Hospital Utilization Among Children With the Highest Annual Inpatient Cost

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abstract

BACKGROUND AND OBJECTIVES: Children who experience high health care costs are increasingly enrolled in clinical initiatives to improve their health and contain costs. Hospitalization is a significant cost driver. We describe hospitalization trends for children with highest annual inpatient cost (CHIC) and identify characteristics associated with persistently high inpatient costs in subsequent years.

METHODS: Retrospective study of 265 869 children age 2 to 15 years with ≥1 admission in 2010 to 39 children's hospitals in the Pediatric Health Information System. CHIC were defined as the top 10% of total inpatient costs in 2010 (n = 26 574). Multivariate regression and regression tree modeling were used to distinguish individual characteristics and interactions of characteristics, respectively, associated with persistently high inpatient costs (≥80th percentile in 2011 and/or 2012).

RESULTS: The top 10% most expensive children (CHIC) constituted 56.9% ($2.4 billion) of total inpatient costs in 2010. Fifty-eight percent (n = 15 391) of CHIC had no inpatient costs in 2011 to 2012, and 27.0% (n = 7180) experienced persistently high inpatient cost. Respiratory chronic conditions (odds ratio [OR] = 3.0; 95% confidence interval [CI], 2.5–3.5), absence of surgery in 2010 (OR = 2.0; 95% CI, 1.8–2.1), and technological assistance (OR = 1.6; 95% CI, 1.5–1.7) were associated with persistently high inpatient cost. In regression tree modeling, the greatest likelihood of persistence (65.3%) was observed in CHIC with ≥3 hospitalizations in 2010 and a chronic respiratory condition.

CONCLUSIONS: Most children with high children's hospital inpatient costs in 1 year do not experience hospitalization in subsequent years. Interactions of hospital use and clinical characteristics may be helpful to determine which children will continue to experience high inpatient costs over time.

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WHAT'S KNOWN ON THIS SUBJECT: Children who experience high health care costs are increasingly enrolled in clinical initiatives to improve their quality of care and contain their health care costs over time. However, little is known about longitudinal trends in hospital costs of these children.

WHAT THIS STUDY ADDS: Most children with high inpatient costs in 1 year are not hospitalized in subsequent years. Children with a respiratory chronic condition and multiple hospitalizations were most likely to experience persistently high inpatient costs.

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Pediatric health care costs are highly concentrated among a small group of children with chronic conditions.[1–6] In recent years, there has been a significant rise in innovative clinical programs targeting this population of children.[7] Health plans, children's hospitals, and other entities are enrolling high-cost children into care management programs to improve their health.[8] Some of these programs have reported a major impact on health care utilization and costs, suggesting that they may help interrupt the cycle of persistent health care spending that the children would have experienced otherwise.[9–13]

As for their adult counterparts,[14] hospital care is a significant contributor to the overall cost accrued by children with chronic conditions.[2,5,6] Many children who experience high health care costs incur frequent hospital admissions and lengthy hospitalizations.[15–18] Previous studies have reported that hospital care accounts for as much as 80% of total health care spending in children with severe chronic conditions.[2,5,6] Spending on other health services, such as emergency department care, medications, and primary care, is much smaller.[19] Hospital costs and how the costs are distributed (eg, to ICU or surgical care) vary significantly by the chronic conditions experienced by the children.[17]

The financial value proposition of many care management programs for patients with chronic conditions centers on containing and reducing inpatient utilization. It is believed that some of the hospital costs incurred by these patients might have been avoided with better quality of care and better care coordination.[20,21] However, there is little information on longitudinal trends in hospital costs for children and on the predictors of persistently high hospital costs.[2,21] Without this information, it is difficult to target the correct patients to help and to discern the true impact of interventions.

A better understanding of the characteristics of children who incur high inpatient costs and of when the high costs are most likely to persist may enable care management initiatives to focus enrollment on children who are most likely to benefit from them. Therefore, the objectives of this study are to describe trends in hospital use for children with the highest annual inpatient cost (CHIC) in children's hospitals throughout the United States and to distinguish characteristics of children who experience persistently high inpatient costs over time.

METHODS

Study Design, Setting, and Population

We conducted a retrospective cohort analysis of 265 869 children ages 2 to 15 years who were hospitalized at least once between January 1, 2010 and December 31, 2010 in 1 of 39 freestanding children's hospitals from 24 states and the District of Columbia in the Pediatric Health Information System (PHIS) data set. All hospitals participating in PHIS are members of the Children's Hospital Association.[22] PHIS includes a unique patient identifier that permits the measurement of repeated hospitalizations for the same patient within the same hospital but not at different PHIS hospitals. The Boston Children's Hospital Institutional Review Board approved this study with a waiver for informed consent.

Identifying Children With the Highest Inpatient Costs in 2010

We categorized each child into 1 of 10 cost deciles based on their total inpatient costs accrued in 2010. Hospital costs included room and board, laboratory, imaging, pharmacy, medical supplies, and ancillary services. We did not include professional fees (eg, physician consultation) because PHIS does not contain these data. Costs were calculated from charges based on annual hospital specific cost-to-charge ratios. CHIC were the top 10% of children who incurred the highest total inpatient costs in 2010. All other children (non-CHIC) were the remaining 90% of children in the cohort. We used the most expensive 10% as a threshold based on previous surveys of high-cost children,[23] previous evaluations of adult Medicare beneficiaries,[24] and the distribution of costs across hospitalized children (Fig 1).

Main Outcome Measures

The main outcome measures were trends in hospital use for CHIC and non-CHIC and the persistence of high inpatient cost. For each child who was hospitalized at least once in 2010, we measured their hospital utilization back to January 1, 2008 and forward to December 31, 2012. Hospital utilization included the number of admissions, hospital days, and hospital costs. Children aged <2 years on January 1, 2010 were excluded from the analysis because they were not able to experience 2 full years of exposure for hospitalization before 2010. Children aged >15 years on January 1, 2010 were excluded to create an age ceiling of <18 years at the end of the study period. Children aged ≥18 years may be more likely to transfer their inpatient care to an adult hospital. We excluded children who experienced in-hospital mortality during any year of the study period, because they did not have the opportunity to experience hospitalization throughout the study period.

Characteristics Associated With Persistent High Inpatient Cost

We assessed patients' demographic, clinical, and hospitalization characteristics from 2008 to 2010

that might correlate with persistent high inpatient cost in 2011 and/or 2012.

Demographic Characteristics

Demographic characteristics included age, gender, race or ethnicity, and insurance (public, private, and other).

Clinical Characteristics

Clinical characteristics included the number, type, and complexity of patients' chronic conditions and assistance with medical technology. These characteristics were identified with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. To evaluate for the number of comorbid chronic health conditions, we used the Chronic Condition Indicator classification system, developed by the Agency for Healthcare Research and Quality, to identify the presence of a chronic condition.[25] We used complex chronic conditions (CCCs) to identify children with a complex medical condition expected to last ≥12 months and involve either severe single-organ disease or multiple-organ dysfunction.[26] Patients assisted with medical technology, defined as a device used to overcome a severe limitation in physiologic functioning (eg, tracheostomy tube, gastrostomy tube), were identified with an established set of ICD-9-CM codes known to correlate with hospital resource use.[27–29]

Hospitalization Characteristics

We assessed the reasons for hospitalization in 2010, distinguishing medical from surgical admissions by using 3M's All Patient Refined Diagnosis Related Groups (3M Health Information Systems, Wallingford, CT).[30] We assessed for hospitalizations related to ambulatory care sensitive conditions, defined as conditions (eg, asthma, dehydration) for which hospitalization may be avoided with high-quality outpatient care.[31]

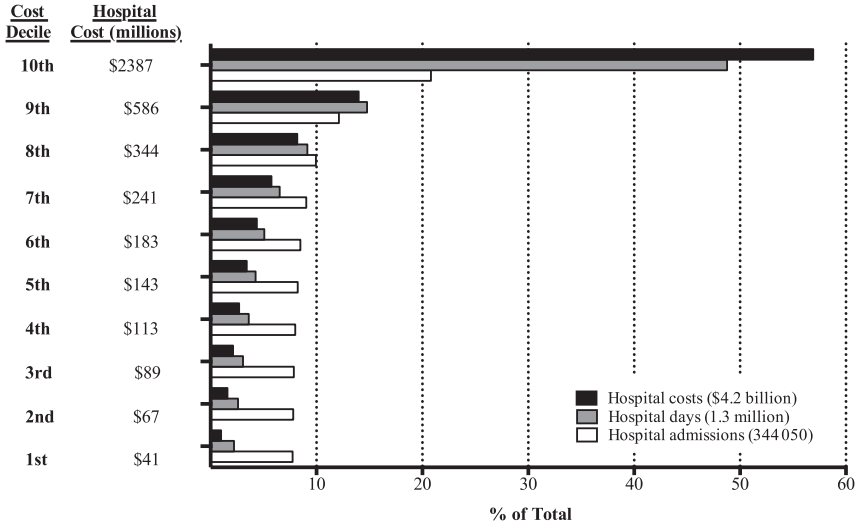

FIGURE 1

Hospital utilization in 2010 by patients' inpatient cost decile. Median annual hospitalizations, hospital bed days, and aggregate inpatient costs in 2010, and percentage of total, for each of the 10 cost groups (ie, deciles) based on their total inpatient costs accrued in 2010.

Statistical Analysis

In bivariate analysis, we used Wilcoxon rank sum and χ^2 tests to distinguish the demographic, clinical, and hospitalization characteristics of CHIC. In multivariate analysis, we assessed these relationships by using a generalized estimating equation (GEE) clustered by hospital. We derived the GEE model by simultaneously entering all the covariates and retaining them regardless of statistical significance.

We also used classification and regression tree (CART) modeling with binary split and postpruning goodness-of-fit rules to assess the most statistically significant interactions between multiple characteristics and to assess which unique patients had the highest likelihood of persistent high inpatient cost.[32] The CART model complements the GEE model by assessing patient-level probabilities of persistent high inpatient costs for every possible interaction of characteristics (eg, 833 possible 3-level interactions of characteristics assessed in the current study). Statistical significance was set at $P < .05$. Statistical Analysis Software version 9.3 (SAS Institute, Inc, Cary, NC) and R version 3.0.2 (Vienna, Austria), with the PARTY package, were used for the analyses.[33]

We conducted sensitivity analyses by excluding 2 populations who might be likely to experience episodic high-cost hospitalization and therefore limit our ability to distinguish children with persistently high inpatient costs: children undergoing a single surgery in 2010 and children with oncologic diagnoses.

RESULTS

Study Population

There were 265 869 children ages 2 to 15 years hospitalized in 2010 across the 39 children's hospitals in the cohort. In total, these children experienced 344 050 hospital admissions, accounted for 1.3 million hospital bed days, and incurred $4.2 billion in hospital costs. Median age at admission was 8 years (interquartile range [IQR] 4–12). Fifty-four percent (n = 144 685) were male, 49.8% (n = 132 362) were non-Hispanic white, and 53.2% (n = 141 468) used public insurance. Sixty-eight percent (n = 180 662) had ≥1 chronic condition, 30.6%

TABLE 1 Characteristics of CHIC Compared With Children Without High Inpatient Costs in 2010

Characteristics[a]	All Children	CHIC in 2010[b]	Children Without Highest Inpatient Cost in 2010
Number of patients, *N* (%)	265 869	26 574 (10.0)	239 295 (90.0)
Age, median (IQR), y	8 (4, 12)	10 (5, 13)	8 (4, 12)
Male gender, *N* (%)	144 685 (54.4)	13 948 (52.5)	130 737 (54.6)
Public insurance, *N* (%)	141 468 (53.2)	14 215 (53.5)	127 253 (53.2)
Race or ethnicity, *N* (%)			
Non-Hispanic white	132 362 (49.8)	14 145 (53.2)	118 217 (49.4)
Non-Hispanic black	55 575 (20.9)	4797 (18.1)	50 778 (21.2)
Hispanic	48 257 (18.2)	4495 (16.9)	43 762 (18.3)
Asian	5399 (2.0)	589 (2.2)	4810 (2.0)
Other	24 276 (9.1)	2548 (9.6)	21 728 (9.1)
No. of chronic conditions, *N* (%)			
None	85 207 (32.0)	1123 (4.2)	84 084 (35.1)
1	93 916 (35.3)	4782 (18.0)	89 134 (37.2)
2	44 127 (16.6)	5368 (20.2)	38 759 (16.2)
3+	42 619 (16.0)	15 301 (57.6)	27 318 (11.4)
Chronic condition type, *N* (%)			
Noncomplex, chronic	100 535 (37.8)	4289 (16.1)	96 246 (40.2)
Complex, chronic	81 450 (30.6)	21 217 (79.8)	60 233 (25.2)
Complex Chronic Conditions, *N* (%)[c]			
Cardiology	15 421 (5.8)	5457 (20.5)	9964 (4.2)
Gastrointestinal	4673 (1.8)	1329 (5.0)	3344 (1.4)
Hematology and immunology	9042 (3.4)	1786 (6.7)	7256 (3.0)
Malignancy	12 159 (4.6)	5430 (20.4)	6729 (2.8)
Metabolic	6060 (2.3)	2564 (9.6)	3496 (1.5)
Neurology	31 981 (12.0)	7181 (27.0)	24 800 (10.4)
Renal	4389 (1.7)	1326 (5.0)	3063 (1.3)
Respiratory	5437 (2.0)	1908 (7.2)	3529 (1.5)
Other	15 801 (5.9)	5692 (21.4)	10 109 (4.2)
Technological assistance, *N* (%)	26 242 (9.9)	9067 (34.1)	17 175 (7.2)

[a] All *P* values <.001 when we compared CHIC in 2010 and children without highest inpatient costs in 2010 as calculated by using either Wilcoxon rank sum or χ^2 tests.
[b] CHIC are defined as the 10% most expensive children hospitalized between January 1, 2010 and December 31, 2010.
[c] Patients may have zero, one, or more than one CCC. Column totals will not add up to 100%.

(*n* = 81 450) had a CCC, and 9.9% (*n* = 26 242) had technological assistance (Table 1).

Children With Highest Inpatient Cost in 2010

In 2010 the top 10% most expensive children (CHIC) accounted for 20.8% (*n* = 71 616) of all hospital admissions, 48.8% (*n* = 625 832 days) of all hospital days, and 56.9% (*n* = $2.4 billion) of all hospital costs (Fig 1).

CHIC experienced a median of 2 hospitalizations (IQR 1–3) in 2010. Seventy percent (*n* = 51 097) of hospitalizations experienced by CHIC were for medical treatment, and 30.2% (*n* = 22 068) were for surgery. Chemotherapy, sickle cell crisis, and seizure were among the most common medical reasons for admission when all causes for hospitalization were considered. Spinal fusion for scoliosis and cerebrospinal fluid ventricular shunt operations were the most common surgeries. Only 8.5% (*n* = 6206) of hospitalizations experienced by CHIC were for ambulatory care sensitive conditions. Seizures and pneumonia were the most common ambulatory care sensitive reasons for hospitalization.

Compared with all other children, CHIC had an older median age (10 years [IQR 5–13] vs 8 years [IQR 4–12], *P* < .001) and a higher percentage of non-Hispanic white race and ethnicity (53.2% vs 49.4%, *P* < .001). CHIC had a higher prevalence of ≥1 comorbid chronic health condition (95.8% vs 64.9%, *P* < .001) and ≥3 comorbid chronic health conditions (57.6% vs 11.4%, *P* < .001). CHIC also had a higher prevalence of CCCs (79.8% vs 25.2%, *P* < .001) and technological assistance (34. 1% vs 7.2%, *P* < .001) (Table 1).

Trends in Hospital Utilization (2008–2012)

Both CHIC and children with less inpatient cost in 2010 experienced significantly fewer median admissions, hospital bed days, and hospital costs in the 2 preceding and subsequent years (Fig 2): The median number of admissions, hospital days, and hospital costs were 0 in 2008 to 2009 and in 2011 to 2012 for both groups. Regarding inpatient costs for CHIC, 57.9% (*n* = 15 391) had no inpatient costs in 2011 or 2012 (because they had no hospital admissions); 15.1% (*n* = 4003) had inpatient costs <80th percentile in 2011 or 2012. More than one-quarter (27.0%, *n* = 7180) of CHIC

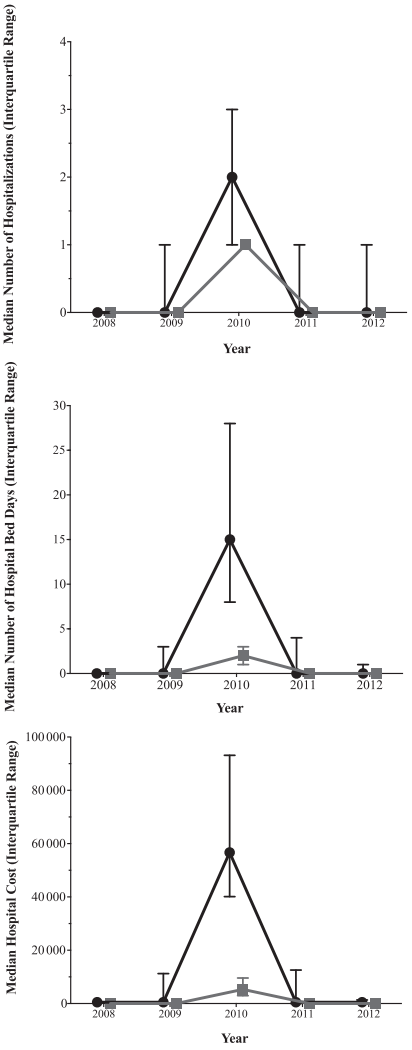

FIGURE 2

Trends in hospital utilization of CHIC and children without highest inpatient cost (n = 265 869). Median annual hospitalizations, bed days, and aggregate inpatient costs in 2008 to 2012 for all children hospitalized in 2010. Black circles denote CHIC. Gray squares denote all other children. Vertical bars denote the IQRs.

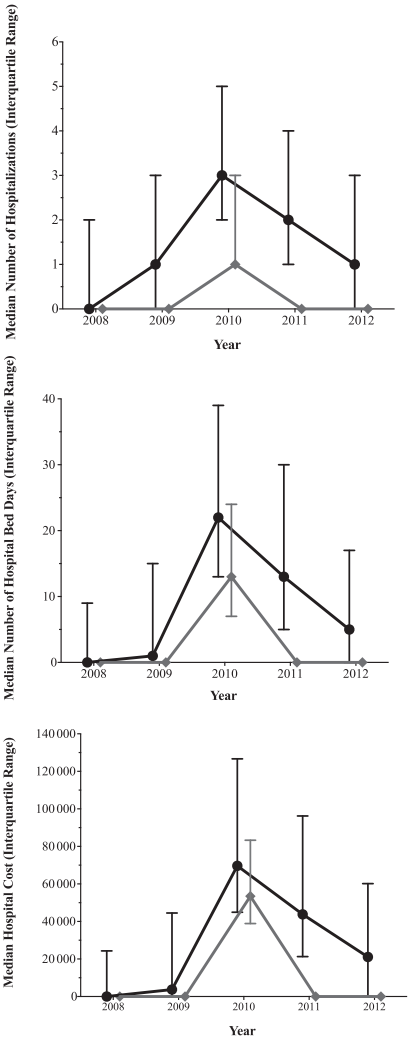

FIGURE 3

Comparison of hospital utilization in 2008 to 2012 for persistent high-cost and nonpersistent high-cost children (n = 26 574). Median annual hospitalizations, bed days, and aggregate inpatient costs in 2008 to 2012 for CHIC in 2010. Black circles denote CHIC with persistently high cost. Gray squares denote CHIC with nonpersistently high cost. Vertical bars denote IQRs.

experienced persistent high inpatient costs (≥80th percentile) in 2011 or 2012 (Fig 3). Similar longitudinal trends in utilization were observed when we excluded children with an oncologic diagnosis and children undergoing a high-cost surgery in 2010.

Distinguishing Children With Persistent High Inpatient Cost

In bivariate analysis, CHIC in 2010 with persistent high inpatient costs in 2011 or 2012 had a higher percentage of public insurance (60.1% vs 51.1%, P < .001), CCCs (90.6% vs 75.9%, P < .001), and technological assistance (49.4% vs 28.5%, P < .001) when compared with CHIC in 2010 without persistent high inpatient cost. CHIC with persistent high inpatient cost also had a higher percentage of ≥3 comorbid chronic health conditions (77.9% vs 50%) compared with CHIC with no persistent high inpatient cost (Table 2).

In multivariable regression, CHIC with the highest likelihood of persistent high cost were those with a respiratory CCC (adjusted odds ratio [OR] 3.0; 95% confidence interval [CI], 2.5–3.5; P < .001), those who did not undergo surgery in 2010 (OR 2.0; 95% CI, 1.8–2.1; P < .001), and those with technological assistance (OR 1.6; 95% CI, 1.5–1.7; P < .001) (Table 2). The presence of ≥3 comorbid chronic health conditions was not significantly associated with persistent high inpatient costs in 2011 or 2012 (P = .1).

In CART analysis we assessed 833 potential interactions of patient characteristics. The greatest likelihood (65.3%) of persistent high costs was observed in CHIC with a respiratory chronic condition and ≥3 hospitalizations in 2010 (Fig 4). This combination of characteristics was observed in 3.4% (n = 930) of CHIC with persistently high inpatient cost. The second greatest likelihood (63.9%) of persistently high inpatient cost was observed in CHIC with a respiratory chronic condition, with <3 hospitalizations in 2010 and no surgery in 2010. Cystic fibrosis and bronchopulmonary dysplasia were the most common respiratory CCCs experienced by these children.

DISCUSSION

Consistent with previous studies,[14,23,24,34] our findings suggest that hospital costs are concentrated among a small group of patients: 10% of children with highest inpatient costs in children's hospitals in 2010 accounted for more than one-half of total hospital expenditures. Most children with the highest inpatient costs in 2010 were not admitted again to the same children's hospital over the next 2 years, nor had they been admitted in the 2 previous years. Only one-fourth of the children with highest annual inpatient costs in 2010 went on to experience inpatient costs in the top 20% in

TABLE 2 Characteristics of CHIC in 2010 With Persistent High Cost in 2011 or 2012 ($N = 26\,574$)

Characteristics	CHIC in 2010		Likelihood of Persistent High Cost		
	No Persistent High Cost	Persistent High Cost	OR[a]	95% CI[a]	P[a]
Number of patients (%)	19 394 (73.0)	7180 (27.0)	—	—	—
Age, median (IQR), y	10 [5, 14]	9 [4, 13]	1.0	[1.0–1.0]	1.0
Male gender, no. (%) of patients	10 175 (52.5)	3773 (52.5)	1.0	[0.9–1.0]	.2
Public insurance[b]	9902 (51.1)	4313 (60.1)	1.2	[1.1–1.4]	<.001
Race or ethnicity					
Non-Hispanic white	10 394 (53.6)	3751 (52.2)	Reference	—	—
Non-Hispanic black	3449 (17.8)	1348 (18.8)	1.0	[0.9–1.1]	.9
Hispanic	3112 (16)	1383 (19.3)	1.1	[0.9–1.2]	.3
Asian	455 (2.3)	134 (1.9)	0.8	[0.6–1.0]	.03
Other	1984 (10.2)	564 (7.9)	0.8	[0.7–1.0]	.007
No. of chronic conditions					
1	4236 (21.8)	546 (7.6)	Reference	—	—
2	4375 (22.6)	993 (13.8)	1.7	[0.6–4.4]	.3
3+	9706 (50)	5595 (77.9)	2.3	[0.8–6.0]	.1
Chronic condition grouping					
None	1026 (5.3)	42 (0.6)	Reference	—	—
Noncomplex, chronic	3654 (18.8)	635 (8.8)	1.3	[0.5–3.6]	.6
Complex, chronic	14 714 (75.9)	6503 (90.6)	2.0	[0.7–5.5]	.2
Complex Chronic Conditions, N (%)[c]					
Cardiology	4162 (21.5)	1295 (18.0)	0.8	[0.7–0.9]	<.001
Gastrointestinal	836 (4.3)	493 (6.9)	1.2	[1.1–1.4]	.005
Hematology/immunology	1038 (5.4)	748 (10.4)	1.4	[1.3–1.6]	<.001
Malignancy	3556 (18.3)	1874 (26.1)	1.0	[0.9–1.2]	.6
Metabolic	1545 (8.0)	1019 (14.2)	1.0	[0.9–1.1]	.6
Neurology	4665 (24.1)	2516 (35.0)	1.2	[1.1–1.3]	.002
Renal	749 (3.9)	577 (8.0)	1.5	[1.4–1.7]	<.001
Respiratory	781 (4.0)	1127 (15.7)	3.0	[2.5–3.5]	<.001
Technological assistance	5523 (28.5)	3544 (49.4)	1.6	[1.5–1.7]	<.001
Number of hospitalizations (2010)	1 [1–3]	3 [2–5]	1.1	[1.1–1.2]	<.001
Hospital bed days (2010)	13 [7–24]	22 [13–39]	1.0	[1.0–1.1]	<.001
No surgical admissions in 2010[d]	5732 [29.6]	3489 [48.6]	2.0	[1.8–2.1]	<.001

Non-applicable denoted by em dash (—).

[a] Obtained from multivariate regression by using GEEs clustered on hospital representing the association between the clinical, demographic, and utilization characteristic and the persistence of high inpatient costs as defined by cost ≥80th percentile in 2011 or 2012.

[b] Reference group is private insurance.

[c] Reference group is children without the CCC

[d] Reference group is children with at least one surgical admission in 2010

subsequent years. Children with a respiratory CCC (eg, cystic fibrosis, bronchopulmonary dysplasia) who experienced multiple hospitalizations in 2010 had the highest likelihood of persistent high inpatient costs in subsequent years.

Our findings complement a growing body of literature suggesting that many high-cost patients experience substantially less health care expenditures after their high-cost year. For example, a majority (ie, up to 75%) of highest-cost adult Medicare beneficiaries in 1 year may not remain highest cost in consecutive years.[14,24,35] One recent study found that few adult "super-utilizers" experienced consistently high levels of utilization over time.[36] Data from the Medical Expenditure Panel Survey reveal that approximately half of the most expensive children in 1 year will not remain in the highest-cost decile in the next year. For these children, the rates of hospitalization and the number of hospital days decreased by 75% and 84%, respectively, after their high-cost year.[23] These data, and ours, suggest transiency in hospital costs for most children after a year in which they experienced high inpatient costs.

This study also contributes to the understanding of the reasons why some children might accrue high inpatient costs. We excluded patients prone to particularly expensive episodes of inpatient care: infants (including those using neonatal intensive care[37]) and children dying in the hospital.[38] These children did not contribute to the findings. Acute illness (eg, infection, trauma) in previously healthy children probably was not a major factor either, because a small minority (4%) of children with the highest inpatient costs did not have a chronic health condition. Undergoing surgery in the high-cost year was associated with lower likelihood of persistent high costs in subsequent years, although we observed similar longitudinal trends in hospital utilization after exclusion of children

who experienced a single high-cost surgical-related hospitalization in 2010. Additional investigation is necessary to determine which surgical procedures might portent persistently high costs and whether the clinical effectiveness of select surgeries may contribute to lower inpatient costs in subsequent years.

We found that children with a respiratory CCC who experienced ≥3 hospitalizations in their high-cost year were the most likely to experience persistent high costs. Many respiratory CCCs may be incurable. A cluster of multiple hospitalizations experienced by these children may indicate that their condition is unstable or becoming more severe with time.[39] These multiple hospitalizations may also represent interventions to optimize the quality of life for children whose chronic illness is becoming more severe. A better understanding of the health and chronic illness trajectories for these children and other children with CCCs may be very helpful when estimating their future health care expenditures and developing interventions to improve their quality of care.

Although we identified combinations of clinical and demographic characteristics that were associated with persistent high inpatient costs, the highest rate of persistence in patients with these characteristics was 65%. That is, nearly 1 in 3 of these children did not experience persistent high inpatient costs in subsequent years. Clinical initiatives to contain costs may prefer to target children with a higher specificity of persistence. There are several potential explanations for why higher rates of persistence were not observed in the current study. First, we aggregated costs on an annual basis. Shorter time frames (eg, monthly) or time frames not fixed to the calendar year might allow more precise modeling; however, they may also introduce

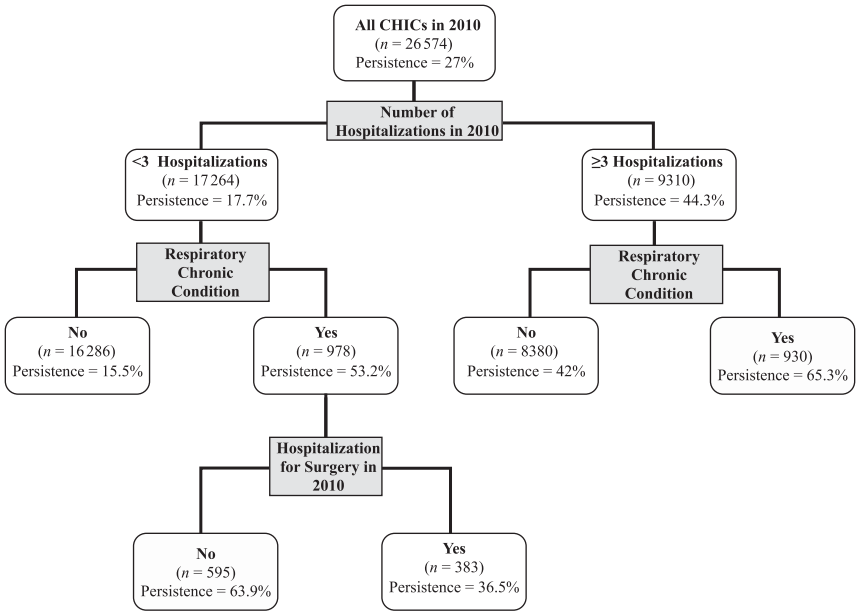

FIGURE 4

Patient characteristics and interactions of patient characteristics associated with greatest likelihood of persistently high inpatient cost in 2011 and/or 2012. The CART model included all characteristics outlined in Table 2. Individual characteristics, and interactions between multiple characteristics, were assessed. Persistence denotes patient-level probabilities of inpatient costs ≥80th percentile in 2011 and/or 2012. The gray shadowing denotes the terminal nodes in the decision tree analysis.

other confounders (eg, seasonality). Second, clinical assessment may be more accurate than the ICD-9 coding-based algorithms we used to identify children with different types of chronic conditions. Third, we did not assess functional status,[40,41] disease severity,[42] or other patient attributes that may influence trends in health care utilization because this information is not contained in PHIS. Lastly, we did not evaluate family socioeconomic status and the availability of outpatient and community health services, both of which may be associated with challenges accessing health services. Additional evaluations incorporating these elements into predictive models for future hospital expenditures should be considered.

This study has several other limitations. A gold standard definition of persistent, high health care costs does not exist. In a post hoc analysis, when the definition of high-cost patients was limited to a more or less strict percentile (eg, 90th or 70th percentile) for persistence, the findings remained the same. We converted hospital charges to costs, which could have underestimated or overestimated costs for some hospitalizations. Generalizability may be limited to patients hospitalized in children's hospitals because the PHIS database does not contain data from non–children's hospitals. Some children could have used non-PHIS hospitals during the study period, which may have led to undercounting of hospital use. A recent study found that 13% of readmissions in children occur at a different hospital.[43] The likelihood of using different hospitals is significantly lower when children have a chronic condition, which most children had in our study. Health care utilization and costs for community, emergency, outpatient, and other nonhospital health services are not available in PHIS. Subsequent investigation of longitudinal spending across the care continuum in high-cost children is necessary; such investigation using comprehensive payer claim data

may help contextualize the trends in hospital care observed in the current study.

We were unable to identify children who died outside the hospital during the study period. Some children experience high hospital use at their end of life.[44] The study is not positioned to adequately assess longitudinal trends in hospital use by infants and children <2 years of age. We used ICD-9-CM codes to identify technological assistance, which may underreport the prevalence of certain technologies that do not have an ICD-9-CM code (eg, wheelchairs). We were unable to validly distinguish planned from unplanned hospitalizations, so this information was not assessed in the study. Using PHIS, we could not distinguish which children were exposed to clinical services that might affect their hospital use (eg, a care coordination or managed care program).

Despite these limitations, the findings from this study have implications for initiatives striving to improve quality of care and reduce costs. The transiency of hospital expenditures for children with highest inpatient costs may make it difficult to distinguish the effectiveness of initiatives that target children who have already accrued high costs. Absent the use of research methods (eg, a contemporaneous control group) that account for an expected transiency in inpatient costs, some initiatives may find difficulty correlating their clinical interventions with a reduction in hospital expenditures, even when the interventions have been effective. As children's hospitals, pediatric practices, and payers continue to explore alternative payment models (eg, accountable care organizations), the unpredictability and nonpersistence of patients with high inpatient costs should be taken into account in setting cost containment goals. Future investigation is needed to identify high-cost children in advance of their cost accumulation, determine how to optimize the quality of care for these children, and understand how to intervene with targeted care management ahead of time.

CONCLUSIONS

Hospital costs are concentrated in a small number of high-cost, high-need children. Most children with high inpatient costs in 1 year may experience transient costs, with few hospitalizations in preceding and subsequent years. Only one-fourth of these high-cost children experience persistent high children's hospital costs in subsequent years. Children with a respiratory CCC, who experienced multiple hospitalizations in their high-cost year, had the strongest correlation with persistently high inpatient costs. Clinical initiatives striving to contain hospital use in children may find this information useful.

ABBREVIATIONS

CART: classification and regression tree
CCC: complex chronic condition
CHIC: children with highest annual inpatient cost
CI: confidence interval
GEE: generalized estimating equations
ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification
IQR: interquartile range
OR: odds ratio
PHIS: Pediatric Health Information System

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