

Contributions of Children With Multiple Chronic Conditions to Pediatric Hospitalizations in the United States: A Retrospective Cohort Analysis

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ABSTRACT

BACKGROUND: Children with multiple chronic conditions (CMCC) are increasingly using hospital care. We assessed how much of US pediatric inpatient care is used by CMCC and which chronic conditions are the key drivers of hospital use.

METHODS: A retrospective analysis of all 2.3 million US acute-care hospital discharges in 2012 for children age 0 to 18 years in the Kids' Inpatient Database. The ~4.5 million US hospitalizations for pregnancy, childbirth, and newborn and neonatal care were not assessed. We adapted the Agency for Healthcare Research and Quality's Chronic Condition Indicators to classify hospitalizations for children with no, 1, or multiple chronic conditions, and to determine which specific chronic conditions of CMCC are associated with high hospital resource use.

RESULTS: Of all pediatric acute-care hospitalizations, 34.3% were of children with no chronic conditions, 36.5% were of those with 1 condition, and 29.3% were of CMCC. Of the \$23.6 billion in total hospital costs, 19.7%, 27.4%, and 53.9% were for children with 0, 1, and multiple conditions, respectively, and similar proportions were observed for hospital days. The three populations accounted for the most hospital days were as follows: children with no chronic condition (20.9%), children with a mental health condition and at least 1 additional chronic condition (20.2%), and children with a mental health condition without an additional chronic condition (13.3%). The most common mental health conditions were substance abuse disorders and depression.

CONCLUSIONS: CMCC accounted for over one-fourth of acute-care hospitalizations and one-half of all hospital dollars for US pediatric care in 2012. Substantial CMCC hospital resource use involves children with mental health–related conditions.



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Many individuals living with multiple (2 or more) chronic conditions receive inadequate health care and experience suboptimal health outcomes.¹⁻³ They can have a primary chronic disease, such as cerebral palsy, and 1 or more comorbid conditions, such as asthma, gastroesophageal reflux, or scoliosis, or 2 or more coexisting primary conditions (eg, asthma and obesity). Individuals with multiple chronic conditions account for upwards of two-thirds of the nation's health care costs⁴, and often receive fragmented, uncoordinated, and crisis-driven care, with no strong evidence base guiding their management and treatment.¹ Such fragmentation leads to excessive utilization of expensive health care resources, including emergency department visits, hospitalizations, and suboptimal health outcomes.¹

Multiple chronic conditions are emerging as a cardinal attribute of medical complexity.^{5,6} The conditions in combination contribute to medical complexity because of their clinical interactions, their additive effects on health status and quality of life, and the care coordination activities required to manage the problems among multiple providers.^{5,6} These are some of the main reasons why clinicians, hospitals, health systems, payors, and state and federal agencies are concentrating specifically on multiple chronic conditions among patients with medical complexity.⁷ Most of what is known about individuals living with multiple chronic conditions comes from studies in adult patients.⁸⁻¹⁸ Children with multiple chronic conditions (CMCC) are, however, an important population with a major impact on the pediatric health care system.

Previous work on children with medical complexity found that CMCC were the fastest growing population of patients in children's hospitals over the last decade.¹⁹ CMCC often do not successfully transition from hospital to home. For children with 2, 3, and 4 or more chronic conditions, 30-day rates of unplanned readmission are 9%, 12%, and 17%, respectively.²⁰ These rates are similar to those experienced by Medicare beneficiaries.²¹ Because of their fragile health status, unmet needs, and low-quality

care, many CMCC experience recurrent readmissions.²²

Little is known about which chronic conditions of CMCC affect the pediatric health care system the most. Because CMCC are frequently hospitalized, we sought to (1) assess the fraction of US hospital discharges, bed days, and hospital charges attributable to CMCC, and (2) determine which chronic conditions of CMCC have the largest impact on hospital care for children.

METHODS

Study Design, Setting, and Population

This is a retrospective cohort analysis of hospital discharges for 0- to 18-year-old children in the Agency for Healthcare Research and Quality (AHRQ) 2012 Healthcare Cost and Utilization Project Kids' Inpatient Database (KID). The 2012 KID database contains ~3.2 million discharges, representing an estimated 6.7 million hospital discharges nationally; the KID draws on data from 4179 hospitals in 44 states.¹² The KID data include a random sample of 10% of uncomplicated births and 80% of all other pediatric discharges from each hospital,¹² and the KID includes weights to enable calculating national estimates of US total discharges for specific diagnoses and procedures.¹²

For the current study, we removed ~4.5 million hospitalizations for pregnancy, childbirth, and newborn and neonatal care by using indicators based on the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) coding for those hospitalizations in the KID. These indicators included Major Diagnostic Category 14 (Pregnancy, Childbirth, and the Puerperium) as well as 3M Health System's All Patient Refined Diagnosis Related Groups (APR-DRG; 3M, Salt Lake City, UT) for prematurity, low birth weight, and congenital anomalies as well as acute neonatal issues, such as respiratory distress syndrome, hyperbilirubinemia, neonatal abstinence syndrome, and hypoglycemia. Our study explores the role of chronic conditions as drivers of resource use among the remaining 2.3 million pediatric hospitalizations. This analysis of publicly available deidentified data does not constitute human subjects research.

Identifying CMCC

We used AHRQ's open-source, publicly available diagnosis classification schemes, namely the Chronic Condition Indicator (CCI) and the Clinical Classification System (CCS), to identify CMCC.²³ CCI classifies ~14 000 ICD-9-CM codes as chronic or not chronic. In CCI, a chronic condition is defined as a condition that lasts 12 months or longer and has one or both of the following effects: (1) it places limitations on self-care, independent living, and social interactions, and (2) it results in the need for ongoing intervention with medical products, services, and special equipment.^{23,24} The CCS collapses the CCI ICD-9-CM codes, indicating the same chronic condition, into 372 clinically meaningful, mutually-exclusive diagnosis categories.^{23,24} The CCS component also contains indicators of impaired functional status that are not disease specific (eg, the presence of a gastrostomy tube to help overcome chronic eating and digestive problems). All CCI ICD-9-CM codes and CCS diagnosis categories map exclusively to 1 of 18 overarching groupings, largely organized by organ system.

AHRQ's CCI and CCS tools can be used to (1) determine if a patient's diagnosis is a chronic condition, (2) identify the specific organ system primarily affected by each chronic condition, and (3) count and name each chronic condition noted for a patient. Both CCI and CCS use information from diagnoses and procedures recorded in ICD-9-CM codes. The AHRQ scheme can be used with the KID data because they contain up to 25 diagnosis ICD-9-CM codes per hospitalization. We defined multiple chronic conditions as 2 or more chronic conditions that affect 2 or more organ systems.

Adapting the AHRQ CCI and CCS System for Children

Although the AHRQ classification contains a broad array of childhood chronic conditions, it was not designed specifically for use in children. Therefore, we adapted it to improve its utility in children. Two complex care pediatricians with experience caring for children with a broad array of multiple chronic conditions (J.G.B., E.C.,

unpublished observations) independently reviewed the AHRQ scheme, assessing first the face validity of the organ system categories, second the CCS diagnosis categories, and third their associated ICD-9-CM codes as they relate to children. After this work, the pediatricians reviewed ICD-9-CM codes not classified as a chronic condition in the existing scheme. Suggested revisions throughout this hierarchy, from the organ system level to ICD-9-CM codes, were reviewed by a larger study team (see Acknowledgments) that also adjudicated the few instances of differences in these 2 independent judgments.

We adapted the AHRQ classifications as follows:

1. creating 8 new organ systems (eg, metabolism) that were originally grouped with a more heterogeneous organ system (eg, genetics and/or metabolism), leading to a total of 25 organ systems;
2. distinguishing 159 new distinct CCS categories of chronic conditions (eg, gastroesophageal reflux disease) by ICD-9-CM codes that were grouped nonspecifically (eg, other digestive disorders) into an expanded list of more specific categories, leading to a total of 531 categories of chronic conditions (372 existing and 149 new);
3. redesignating 39 CCS diagnoses from chronic to nonchronic when applied to children (eg, cystitis); and
4. reassigning 13 CCS categories from nonchronic to chronic (eg, chronic kidney disease).

The adaptations are presented in the Supplemental Information.

Main Outcome Measures

We separately examined 3 summary measures of hospital use (numbers of hospitalizations, numbers of days spent in the hospital [bed days], and hospital cost [converted from charges]) for hospitalized children with no chronic condition, 1 chronic condition, and multiple chronic conditions. Our primary focus was the total number of bed days attributable to populations of children, an outcome that

captures both the number of admissions and their duration and that is not affected by differences in hospital charge or cost structures. Moreover, measurement of bed days permits the possibility of recognizing an important population of children who have a low prevalence of hospitalizations but long hospital lengths of stay.

For each hospitalized child, we created a chronic condition profile (of 51 total) organized by the organ system assigned to each chronic condition (ranging from none to several) identified. To see which profiles accounted for the greatest number of bed days, we first identified children with no chronic conditions and counted their bed days. Next, we identified children with exactly 1 chronic condition and counted the bed days for the 1 of 25 organ systems (eg, mental health) assigned to each chronic condition (eg, bipolar disorder, depression, etc).

Finally, we identified CMCC and apportioned their hospital days by organ system, noting that each hospitalization contributes bed days to at least 2 chronic conditions affecting at least 2 different organ systems. We counted the bed days by organ system (eg, mental health in the presence of any of the 24 other organ systems) and identified the one that had the most bed days. We attributed those days to that system, regardless of whether the system represented a primary comorbid chronic condition. We then removed all the system's bed days from further consideration. We repeated this process on the remaining cohort of hospitalizations for CMCC with at least 2 among the 24 organ systems that had not yet been ranked. We identified the system with the most days, attributed those days to that system, and removed those bed days from the remaining cohort of hospitalizations for CMCC. We continued this process until all hospital bed days for CMCC had been attributed to a unique organ system.

Demographic and Hospitalization Characteristics

We assessed patient demographic characteristics that may correlate with the number of chronic conditions of

hospitalized children. These included age in years at admission, insurance type (eg, public [including Medicaid], private, and other), and race and ethnicity (Asian American and American Indian, Hispanic, non-Hispanic African American, non-Hispanic white, and other). We also assessed reason for admission by using 3M Health System's APR-DRG software.

Analyses

By using the KID weights to generate national estimates of hospital resources used, we compared the demographic characteristics of hospitalized children with their number of chronic conditions by using Rao-Scott χ^2 tests for categorical variables and Wilcoxon rank sum tests for continuous variables that were not normally distributed. Although not the main intention of the current manuscript, we did the comparison described above to assess whether the number of chronic conditions correlated with characteristics, such as age at admission or race and ethnicity. Given the size of the data, all *P* values were $<.001$, and thus are omitted from the body of the text. Statistical Analysis Software, version 9.3 (SAS Institute, Cary, NC) was used for all analyses.

RESULTS

Study Population

Of the 6.68 million hospital discharges represented in the 2012 KID, 4.42 million (66.1%) were excluded for pregnancy, childbirth, and newborn and neonatal care, leaving 2.26 million hospital discharges in the final cohort that accounted for 9.50 million bed days and \$23.58 billion in hospital costs.

Demographic Characteristics by Number of Chronic Conditions

Age, race and ethnicity, and payor varied significantly ($P < .001$) by the number of chronic conditions of the pediatric hospitalizations (Table 1). The median age at admission of hospitalizations without a chronic condition (3 years; interquartile range [IQR]: 0–12 years) was lower than the ages of hospitalizations with 1 chronic condition (10 years; IQR: 2–16 years) and multiple chronic conditions (12 years; IQR: 4–17 years) (Table 1). A lower percentage of hospitalizations without a chronic

condition were for non-Hispanic African Americans (13.3%) compared with hospitalizations with 1 chronic condition (19.0%) and multiple chronic conditions (18.2%) (Table 1).

Hospital Use by Number of Chronic Conditions

Pediatric hospitalizations for children in the United States in 2012 were mostly used by patients with 0 chronic conditions or 1 chronic condition. There were 0.77 million hospitalizations (34.3%) with no chronic conditions and 0.82 million (36.5%) with 1 condition, compared with 0.66 million (29.3%) with 2 or more chronic conditions (Fig 1). In contrast, the total of \$23.5 billion in costs was disproportionately incurred for hospitalizations with more chronic conditions: 18.7%, 27.4%, and 53.9% for 0, 1, and 2 or more chronic conditions, respectively. Similar findings were observed for the 9.5 million hospital days and are as follows: 20.9%, 32.4%, and 46.7% were for hospitalizations with 0, 1, and 2 or more chronic conditions, respectively (Fig 1). The most common chronic conditions of hospitalized children were asthma (13.1%),

substance abuse disorder (9.0%), and depression (5.7%) (Fig 2).

Children With the Most Hospital Days

Eleven groups of children (out of 51), distinguished by their organ-system–based chronic condition profile, accounted for 89% of hospital bed days (Fig 3). Three groups accounted for 45.8% of bed days. The first group, hospitalized children without a chronic condition, accounted for the most days (number of bed days = 2.0 million; 20.9%). Bronchiolitis and pneumonia were the reasons for admission (distinguished by the APR-DRG) that accounted for the most bed days (12.4% and 8.6%, respectively) for these children. The second and third groups of children that had a mental health chronic condition were as follows: (second group) children with a mental health chronic condition plus at least 1 additional comorbidity (rank = 2; number of bed days = 1.9 million, 20.2%), and (third group) children with a mental health condition without 1 additional comorbidity (rank = 3; number of bed days = 1.3 million; 13.3%). Combined, these second and third groups of children with a mental health condition accounted

for 33.5% (ie, 1 in every 3) of bed days (Fig 3).

Hospitalized Children With a Mental Health Condition and No Additional Chronic Condition Affecting a Different Organ System

The mental health chronic conditions with the greatest amount of hospital bed days for these children were depression (number of hospital days = 431 290; 34.2%), bipolar disorders (number of hospital days = 383 751; 30.5%), and substance abuse disorders (number of hospital days = 128 269; 10.2%). Depression and bipolar disorders were the reasons for admission (distinguished by the APR-DRG) that accounted for the most bed days (31.5% and 24.8%, respectively) of children with a mental health condition and no additional chronic condition.

Hospitalized Children With a Mental Health Condition and an Additional Chronic Condition Affecting a Different Organ System

The mental health chronic conditions with the greatest amount of hospital bed days for these children were depression (number of hospital days = 431 400; 22.4%), substance-related disorders (number of hospital days = 412 689; 21.5%), and bipolar disorders (number of hospital days = 410 720; 21.4%) (Fig 4). In these children, the additional comorbid conditions affecting other organ systems that were associated with the greatest amount of hospital bed days were asthma (number of hospital days = 451 259; 23.5%), epilepsy (number of hospital days = 304 440; 15.8%), and esophageal reflux (number of hospital days = 291 773; 15.2%).

Depression and bipolar disorders were the reasons for admission (distinguished by the APR-DRG) that accounted for the most bed days (14.4% and 8.4%, respectively) of children with a mental health condition and additional chronic conditions. Seizure (3.4%) and asthma (1.1%) were among the most common non-mental health–related reasons for admission that accounted for the most bed days in these children (Fig 4).

TABLE 1 Demographic Characteristics of Children Hospitalized in the United States in 2012 by Number of Chronic Conditions, KID

Characteristics	Number of Chronic Conditions		
	None	One	Multiple
No. of discharges	774 553	824 376	661 188
Median (IQR) age (y)	3 [0–12]	10 [2–16]	12 [4–17]
Age (y), %			
0	30.1	11.8	9.4
1–5	28.7	24.9	19.9
6–10	12.2	14.4	14.1
11–15	12.3	19.4	21.0
16–18	16.8	29.6	35.6
Race and ethnicity, %			
Hispanic	24.1	17.5	16.5
Non-Hispanic African American	13.0	19.0	18.2
Non-Hispanic white	46.5	47.0	48.4
Asian American, Native American, or other	9.0	7.9	7.8
Missing	7.4	8.6	9.1
Medicaid, %	50.3	46.8	48.3

Shown are the national estimates of all hospitalizations for children in 2012, excluding those for pregnancy, childbirth, and newborn and neonatal care.

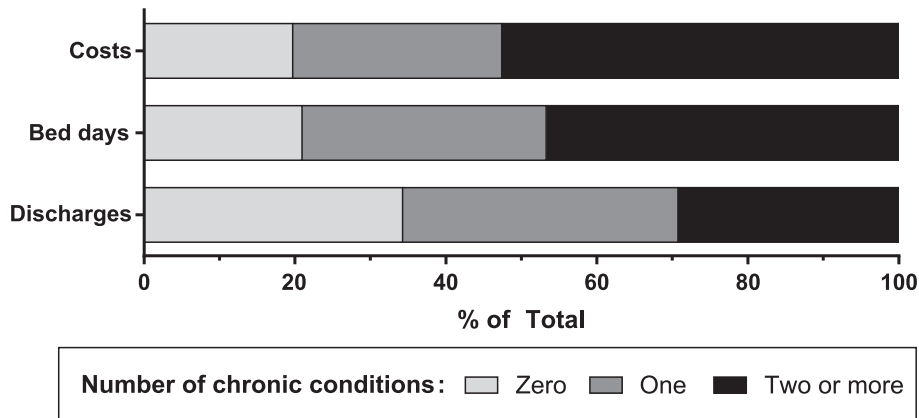


FIGURE 1 The distribution of US 2012 pediatric hospital bed-days by number and nature of patient's chronic conditions. US hospital discharges (2.3 million), hospital bed days (9.5 million), and hospital cost (\$23.6 billion) attributable to children with 0, just 1, or 2 or more (ie, multiple) chronic conditions. Approximately 4.5 million discharges for pregnancy, childbirth, and newborn and neonatal care are not included.

DISCUSSION

The findings from the current study suggest that CMCC account for 1 of every 4 acute-care US hospitalizations and 1 of every 2 US dollars of pediatric hospital care costs. Age

and race and ethnicity varied significantly across the hospitalized children's number of chronic conditions. Hospitalized CMCC were more often older and non-Hispanic African American than other children. Among CMCC,

children with a mental health condition and at least 1 additional chronic condition accounted for the most hospital days.

The proportion of hospital use attributable to CMCC in the current study compares and contrasts with previous studies of children with medical complexity. For example, previous studies report that children with medical complexity also account for a large proportion of hospital resources used.^{19,25-27} The hospital bed days attributable to CMCC in the current study, however, are up to 20% greater than the days reported in those previous studies for children with medical complexity across all US hospitals.²⁵ This difference occurred because we measured hospital resource use for children with coexisting chronic conditions (eg, depression, type 1 diabetes mellitus, asthma, etc) that were not counted in the previous studies' definition of complexity. Our measurement approach was intended to distinguish which chronic conditions, of any degree of complexity, had the greatest presence in hospitalized children throughout the United States.

Remarkably and importantly, the current study suggests that mental health conditions are the most prevalent chronic conditions to be found in acute-care hospitalizations, and mental health conditions are also associated with the greatest number of pediatric hospital days (ie, 1 in every 3) throughout the United States. These findings complement previous

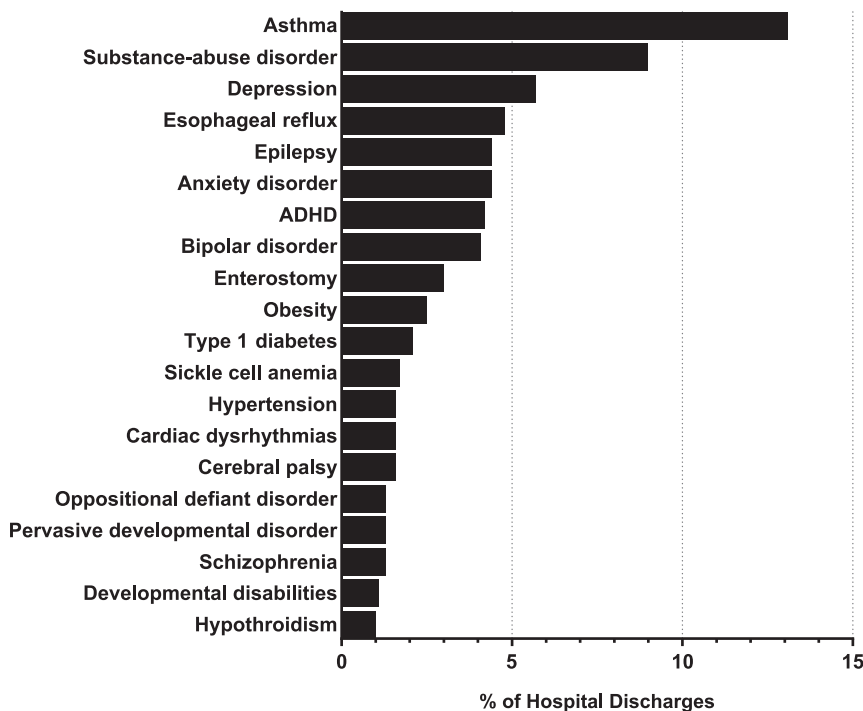
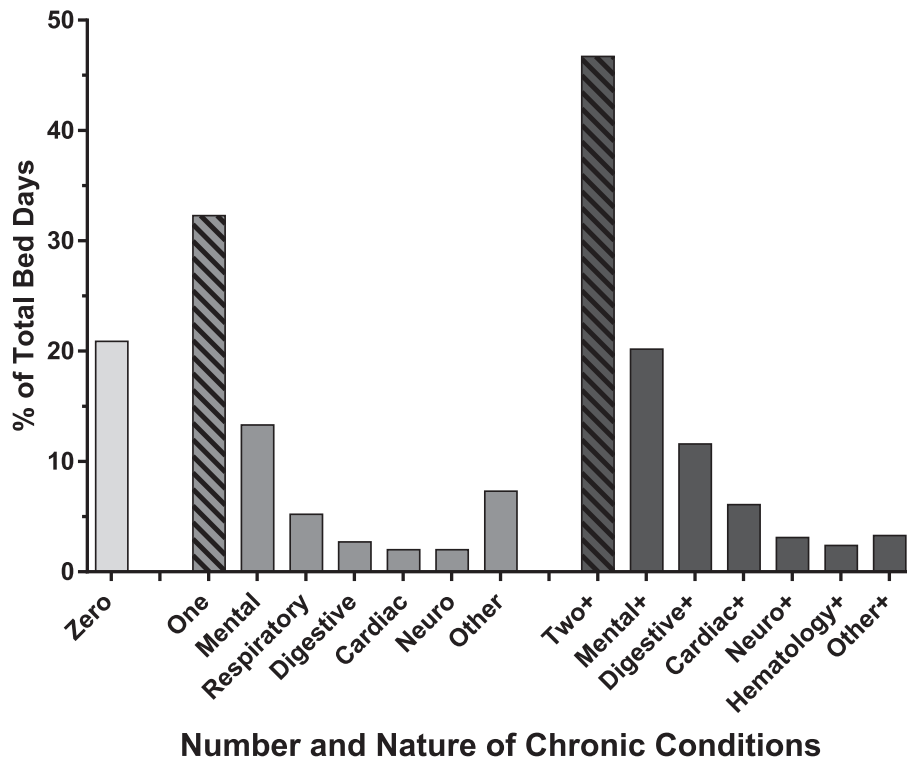


FIGURE 2 The most common chronic conditions of US 2012 pediatric hospitalizations. Presented are the 20 (out of 531) most common chronic conditions coded during US hospital discharges for children (2.3 million), categorized by the AHRQ CCI and CCS, adapted for children.



Number and Nature of Chronic Conditions

FIGURE 3 The distribution of US 2012 pediatric hospital bed-days by number and nature of patient's chronic conditions. Profiles of children based on their chronic condition profile and their contributions to total hospital bed days (9.5 million) of all hospitalized children in the United States in 2012, excluding the 4.5 million hospitalizations for pregnancy, childbirth, and newborn and neonatal care. The symbol “+” indicates that the child has at least 1 additional chronic condition affecting a separate body system.

national studies reporting that mental health conditions are common across pediatric hospitalizations; up to 1 in every 10 hospitalizations is associated with mental health conditions.^{28,29} In the current study, substance abuse was the most common mental health condition in hospitalized children. Although not determined from our study, the rising use of prescription opioids, marijuana legalization, and other societal factors could have contributed to this finding.^{30,31} In the current study, less prevalent pediatric mental health conditions (eg, mood disorders), rather than the most prevalent ones (eg, attention-deficit/hyperactivity disorder [ADHD]), were associated with the greatest hospital resource use. Longer length of stay may be one reason for this finding. Doupnik et al³² found that mood disorders tended to be more strongly associated with a longer pediatric length of stay for common medical and surgical admissions than with ADHD. We observed that over one-half of all bed days for hospitalized children with a mental

health condition were attributable to children with additional chronic conditions, including asthma, epilepsy, and obesity. This finding complements previous reports that mental health conditions are prevalent in children with at least 1 chronic health condition.^{33,34} Recent trends in children's hospitals suggest significant increases in children admitted with a medical problem (including a chronic one) who also had a coexisting mental health condition.³⁵ Future investigation is needed on how to best provide high-quality inpatient care to children with mental health conditions, especially those with additional medically based comorbidities that might be predominately managed or comanaged by nonpsychiatric inpatient providers.³⁶ This study has several limitations. KID data do not provide sufficient information to judge the appropriateness of hospital use or the possibility that a hospitalization could have been averted with better care. In this broad population-level analysis, we categorized all resource use (eg, all bed

days during a length of stay) for each hospital discharge to a mutually exclusive chronic condition profile. Subsequent studies are necessary to assess which profiles have the greatest impact on individual discharges' length of stay. This is a 1-year, cross-sectional study, and there may be year-to-year variation in hospital resources used by children's chronic condition profiles. Neither the AHRQ CCS/CCI system nor KID contains enough clinical information to distinguish children's primary chronic conditions versus comorbid chronic conditions; we therefore did not attempt to denote either of them in the current study.

Additionally, the KID 2012 data are not sufficient to compare resource use between children's and nonchildren's hospitals, and the findings from the current study may differ between those hospital types.¹⁹ KID data are available on the discharge rather than patient level; therefore, ascertaining rates of multiple hospitalizations from the same patient is not possible. Inaccuracies in health administrative data, including the

Mental Chronic Conditions With the Greatest Amount of Hospital Days

Mental Health Condition	% of Days ^a
Depressive disorders	22.4
Substance disorders	21.5
Bipolar disorders	21.4
Anxiety disorders	16.7
ADD and ADHD	16.4



Additional Chronic Conditions With the Greatest Amount of Hospital Days Among Children With a Mental Chronic Condition

Additional Chronic Condition	% of Days ^a
Neuro	
Epilepsy	15.8
Cerebral palsy	7.6
Cardiac	
Hypertension	7.3
Dysrhythmia	7.0
Respiratory	
Asthma	23.5
Digestive	
Esophageal reflux	15.2
Enterostomy	11.5
Obesity	11.4
Dysphagia	5.5

FIGURE 4 The number of hospital bed-days of hospitalized children with a mental chronic condition and additional chronic conditions in the United States in 2012, KID. Shown are the percentages of total hospital bed days ($n = 1.9$ million days) for hospitalized children with a mental chronic condition plus an additional chronic condition affecting a different (ie, nonmental) organ system in the United States in 2012. The 5 mental conditions accounting for the most hospital days are presented on the left. The additional comorbid conditions accounting for the most hospital days in the children are presented on the right. For example, hospitalized children with a mental chronic condition and epilepsy accounted for 15.8% of hospital days of all hospitalized children with a mental health condition and additional chronic conditions. ADD, attention-deficit disorder. ^a Total hospital days for children with a mental health chronic condition and an additional chronic condition = 1.9 million.

ICD-9-CM codes in KID have been reported. Data on the type and number of chronic conditions are limited by the ICD-9-CM codes available to distinguish them, and clinical data from chart review or other methods might identify additional chronic conditions. Some children living with chronic conditions may not have had them coded during hospitalization, especially if the conditions did not influence their health, hospital treatments, or resources. The adaptations made of the AHRQ system in the current study were based on subjective judgments regarding chronicity and how diseases should be categorized.

Still, hospitals, states, federal agencies, and others can use this work in population health initiatives for those children who account for the most hospital days across the United States. For example, hospitals might benefit from exploring the efficiency and effectiveness of inpatient care delivery for children with a chronic mental health condition, especially those with an additional chronic condition. States, federal agencies, and others may benefit from

assessing systems of care in particular for those CMCC to ensure that their hospital use is appropriate and delivered at the highest level of quality possible.

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