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Factors Associated with Inpatient Hospitalizations among Patients Aged 1 to 64 Years with Congenital Heart Defects, Arkansas 2006 to 2011

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Abstract

Background—Individuals with congenital heart defects (CHDs) have high hospital resource use. We sought to identify factors associated with hospital costs and multiple hospitalizations among individuals with CHDs.

Methods—Data from the 2006 to 2011 Healthcare Cost and Utilization Project Arkansas State Inpatient Databases were linked across encrypted patient identifiers to develop a cohort of Arkansas residents aged 1 to 64 years who were hospitalized at least once with a CHD during this time period. Infants were excluded because patient identifiers were missing for 18 to 52% each year. CHDs were identified using principal and secondary International Classification of Diseases, Ninth Revision, Clinical Modification diagnoses codes. All hospitalizations of individuals ever admitted with a CHD were included. Mean and median patient-level costs were estimated; the association of hospital costs and patient readmissions were examined with linear and logistic regression.

Results—There were 1,185,868 inpatient hospitalizations of Arkansas residents aged 1 to 64 years between 2006 and 2011; these were accrued by 603,925 patients. Of those, 2542 patients (0.42%) had at least one hospitalization with a CHD diagnosis. Total costs for these 2542 patients were $126,999,837 and they accumulated 7898 hospitalizations. Factors associated with increased costs included patient age, CHD type, cardiac procedures, and comorbidities. Factors associated with hospital readmission within 1 year included age, CHD type, expected payer, and comorbidities.

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Conclusion—Individuals with CHDs in Arkansas experience variation in hospital use and costs by patient characteristics. Future research should investigate factors associated with readmissions, cardiac procedures, and comorbidities, as these are strongly associated with hospital costs.

Keywords

Congenital heart defects; hospital costs; Healthcare Cost and Utilization Project; Arkansas; Person-level; One-year readmission

Introduction

Congenital heart defects (CHDs) are a relatively common birth defect affecting approximately 8 to 10 per 1000 infants (Reller et al., 2008; Bjornard et al., 2013). Survival among infants born with CHD has improved over time (Oster et al., 2013). Currently, it is estimated that more adults (over the age of 18 years) than children are living with a CHD in the United States (Warnes et al., 2001); moreover, the number of hospitalizations of adults with CHD is increasing compared with hospitalizations of children with CHD (O'Leary et al., 2013). The medical needs of patients with CHD beyond infancy are largely unknown. A better understanding of the patient-level hospital resource use of children and adults with CHD is needed.

At the hospital level, hospitalizations of individuals with CHD have high costs in both pediatric and adult admissions (Connor et al., 2005; Opotowsky et al., 2009; O'Leary et al., 2013; Simeone et al., 2014). Additionally, hospital costs are influenced by age, CHD complexity, payer status, hospital or surgical center, and complications during treatment (Connor et al., 2005; Benavidez et al., 2007; Pasquali et al., 2011, 2014). A hospital-level analysis of hospitalization costs for CHDs found that across the life-span CHDs accounted for approximately 0.4% of hospitalizations and 2.2% of hospital costs (Simeone et al., 2015).

To address the gap in knowledge, we aim to describe the patient-level hospital use and costs for individuals aged 1 to 64 years with a CHD diagnosis and to identify factors associated with higher hospital costs and multiple hospitalizations among patients with CHDs admitted to Arkansas hospitals between 2006 and 2011. This builds on earlier work to examine hospital-level costs for Arkansas patients of all ages with CHDs (Simeone et al., 2015).

Materials and Methods

DATA SOURCE

This was a longitudinal study of hospitalizations of Arkansas residents with CHD admitted to Arkansas acute care hospitals between 2006 and 2011. Data were obtained from the Agency for Healthcare Research and Quality's 2006 to 2011 Arkansas State Inpatient Databases (SID), a set of inpatient all-payer administrative databases of hospital discharges (AHRQ, 2013b, 2014b). The Arkansas SID provides encrypted patient identifiers (PI), which allow linkage of inpatient admissions at the patient level (AHRQ, 2014a, 2015).

CASE DEFINITION AND STUDY VARIABLES

We included hospitalizations of individuals aged 1 to 64 years admitted between January 1, 2006 and December 31, 2011 with at least one hospitalization discharge record including a principal or secondary CHD International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code (745.0–747.49). We defined critical CHDs (CCHD) as the following CHD phenotypes, which are primary and secondary targets of newborn screening for CCHD using pulse oximetry: hypoplastic left heart syndrome (746.7), pulmonary atresia (746.01), tetralogy of Fallot (745.2), total anomalous pulmonary venous return (747.41), transposition of the great arteries (745.10), tricuspid atresia (746.1), truncus arteriosus (745.0), double outlet right ventricle (745.11), single ventricle (745.3), Ebstein anomaly (746.2), coarctation/hypoplasia of aortic arch (747.10), and aortic interruption/atresia/hypoplasia (747.11, 747.22) (Mahle et al., 2009; Kemper et al., 2011). Patients who ever had an ICD-9-CM code indicating a CCHD or non-critical CHD during the study period (2006–2011) were considered to have a CHD even if previous or subsequent hospitalization during the study period did not include a CHD ICD-9-CM code.

We excluded hospitalizations of infants (patients <1 year of age), of patients ≥ 65 years of age, and of out of state residents; we also excluded those with missing data on age, hospital charges, state of residence, length of stay, payer, or PI. Hospitalizations missing length of stay were excluded because patient linkage and estimates of time between hospitalizations could not be calculated without length of stay. While infants incur approximately three-quarters of all hospital costs for CHDs (Simeone et al., 2015), hospitalizations of infants were excluded from this analysis because of the large number of infant hospitalizations without a verified PI in each year (17.8–51.9% each year), preventing the identification of individual patients (AHRQ, 2015). After excluding these hospitalizations, the PI was used to identify all hospitalizations for unique individuals; patients who never had a hospitalization that included at least one ICD-9-CM for a CHD were excluded from the analysis.

Variables of interest for the analysis included patient age, race at first hospitalization (non-Hispanic white, non-Hispanic black, and other race), sex, expected primary payer (public [Medicare and Medicaid], private, and other [self-pay, no charge, and other payer]), urban/rural residence (based on the 2006 National Center for Health Statistics Urban-Rural classification scheme [Ingram et al., 2012], provided in Healthcare Cost and Utilization Project data), greater than one hospitalization within a 365-day period, performance of a cardiac procedure at any hospitalization (Supp Table 1, which is available online), and number of comorbidities. Comorbidities were defined using the Elixhauser comorbidity measures, which measure coexisting conditions on the discharge record. These comorbidity measures were developed for use with administrative datasets and take into account ICD-9-CM codes on the discharge record, principal diagnosis, and diagnosis related groups (Elixhauser et al., 1998; Healthcare Cost and Utilization Project, 2013). Separate comorbid conditions were counted once, regardless of the number of hospitalizations in which they occurred. Total number of hospitalizations was calculated by summing the unique hospital visits accumulated by each individual; consecutive hospitalizations in which the discharge date of the first hospitalization was the same as or overlapped the admission date of the second hospitalization were considered one hospitalization.

COSTS

Total hospital charges are reported on each discharge record in the SID. Total hospital charges on each discharge record were multiplied by hospital- and year-specific cost-to-charge ratios provided by HCUP (AHRQ, 2013a). Methods have been described in detail elsewhere (Simeone et al., 2015). Costs are reported in 2012 U.S. dollars calculated using the Purchaser Price Index for Hospitals (U.S. Bureau of Labor Statistics).

STATISTICAL ANALYSIS

The total and per-patient mean and median costs for all individuals who had at least one CHD hospitalization and were between 1 and 64 years of age were estimated. Mean patient-level costs were compared using *t* tests or analysis of variance; median costs were compared using the Wilcoxon-Mann-Whitney or Kruskal-Wallis tests for nonparametric distributions. Because the distribution of costs was skewed toward higher costs, linear regression analysis was used to estimate the association between demographic characteristics and the natural logarithm of patient costs (ln(costs)). Results of the linear regression analysis are presented as exp(β); these exponentiated coefficients can be interpreted as percent changes in cost associated with a unit change in the independent variables in the model. Per-person costs and number of hospitalizations associated with Elixhauser comorbidities were also estimated; logistic regression was used to examine which comorbidities were most strongly associated with multiple hospitalizations within a 365-day period.

In addition, adjusted logistic regression analysis was used to estimate the adjusted odds ratios (ORs) for the association between multiple hospitalizations (≥ 2 hospitalizations) within a 365-day period and patient factors, with analysis limited to individuals who did not die in their first hospitalization and who had their first hospitalization before 2011. One sub-analysis was conducted, examining mean hospital costs among patients ever experiencing a cardiac procedure; linear regression of ln(costs) of hospital costs, by age group, was used to examine the impact of cardiac procedures on costs. In analyses, patients 4 to 17 years were selected a priori as the referent group because we hypothesized this group would use the least resources because the majority of costly CHD surgical repairs were anticipated to occur in children before 4 years of age, with any additional repairs occurring later in adulthood.

Inclusion criteria may have resulted in an overestimation of the number of individuals aged 1 to 64 years hospitalized with a CHD due to misclassification of individuals with numerous comorbidities and acquired heart disease as having a CHD, particularly among individuals with seemingly minor CHDs, such as atrial septal defects. We conducted a sensitivity analysis restricting the study population. The population for the sensitivity analysis was developed using inclusion and exclusion criteria to exclude subjects whose primary source of morbidity was unlikely to be a CHD. All patients who were ever diagnosed with a CCHD, ever had a principal diagnosis of a CHD, or those ever diagnosed with a CHD who also had a cardiac procedure during the same hospitalization were included, regardless of any additional diagnoses. Any patient without a CCHD, without a principal diagnosis of a CHD, or without a CHD diagnosis and cardiac procedure during the same hospitalization were considered for the sensitivity exclusion. Sensitivity exclusion criteria were diagnosis of

ischemic heart disease (ICD-9-CM 410.xx-414.xx), diabetes (ICD-9-CM 250.xx), or sickle cell disease (ICD-9-CM 282.41-282.42, 282.6) (Supp. Fig. 1).

Results

After excluding hospitalizations of infants (n = 269,809), of patients ≥ 65 years of age (n = 947,229), and of out of state residents (n = 63,107), as well as hospitalizations missing data on age at admission (n = 1193), hospital charges (n = 2189), residence (n = 275), length of stay (n = 224), payer status (n = 15,284), and PI (n = 38,118), there were 1,185,868 hospitalizations available for patient-level analysis. These hospitalizations were accumulated by 603,925 individual patients, 2542 (0.42%) of whom had at least one hospitalization with a CHD diagnosis (Supp. Fig. 2).

The total 2006 to 2011 hospital costs of the 2542 individuals aged 1 to 64 years were $126,999,837 and these patients accumulated 7898 hospitalizations with and without a CHD diagnosis between 2006 and 2011. Of those 7898 hospitalizations, 4866 (61.6%) had no CHD diagnosis, 761 (9.6%) included the CHD as the principal diagnosis, and 2271 (28.5%) included the CHD as a secondary diagnosis. Average per-patient cost was $49,961 (standard error [SE]: 1626). Median per-patient hospital costs for all hospitalizations were $28,482 (interquartile range [IQR]: $10,899, $53,530). Among hospitalizations of individuals ever admitted with CHD but with no CHD diagnosis, per-hospitalization mean costs were $10,289 (SE = 322); median costs were $5505 (IQR = $3174, $10,097). Hospitalizations in which the CHD was the principal diagnosis had mean per-hospitalization costs of $36,736 (SE = 1587) and median costs of $29,104 (IQR = $12,722, $44,211). Hospitalizations in which the CHD was a secondary diagnosis had mean per-hospitalization costs of $17,433 (SE = 920) and median costs of $6651 (IQR = $3482, $17,364).

Thirty-eight percent of patients ever admitted with a CHD between 2006 and 2011 were 46 to 64 years old at their first admission (Table 1). Patients with CCHDs comprised 13.4% of all individuals ever hospitalized with CHD over the study period. Of patients ever admitted with a CHD between 2006 and 2011, 45.5% had an expected private payer, 49.1% experienced multiple inpatient hospitalizations within 365 days, 38.6% had ever undergone a prior cardiac procedure, and 28.8% of patients were ever admitted with a CHD as the principal diagnosis. By demographic characteristic, children aged 1 to 3 years at their first admission during this time period had more costly hospitalizations compared with patients at older ages at their first admission; non-Hispanic black patients had more costly hospitalizations than patients of other races; patients with an expected public payer had more costly hospitalizations than patients with private or other expected payers; patients ever admitted with a CHD as the principal diagnosis had more costly hospitalizations than patients who were never admitted with a CHD as the principal diagnosis.

In an adjusted linear regression, several patient factors were associated with increased hospital costs (Table 2). Hospital costs were nearly 1.5 times higher in those with a CCHD compared with those without a CCHD. Multiple hospitalizations within 365 days more than doubled hospital costs compared with patients with no more than one hospitalization within any 365-day period. A history of at least one cardiac procedure during the study period

nearly tripled hospital costs. Cardiac procedures were associated with higher hospital costs at all ages (Supp Table 2). Cardiac procedures were more common among patients less than 18 years of age compared with patients 18 to 64 years of age. Similarly, mean per-patient hospital costs were highest in pediatric hospitalizations. Among patients aged 1 to 3 years, hospital costs of patients with a cardiac procedure were over 4 times higher than hospital costs of patients of the same age without a procedure (Supp Table 2). Older age at first admission and female sex were both associated with decreased per-patient costs (Table 2).

In an adjusted logistic regression, patients aged 1 to 3 years and 18 to 45 years at their first admission were 1.84 and 1.63 times more likely to experience multiple hospitalizations within 365 days compared with patients aged 4 to 17 years at their first admission (Table 3). Elevated ORs for multiple hospitalizations within 365 days were also observed among patients with CCHDs, patients with an expected public payer, and patients with a greater number of comorbid conditions. A history of at least one cardiac procedure during the study period was not associated with multiple admissions.

Among all patients ever admitted with a CHD, 1750 (68.8%) patients were admitted with at least one Elixhauser comorbidity measure (Table 1). Hypertension-related comorbidities were most common (40.2% of patients), followed by fluid and electrolyte disorders (23.3% of patients) and chronic pulmonary disease (18.8% of patients) (Table 4). Patients ever diagnosed with congestive heart failure had the highest mean per-patient costs and number of hospitalizations. Having multiple admissions within 365 days was most strongly associated with the presence of congestive heart failure (OR=7.5, 95% confidence interval [CI], 5.2–10.2), depression (OR=6.4, 95% CI, 4.6–8.9), and deficiency anemias (OR=5.8, 95% CI, 4.3–7.7).

When a sensitivity analysis was performed excluding individuals whose hospital costs might have been primarily due to other illnesses and not a CHD (n = 524), total per-patient costs among individuals whose hospitalizations were not due to other illnesses were $98,067,250; mean (SE) costs were $48,596 ($1832) with median (IQR) costs of $28,218 ($10,540–$51,650). The total number of hospitalizations in the remaining 2018 patients decreased to 5265 (mean 2.6 [0.7] hospitalizations per patient). Adjusted linear regression of ln(cost) associations and estimated adjusted ORs were similar to those observed in the full analysis (data not shown).

DISCUSSION

Arkansas children and adults with CHDs experience variation in hospital use and costs by demographic factors and comorbidities. Adults over the age of 45 at first hospitalization between 2006 and 2011 accounted for the largest patient group, but infants and children aged 1 to 3 years had the highest average per-patient costs. Approximately half of patients with a CHD had multiple hospitalizations within 365 days of each other. After adjusting for patient demographic characteristics, factors associated with increased costs were hospital readmission within 1 year, presence of a CCHD, cardiac procedures, and increased number of comorbidities. Additionally, having multiple hospitalizations within 365 days was associated with having a CCHD, having an expected public payer, and having additional

comorbidities. Congestive heart failure was associated with high costs and multiple admissions within a 365-day period. While presence of a cardiac procedure at any age increased costs, cardiac procedures occurring in childhood had the largest impact on costs.

Previous studies have demonstrated higher costs and associated resource usage in those patients with CHDs whose hospitalizations included CCHDs (Mackie et al., 2007; Simeone et al., 2014), hospitalizations during infancy and childhood (Connor et al., 2005; Simeone et al., 2014), complex surgical procedures (Connor et al., 2005; Pasquali et al., 2011), or in which a complication occurred (Benavidez et al., 2007). Our results add to the literature by demonstrating that individuals with multiple hospitalizations account for a meaningful proportion of patients with CHD and are associated with greater hospital costs.

Adults with a CHD diagnosis comprise a large proportion of the Arkansas inpatient population with CHD. This pattern is seen at both the patient and hospital level (Simeone et al., 2015). This observation also follows trends of increasing numbers of adult hospitalizations with CHD, which are likely the result of improvements in diagnosis and treatment in infancy and childhood (Warnes et al., 2001; Marelli et al., 2007, 2014; Oster et al., 2013). Understanding the medical needs of this growing patient population will impact resource allocation and planning within hospital and healthcare systems.

This study was limited by several factors. Inclusion and exclusion criteria were developed to be inclusive; patients were included if at least one hospital discharge during this 6-year period included a diagnosis of any CHD. This may have led to an overestimation of costs and patient hospitalizations, particularly among those individuals who were high resource users, but had very few hospitalizations that included a CHD diagnosis. In a sensitivity analysis, we excluded patients whose primary morbidity seemed unlikely be a CHD; total costs and number of hospitalizations were reduced by 22.8% and 33.3%, respectively, but associations between costs, multiple hospitalizations, and patient characteristics did not change. Additionally, our study was constrained by inherent limitations of administrative datasets. ICD-9-CM codes were used to identify any hospitalization and patient for whom a CHD diagnosis was ever coded and CHDs are prone to misclassification (Frohnert et al., 2005; Strickland et al., 2008). Patients might have been misclassified as having or not having a CHD depending on what was recorded on discharge summaries; this is particularly important for the adult population with CHD, where the ICD-9-CM code may be less likely to be noted and nonspecific cardiovascular disease codes might be used instead. Due to lack of encrypted PI among infants, we were unable to estimate patient-level infant costs. Infants accounted for a large proportion of the hospitalizations and costs for CHDs in Arkansas and nationwide (Connor et al., 2005; Simeone et al., 2014, 2015); excluding hospitalizations of patients less than a year old underestimated patient-level CHD costs, particularly for patients with complex surgeries occurring in the first year of life (Moons et al., 2009; Burstein et al., 2011; Pasquali et al., 2011). Finally, cost data in the SID may be underestimated, as physician fees are not included in the discharge summary (Rogowski, 1998).

Despite these limitations, we were able to analyze patient-level data over multiple years from a large, population-based, all-payer system. The availability of patient-level identifiers

allowed an investigation of per-patient characteristics and costs, which are often unavailable with administrative data.

Conclusions

In an analysis of state inpatient hospital costs, patients with CHDs were more likely to have higher costs when they had a more severe CHD, comorbidities, cardiac procedures, or multiple hospitalizations within 365 days. CCHDs, presence of comorbidities, and having a public payer were associated with increased odds of multiple stays within 365 days. Future research should investigate factors associated with multiple hospitalizations, need for cardiac procedures, and comorbidities in the CHD population, as these appear to be strongly associated with hospital costs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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TABLE 1

Patient-Level Analysis of Demographic Characteristics and Mean and Median Costs of Individuals Aged 1 to 64 Ever Diagnosed with a Congenital Heart Defect and Admitted to a Hospital, Arkansas State Inpatient Databases 2006 to 2011[a]

	N (%)	Mean per-patient cost[b] (SE) (US $)	Median per-patient Cost[b] (25th–75th percentile) (US $)	*P* (ANOVA)	*P* (Wilcoxon)
Age at first hospitalization					
1–3 years	321 (12.6)	73,767 (7,482)	38,400 (14,436 – 72,077)		
4–17 years	362 (14.2)	63,801 (5,551)	37,401 (19,897 – 60,265)	<0.0001	<0.0001
18–45 years	882 (34.7)	39,672 (2,138)	19,678 (8,208 – 43,608)		
46–64 years	977 (38.4)	46,299 (1,883)	28,884 (12,511 – 53,264)		
Race					
Non-Hispanic white	2,049 (80.6)	47,456 (1,634)	27,722 (10,596 – 51,594)		
Non-Hispanic black	356 (14.0)	67,675 (6,537)	33,793 (13,485 – 64,907)	<0.0001	0.0029
Other	133 (5.2)	42,074 (4,357)	25,370 (10,034 – 51,089)		
Missing	4 (0.2)				
Critical congenital heart defect					
No	2,201 (86.6)	44,276 (1,508)	25,905 (10,390 – 48,016)	<0.0001	<0.0001
Yes	341 (13.4)	86,649 (6,904)	54,107 (25,152 – 99,566)		
Sex					
Male	1,262 (49.7)	50,812 (2,009)	31,098 (12,240 – 56,709)	0.6032	<0.0001
Female	1,280 (50.4)	49,121 (2,550)	25,366 (9,965 – 50,073)		
Expected payer at first visit					
Public	990 (39.0)	60,541 (3,312)	33,071 (12,891 – 62,065)		
Private	1,156 (45.5)	44,767 (1,968)	26,260 (10,763 – 48,595)	<0.0001	<0.0001
Other	396 (15.6)	38,671 (2,485)	23,949 (9,142 – 46,704)		
Residence at first visit					
Rural	974 (38.3)	49,289 (2,537)	28,461 (12,392 – 52,942)	0.7401	0.5063
Urban	1,566 (61.6)	50,399 (2,115)	28,525 (10,375 – 54,467)		
Missing	2 (0.1)				
Multiple hospitalizations within 365 days[c]					
No	1,147 (50.9)	28,786 (1,587)	17,425 (6,734 – 35,081)	<0.0001	<0.0001
Yes	1,107 (49.1)	75,359 (3,082)	44,505 (23,662 – 84,831)		
Cardiac procedure[d]					
No	1,560 (61.4)	38,829 (1,790)	16,508 (6,992 – 41,802)	<0.0001	<0.0001
Yes	982 (38.6)	67,645 (3,018)	42,299 (28,471 – 68,393)		
Number of comorbidities[e]					
0 comorbidities	792 (31.2)	29,722 (1,321)	20,193 (7,942 – 37,838)		
1 comorbidity	501 (19.7)	42,061 (3,230)	21,474 (7,436 – 45,287)	<0.0001	<0.0001

	N (%)	Mean per-patient cost[b] (SE) (US $)	Median per-patient Cost[b] (25th–75th percentile) (US $)	*P* (ANOVA)	*P* (Wilcoxon)
2 comorbidities	380 (15.0)	43,907 (4,778)	24,826 (11,452 – 43,888)		
3+ comorbidities	869 (34.2)	75,607 (3,479)	46,259 (22,703 – 83,564)		
CHD as principal diagnosis[f]					
No	1,809 (71.2)	47,543 (1,877)	23,464 (8,409 – 50,977)	0.0195	<0.0001
Yes	733 (28.8)	55,926 (3,204)	35,458 (21,474 – 58,511)		

[a] Excludes hospitalizations of patients who were less than one year of age at their first hospitalization, greater than 64 years of age at their first hospitalization, non-Arkansas residents, as well as patients missing data on age, hospital charges, residence, length of stay, payer status, and encrypted patient identifier; after combining hospitalizations by patient identifier, the patient population excludes 601,352 individuals without any congenital heart defect diagnosis at any hospitalization.

[b] Costs have been adjusted to 2012 dollars using the Purchaser Price Index for Hospitals.

[c] Excludes 288 patients who died during their first hospitalization or who were admitted for the first time in 2011.

[d] At least one inpatient cardiac procedure during any hospitalization.

[e] Comorbidities defined using the Elixhauser comorbidity measures; separate comorbid conditions were counted once regardless of the number of hospitalizations in which they were diagnosed.

[f] Ever had a hospitalization in which the CHD was the principal diagnosis.

SE, standard error.

TABLE 2

Patient-Level Analysis of Factors Contributing to Costs, Assessed with Adjusted Multiple Linear Regression of the Natural Log of Hospital Costs, Arkansas State Inpatient Databases, 2006 to 2011

	exp(β)	95% Confidence Interval
Age at first hospitalization		
1–3 years	0.98	(0.86, 1.12)
4–17 years	Ref	
18–45 years	**0.65**	**(0.58, 0.74)**
46–64 years	**0.73**	**(0.64, 0.82)**
Race		
Non-Hispanic white	Ref	
Non-Hispanic black	**1.16**	**(1.05, 1.28)**
Other	1.09	(0.93, 1.27)
Critical congenital heart defect		
No	Ref	
Yes	**1.47**	**(1.32, 1.63)**
Sex		
Male	Ref	
Female	**0.90**	**(0.84, 0.97)**
Expected payer at first visit		
Public	0.99	(0.92, 1.08)
Private	Ref	
Other	1.00	(0.90, 1.11)
Residence at first visit		
Rural	Ref	
Urban	1.04	(0.97, 1.12)
Multiple hospitalizations within 365 days		
No	Ref	
Yes	**2.26**	**(2.09, 2.45)**
Cardiac procedure[a]		
No	Ref	
Yes	**2.79**	**(2.59, 3.02)**
Number of comorbidities[b]		
0 comorbidities	Ref	
1 comorbidity	**1.20**	**(1.08, 1.33)**
2 comorbidities	**1.33**	**(1.18, 1.50)**
3+ comorbidities	**2.29**	**(2.05, 2.57)**

Bolded font indicates significant at $P < 0.05$ level; model adjusted for all variables listed in table as well as year at first hospitalization; results have been exponentiated.

[a] At least one inpatient cardiac procedure during any hospitalization.

[b] Comorbidities defined using the Elixhauser comorbidity measures; separate comorbid conditions were counted once regardless of the number of hospitalizations in which they were diagnosed.

TABLE 3

Patient-Level Analyses of Associations between Patient Characteristics and Multiple Hospitalizations within 365 Days, Arkansas State Inpatient Databases, 2006 to 2011

Age at first hospitalization	Adjusted odds ratio	95% Confidence Interval
1–3 years	**1.83**	**(1.26, 2.67)**
4–17 years	Ref	
18–45 years	**1.61**	**(1.14, 2.27)**
46–64 years	1.35	(0.94, 1.93)
Race		
Non-Hispanic white	Ref	
Non-Hispanic black	1.20	(0.91, 1.58)
Other	0.69	(0.43, 1.11)
Critical congenital heart defect		
No	Ref	
Yes	**1.56**	**(1.17, 2.08)**
Sex		
Male	Ref	
Female	0.93	(0.77, 1.13)
Expected payer at first visit		
Public	**1.50**	**(1.20, 1.88)**
Private	Ref	
Other	1.06	(0.79, 1.41)
Residence at first visit		
Rural	Ref	
Urban	1.05	(0.86, 1.29)
Cardiac procedure[a]		
No	Ref	
Yes	0.96	(0.78, 1.19)
No. of comorbidities[c]		
0 comorbidities	Ref	
1 comorbidity	**1.60**	**(1.19, 2.17)**
2 comorbidities	**4.35**	**(3.17, 5.96)**
3+ comorbidities	**13.69**	**(10.10, 18.54)**

Bolded text indicates significant at $P < 0.05$ level; model adjusted for all variables listed in table as well as year at first hospitalization. Excludes 288 patients who died during their first hospitalization or who were admitted for the first time in 2011.

[a] At least one inpatient cardiac procedure during any hospitalization.

[b] Comorbidities defined using the Elixhauser comorbidity measures; separate comorbid conditions were counted once regardless of the number of hospitalizations in which they were diagnosed.

TABLE 4

Ten Most Common Elixhauser Comorbidity Indicators among 2,542 Patients Ever Experiencing an Inpatient Hospitalization with a Congenital Heart Defect, Arkansas State Inpatient Databases, 2006 to 2010

				Multiple admissions within 365 days[c]		
Comorbidity	**n (%)[a,b]**	**Mean per-patient cost (U.S. $) (SE)**	**Mean per-patient hospitalizations (SE)**	**Patients with comorbidity (Yes/No multiple admissions)**	**Patients with comorbidity (Yes/No multiple admissions)**	**Unadjusted OR (95% CI) for multiple admissions within 365 days[d]**
Hypertension	1,021 (40.2)	61,697 (2,938)	4.5 (0.2)	619 / 299	488 / 848	3.6 (3.0–4.3)
Fluid and electrolyte disorders	591 (23.3)	90,772 (4,855)	6.1 (0.3)	417 / 113	690 / 1,034	5.5 (4.4–7.0)
Chronic pulmonary disease	478 (18.8)	69,378 (3,760)	5.7 (0.3)	332 / 104	775 / 1,043	4.3 (3.4–5.5)
Deficiency anemia	380 (15.0)	94,275 (5,165)	6.4 (0.4)	279 / 63	828 / 1,084	5.8 (4.3–7.7)
Uncomplicated diabetes	335 (13.2)	72,855 (4,990)	5.9 (0.4)	231 / 81	876 / 1,066	3.5 (2.7–4.5)
Valvular disease	329 (12.9)	73,314 (4,877)	5.2 (0.4)	215 / 81	892 / 1,066	3.2 (2.4–4.2)
Obesity	327 (12.9)	58,704 (3,834)	4.7 (0.3)	208 / 92	899 / 1,055	2.7 (2.0–3.4)
Depression	309 (12.2)	73,389 (5,136)	6.9 (0.4)	238 / 47	869 / 1,100	6.4 (4.6–8.9)
Congestive heart failure	267 (10.5)	100,131 (6,420)	7.2 (0.5)	211 / 35	896 / 1,112	7.5 (5.2–10.8)
Neurological disorders	208 (8.2)	95,506 (9,221)	6.5 (0.5)	144 / 39	963 / 1,108	4.3 (3.0–6.1)

[a] Patients could have multiple comorbidities and were counted in each category.

[b] Percent of 2,542 patients ever hospitalized with a congenital heart defect.

[c] Excluding 288 patients who died during their first hospitalization or who were admitted for the first time in 2011.

[d] All significant at $P < 0.001$.

SE, standard error; OR, odds ratio; CI, confidence interval.