ARTICLE

Inpatient Growth and Resource Use in 28 Children's Hospitals

A Longitudinal, Multi-institutional Study

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Objective: To compare inpatient resource use trends for healthy children and children with chronic health conditions of varying degrees of medical complexity.

Design: Retrospective cohort analysis.

Setting: Twenty-eight US children's hospitals.

Patients: A total of 1 526 051 unique patients hospitalized from January 1, 2004, through December 31, 2009, who were assigned to 1 of 5 chronic condition groups using 3M's Clinical Risk Group software.

Intervention: None.

Main Outcome Measures: Trends in the number of patients, hospitalizations, hospital days, and charges analyzed with linear regression.

Results: Between 2004 and 2009, hospitals experienced a greater increase in the number of children hospitalized with vs without a chronic condition (19.2% vs 13.7% cumulative increase, $P<.001$). The greatest cumulative increase (32.5%) was attributable to children with a significant chronic condition affecting 2 or more body systems, who accounted for 19.2% (n=63 203) of patients, 27.2% (n=111 685) of hospital discharges, 48.9% (n=1.1 million) of hospital days, and 53.2% ($9.2 billion) of hospital charges in 2009. These children had a higher percentage of Medicaid use (56.5% vs 49.7%; $P<.001$) compared with children without a chronic condition. Cerebral palsy (9179 [14.6%]) and asthma (13 708 [21.8%]) were the most common primary diagnosis and comorbidity, respectively, observed among these patients.

Conclusions: Patients with a chronic condition increasingly used more resources in a group of children's hospitals than patients without a chronic condition. The greatest growth was observed in hospitalized children with chronic conditions affecting 2 or more body systems. Children's hospitals must ensure that their inpatient care systems and payment structures are equipped to meet the protean needs of this important population of children.

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THE TYPES OF PEDIATRIC PATIENTS requiring hospitalization may be changing. Healthy children with acute illnesses and children with common chronic conditions are hospitalized less often.[1-3] It is suspected that this trend is due to improved ambulatory care–based prevention and management services.[1-3] There is a rising proportion of pediatric hospitalizations attributable to children with rare, chronic conditions that are believed to be more complex in nature.[4-6] Presumably, this trend is due to the increased survival of these children, a health system that is struggling to meet their needs, and a frequent reliance on inpatient care to maintain their health.[4,5]

These trends may vary across different types of hospitals. Children's hospitals may be encountering a larger influx of children with complex chronic conditions compared with community hospitals. Children's hospitals have become the hub for pediatric specialty care and care coordination programs for children with complex chronic conditions.[7] During the past decade, children with severe neurologic impairment, who are prone to experience multiple comorbid conditions, have used children's hospitals more and community hospitals less.[8] Only 3% of all US hospitals have a children's hospital designation. Yet, the children's hospitals serve nearly 25% of all hospitalized children and 80% of children with a complex chronic condition.[9,10]

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It has been postulated that children's hospitals may not be positioned to respond to this demand because it is not known (1) how many or how quickly hospital resources are being consumed by one group of children vs another (eg, children with vs without chronic illness) and (2) which specific diseases and comorbid conditions are experienced by children with the greatest growth in hospital resource use.[11] A better understanding of this information will help ensure that hospitals are prepared to meet the inpatient needs of and deliver the highest quality of care to the pediatric patients who will increasingly rely on them. Community-based providers may also benefit from this information since they are increasingly encouraged to integrate with hospital networks, control and reduce local hospitalization rates, and potentially share financial risk with hospitals under new payment reform initiatives.

This study was conducted to assess recent trends in the population growth and inpatient resource use of pediatric patients over time. We assessed trends for children who were presumed to be relatively healthy without a chronic condition and for children with chronic conditions of varying medical complexity within a national cohort of children's hospitals. We also described the underlying primary diagnoses and comorbidities experienced by these children.

METHODS

STUDY DESIGN AND SETTING

This study is a retrospective cohort analysis of the Pediatric Health Information System approved by the institutional review board at the Children's Hospital in Boston. The Pediatric Health Information System is an administrative database containing hospitalization data from 28 freestanding, urban pediatric hospitals located in noncompeting catchment areas in the United States. These hospitals are members of the Children's Hospital Association, a business alliance of children's hospitals in the United States (Shawnee Mission, Kansas).[12] The eTable (http://www.jamapeds.com) displays the characteristics of hospitals in the study cohort compared with hospitals throughout the United States.[13] The Pediatric Health Information System data are maintained by the Children's Hospital Association and Thomson-Reuters Healthcare (New York, New York). Children are followed up across multiple admissions using a unique numerical patient identifier.

STUDY POPULATION

Patients of all ages admitted to one of the Pediatric Health Information System children's hospitals at least 1 time from January 1, 2004, through December 31, 2009, were included for analysis. Patients aged 18 years or older were included because many with chronic conditions continue to use children's hospitals.[14]

CHRONIC CONDITION CLASSIFICATION

We used the Clinical Risk Groups (CRGs), version 1.7, developed by 3M Health Information Systems, and the National Association of Children's Hospitals and Related Institutions to assign each patient to 1 of 9 mutually exclusive CRGs according to the presence, type, and severity of the chronic condition.[15-18]

Each patient's CRG designation was based on 3 years of hospital encounters. For example, in 2004, patients were classified using their hospital encounters for 2004 (the index year of the study) and the preceding 2 years: 2003 and 2002. We included multiple years of data because the performance of the CRG software improves when used with diagnostic administrative data across multiple health care encounters. The CRG designation process has been detailed in previous literature.[15-18]

To achieve the study objectives, the CRGs were categorized into 5 study cohorts (eFigure). Children without chronic conditions represented the first study cohort. This cohort included children hospitalized with an acute illness who have no history of a diagnosis, procedure, or other treatment suggestive of the presence of a chronic disease. The remaining 4 study cohorts included children with a chronic condition. Children with episodic chronic conditions (study cohort 2) represented children hospitalized with a primary condition (eg, asthma) that can be episodic and, if appropriately managed, associated with minimal risk of complications. Children with lifelong chronic conditions affecting 1 body system (study cohort 3) represented children with a more severe primary condition (ie, more likely to cause significant long-lasting health impairment) who did not have additional comorbid conditions (eg, a child with type 1 diabetes mellitus who does not have any other health problems).

Children with significant chronic conditions affecting 2 or more body systems and/or a complex or progressive chronic condition (study cohort 4) represented the children with the most complex conditions. These children had a severe primary condition and related comorbidities (eg, a child with diabetes, encephalopathy, and chronic pulmonary disease) or a primary condition that is progressive, leading to worsening debility and health (eg, a child with Duchenne muscular dystrophy). Children with malignancy (study cohort 5) represented children with a primary hematologic or oncologic malignant disease.

PATIENT DEMOGRAPHIC CHARACTERISTICS

We described demographic characteristics for each CRG cohort, including age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), and insurance type (government, commercial, and other). Age was assessed in categories (neonate, 0-30 days; infancy, 31-365 days; early childhood, 1-4 years; late childhood, 5-12 years; adolescence, 13-18 years; and adulthood, >18 years).[4,9,19]

HOSPITALIZATION CHARACTERISTICS

We also described admission characteristics (ie, transfer from another acute care hospital, emergency department use, and surgical admissions), characteristics of in-hospital care (length of stay and use of intensive care services), and discharge characteristics (eg, died or discharged to home with home nursing).

HOSPITAL RESOURCE USE

The number of unique patients, hospital discharges, days spent in the hospital (ie, bed days), and aggregate hospital charges accrued within each of the CRG study cohorts were determined for each calendar year during the study period. We assessed hospital discharges in addition to individual patients because some patients may experience multiple hospitalizations over time. Hospital charges were a sum charge for all aspects of inpatient care delivery. Hospital charges from 2004 through 2008 were converted to 2009 dollars using the Consumer Price Index for hospital and related services.[20]

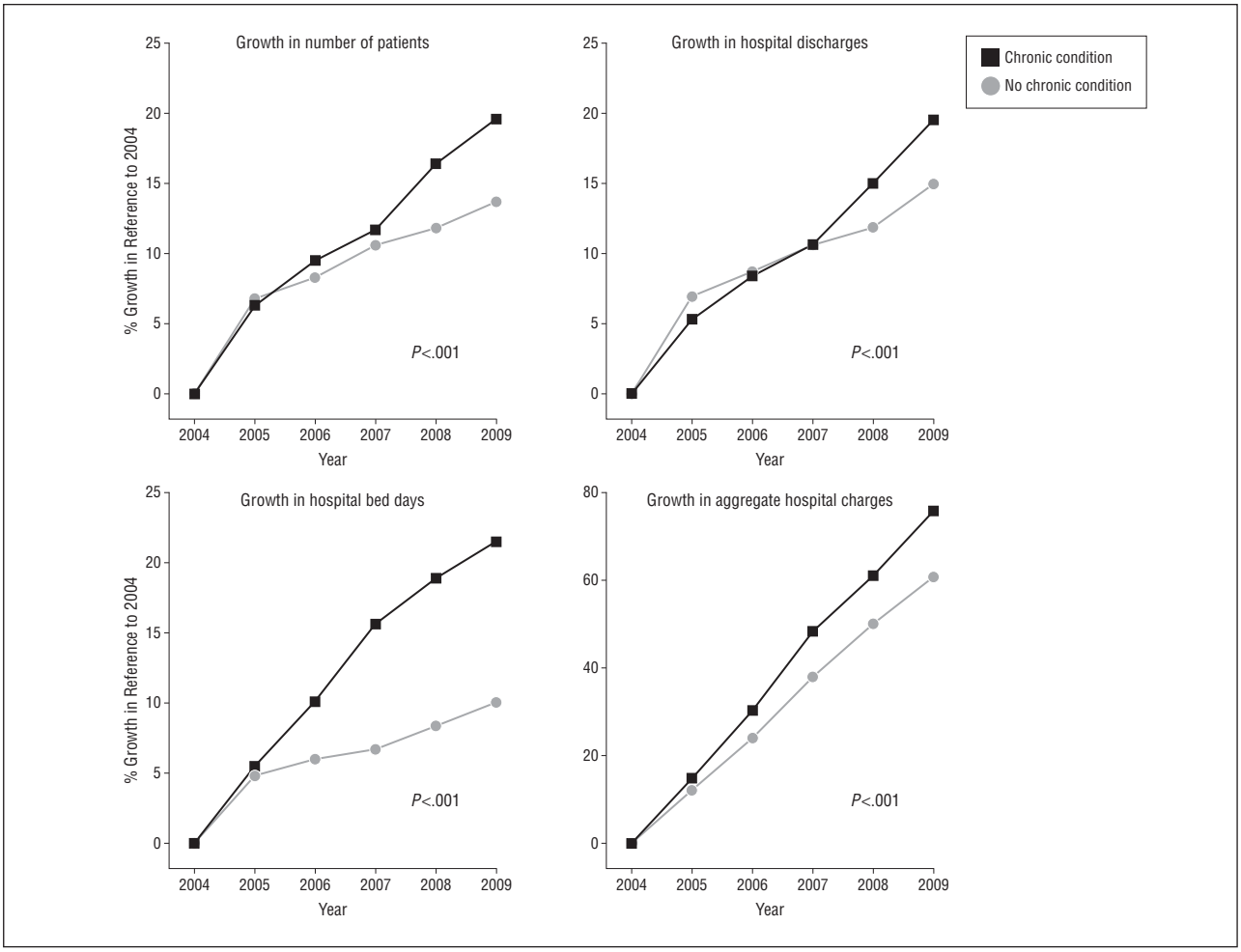

Figure 1. Patient and resource use growth trends of patients with and without chronic conditions in 28 children's hospitals. This figure presents the cumulative percent growth of the number of individual patients, hospitalizations, bed days, and charges in reference to 2004. The *P* value indicates the difference in the slope of the trend for the 2 groups of patients, adjusted for confounders in a generalized estimation equation.

FACTORS THAT MAY INFLUENCE RESOURCE USE

We assessed trends in the number of operational beds for 19 of 28 hospitals in the data set.[21] We used published reports to account for population trends, including the total population of children,[22] the total number of US pediatric hospitalizations,[10] the total number of US children using Medicaid insurance,[23] and the total number of US children living in poverty.[24]

STATISTICAL ANALYSIS

We evaluated growth trends in the number of patients, hospital discharges, hospital days, and total aggregate charges for hospitalized patients within each CRG study cohort over time using generalized estimating equations. The generalized estimating equation models contained a random effect for hospital, fixed effects for factors that may influence the growth trends, and interaction terms for CRG group and year. The interaction terms were used to compare the adjusted slope of the growth over time among the CRG groups. Children with no chronic condition were set as the reference group. Cumulative growth was calculated as the overall percent change between 2004 and 2009. Mean annual growth was calculated as the annual percent change within each CRG between consecutive years (eg, 2004-2005). Tests with 2-sided *P* values of .05 or less were considered statistically significant. All statistical analyses were performed using SAS, version 9.2 (SAS Institute, Inc).

RESULTS

There were 2 003 749 hospitalizations of 1 526 051 unique patients in the 28 freestanding children's hospitals from 2004 through 2009. During the study period, there was a significant increase ($P \leq .01$) in the number of individual patients hospitalized between 2004 and 2009 (16.7% cumulative increase) and from year to year (mean [SD] annual increase, 3.3% [1.8%]). Between 2004 and 2009, there were also significant (all $P \leq .01$) increases in the number of hospital bed days (cumulative increase, 18.3%; mean [SD] annual increase, 3.7% [1.3%]) and aggregate hospital charges (72.1%; 14.4% [3.8%]).

TRENDS IN CHILDREN WITH AND WITHOUT CHRONIC CONDITIONS

Between 2004 and 2009, there were greater ($P < .001$) increases in the number of patients, bed days, and hos-

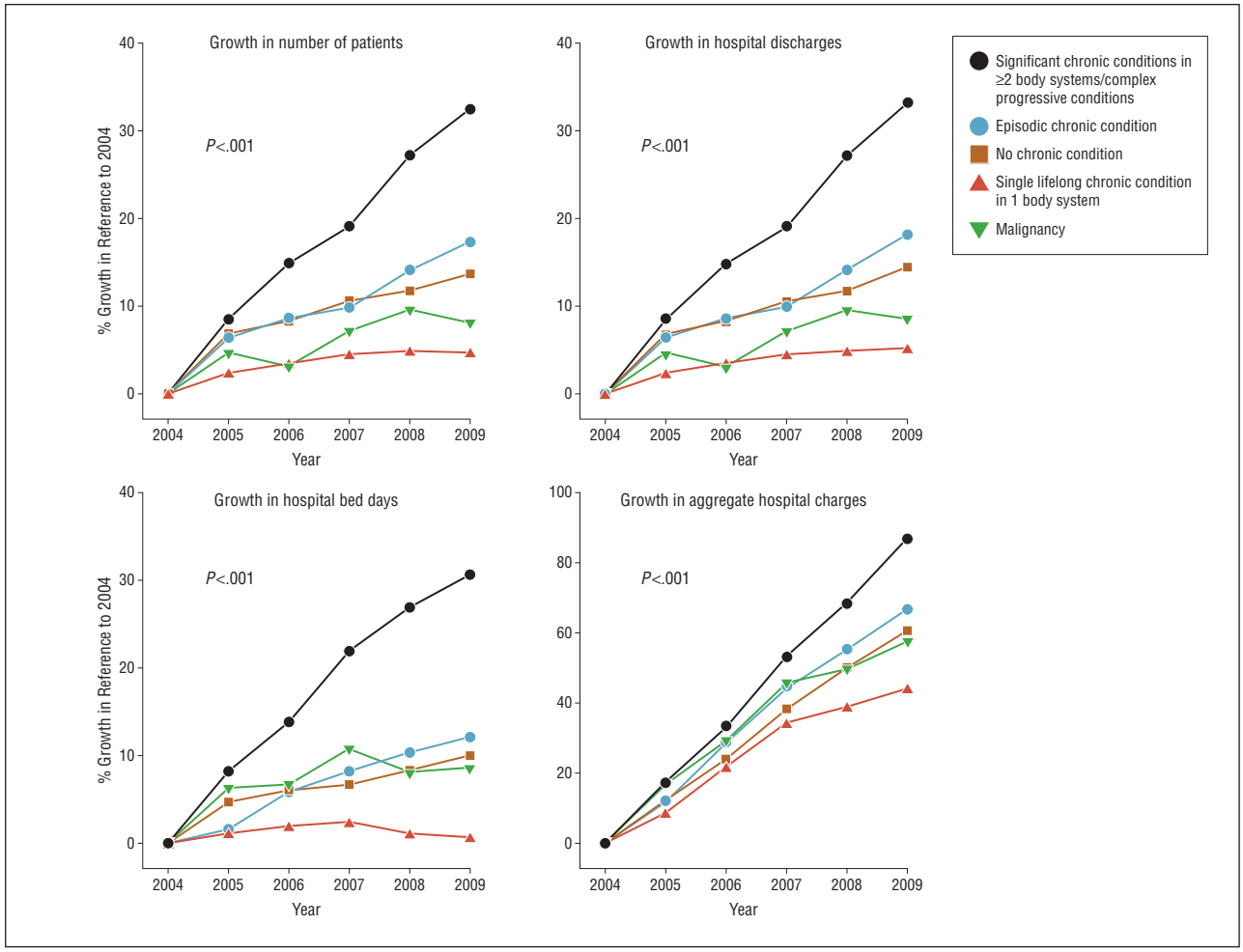

Figure 2. Patient and resource use growth trends of patients in the chronic condition cohort groupings in 28 children's hospitals. This figure presents the cumulative percent growth of the number of individual patients, hospitalizations, bed days, and charges in reference to 2004. The *P* value indicates the difference in the slope of the trend for children with chronic conditions in 2 or more body systems compared with children who did not have a chronic condition, adjusted for confounders in a generalized estimation equation.

pital charges attributable to children with chronic conditions compared with children who did not have a chronic condition (**Figure 1**). There was a mean (SD) annual increase of 3.6% (1.6%) in the number of hospitalized patients who had a chronic illness compared with 2.6% (2.4%) in patients who did not have a chronic condition. Between 2004 and 2009, this cohort size of children with a chronic condition increased by 19.2% (from 155 422 to 185 245) compared with 13.7% (from 126 848 to 144 270) for children without a chronic condition ($P<.001$). In 2009, children with a chronic condition accounted for 56.2% (n=185 245) of patients, 81.7% (n=1.8 million) of hospital days, and 86.1% ($14.9 billion) of hospital charges.

TRENDS IN CHILDREN WITH CHRONIC CONDITIONS

Hospitals experienced the largest growth in children with significant chronic conditions that affected 2 or more body systems or were complex or progressive (**Figure 2**). Between 2004 and 2009, the growth of these patients varied across hospitals, with a median (interquartile range) increase of 35.6% (22.3%-50.2%) by hospital. Across all hospitals during this time, there was a significantly greater increase in the number of individual patients (32.5% vs

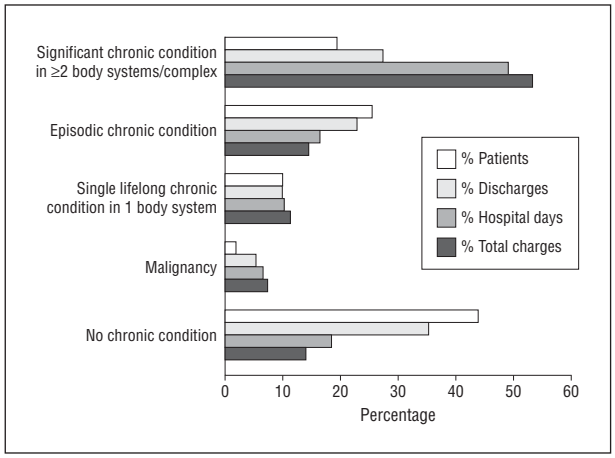

Figure 3. Inpatient health services use by chronic condition cohort groupings in 28 children's hospitals. This figure presents the percent of hospital use attributable to each group of patients in 2009.

Table 1. Demographic Characteristics of Children Hospitalized to 1 of 28 Children's Hospitals in 2009 by Chronic Condition Cohort Grouping[a]

Characteristic	No. (%)					
			Chronic Condition Type			
					Lifelong Chronic Condition	
	Total Cohort (N = 408 669)	No Chronic Condition[b] (n = 143 614)	Episodic Chronic[c] (n = 92 661)	Malignancy[d] (n = 20 701)	In 1 Body System[e] (n = 40 008)	In 2 or More Body Systems[f] (n = 111 685)
Age, y[g]						
Neonate	**35 963** (8.8)	21 398 (14.9)	5467 (5.9)	21 (0.1)	3567 (8.9)	5584 (5.0)
Infancy (≤1)	**68 248** (16.7)	34 324 (23.9)	11 305 (12.2)	704 (3.4)	7248 (18.1)	14 631 (13.1)
Early childhood (1 to ≤5)	**104 619** (25.6)	38 632 (26.9)	26 594 (28.7)	5134 (24.8)	8608 (21.5)	25 799 (23.1)
Late childhood (5 to ≤13)	**108 706** (26.6)	31 164 (21.7)	28 540 (30.8)	7825 (37.8)	10 609 (26.5)	30 602 (27.4)
Adolescence (13 to ≤18)	**73 152** (17.9)	16 372 (11.4)	18 625 (20.1)	4906 (23.7)	7808 (19.5)	25 352 (22.7)
Adulthood (>18)	**17 981** (4.4)	1723 (1.2)	2131 (2.3)	2112 (10.2)	2167 (5.4)	9717 (8.7)
Race/ethnicity						
Non-Hispanic white	**214 449** (52.5)	74 643 (52.0)	47 396 (51.1)	12 115 (58.5)	20 844 (52.1)	59 444 (53.2)
Non-Hispanic black	**90 214** (22.1)	28 112 (19.6)	23 119 (25.0)	2593 (12.5)	10 282 (25.7)	26 051 (23.3)
Hispanic	**78 362** (19.2)	30 554 (21.3)	16 355 (17.7)	4766 (23.0)	6441 (16.1)	20 243 (18.1)
Other	**25 644** (6.3)	10 304 (7.2)	5791 (6.2)	1227 (5.9)	2440 (6.1)	5947 (5.3)
Insurance						
Government	**197 796** (48.4)	71 328 (49.7)	45 249 (48.8)	9322 (45.0)	19 644 (49.1)	63 102 (56.5)
Commercial	**154 477** (37.8)	57 398 (40.0)	37 188 (40.1)	8743 (42.2)	15 883 (39.7)	37 861 (33.9)
Other	**56 396** (13.8)	14 888 (10.4)	10 224 (11.0)	2636 (12.7)	4481 (11.2)	10 722 (9.6)
Hospitalization characteristics						
Transfer from an acute care hospital	**57 214** (14.0)	24 414 (17.0)	12 231 (13.2)	3333 (16.1)	4841 (12.1)	4244 (3.8)
Admitted from ED	**200 656** (49.1)	89 184 (62.1)	45 126 (48.7)	8529 (41.2)	15 723 (39.3)	26 358 (23.6)
PICU use	**45 362** (11.1)	6463 (4.5)	8062 (8.7)	3954 (19.1)	7682 (19.2)	9940 (8.9)
NICU use	**21 251** (5.2)	8617 (6.0)	4355 (4.7)	21 (0.1)	2721 (6.8)	5584 (5.0)
Surgical admission	**102 167** (25.0)	30 733 (21.4)	25 018 (27.0)	6293 (30.4)	11 162 (27.9)	16 194 (14.5)
Length of stay, mean (SD)	**5.2** (14.6)	2.7 (3.9)	3.7 (8.1)	6.4 (11.4)	5.4 (13.8)	9.3 (24.2)
Discharge disposition						
Home	**384 660** (94.1)	139 126 (96.9)	87 935 (94.9)	19 588 (94.6)	37 688 (94.2)	100 154 (89.7)
To rehab/long-term care	**15 632** (3.8)	3411 (2.4)	3706 (4.0)	523 (2.5)	1400 (3.5)	6673 (6.0)
To home with home nursing	**5415** (1.3)	969 (0.7)	649 (0.7)	378 (1.8)	480 (1.2)	2988 (2.7)
Died	**2963** (0.7)	108 (0.1)	371 (0.4)	212 (1.0)	440 (1.1)	1871 (1.7)

Abbreviations: ED, emergency department; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.

[a] $P < .001$ for all by a χ^2 test for categorical data and a *t* test for continuous data (ie, length of stay). Missing data are not shown. Column numbers and percentages may not add to 100%.

[b] Children without chronic conditions represent children hospitalized with an acute illness who have no history of a diagnosis, procedure, or other treatment suggestive of the presence of a chronic disease.

[c] Children with episodic chronic conditions represent children hospitalized with conditions such as asthma that can be episodic and, if appropriately managed, are associated with minimal risk of complications and the potential for disease remission as the child ages.

[d] Children with malignancy represent children with a primary hematologic or oncologic malignant disease.

[e] Children with lifelong chronic conditions affecting 1 body system represent children with more severe conditions that are more likely to cause significant long-lasting health impairment who do not have additional, related comorbid health conditions (eg, a child with type 1 diabetes who does not have any other health problems).

[f] Children with significant chronic conditions affecting 2 or more body systems and/or a complex or progressive chronic condition represent children with even more severe conditions that have related comorbidities (eg, a child with diabetes, encephalopathy, and chronic pulmonary disease) or that are progressive in nature, leading to worsening debility and health (eg, a child with Duchenne muscular dystrophy).

[g] Three years of hospitalization data were used to classify children into the clinical risk groups (2007-2009). Children younger than 3 years were classified the same way as older children.

13.7%; $P < .001$), hospital bed days (30.7% vs 10.0%; $P < .001$), and aggregate hospital charges (87.1% vs 60.7%; $P < .001$) attributable to children with significant chronic conditions affecting 2 or more body systems or that were complex or progressive compared with children hospitalized without a chronic condition (Figure 2). In 2009, these children accounted for 19.2% (n=63 203) of patients, 48.9% (n=1.1 million) of hospital days, and 53.2% ($9.2 billion) of hospital charges (**Figure 3**).

Compared with patients without a chronic condition, children with significant chronic conditions that affected 2 or more body systems or were complex or progressive had a higher percentage of Medicaid use (56.5% vs 49.7%; $P < .001$) and were aged 13 years or older (31.4% vs 12.6%; $P < .001$) (**Table 1**). Cerebral palsy (9179 [14.6%]), complex chromosomal anomalies (4072 [6.5%]), and major congenital heart disease (3912 [6.2%]) were the most common primary chronic diagnoses observed among this category of patients. Asthma (13 708 [21.8%]), cardiac dysrhythmia and conduction disorders (4129 [6.6%]), and obesity (3773 [6.0%]) were the most common comorbid conditions among them (**Table 2**).

The growth experienced by the hospitals in children with malignancies, those with episodic chronic conditions, those with lifelong chronic conditions affecting a single body system, and those without chronic condi-

Table 2. Most Common Diagnoses Observed Among Hospitalized Patients With Significant Chronic Conditions Affecting 2 or More Body Systems in 2009[a]

Chronic Condition	No. (%) in 2009	% Change in 2004-2009[b]
Primary Chronic Condition		
Cerebral palsy	9179 (14.6)	+43.9
Complex chromosomal anomalies	4072 (6.5)	+60.5
Major congenital heart disease[c]	3912 (6.2)	+51.9
Bronchopulmonary dysplasia	3823 (6.1)	+41.7
Anomalies of trachea, larynx, and bronchus	3258 (5.2)	+43.9
Hydrocephalus	2623 (4.2)	+36.1
Diabetes	2390 (3.8)	+161.8
Coagulation disorders	2189 (3.5)	+42.2
Down syndrome	1908 (3.0)	+43.4
Craniofacial anomalies excluding simple cleft lip/palate	1845 (2.9)	+52.5
Comorbid Chronic Condition		
Asthma	13 708 (21.8)	+62.6
Cardiac dysrhythmia and conduction disorders	4129 (6.6)	+81.8
Obesity	3773 (6.0)	+88.6
Curvature or anomaly of the spine	3352 (5.3)	+67.0
Epilepsy	2545 (4.1)	+271.5
Conduct, impulse control, and other disruptive behavior disorders	2130 (3.4)	+62.7
Rickets, vitamin D deficiency, and disorders of phosphorus, calcium, and parathyroid	2002 (3.2)	+70.3
Developmental delay	1864 (3.0)	+63.1
Significant skin and subcutaneous tissue diagnoses	1688 (2.7)	+79.1
Spinal cord conditions	1587 (2.6)	+44.3

[a] The chronic conditions are derived from the Clinical Risk Group with further aggregation into primary chronic disease categories and then into diagnostic subgroups. In children with significant chronic conditions affecting 2 or more body systems, these chronic condition categories are not mutually exclusive and may occur more than once in a single patient.

[b] Shown are the percent change in the number of hospitalized patients between 2005 and 2009.

[c] Includes tetrology of Fallot, transposition of great vessels, hypoplastic left heart syndrome, valvular atresias or stenosis, double outlet right ventricle, single ventricle, and endocardial Cushing defects, aortic coarctation, subaortic stenosis, coronary artery anomaly, and transposition of the great arteries.

Table 3. Most Common Episodic, Single Lifelong Chronic Conditions and Malignancies Among Hospitalized Patients in 2009[a]

Chronic Condition	No. (%) in 2009	% Change in 2004-2009
Episodic Chronic Condition		
Asthma	25 608 (35.7)	+13.8
Sleep apnea and related conditions	3081 (4.3)	+11.9
Attention-deficit/hyperactivity disorder	2737 (3.8)	+50.6
Epilepsy	2295 (3.2)	+55.9
Ventricular and atrial septal defects	2221 (3.1)	–6.3
Cardiac dysrhythmia and conduction disorders	2109 (2.9)	+25.3
Conduct, impulse control, and other behavior disorders	1902 (2.7)	+26.2
Curvature or anomaly of the spine	1619 (2.3)	+29.2
Vesicoureteral reflux	1359 (1.9)	+1.7
Urinary tract obstruction	1349 (1.9)	+32.7
Lifelong Chronic Condition Affecting a Single Body System		
Sickle cell disease	3400 (12.0)	+0.4
Major congenital heart disease[b]	3395 (12.0)	+11.8
Type I diabetes	2698 (9.5)	+20.5
Hydrocephalus	1882 (6.6)	–2.2
Down syndrome	1579 (5.6)	+1.0
Anomalies of trachea, larynx, and bronchus	1446 (5.1)	+5.1
Complex chromosomal anomalies	1303 (4.6)	+7.5
Other major congenital heart diagnoses except valvular	1300 (4.6)	–7.7
Craniofacial anomalies excluding simple cleft lip/palate	1295 (4.6)	–0.6
Bronchopulmonary dysplasia	1274 (4.5)	+32.5
Cerebral palsy	1183 (4.2)	–22.2
Malignancies		
Acute lymphoid leukemia	2298 (39.9)	+0.1
Brain and central nervous system malignancies	1760 (30.6)	+3.7
Bone malignancy	776 (13.5)	–3.1
Acute nonlymphoid leukemia	505 (8.8)	+10.6
Other malignancy	451 (7.8)	+9.6

[a] The chronic conditions are derived from the Clinical Risk Group with further aggregation into primary chronic disease categories and then into diagnostic subgroups. The numbers represent single patients without duplication.

[b] Includes tetrology of Fallot, transposition of great vessels, hypoplastic left heart syndrome, valvular atresias or stenosis, double outlet right ventricle, single ventricle, and endocardial Cushing defects, aortic coarctation, subaortic stenosis, coronary artery anomaly, and transposition of the great arteries.

tions was similar to each other (Figure 2). The mean annual individual patient, bed days, and growth rates in hospital charges did not vary significantly among these patient groups ($P > .10$). Children with significant chronic conditions affecting a single body system had the lowest growth rate of patients, hospital discharges, hospital bed days, and total charges (Figure 2). Major congenital heart disease (3395 [12.0%]) and sickle cell disease (3400 [12.0%]) were the most common conditions within this category of patients (**Table 3**).

COMMENT

The study findings suggest that a group of children's hospitals experienced a recent increase in resource use for all types of children. Contrary to past literature,[1-3] there was an increase, rather than a decrease, in children hospitalized without a chronic condition (14% increase) and children hospitalized with an episodic chronic condition (18% increase). The cohort size of hospitalized children with significant chronic conditions that affected 2 or more body systems or were complex or progressive increased at the highest rate (32% increase). These children had a high prevalence of primary conditions associated with neurologic impairment and comorbidities such as asthma.

Population growth, rising disease prevalence, and improved patient survival do not fully explain these trends. During the study period, the US population size of all children increased by 1% to 2%.[25] The prevalence of asthma, the most common episodic chronic condition in our study, increased by 8%.[26] During the past decade, the prevalence of children with special health care needs (ie, children with a chronic condition who require health services beyond that required by children generally) increased by 9%.[27] Survival increased for many children with com-

plex chronic conditions but at a much lower rate than the hospitalization growth for these children observed in the present study.[5,28,29]

The trends could have been influenced by increasing hospital use by children who were socioeconomically disadvantaged. On the basis of their urban location, most children's hospitals serve an inner-city population of children from low-income families and this population of children increased in size by nearly 20% during the past decade.[24] These children are at risk for substandard receipt of preventive care, incomplete vaccinations, and obesity.[30-32] They have higher rates of severe asthma than children from higher-income families.[33] Hospitalizations for children from low-income families have increased across the United States in the past decade.[34]

In the present study, children with the greatest hospitalization growth had a high prevalence of diagnoses that result in neurologic impairment with additional comorbidities. This growth is consistent with a reported 46% increase in hospitalization rates between 1991 and 2005 for children with cerebral palsy who had an additional complex chronic condition.[35] This trend may be partially explained by an increasing number of surgical operations performed on these children. For example, the number of gastrointestinal operations to improve nutrition and digestion increased by 25% in children with neurologic impairment during the past decade.[8] The trend may also be explained by substandard receipt of ambulatory care. It is challenging in the outpatient setting to manage the care of children with neurologic impairment who have additional comorbidities. Ambulatory care has been less effective in preventing hospitalizations for acute respiratory illnesses, such as asthma, in children with neurologic impairment than in healthier children.[36] Two-thirds of children with neurologic impairment do not receive comprehensive care within a primary care medical home.[37]

There could have been a shift in referral patterns and local specialty pediatric inpatient care away from community hospitals and into children's hospitals during the study period. One study[8] reports that children with neurologic impairment experienced this shift. Children's hospitals are the primary source of care delivered by pediatric specialists. Specialty physician referrals have increased substantially for all patients during the past decade.[38] A shift in inpatient care to children's hospitals could have occurred to improve patient access to pediatric specialists[39] and hospital-based care coordination services for children with medical complexity.[40,41] Characterization of hospitalization trends in non–children's hospitals for patients with and without chronic conditions is needed to further assess this situation.

The growth trends could have been partly influenced by changes in hospital administrative data coding practice (eg, better capture of comorbid diagnoses over time). Although we are unaware of initiatives to alter children's hospital coding practices during the study period, we minimized the effect of this situation by aggregating each patient's diagnosis codes for a 3-year period (across multiple hospitalizations) to classify his or her chronic condition complexity. Diagnosis and chronic condition assignment from clinical personnel may be preferable. However, prior research[17] found that CRG assignment using administrative data is highly specific (95%) and moderately sensitive (76%) for children with chronic conditions compared with medical record review.

The study has several other limitations. The study cohort did not contain non–children's hospitals. The results are most likely applicable to children's hospitals (eTable). We did not have access to outpatient administrative data that may be helpful when classifying patients with and without chronic illness. For example, outpatient data may provide more diagnostic information for each patient to improve the accuracy of assigning patients to the CRG categories. The data set contained charge but not cost data. Charges may not represent actual expenditures or costs of care. The data set does not contain administrative information on patient referrals. Although we controlled for population changes throughout the United States that may have influenced the hospital resource trends, we were unable to control for these changes in areas specific to the hospitals in the study cohort.

Despite these limitations, the study findings have implications for children's hospitals represented in this study. If children's hospitals experience continued growth caring for pediatric patients with complex conditions at a rate that is twice as high or higher than the growth of patients with less complex conditions, then these hospitals may ultimately find themselves structurally and financially stressed to meet the inpatient needs of both types of children. If fewer patients with medical complexity are ultimately diverted to other hospitals, then children's hospitals may predominately care for a patient population that, by nature, is expensive, has a major risk for experiencing suboptimal health outcomes, and tends to draw inadequate reimbursement from payers to cover inpatient care costs.[19,42]

We hope the findings from this study may help inform (1) the development of financial strategies to reimburse the costly inpatient needs of children with complex chronic conditions, (2) structural plans to accommodate their inpatient resource growth without jeopardizing the ability to offer continued care to less-complex patients, and (3) the identification of children with complex conditions who may benefit from proactive hospital and community care integration experiments to help meet their health care needs, maximize their health, and minimize their need for inpatient care.

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