urban nonteaching), and hospital-bed size category (small, medium, and large), which is categorized by HCUP and specific to the hospital's location and teaching status.[14] Urban hospitals are identified as those in a core-based statistical area as defined by the US Census Bureau, and all other hospitals are defined as rural.

Primary Admission Diagnoses

KID 2012 provides a primary admission diagnosis ICD-9-CM code for each subject and additionally provides a Clinical Classifications Software, which collapses codes into clinically meaningful categories of diagnoses.[24] HCUP determines the discharge diagnosis thought to be chiefly responsible for causing the admission of the patient, and defines this as the primary admission diagnosis. The primary Clinical Classifications Software diagnosis for all discharges was studied.

Outcome Measures

The primary outcome of interest was the proportion of patient discharges at each hospital type by patient demographics and clinical and hospital characteristics. Secondary outcomes were LOS in days and estimated cost in dollars for each hospital type. Cost was estimated from charge data provided for each discharge by using hospital-specific cost/charge ratios provided by HCUP.[25] These ratios were obtained by using cost data that hospitals provided to the Centers for Medicare and Medicaid Services. Among all hospitals in KID 2012, the median cost/charge ratio is 0.39 with an IQR 0.28 to 0.60.

Statistical Analyses

All analyses reflected the KID 2012 complex sampling design; the stratification, hospital-level clustering, and sampling-weight variables from the KID 2012 database, as well as the definition of the specified study group (TDC) as a study subpopulation, were used to obtain national estimates as well as SEs and 95% confidence intervals. We conducted bivariate analyses to assess the relationships between hospital type and all other variables. Descriptive statistics generated national estimates of numbers and proportions (with 95% confidence intervals) of TDC by patient demographics, patient clinical characteristics, and hospital characteristics in CHs and NCHs. Differences in proportions on each characteristic between CHs and NCHs were statistically tested with a Pearson's χ^2 test statistic that was corrected for the survey design effects and reported as an F-statistic.

Generalized linear models were used to estimate the association between hospital type and the dependent outcome variables of LOS and cost. LOS used a negative binomial regression (negative binomial random variable, log link function); cost used a gamma regression (gamma random variable, log link function). The stratification, clustering, sampling weight, and subpopulation variables were incorporated into the analysis to provide appropriate estimates of SEs. Associations are presented as exponentiated regression estimates with 95% confidence intervals; exponentiated regression coefficients for these models represent the fold difference (ie, ratio) in the covariate-adjusted mean LOS (or cost) in discharges from CHs compared with NCHs. Covariates used in the adjusted LOS and cost models included hospital type (CH versus NCH), age, sex, race, household income, payer, H-RISK, number of technologies, number of CCCs, hospital region, major operating-room procedures, and hospital location and/or teaching status. Our cost model also included LOS as a covariate.

All analyses used 2-tailed tests with a significance level of 0.05. Statistical analysis was conducted by using Stata software (version 15; Stata Corp, College Station, TX) for survey data analysis.

RESULTS

Study Population

Of 6.7 million discharges in KID 2012, 64 521 met all of our inclusion and exclusion criteria. The majority of discharges of TDC were from NCHs (n = 35 430; 55%). The discharges in our study came from 1408 hospitals, and 1345 (95.5%) were NCHs. Most NCHs were rural (23.3%; n = 314) or urban nonteaching (39.0%; n = 524) versus urban teaching (37.7%; n = 507). There were no rural CHs, and most were urban teaching hospitals (88.9%; n = 56). When compared with NCHs, CHs had higher mean numbers of discharges in a year for children with tracheostomies (91 vs 5), gastrostomy tubes (320 vs18), and ventricular shunts (143 vs 8).

Patient Demographics

The study sample was primarily male (55.2%; n = 35 622), non-Hispanic white (53.4%; n = 34 422), and on public insurance (59.3%; n = 38 232) and had a median age of 4 years (IQR 2–10 years). Most patient demographics were similar between CHs and NCHs (Table 1), although NCHs had a higher proportion <5 years of age (56.6% vs 53.7%; P < .001), and CHs had a higher proportion from the counties of

TABLE 1 Patient, Clinical, and Hospital Characteristics of Discharges of Nontransferred TDC From NCHs Versus CHs

	Total Discharges (N = 64 521)		NCH Discharges (N = 35 430)		CH Discharges (N = 29 091)		P
	No.	%	No.	% (95% CI)	No.	% (95% CI)	
Patient demographics							
Age group, y							<.001
<1	8246	12.8	4861	13.7 (12.9–14.6)	3385	11.6 (10.8–12.6)	
1–5	27 426	42.5	15 182	42.9 (41.9–43.9)	12 244	42.1 (40.8–43.4)	
6–12	17 682	27.4	9064	25.6 (24.7–26.5)	8618	29.6 (27.8–31.5)	
13–18	11 167	17.3	6323	17.9 (17.0–18.7)	4844	16.7 (15.2–18.2)	
Sex							.04
Male	35 622	55.2	19 773	55.8 (55.0–56.7)	15 849	54.5 (53.5–55.4)	
Female	28 899	44.8	15 657	44.2 (43.3–45.1)	13 242	45.5 (44.6–46.5)	
Race and/or ethnicity							.09
White	34 422	53.4	18 875	53.3 (49.2–57.3)	15 547	53.4 (45.0–60.9)	
African American	10 036	15.6	6165	17.4 (15.4–19.6)	3871	13.3 (10.7–16.4)	
Hispanic	14 841	23.0	7116	20.1 (16.9–23.8)	7725	26.6 (19.6–34.9)	
Other	5223	8.1	3274	9.2 (7.3–11.6)	1949	6.7 (5.3–8.4)	
Median household income for zip code, quartile							.08
1 ($1–$38 999)	18 343	28.4	10 316	29.1 (26.6–31.7)	8027	27.6 (23.1–32.6)	
2 ($39 000–$47 999)	16 649	25.8	9904	29.0 (26.1–29.9)	6745	23.2 (20.9–25.6)	
3 ($48 000–$62 999)	16 070	24.9	8539	24.1 (22.8–25.5)	7531	25.9 (23.2–28.8)	
4 (>$63 000)	13 461	20.9	6671	18.8 (16.4–21.5)	6790	23.3 (19.2–28.1)	
Payer							.16
Public insurance	38 232	59.3	22 009	62.1 (59.9–64.3)	16 223	55.8 (29.5–35.3)	
Private insurance	21 793	33.8	11 454	32.3 (29.5–35.3)	10 339	35.5 (31.6–39.7)	
Other	4496	7.0	1967	5.6 (3.8–8.1)	2529	8.7 (4.8–15.3)	
Patient location							.005
Central and/or fringe counties of metropolitan population >1 million	37 449	58.0	17 984	50.8 (44.0–57.5)	19 465	66.9 (58.1–74.6)	
Counties of metropolitan population 50 000–999 999	19 142	29.7	12 529	35.4 (30.1–41.1)	6613	22.7 (16.1–31.0)	
Micropolitan and/or nonmetropolitan county population <50 000	7931	12.3	4918	13.9 (12.0–16.1)	3013	10.4 (7.6–14.0)	
Clinical characteristics							
Technology							
Tracheostomy	12 749	19.8	7029	19.8 (18.8–20.9)	5720	19.7 (17.6–21.9)	.89
Gastrostomy tube	44 523	69.0	24 340	68.7 (67.3–70.1)	20 183	69.4 (66.9–71.8)	.64
Ventricular shunt	20 019	31.0	10 986	31.0 (29.7–32.3)	9033	31.1 (28.7–33.5)	.98
No. technologies							.62
1	52 590	81.5	28 946	81.7 (80.7–82.6)	23 644	81.3 (79.8–82.6)	
2–3	11 931	18.5	6484	18.3 (17.4–19.3)	5447	18.7 (17.4–20.2)	
H-RISK quartile							<.001
First (<1.2)	14 234	22.1	8803	24.9 (23.5–26.3)	5431	18.7 (17.3–20.1)	
Second (1.2–1.89)	16 870	26.1	9180	25.9 (25.0–26.8)	7690	26.4 (25.2–27.7)	
Third (1.9–3.19)	16 290	25.2	8694	24.5 (23.7–25.4)	7596	26.1 (25.0–27.3)	
Fourth (>3.2)	17 127	26.5	8753	24.7 (23.4–26.1)	8374	28.8 (27.4–30.2)	
Major operating-room procedure							<.001
Yes	16 582	25.7	8463	23.9 (22.4–25.4)	8119	27.9 (261–29.8)	
No	47 939	74.3	26 967	76.1 (74.6–75.6)	20 972	72.1 (70.2–73.9)	

TABLE 1 Continued

	Total Discharges (N = 64 521)		NCH Discharges (N = 35 430)		CH Discharges (N = 29 091)		P
	No.	%	No.	% (95% CI)	No.	% (95% CI)	
CCC							
Gastrointestinal	46 185	71.6	25 137	71.0 (69.6–72.3)	21 048	72.4 (69.9–74.7)	.32
Neuromuscular	37 260	57.7	20 455	57.7 (56.4–59.1)	16 805	57.8 (55.6–59.9)	.98
Respiratory	17 507	27.1	9537	26.9 (25.9–28.0)	7970	27.4 (25.5–29.4)	.67
Congenital and/or genetic	14 487	22.5	7482	21.1 (20.3–21.9)	7005	24.1 (22.9–25.3)	<.001
Cardiovascular	8774	13.6	4627	13.1 (12.3–13.9)	4147	14.3 (12.9–15.7)	.14
Renal	6763	10.5	3363	9.5 (8.6–10.5)	3400	11.7 (10.6–12.9)	.004
Metabolic	5716	8.9	3065	8.7 (8.1–9.2)	2651	9.1 (8.5–9.8)	.31
Malignancy	4398	6.8	2283	6.4 (5.7–7.3)	2115.	7.3 (6.1–8.6)	.26
Neonatal	3410	5.3	1826	5.2 (4.5–5.9)	1584	5.4 (4.5–6.5)	.64
Hematologic and/or immunologic	2762	4.3	1397	3.9 (3.5–4.4)	1365	4.7 (4.2–5.2)	.03
Transplant	1772	2.7	855	2.4 (1.9–3.0)	917	3.2 (2.5–3.9)	.10
Hospital characteristics							
Hospital region							.13
Northeast	11 628	18.0	7167	20.2 (14.5–27.6)	4461	15.3 (5.7–35.2)	
Midwest	14 030	21.7	6832	19.3 (13.3–27.2)	7198	24.7 (12.7–42.6)	
South	22 386	34.7	15 119	42.7 (34.7–51.1)	7267	25.0 (13.52–41.5)	
West	16 477	25.5	6312	17.8 (12.4–25.0)	10 165	34.9 (20.3–53.0)	
Hospital location and/or teaching status							.01
Rural	986	1.5	986	2.8 (1.9–4.2)	0	0	
Urban nonteaching	3781	5.9	2925	8.3 (6.3–10.7)	856	2.9 (0.9–9.4)	
Urban teaching	59 754	92.6	31 519	89.0 (86.1–91.3)	28 235	97.1 (90.6–99.1)	
Bed size[a]							<.001
Small	4608	7.1	398	1.1 (0.8–1.5)	4210	14.5 (7.8–25.3)	
Medium	3946	6.1	2562	7.2 (5.3–9.7)	1384	47.6 (31.0–64.8)	
Large	43 510	67.4	32 470	91.7 (89.1–93.7)	11 040	38.0 (22.2–56.7)	

[a] The number of beds that corresponds with each category is specific to hospital region and teaching status.

large metropolitan areas (66.9% vs 50.8%; $P = .005$).

Patient Clinical Characteristics

Of the entire sample, 19.8% ($n = 12\,749$) of TDC had tracheostomies, 69% ($n = 44\,523$) had gastrostomy tubes, and 31% ($n = 20\,019$) had ventricular shunts, with the majority having only 1 technology type (81.5%; $n = 52\,590$). There was no difference in the proportion of types of technologies or the number of technologies between CHs and NCHs (Table 1). TDC at CHs had higher H-RISK scores ($P < .001$) and were more likely to have a major operating-room procedure during hospitalization (27.9% vs 23.9%; $P < .001$). The proportions of different CCCs were similar between NCHs and CHs (Table 1), and gastrointestinal, neuromuscular, and respiratory CCCs were the most common. The top 5 primary diagnoses at CHs and NCHs were similar (Supplemental Table 4), with the most frequent being "complications of a device and/or implant."

LOS

On bivariate negative binomial regression analysis, there was a statistically significant but small absolute difference in mean LOS at NCHs versus CHs (4.26 days versus 4.49 days; $P = .002$; Table 2).When controlling for differences in demographics, clinical characteristics, and hospital characteristics, there continued to be a statistically significant but small absolute difference between NCH versus CH admission and adjusted mean estimated LOS (4.31 days versus 4.44 days; $P = .048$; Table 2).

Estimated Total Hospitalization Cost

On bivariate gamma regression analysis, there was significantly increased mean cost, calculated from charges, at CHs versus NCHs ($17 621 vs $11 266; $P < .001$; Table 3). When controlling for differences in demographics, clinical characteristics, and hospital characteristics in our generalized linear (gamma regression) model, the estimated mean cost remained higher at CHs ($16 754 vs $12 023; $P < .001$; Table 3).

DISCUSSION

In this cross-sectional retrospective cohort study of 64 521 pediatric discharges in 2012 with tracheostomy, gastrostomy, and/

TABLE 2 Unadjusted and Multivariable-Adjusted Negative Binomial Regression Model of the Association Between Hospital Type and LOS

	Fold Difference in LOS (95% CI)[a]	P	Estimated Mean LOS in d (95% CI)
Unadjusted model: hospital type		.002	
NCH	Reference		4.26 (4.17–4.35)
CH	1.05 (1.02–1.09)		4.49 (4.37–4.61)
Adjusted model[b]: hospital type		.048	
NCH	Reference		4.31 (4.24–4.39)
CH	1.03 (1.00–1.06)		4.44 (4.34–4.53)

[a] Exponentiated negative binomial regression estimates of the fold difference in mean LOS (CHs versus NCHs).
[b] Adjusted for age, sex, race, median household income, payer, H-RISK, number of technologies, major operating-room procedure, number of CCCs, hospital region, and hospital location and/or teaching status.

or ventricular shunt dependence, the majority of TDC were discharged from NCHs. Because of the large number of NCHs compared with CHs, the average number of TDC discharges per NCH was lower than per CH, indicating a lower rate of exposure to this population at NCHs. TDC discharges from CHs tended to have higher illness severity and higher rates of surgical procedures. Even after controlling for severity and surgical procedures, TDC discharges from CHs had a similar LOS but higher cost than discharges from NCHs.

We showed that a larger number of TDC are discharged from NCHs. We were unable to find previous literature that looks specifically at TDC at CHs versus NCHs to compare our findings; however, in a previous study of children with CCCs, the majority with 1 or more CCCs were discharged from CHs.[11] This difference suggests that TDC, a subset of children with CCCs, are more commonly discharged from NCHs, whereas TDC with other types of CCCs may be more likely to be seen in a CH setting. This has important implications for how and where research is conducted for TDC. For example, research that is done at a CHs or that uses sources such as the Pediatric Health Information System database, a database with information from CHs only, would be missing data from where the majority of these children are actually seen. This could have significant implications on the generalizability of such research.

Additionally, our finding that TDC are seen more often at NCHs but individual NCHs have a low rate of exposure to TDC has important implications for the care of TDC. Smaller-volume NCHs should consider how to maintain adequate staffing and proficiency to care for TDC or may find it is more feasible to regionalize their care and transfer the TDC with rare conditions to the closest CHs. Current Pediatric Hospital Medicine Core Competencies include the care of TDC,[26] and these competencies should be part of the training of pediatric hospitalist fellows[27] as well as ongoing education for hospitalists to maintain the skills to care for this population regardless of hospital setting.

Our study found similar LOS but higher cost at CHs versus NCHs. Many previous studies have shown higher charges or costs at CHs versus NCHs for all pediatric inpatients,[28] pediatric asthma,[29,30] severe pediatric sepsis,[31] and common surgical procedures.[32–37] Some show equivalent outcomes regardless of hospital type, such as for malrotation surgery[38] and neonatal herpes simplex.[7] Others show poorer outcomes at non-CHs, such as increased LOS and complications with pyloromyotomy.[39,40] CHs may have services that are not found at NCHs that contribute to higher costs, such as specialized equipment or ancillary staff. On the other hand, there could be many mediating and unmeasured confounding factors that play into cost that cannot be assessed by using the KID 2012. For example, severity measures available in the KID 2012 may have not completely accounted for the higher disease severity of patients at CHs. Further studies should assess for these factors; if the cost differential is true, studies should investigate if the increased costs lead to better clinical outcomes, such as decreased

TABLE 3 Unadjusted and Multivariable-Adjusted Gamma Regression Model of the Association Between Hospital Type and Cost

	Fold Difference in Cost (95% CI)[a]	P	Estimated Mean Cost in Dollars (95% CI)
Unadjusted model: hospital type		<.001	
NCH	Reference		11 266 (10 505–12 027)
CH	1.56 (1.43–1.71)		17 621 (16 452–18 699)
Adjusted model[b]: hospital type		<.001	
NCH	Reference		12 023 (11 314–12 731)
CH	1.39 (1.26–1.54)		16 754 (15 502–18 006)

[a] Exponentiated γ regression estimates of the fold difference in mean cost (CHs versus NCHs).
[b] Adjusted for age, sex, race, median household income, payer, H-RISK, number of technologies, major operating-room procedure, number of CCCs, hospital region, hospital location and/or teaching status, hospital-bed size, and LOS.

readmission rates, ICU use, or mortality at CHs.

In our study, TDC received care at NCHs without an increase in LOS and at a lower cost. However, given the low exposure of individual NCHs to TDC, there may be subgroups of TDC, such as those who are more severely ill or have more complicated illnesses, who may benefit from regionalization of care to a CH. Future studies should assess clinical outcomes other than LOS and cost for TDC and further define which subpopulations may benefit most from regionalization of care.

There are several limitations in the current study. KID 2012 is an administrative database based on billing data and therefore contains limited clinical information. KID 2012 does not contain detailed information on different hospital characteristics or resources, such as whether a specific NCH might have a PICU or be affiliated with and staffed by a CH. Additionally, KID 2012 does not provide readmission data or unique patient identifiers, so we were unable to account for potential multiple discharges of the same child. Our study relied on the use of ICD-9-CM codes to identify patients who were billed for having tracheostomies, gastrostomies, and ventricular shunts, which may not have been accurately coded by the medical coders; therefore, our study may have underestimated the true prevalence of technology dependence. The ICD-9-CM codes we used have been used in previous studies using administrative data[16–21]; however, use of these codes could have overestimated or underestimated our rates of technology dependence as well. We are dependent on the classification that has been provided by the database for CHs versus NCHs, and there is potential for misclassification. These limitations are balanced by some important strengths of our study. Firstly, the large sample size in the KID 2012 data set is an important prerequisite to study this relatively rare population of TDC. This is further enhanced by the complex survey design with weighted variables provided in KID 2012 that can be used to calculate national estimates. Secondly, the KID 2012 is unique compared with many other data sources in that it provides information from both CHs and NCHs.

CONCLUSIONS

We have demonstrated that the majority of TDC are discharged from NCHs; however, individual NCHs have a lower rate of exposure to TDC than CHs do. Although the patient demographics, clinical characteristics, hospital characteristics, and LOS are fairly similar across hospital types, TDC at CHs have a higher severity of illness and are more likely to have a major operating-room procedure during hospitalization. Even when accounting for these clinical differences, discharge from a CH is associated with higher cost. Future studies should identify subgroups of TDC who might benefit from regionalization of their care.

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