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## Children With Complex Chronic Conditions in Inpatient Hospital Settings in the United States

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### Abstract

**OBJECTIVES**—Hospitalized children are perceived to be increasingly medically complex, but no such trend has been documented. The objective of this study was to determine whether the proportion of pediatric inpatient use that is attributable to patients with a diagnosis of one or more complex chronic condition (CCC) has increased over time and to assess the degree to which CCC hospitalizations are associated with attributes that are consistent with heightened medical complexity.

**METHODS**—A retrospective observational study that used the 1997, 2000, 2003, and 2006 Kids Inpatient Databases examined US hospitalizations for children. Attributes of medical complexity included hospital admissions, length of stay, total charges, technology-assistance procedures, and mortality risk.

**RESULTS**—The proportion of inpatient pediatric admissions, days, and charges increased from 1997 to 2006 for any CCC and for every CCC group except hematology. CCCs accounted for 8.9% of US pediatric admissions in 1997 and 10.1% of admissions in 2006. These admissions used 22.7% to 26.1% of pediatric hospital days, used 37.1% to 40.6% of pediatric hospital charges, accounted for 41.9% to 43.2% of deaths, and (for 2006) used 73% to 92% of different forms of technology-assistance procedures. As the number of CCCs for a given admission increased, all markers of use increased.

**CONCLUSIONS**—CCC-associated hospitalizations compose an increasing proportion of inpatient care and resource use. Future research should seek to improve methods to identify the population of medically complex children, monitor their increasing inpatient use, and assess whether current systems of care are meeting their needs.

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## Keywords

child health services; health care delivery/access; health services research; hospitalization; children with special needs

Children with special health care needs (CSHCN), defined as children who have or at risk for a chronic physical, developmental, behavioral, or emotional condition and require health and related services of a type or an amount beyond that required by children generally, constitute 18% (~12.6 million) of US children.<sup>1</sup> The Institute of Medicine has identified CSHCN as a priority population,<sup>2</sup> in part because of their use of health resources. A small proportion of children account for the bulk of health care expenditures in the United States: 20% of children who use medical services account for ~80% of all children's health care expenditures.<sup>3</sup>

Chronic illness accounts for the majority of children's hospital days and dollars.<sup>4</sup> A smaller set of CSHCN, termed medically complex children, are perceived to use a disproportionate amount of resources, particularly in the inpatient and tertiary care settings.<sup>5</sup> Consistent and complete identification criteria of this subpopulation for administrative, clinical, and research purposes, however, remains elusive.<sup>5-7</sup> A prototypical medically complex child has a diversity of conditions and multisystem disease; may be technology-dependent; has frequent inpatient admissions; and requires multiple medications, multiple subspecialists, and optimal care coordination across inpatient and outpatient settings.<sup>5</sup> Previous work describing the 6.5% of children with disabilities,<sup>8,9</sup> the nearly 5% of children with multiple chronic conditions,<sup>10</sup> or children with technology dependence<sup>5</sup> likely described sets of children with some degree of medical complexity.

For accurate attribution of health care use of medically complex children, an operational definition is needed for use in administrative data sets. One potential method to study medically complex children is to group International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes so as to specify a set of complex chronic conditions (CCCs). Developed initially for the purpose of identifying children who are at risk for death,<sup>11-15</sup> the working definition for a CCC was "any medical condition that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or 1 system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center."<sup>11</sup> Although CCCs likely do not capture all medically complex children, the definition and implementation of the CCC scheme incorporates 3 hallmarks of medical complexity: chronic medical conditions, often existing in comorbid combinations, and associated with intensive inpatient use. In this study, we sought to determine whether the proportion of pediatric inpatient use for CCCs increased over time from 1997 to 2006 and to assess the degree to which hospitalizations of patients with CCCs were associated with use of inpatient health care resources and outcomes consistent with heightened medical complexity.

## METHODS

### Study Design and Setting

We conducted a retrospective observational study by using longitudinal panel data from the 1997, 2000, 2003, and 2006 Healthcare Cost and Utilization Project Kids Inpatient Databases (HCUP KID). HCUP KID includes nationally representative hospital discharges for children on the basis of a random 80% sample of pediatric discharges and 10% of uncomplicated births. Each data set includes weighted discharges (6.657, 7.291, 7.409, and 7.559 million, respectively) from hospitals (2521, 2784, 3438, and 3739, respectively) across various states (22, 27, 36, and 38, respectively). The HCUP KID sampling frame changed over time; the

addition of more states and hospitals in later years and exclusion of short-term rehabilitation hospitals after 1997 has led to a more representative sample.<sup>16</sup> The HCUP KID data set contains publicly available deidentified data. The study was reviewed and deemed exempt from review by the institutional review board at the University of Utah.

### Study Population

We analyzed all hospitalizations for children who were aged 0 to 18 years for consistency during the study period.<sup>16</sup>

### Measured Attributes of Medical Complexity

We examined both proportions and total numbers of pediatric hospital admissions, length of stay (LOS), total charges, technology-assistance procedures,<sup>5,17</sup> and mortality.<sup>13</sup> Technology-assistance procedures were defined by using ICD-9-CM procedure codes for gastrostomy (43.1), permanent tracheostomy (31.2×), and extracranial ventricular shunt (02.3×). The use of these procedure codes alone does not distinguish between first-time placement and replacement of devices<sup>18</sup> but identifies hospitalizations in which devices were placed.

### Main Predictor Variables

All pediatric hospitalizations were classified both by CCC category by using ICD-9-CM diagnosis codes and by CCC category count (0, 1, and multiple consisting of admissions with  $\geq 2$  CCC categories).<sup>11</sup> Hospitalizations were classified by CCC count to provide detail about increasing complexity. CCC categories are neuromuscular (eg, brain and spinal cord malformations, mental retardation, central nervous system degeneration and disease, infantile cerebral palsy, epilepsy, muscular dystrophies and myopathies), cardiovascular (eg, heart and great vessel malformations, cardiomyopathies, conduction disorders, dysrhythmias), respiratory (eg, respiratory malformations, chronic respiratory disease, cystic fibrosis), renal, gastrointestinal, hematology and immunodeficiency, metabolic, other congenital or genetic defect (eg, chromosomal abnormalities, bone and joint abnormalities, diaphragm and abdominal wall), and malignancy.<sup>11</sup> Although there were changes in ICD-9-CM diagnosis and procedure codes during the study period, none that changed either measured attributes of medical complexity or predictor variables (eg, CCC categories) occurred.<sup>19</sup>

### Covariates

Patient and hospital characteristics were defined by using standard categories provided by HCUP KID. Patient characteristics included age, gender, race/ethnicity, and payer. Age was analyzed in categories on the basis of American Academy of Pediatrics age groups 0 to 2, 3 to 5, 6 to 12, and 13 to 18. Race and ethnicity in HCUP KID are determined during each hospital's admission process. Race/ethnicity was categorized into 4 mutually exclusive groups: non-Latino white, non-Latino black, Latino, and other (includes Asian/Pacific Islander, Native American, and other). Primary payer was grouped into private, public (Medicaid and Medicare), self-pay, and other (other insurance [eg, military coverage] and no charge).

Hospital characteristics that are provided by HCUP KID include location (rural versus urban), region (Northeast, Midwest, South, or West), teaching status, and children's hospital designation. Hospital teaching status was determined from the National Association of Children's Hospitals and Related Institutions (NACHRI) through 2003 and the American Hospital Association Annual Survey Database in 2006. Children's hospital designation was determined from NACHRI classification criteria: nonchildren's hospital and children's hospital (children's general hospital, children's specialty hospital, children's unit in general hospital).

## Statistical Analyses

We performed analyses taking into account the complex sampling and weighting scheme of HCUP KID using PROC SURVEY functions in SAS 9.1.3 (SAS Institute, Cary, NC).

We report inpatient health care use in each of the study years, including percentage and numbers of hospital admissions, days, and charges by CCC category count and percentage of hospital admissions, days, and charges by individual CCC. Associated 95% confidence intervals (CIs) for any CCC were also generated. Level of statistical significance is noted in addition to CIs. In addition, tests of linear trend of proportions in a logistic regression model were performed on percentage of hospital use (admissions, days, charges, and deaths), by both CCC count and individual CCC, during the study period. Because of differences in sampling of hospitals in 1997, we additionally examined the trend of proportions of hospital use for any CCC from 2000 to 2006.

To facilitate direct comparisons between years for total charges, we converted 1997, 2000, and 2003 charges to 2006 dollars by using a consumer price index calculator ([www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)). Independent-sample *t* tests were also performed to compare 1997 use with subsequent years.

The proportion of admissions by patient and hospital characteristics were generated for each CCC category, with associated 95% CIs. Statistical significance was noted when CIs did not overlap.

To describe hospital use, we generated median LOS and median hospital charges with interquartile ranges. Annual rates of technology-assistance procedures and deaths were determined by calculating the number of weighted admissions for each category divided by the total numbers of weighted admissions, multiplied by 100.

We report for each year percentages of hospitalizations that were associated with technology-assistance procedures and deaths by CCC count. We performed univariate and multivariable analysis to evaluate the association of CCC category count with resource use. We performed general linear regression for models of log-transformed LOS and charges and logistic regression for models of technology-assistance procedures and death. For unadjusted models, we included only the CCC count variable. For adjusted models, we included all covariates (age, gender, payer, hospital location, hospital region, teaching status, and NACHRI designation) except race because >25% of observations were missing race data. The  $R^2$  statistic provides a measure of how well the model accounts for variation in outcomes. The *c* statistic provides a measure of discriminative abilities; a model is “good” when the *c* statistic is >0.7 and “excellent” when >0.8.

## RESULTS

In 1997, 2000, 2003, and 2006, the HCUP KID provided, respectively, weighted estimates of 6.7, 6.6, 6.7, and 6.9 million discharges for children who were aged 0 to 18 years. Among children with multiple CCCs, the most frequent CCCs were cardiovascular (51.5%), congenital (46.9%), neuromuscular (37.1%), respiratory (22.2%), and malignancy (15.9%); the remaining CCCs were seen in <15% of children with multiple CCCs.

Across the 4 study years, inpatient admissions for children with CCCs accounted for an increasingly disproportionate number of pediatric hospital days and charges (Fig 1). CCCs accounted for 8.9% of US pediatric admissions in 1997 and 10.1% of admissions in 2006 (trend test  $P < .0001$ ). These admissions accounted for 22.7% to 26.1% of pediatric hospital days ( $P < .0001$ ) and 37.1% to 40.6% of pediatric hospital charges ( $P < .0001$ ). Whereas proportions

of hospital days were comparable between 1997 and 2000 ( $P = .08$ ), proportions increased significantly from 2000 to 2003 ( $P < .0001$ ) and 2003 to 2006 ( $P < .0001$ ). Whereas proportions of hospital charges decreased from 1997 to 2000 ( $P < .0001$ ), proportions increased significantly from 2000 to 2003 ( $P < .0001$ ) and 2003 to 2006 ( $P < .0001$ ).

Whereas the total number of inpatient admissions and days for either 1 CCC or multiple CCCs was similar between 1997 and 2003, both increased in 2006 (Table 1). The total number of inpatient charges for either 1 CCC or multiple CCCs increased from 1997 to 2003 and from 1997 to 2006.

Similar patterns are evident for most of the 9 CCC subtypes (Fig 2). The proportion of inpatient pediatric admissions, days, and charges increased from 1997 to 2006 for every CCC except hematology (admissions, days, charges) and respiratory (charges alone). The increase in proportion of admissions, days, and charges was most for those with cardiovascular, followed by neuromuscular, congenital, and metabolic CCCs.

The patient and hospital characteristics of CCC-associated admissions are most clearly and pertinently understood by focusing on the 2006 study year (Table 2). Admissions for children with 1 and multiple CCCs compared with no CCCs was associated with patients who were older, were male, and had less self-pay and more other insurance. As numbers of CCCs increased, the proportion of admissions to urban, teaching, and children's hospitals increased.

As numbers of CCCs increased, all markers of use increased (Table 3). Compared with children with no CCCs, children with multiple CCCs had a threefold longer LOS, 11-fold greater charges, 60-fold higher rate of gastrostomy placement, 80-fold higher rate of tracheostomy placement, 180-fold higher rate of cerebrospinal fluid (CSF) shunt placement, and 15-fold higher inpatient mortality.

CCCs identified a high proportion of patients who underwent placement of technology-assistance devices. In 1997, CCCs identified 67.2% of 12 043 gastrostomies, 59.3% of 912 tracheostomies, and 87.5% of 7255 CSF shunts. By 2006, CCCs identified 72.7% of 14 379 gastrostomies, 75.3% of 784 tracheostomies, and 91.8% of 7100 CSF shunts. Furthermore, CCCs identified 41.9% of 27 983 admissions that ended in death in 1997 and 43.2% of 26 493 admissions that ended in death in 2006 ( $P = .0008$ ).

The CCC coding scheme identifies a subset of all admissions that display certain key attributes of medical complexity. In 2006 data, CCCs demonstrated statistically significant yet limited ability to account for variation in the number of inpatient hospital days (unadjusted  $R^2 = 0.08$ ; adjusted  $R^2 = 0.11$ ) and a greater ability to account for variation in charges (unadjusted  $R^2 = 0.11$ ; adjusted  $R^2 = 0.38$ ; Table 4). Models of CCCs alone were excellent for their discriminative ability with CSF shunt and gastrostomy tube placement with respective  $c$  statistics of 0.89 and 0.80 and modest for tracheostomy tube placement and death with respective  $c$  statistics of 0.65 and 0.64. Models of CCCs that included other covariates (age, gender, payer, hospital location, hospital region, teaching status, and NACHRI designation) displayed excellent discriminative ability for CSF shunt and gastrostomy tube placement, good for inpatient mortality, and modest for tracheostomy tube placement.

## DISCUSSION

The use of pediatric inpatient hospital resources by patients who are admitted with CCCs both as an overall CCC group and as individual CCC types (excepting hematology) has increased over time. CCCs, long used to identify patients who are at risk for death,<sup>11–15,20</sup> are associated with substantial inpatient resource use, including LOS, charges, and particularly technology-assistance procedures. CCCs composed 10% of admissions, 25% of hospital days, 40% of

hospital charges, 75% to 92% of technology-assistance procedures, and 43% of inpatient deaths among US children in 2006. Because individuals are not identified in this data set and patients with CCCs are more likely to be readmitted,<sup>20</sup> these 10% of admissions likely represent a smaller proportion of patients. This study also provides evidence that CCCs seem to identify, in hospital discharge data, a subset of all admissions that have attributes of medical complexity, specifically intensive resource use, particularly placement of technology-assistance devices (CSF shunts and gastrostomy tubes).

These findings should be interpreted with several caveats in mind. First, an adequate description of medically complex children has been elusive.<sup>5-7</sup> Various alternative strategies exist for their identification but tend to focus on smaller populations with particular diagnoses (eg, neurologic impairment<sup>21</sup>) or care needs (eg, palliative, end-of-life<sup>22,23</sup>). Second and related, we used a set of measures that we argue are attributes of medical complexity, rather than direct measurement of complexity per se; therefore, these should be considered candidate rather than definitive measures of medical complexity. In addition, these candidate measures should be considered for use at the population or health system level rather than the individual or clinical level. Third, use of administrative data has inherent limitations. For HCUP KID, the absence of patient identifiers limits the study to description and inferences about admissions, not patients. Some increase in CCCs during the study period may result from increased focus on documenting conditions for reimbursement purposes.

Fourth, ICD-9-CM codes do not characterize patients' functional limitations (or family needs, social factors, or the use of outpatient services or home-based technology that contribute to medical complexity), and some medically complex children may have other diagnoses that are not captured by CCCs. The net result is that CCCs do not identify the complete subset of all admissions of medically complex children. At the same time, as a recent systematic review argued,<sup>7</sup> the ready availability, consistency, and ease of use have made administrative data critical to the development of chronic condition definitions.<sup>7</sup> Within this framework of defining and measuring childhood chronic conditions, children with CCCs constitute (albeit not exclusively) the most intensive third subset of children with chronic conditions with increased health care use. Although the CCC classification scheme can and should be refined, such schemes can serve as useful pragmatic tools to identify a population of medically complex children.

This study provides evidence supporting the perception of an increase in both number and proportion of complex pediatric hospitalizations nationally.<sup>5</sup> This study confirms previous findings that children with chronic illness account for more use, including increasing inpatient hospital days,<sup>4,8</sup> higher expenditures,<sup>8</sup> more technology-dependent device use, and inpatient deaths.<sup>4</sup> Reasons for increasing inpatient use for medically complex children are unclear and likely multifactorial. The prevalence of children with CCCs in the US population may simply be increasing,<sup>12</sup> possibly as a result of improved survival in the neonatal period and subsequently prolonged survival.<sup>24</sup> This potential mechanism may explain the especially noticeable rise in the proportion of admissions that are associated with cardiac, neuromuscular, metabolic, and congenital or genetic CCCs. Inpatient care for children with more common conditions (eg, asthma, gastroenteritis, urinary tract infection) may also be moving from inpatient to outpatient settings, leaving proportionately more children with CCCs in inpatient settings. Alternatively, the population of children with CCCs may be similar in size but their inpatient use may be increasing, particularly as they age. Reasons for the dramatic increase in cardiovascular CCC admissions, hospital days, and charges warrant additional study; adoption of complex cardiac interventions by lower volume centers, a national shift in increasing use of complex cardiac surgery,<sup>25</sup> or decreasing mortality among pediatric cardiac surgery patients<sup>24</sup> might, in part, contribute to this phenomenon.

These results can better inform a system of care for medically complex children. At the population or health system level, the use of CCCs or other classification schemes that can be implemented in large data sets would facilitate studies that evaluate both quality of and evidence in care provided to medically complex children. For example, the Institute of Medicine has prioritized evaluation of the medical home model for this population of children.<sup>26–29</sup> At the individual patient level, inpatient systems of care for medically complex children also need to be optimized. These fragile children are more vulnerable to safety issues in the inpatient setting.<sup>30</sup> Although CCC codes perform well at identifying a medically complex subset of all patients, they do not have adequate positive or negative predictive value for use at the individual or clinical level. We need to develop more robust prospective methods of identifying these children, potentially coupling diagnoses with more noncategorical characteristics, such as technology assistance and/or number of providers. Prospective identification coupled with effectiveness studies may improve our ability to care for these children in hospitals, with tools such as targeted medication reconciliation,<sup>31</sup> family-centered care,<sup>32</sup> teams of integrated providers in outpatient<sup>27–29,33</sup> and inpatient settings,<sup>32</sup> care pathways,<sup>34</sup> or portable medical records.<sup>35</sup> Finally, evidence to guide the provision of optimal inpatient health care for medically complex children remains very limited. High-quality research into the indications, complications, and outcomes of the more common technology-assistance procedures (eg, gastrostomy tubes, tracheostomies, CSF shunts<sup>18,36–38</sup>), coupled with dissemination of these findings, could substantially improve care for these children.

## CONCLUSIONS

CCCs, derived to identify patients who are at risk for death, are associated with intensive inpatient resource use, including LOS, charges, and technology-assistance procedures. CCCs identify a subset of all pediatric hospital admissions with increasing inpatient use nationally. Future research should seek to improve methods to identify medically complex children, monitor the trends of increasing use, and assess whether current systems of care are meeting the needs of medically complex children.

### WHAT'S KNOWN ON THIS SUBJECT

Medically complex children are perceived to use a disproportionate amount of resources, particularly in the inpatient and tertiary care settings.

### WHAT THIS STUDY ADDS

CCCs, derived to identify patients who are at risk for death, are associated with intensive inpatient resource use, including length of stay, charges, and technology-assistance procedures. CCCs identify a subset of all pediatric hospital admissions with increasing inpatient use nationally.

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## ABBREVIATIONS

<b>CSHCN</b>	children with special health care needs
<b>CCC</b>	complex chronic condition
<b>ICD-9-CM</b>	International Classification of Diseases, Ninth Revision, Clinical Modification
<b>HCUP KID</b>	Healthcare Cost and Utilization Project Kids Inpatient Databases
<b>LOS</b>	length of stay
<b>NACHRI</b>	National Association of Children's Hospitals and Related Institutions
<b>CI</b>	confidence interval
<b>CSF</b>	cerebrospinal fluid

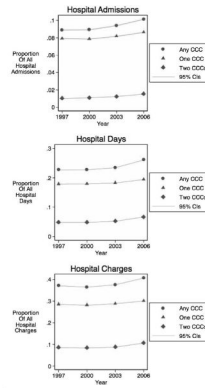
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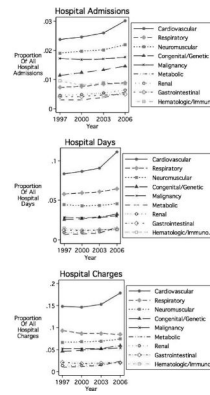
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**FIGURE 1.**

Inpatient health care use for US children from 1997 to 2006, by CCC. For any CCC, an increasing trend in proportion was seen across all study years ( $P < .0001$ ), as well as the last 3 study years ( $P < .0001$ ). Error bars (too small to be visible) indicate 95% CIs.



**FIGURE 2.**

Inpatient health care use for US children from 1997 to 2006, by CCC. For each CCC except hematology (admissions, days, and charges) and respiratory (charges only), an increasing trend in proportion was seen across study years ( $P < .0001$ ).

TABLE 1

Inpatient Health Care Use for US Children From 1997 to 2006, by CCC Count

CCC Category	1997		2000		2003		2006	
	n (SD)	%	n (SD)	%	n (SD)	%	n (SD)	%
Admissions	6 657 325 (122 735) <sup>d</sup>		6 597 323 (125 731)		6 732 415 (112 485) <sup>d</sup>		6 851 400 (115 685) <sup>d</sup>	
No CCC	6 065 283 (108 292)	91.1	6 009 098 (113 096)	91.1	6 100 515 (95 685)	90.6	6 157 546 (96 968)	90.0 <sup>b</sup>
1 CCC	525 333 (22 218)	7.9	517 299 (22 784)	7.8	549 510 (22 400)	8.2	590 617 (23 512) <sup>c</sup>	8.6
≥2 CCCs	66 710 (3690)	1.0	70 926 (4135)	1.1	82 389 (4302)	1.2	103 236 (5558) <sup>c</sup>	1.5
Hospital days	22 668 577 (558 841) <sup>d</sup>		23 217 367 (574 459)		24 182 596 (542 395)		25 395 070 (585 672)	
No CCC	17 526 325 (373 072)	77.3	17 945 562 (386 785)	77.3	18 512 308 (340 898)	76.6	18 775 891 (346 395)	73.9 <sup>b</sup>
1 CCC	4 052 131 (183 071)	17.9	4 155 676 (188 345)	17.9	4 409 928 (185 416)	18.2	4 929 464 (201 124) <sup>c</sup>	19.4
≥2 CCCs	1 090 122 (62 768)	4.8	1 116 129 (66 103)	4.8	1 260 360 (67 674)	5.2	1 689 715 (93 104) <sup>c</sup>	6.7
Charges (\$1000s) <sup>d</sup>	50 929 363 (1 842 363)		56 581 828 (2 411 688)		72 172 848 (2 520 630)		86 047 176 (3 065 975)	
No CCC	32 038 516 (935 190)	62.9	35 941 263 (1 571 581)	63.5	45 058 908 (1 252 651)	62.4	51 059 104 (1 391 950)	59.3 <sup>b</sup>
1 CCC	14 528 747 (832 399)	28.5	15 889 293 (989 013)	28.1	20 790 274 (1 111 980) <sup>c</sup>	28.8	25 848 975 (1 355 093) <sup>c</sup>	30.0
≥2 CCCs	4 362 100 (290 790)	8.6	4 751 272 (293 609)	8.4	6 323 666 (393 137) <sup>c</sup>	8.8	9 139 098 (570 159) <sup>c</sup>	10.6

<sup>a</sup>Estimates of numbers do not sum exactly because of the weighting scheme.

<sup>b</sup>Decreasing trend in proportion with  $P < .0001$  using linear trend of proportion in logistic regression model both from 1997 to 2006 and from 2000 to 2006.

<sup>c</sup>Independent-sample  $t$  test for change in use for children with  $\geq 1$  CCC compared with 1997 ( $P < .01$ ).

<sup>d</sup>Hospital charges were converted to 2006 dollars to facilitate comparisons between years.

TABLE 2

Patient and Hospital Characteristics for US Children With and Without CCCs, 2006

Characteristics	No CCC (N = 6 157 546), Proportion (95% CI), %	1 CCC (N = 590 617), Proportion (95% CI), %	Multiple CCCs (N = 103 236), Proportion (95% CI), %
Patient			
Age, y			
0–2	78.6 (77.9–79.2)	51.1 (49.9–52.3)	58.5 (57.0–59.9)
3–5	2.8 (2.7–3.0)	8.7 (8.1–9.3)	7.8 (7.1–8.5)
6–12	6.1 (5.8–6.4)	18.2 (17.3–19.1)	16.1 (15.3–17.0)
13–18	11.5 (12.2–12.9)	22.0 (21.3–22.7)	17.6 (16.8–18.4)
Gender			
Male	49.8 (49.6–49.9)	53.4 (53.1–53.6)	53.8 (53.3–54.4)
Female	50.2 (50.1–50.4)	46.6 (46.4–46.9)	46.2 (45.6–46.7)
Race/ethnicity			
Non-Latino white	51.3 (49.7–52.9)	50.2 (47.5–53.0)	50.0 (46.5–53.6)
Non-Latino black	14.2 (13.4–15.1)	19.3 (17.6–21.0)	16.6 (14.8–18.3)
Latino	24.6 (22.9–26.3)	21.4 (18.7–24.2)	23.7 (19.8–27.5)
Other	9.9 (9.1–10.7)	9.0 (7.9–10.1)	9.7 (8.3–11.2)
Payer			
Private	47.5 (46.2–48.7)	46.2 (44.3–48.2)	42.5 (40.1–45.0)
Public	44.4 (43.3–45.5)	45.9 (44.2–47.6)	50.0 (47.9–52.2)
Self-pay	5.1 (4.7–5.5)	3.0 (2.5–3.4)	2.0 (1.4–2.5)
Other	3.0 (2.7–3.3)	4.9 (3.7–6.1)	5.5 (3.7–7.2)
Hospital			
Location			
Rural	12.2 (11.6–12.8)	4.1 (3.4–4.9)	2.2 (1.2–3.3)
Urban	87.8 (87.2–88.4)	95.9 (95.1–96.6)	97.8 (96.7–98.8)
Region			
Northeast	17.0 (15.8–18.3)	17.6 (13.9–21.3)	15.1 (10.6–19.6)
Midwest	21.7 (20.4–23.0)	22.7 (17.8–27.5)	24.8 (18.0–31.5)
South	38.0 (36.2–39.7)	37.0 (31.8–42.2)	34.3 (27.6–41.1)
West	23.3 (21.8–24.7)	22.7 (17.8–27.7)	25.8 (18.9–32.7)
Teaching status			
Nonteaching	48.8 (47.1–50.4)	21.8 (18.9–24.6)	14.5 (11.0–17.9)
Teaching	51.2 (49.6–52.9)	78.2 (75.3–81.1)	85.5 (82.1–89.0)
NACHRI designation			
Nonchildren's	79.2 (76.5–81.8)	39.3 (35.2–43.3)	27.2 (23.2–31.0)
Children's	20.8 (18.2–23.4)	60.7 (56.7–64.7)	72.8 (69.0–76.7)

**TABLE 3****Inpatient Use for US Children With and Without CCCs, 2006**

<b>Parameter</b>	<b>No CCC (N = 6 157 546)</b>	<b>1 CCC (N = 590 617)</b>	<b>Multiple CCC (N = 103 236)</b>
LOS, median (IQR), d	1.6 (1.1–2.5)	2.8 (1.4–6.4)	5.2 (2.0–15.1)
Charge, median (IQR), \$2006	2918 (1667–7171)	15 676 (6608–40 152)	32 844 (12 865–97 318)
Gastrostomy tube rate (per 100)	0.060	1.100	3.850
Tracheostomy rate (per 100)	0.003	0.060	0.240
CSF shunt rate (per 100)	0.010	0.780	1.830
Inpatient death rate (per 100)	0.240	1.310	3.610

IQR indicates interquartile range from 25th to 75th percentiles.

TABLE 4

Odds of Technology Placement and Death for Children with CCCs, 2006

Technology	Unadjusted OR (95% CI)			Adjusted OR (95% CI) <sup>d</sup>		
	1 CCC	Multiple CCCs	c Statistic <sup>b</sup>	1 CCC	Multiple CCCs	c Statistic <sup>b</sup>
Gastrostomy tube	17.8 (16.3–19.4)	64.5 (57.3–72.8)	0.80	9.2 (8.1–10.4)	27.0 (22.8–31.9)	0.85
Tracheostomy tube	17.4 (12.3–24.8)	72.7 (45.7–115.4)	0.65	8.8 (5.4–14.3)	31.4 (17.3–56.9)	0.61
CSF shunt	84.9 (72.0–100.1)	197.0 (162.1–239.5)	0.89	51.2 (41.6–63.0)	95.5 (74.7–122.0)	0.90
Inpatient death	5.5 (5.2–5.8)	15.4 (14.2–16.6)	0.64	5.2 (4.8–5.6)	12.5 (11.4–13.8)	0.74

Reference category is no CCC. OR indicates odds ratio.

<sup>a</sup>Models are adjusted for age, gender, payer, hospital location, hospital region, teaching status, and NACHRI designation.<sup>b</sup>The discriminative ability of a model is "good" when the c statistic is >0.7 and "excellent" when >0.8.