HHS Public Access

Author manuscript

Birth Defects Res A Clin Mol Teratol. Author manuscript; available in PMC 2016 September 01.

Published in final edited form as:

Birth Defects Res A Clin Mol Teratol. 2015 September ; 103(9): 814–820. doi:10.1002/bdra.23379.

Population-Based Study of Hospital Costs for Hospitalizations of Infants, Children, and Adults with a Congenital Heart Defect, Arkansas 2006 to 2011

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Abstract

Background—Congenital heart defects (CHDs) are common birth defects and are associated with high hospital costs. The objectives of this study were to assess hospitalization costs, across the lifespan, of patients with CHDs in Arkansas.

Methods—Data from the 2006 to 2011 Healthcare Cost and Utilization Project Arkansas State Inpatient Databases were used. We included hospitalizations of patients whose admission occurred between January 1, 2006, and December 31, 2011, and included a principal or secondary CHD ICD-9-CM diagnosis code (745.0–747.49, except 747.0 and 745.5 for preterm infants). Hospitalizations were excluded if they involved out-of-state residents, normal newborn births, or if missing data included age at admission, state of residence, or hospital charges. Children were defined as those < 18 years-old at time of admission.

Results—Between 2006 and 2011, there were 2,242,484 inpatient hospitalizations in Arkansas. There were 9071 (0.4%) hospitalizations with a CHD, including 5,158 hospitalizations of children (2.2% of hospitalizations among children) and 3,913 hospitalizations of adults (0.2% of hospitalizations of adults). Hospital costs for these CHD hospitalizations totaled $355,543,696. The average annual cost of CHD hospitalizations in Arkansas was $59,257,283 during this time period. Infants accounted for 72% of all CHD-related hospital costs; total costs of CHD hospitalizations for children were almost five times those of hospitalization costs for adults with CHD.

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The authors have no financial relationships relevant to this article to disclose and no conflicts of interest to disclose.

Additional Supporting information may be found in the online version of this article.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Conclusion—Hospitalizations with CHDs account for a disproportionate share of hospital costs in Arkansas. Hospitalizations of children with CHD accounted for a higher proportion of total hospitalizations than did hospitalizations of adults with CHD.

Keywords

arkansas; congenital heart defects; hospital costs; state inpatient database; healthcare cost and utilization project

Introduction

Congenital heart defects (CHDs) are estimated to occur in 8 to 9 per 1000 live births, making them one of the most common birth defects (Botto et al., 2001; Reller et al., 2008). With improvements in detection and treatment, most infants are surviving into adulthood (Khairy et al., 2010; Oster et al., 2013a), leading to a growing population of adolescents and adults with CHDs (Marelli et al., 2007, 2014; O'Leary et al., 2013; Opotowsky et al., 2009). CHDs are associated with increased hospital costs in infancy; moreover, they are associated with lifelong morbidity and the need for ongoing medical care. In a nationally representative sample from 2004, 33.5% of all newborn hospitalizations for birth defects were principally due to cardiac and circulatory anomalies (Russo and Elixhauser, 2007). Among hospitalizations of neonates with birth defects, over half of those with the highest hospital charges were for a CHD (CDC, 2007). High hospital costs are not limited to infancy. In a recent analysis of hospitalizations of individuals up to 20 years old, hospitalizations including a CHD as a principal or secondary diagnosis accounted for 15.1% of total pediatric hospital costs (Simeone et al., 2014).

While U.S.-level cost estimates are important to understanding the nationwide impact of CHDs, individual states differ in their management and resource allocation for CHD care. Information on the state-specific contribution of CHD hospitalizations to total hospital costs will facilitate planning for state-wide needs. The State Inpatient Databases (SID) of the Healthcare Cost and Utilization Project (HCUP) allow state-specific estimates of hospital costs to be developed (AHRQ, 2013c). This might be particularly important for estimates of adults with CHD using hospital resources, as surveillance of CHDs does not often extend beyond infancy (Oster et al., 2013b).

Each state is unique in its population of infants, children, and adults with CHD and how and where healthcare is delivered to these individuals. Arkansas is a state with an active, population-based birth defects surveillance system (NBDPN, 2014), high infant mortality (Matthews and MacDorman, 2013), and a large children's hospital delivering care to infants and adults with CHD (Arkansas Children's Hospital, 2013a,2013b). The objectives of this study were to assess costs associated with statewide hospitalizations of individuals with CHDs, across the lifespan, in Arkansas from 2006 to 2011 and assess the contribution of costs for infant and childhood hospitalizations compared with adult hospitalizations. Using the Arkansas SID to estimate costs of hospitalizations of patients with CHDs could serve as a model to other states interested in investigating the contribution of CHD hospitalizations to their total hospital resource use.

Methods

DATA SOURCE

This was a cross-sectional study of acute care hospitalizations of Arkansas residents with CHD admitted to Arkansas facilities. Data were obtained from the Agency for Healthcare Research and Quality's 2006 to 2011 Arkansas SID (AHRQ, 2013c; 2014). The SID are administered by the Healthcare Cost and Utilization Project (HCUP) and are a set of inpatient, all-payer administrative databases. Each observation represents one hospital admission and includes information about discharge records of hospital admissions from all acute care hospitals in Arkansas. Each discharge record contains basic demographic information, payer information, and principal and secondary International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes. We hypothesized low levels of in- and out-migration from the state to obtain care for CHDs based on previous work (Mosley et al., 2002).

CASE DEFINITION AND STUDY VARIABLES

We included hospitalizations of patients whose admission occurred between January 1, 2006, and December 31, 2011, and included a principal or secondary CHD ICD-9-CM diagnosis code (745.0–747.49). Hospitalizations were excluded if they involved out-of-state residents or normal newborn births, or if missing data included age at admission, state of residence, or hospital charges. Children were defined as those < 18 years old at the time of discharge. If an infant hospitalization had a diagnosis of preterm birth and the only CHD diagnosis was isolated patent ductus arteriosus (ICD-9-CM 747.0) or secundum atrial septal defect (ICD-9-CM 745.5), then the patient was not considered to have a CHD.

Variables of interest included patient race (non-Hispanic white, non-Hispanic black, and other race at first hospital visit), sex, age (children vs. adults) and expected primary payer (public [Medicare and Medicaid], private, and other [self-pay, no charge, and other payer]).

HOSPITAL COSTS

All costs are reported in 2012 U.S. dollars calculated using the Purchaser Price Index for Hospitals (U.S. Bureau of Labor Statistics). HCUP provides total hospital charges on each discharge record in the SID. Charges represent what hospitals bill for services and do not include physician fees. Costs represent actual expenses resulting from a hospital stay, and include components such as supplies and wages (AHRQ, 2013a). Because hospital costs are not available in HCUP, they were obtained by multiplying charges by hospital- and year-specific cost-to-charge ratios (CCRs) provided by HCUP. The HCUP CCRs are developed annually using cost and charge data sent by hospitals to the Centers for Medicare and Medicaid Services. Two CCRs are calculated for each hospital participating in the SID: a hospital-specific CCR and a group-average CCR, which is a weighted average CCR for hospitals grouped by states, location, ownership, and bedsize (AHRQ, 2013a,2013b). If hospital-specific CCRs were unavailable, group-average CCRs were used. If both hospital-specific and group-average CCRs were missing, then missing CCRs were assigned a value equal to the mean group-average CCRs for that year. Total costs were obtained by summing hospital costs for all hospitalizations; total CHD costs were obtained by summing hospital

costs for those hospitals that included a CHD diagnosis. Total and mean costs for all hospitalizations, both with a CHD and without a CHD, were estimated for all years (2006–2011).

Results

Between 2006 and 2011, there were 2,523,296 inpatient hospitalizations in Arkansas. After excluding hospitalizations missing data on age at admission (n = 1200), hospital charges (n = 2735), residency data (n = 346), or hospitalizations involving non-Arkansas residents (n = 121,772), and hospitalizations of normal newborn births (n = 154,759), there were 2,242,484 inpatient hospitalizations available for analysis. Of those, 9071 (0.4%) included a CHD diagnosis code. The total cost of all hospitalizations in Arkansas between 2006 and 2011 was $19,168,320,183; on average, total annual cost for hospitalizations without CHDs was $3,135,462,748 (standard error [SE]: 36,725,366). The total cost of all hospitalizations including a CHD between 2006 and 2011 was $355,543,696 (1.9% of total hospital costs between 2006 and 2011) (Table 1); total annual cost of hospitalizations with a CHD averaged $59,257,283 (SE: 6,374,345). A CHD was the principal diagnosis in 1443 hospitalizations with CHD (15.9%); however, children less than 18 years of age were more likely to have a CHD as their principal diagnosis (n = 972, 18.8% of children with CHD) compared with adults over 18 years of age (n = 471, 12.0% of adults with CHD, $p < 0.001$).

Hospitalizations of children accounted for 57% of all hospitalizations with a CHD and accumulated $292,432,282 in hospital costs, 82% of all CHD costs (Table 1). In contrast, hospitalizations of children accounted for only 10.1% of non-CHD admissions and these hospitalizations accumulated $1,709,930,181 in hospital costs, 9% of all non-CHD costs. The majority of hospital costs among those with CHD were incurred for admissions of individuals < 1 year of age (72% of total costs). Among hospitalizations without a CHD, individuals over 64 years of age incurred 45% of total costs.

Hospitalizations of patients with and without a CHD differed by several demographic characteristics. Hospitalizations of those who were < 1 year of age accounted for 46.5% of hospitalizations that included a CHD, but 4.6% of hospitalizations without a CHD (Table 2). While the proportion of male and female hospitalizations among those with CHD was approximately equal (49.7% and 50.3%, respectively), among hospitalizations without a CHD, women accounted for 60.2% of hospitalizations. By race, hospitalizations of non-Hispanic white patients represented a slightly smaller proportion of CHD hospitalizations compared with non-CHD hospitalizations; hospitalizations of other-race individuals represented a slightly higher proportion of CHD hospitalizations compared with non-CHD hospitalizations. Overall, a slightly higher percentage of hospitalizations without a CHD had an expected public payer (64.8%) compared with hospitalizations with a CHD (60.3%); however, expected payer varied substantially by age at admission. Among hospitalizations with a CHD, 57.6% of patients with an expected public payer were < 1 year of age; among hospitalizations without a CHD, 4.5% of patients with an expected public payer were < 1 year of age.

Overall, hospitalizations with a CHD had higher mean and median hospitalization costs than hospitalizations without a CHD (mean costs: $39,196 and $8423, respectively; Median costs: $11,133 and $5034, respectively) (Table 2). Mean and median per-hospital costs were higher for hospitalizations with a CHD at all levels of age, gender, race, and payer. Within levels of expected payer, hospital costs of hospitalizations with a CHD varied widely by age at admission. Among CHD hospitalizations with a public payer, hospital costs averaged $42,053, with a median of $11,436; however, these mean hospital costs ranged from $12,166 per hospitalization among patients 18 to 45 years of age to $66,074 per hospitalization for patients < 1year of age. Mean and median hospital costs varied by hospital experience. Admission type, presence of an injury, experiencing an invasive surgical procedure, and length of stay impacted hospital costs among hospitalizations with and without a CHD (Supplementary Table S1, which is available online).

Discussion

This analysis of population-based hospital discharge data from patients with CHD reveals variations in hospital costs by patient demographic characteristics. Hospitalizations with CHD accounted for approximately 2% of the total inpatient hospital costs in Arkansas; average hospital cost was significantly higher for hospitalizations with a CHD compared with hospitalizations without a CHD. Among hospitalizations with a CHD, the majority of costs were accrued by hospitalizations of children, with nearly three-fourths of hospital costs originating from those < 1 year of age. Moreover, hospitalizations of patients with CHD and an expected public payer were most costly on average than other hospitalizations. While not representative of national hospital costs for CHDs, these costs provide insight into Arkansas-specific costs for the hospitalizations of patients CHD and this analytic approach can be a model for use in other states.

Our findings are consistent with literature demonstrating high costs for hospitalizations with CHDs among infants and children. Lu et al. (2014), noted that during the transition from childhood to young adulthood, total annual costs among hospital admissions with a CHD decreased as a percent of all-patient costs. Similarly, total Arkansas 2006 to 2011 costs decreased relative to total costs as age at admission increased. Other studies have demonstrated higher mean costs for CHD hospitalizations occurring in childhood compared with adulthood. In a recent analysis of national data using the Kids' Inpatient Database, hospitalizations of those < 1 year had higher mean costs than hospitalizations of other pediatric patients (Simeone et al., 2014). Additionally, as evidenced by our findings, differences in payer type have been found to be associated with hospital costs (Connor et al., 2005; Simeone et al., 2014; Bhatt et al., 2015). Generally, CHD hospitalizations with an expected public payer have been associated with increased costs. We also observed that mean costs of hospitalizations with CHD decrease among all payer types as age at admission increases.

Hospitalizations of adults with a CHD diagnosis accounted for 40% of the Arkansas inpatient population with CHD. In the United States, the population of adults with CHD is increasing as a result of improved diagnosis, advancements in medical and surgical care, and resultant survival past infancy (Warnes et al., 2001; Oster et al., 2013a). In Canada, the

number of adults with CHD is now approximately double the number of children with CHD (Marelli et al., 2014), and the hospitalization rate of adults with CHDs is growing faster than that of children with CHDs. Between 2004 and 2010, 37% of U.S. hospitalizations of individuals with CHDs occurred in those over age 18 (O'Leary et al., 2013). Our study observed that adults admitted with a CHD experienced substantially higher costs than those admitted without a CHD. Because the adult population with CHD is growing, understanding factors associated with hospital costs is becoming more important.

Our study was subject to several limitations. First, the SID are a collection of multiple administrative datasets. We used ICD-9-CM codes to identify any hospitalization in which a CHD diagnosis was ever coded. Lack of clinically verified diagnosis codes are a known weakness of administrative data and CHDs are prone to misclassification (Frohnert et al., 2005; Strickland et al., 2008). In a recent analysis of the Pediatric Health Information Systems database (an administrative database) and the Society of Thoracic Surgeons Congenital Heart Surgery Database (a clinical registry), differential case ascertainment of children with CHDs undergoing surgical procedures existed (Pasquali et al., 2013). In situations in which a surgical procedure does not occur, there may be also systematic differences impacting when a CHD ICD-9-CM code is recorded. Misclassification of hospitalizations with or without CHDs, particularly in hospitalizations of older patients, could inflate or deflate estimates of costs. Additionally, some CHDs may be more likely to be coded than others, leading to over-representation and under-representation of CHDs of varying severity. Second, inclusion and exclusion criteria were developed to be inclusive; hospitalizations were included if their hospital discharges included a diagnosis of any CHD. For example, secundum atrial septal defect (ICD-9-CM 745.5) was diagnosed in 34.2% of all CHD hospitalizations (data not shown); it was the only CHD ICD-9-CM code in 21.6% of CHD hospitalizations. While we excluded preterm births with only this code, presence of this diagnosis code alone among patients without a preterm birth code might have inflated our estimates of hospital costs.

Third, there are known issues with estimates of hospital costs. The costs presented did not include physician fees, which increase the total cost of hospitalizations (Rogowski, 1998). Nursing wages, which are incorporated into HCUP charges, are lower in Arkansas compared with the U.S. population (U.S. Bureau of Labor Statistics, 2014). Therefore, all cost estimates are specific to CHDs treated in Arkansas hospitals and cannot be extrapolated to represent U.S. costs or costs for CHDs treated in an outpatient setting. In addition, this analysis only considers costs to hospitals treating Arkansas residents; costs to Arkansas hospitals for treatment of CHDs of nonresidents traveling to specialized treatment centers are not considered. Hospitalizations of Arkansas residents occurring out of state are also not considered, which may underestimate the true burden of CHD care to Arkansas. In a study of differences in birth defects ascertainment in three Arkansas regions, approximately 7% of births occurred out of state; moreover, birth defects prevalence was significantly lower in the northeastern region of the state, where a large hospital in Tennessee is likely providing care to Arkansas residents (Mosley et al., 2002).

Fourth, survival among infants born with CHD has improved significantly over time, such that the population of infants and children currently being treated for CHDs is likely

different from the population of older adults with CHDs (Warnes et al., 2001; Hoffman et al., 2004; Oster et al., 2013a; Wang et al., 2015). Different factors may be influencing costs and hospitalization experiences of the younger cohort with CHD compared with the older cohort with CHD, as those surviving to an older age may have less severe CHD types. Finally, because this analysis was conducted at the hospital level, we could not assess patient level factors that may contribute to hospital costs, including transfers into and out of the hospital. The lack of ability to examine hospital transfers may have inflated costs or biased mean and median estimates, particularly among infants, when transfers soon after birth may be more likely.

Despite these weaknesses, our study benefited from using 6 years of data to examine total costs of hospitalizations with CHDs. Additionally, because the SID include allpayers, we were able to examine all hospitalizations within Arkansas, as opposed to only hospitalizations specific to a single payer type.

Conclusions

In an analysis of Arkansas inpatient hospital costs, hospitalizations including a CHD were, on average, more expensive than other, non-CHD hospitalizations. Costs of hospitalizations for a CHD were highest for children. Because the population with CHDs is growing, hospital resources dedicated to their care are expected to increase. Using state-specific administrative datasets may provide insight to state-specific needs beyond national estimates to the costs of inpatient treatment of serious conditions such as CHDs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors gratefully acknowledge the Arkansas Department of Health for providing data to the Healthcare Cost and Utilization Project. The authors also thank Dr. Hilda Razzaghi for her thorough data replication.

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TABLE 1

Total Costs of Hospitalizations with and without a Congenital Heart Defect Diagnosis, by Age at Admission, Arkansas State Inpatient Database, 2006 to 2011[a]

	Hospitalizations including a congenital heart defect diagnosis			Hospitalizations not including a congenital heart defect diagnosis		
	N	%	Total cost (U.S. $)[b]	*N*	%	Total cost (U.S. $)[b]
All hospitalizations	9071		355,543,696	2,233,413		18,812,776,487
Age (years)						
<1	4214	46.5	254,253,464	102,112	4.6	780,125,059
1-3	469	5.2	18,158,956	24,905	1.1	155,520,983
4-17	475	5.2	20,019,861	98,248	4.4	774,284,139
18-45	1161	12.8	16,467,877	584,937	26.2	3,424,832,597
46-64	1200	13.2	21,169,246	528,099	23.7	5,242,707,765
≥65	1552	17.1	25,474,292	895,112	40.1	8,435,305,944
Patients < 18 years of age	5158	56.9	292,432,282	225,265	10.1	1,709,930,181
Patients ≥ 18 years of age	3913	43.1	63,111,415	2,008,148	89.9	17,102,846,306

[a] Excludes hospitalizations missing age, hospital charges, and hospitalizations of out of state residents and normal newborn births

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

TABLE 2

Hospital-Level Characteristics and Costs for Congenital Heart Defect and Other Hospitalizations, Arkansas State Inpatient Databases 2006 to 2011[a]

	Hospitalizations including a congenital heart defect diagnosis			Hospitalizations not including a congenital heart defect diagnosis		
	N (%)	Mean cost[b]	Median cost[b] (25th–75th percentile)	*N*	Mean cost[b]	Median cost[b] (25th–75th percentile)
All hospitalizations	9071	39,196 (1020)	11,133 (3851-36,041)	2,233,413	8423 (9)	5034 (2883-9382)
Age (years)						
<1	4214 (46.5)	60,335 (2039)	16,371 (2507-60,255)	102,112 (4.6)	7640 (94)	1438 (830-3581)
1-3	469 (5.2)	38,718 (3291)	17,586 (3660-41,775)	24,905 (1.1)	6245 (140)	2422 (1485-4486)
4-17	475 (5.2)	42,147 (4049)	29,084 (4672-49,142)	98,248 (4.4)	7881 (64)	3660 (2404-5966)
18-45	1161 (12.8)	14,184 (656)	6564 (3510-15,393)	584,937 (26.2)	5855 (14)	3686 (2388-6010)
46-64	1200 (13.2)	17,641 (302)	10,203 (5592-23,666)	528,099 (23.7)	9928 (19)	6299 (3648-11,236)
≥65	1552 (17.1)	16,414 (506)	9566 (5200-19,747)	895,112 (40.1)	9424 (12)	6339 (3697-11,073)
Gender						
Male	4510 (49.7)	43,382 (1503)	13,338 (4205-40,744)	888,837 (39.8)	9724 (18)	5642 (3049-10,820)
Female	4559 (50.3)	35,071 (1377)	9636 (3578-32,113)	1,344,437 (60.2)	7564 (10)	4713 (2799-8494)
Missing	2 (0.0)			139 (0.0)		
Race						
Non-Hispanic White	6959 (76.7)	36,361 (1088)	10,699 (3910-33,950)	1,804,528 (80.8)	8508 (10)	5185 (2954-9640)
Non-Hispanic Black	1385 (15.3)	50,972 (2896)	13,625 (4342-48,547)	343,487 (15.4)	8306 (28)	4724 (2803-8590)
Other[c]	714 (7.9)	44,431 (4820)	12,056 (2809-43,045)	83,323 (3.7)	6936 (56)	3524 (2079-6234)
Missing	13 (0.1)			2075 (0.1)		
Expected payer (overall and by age at admission)						
Public	5471 (60.3)	42,056 (1490)	11,436 (3911-36,568)	1,447,051 (64.8)	8621 (12)	5215 (2983-9680)
<1	2603 (47.6)	66,074 (2934)	18,810 (2980-63,141)	65,585 (4.5)	8032 (124)	1511 (853-3676)
1-3	298 (5.5)	34,681 (3894)	13,889 (3170-39,635)	16,738 (1.2)	6376 (179)	2405 (1489-4394)
4-17	285 (5.2)	41,203 (5752)	26,931 (3847-46,394)	61,271 (4.2)	73,987 (77)	3596 (2440-5516)
18-45	462 (8.4)	12,166 (1094)	5133 (3058-12,208)	252,215 (4.2)	5594 (22)	3462 (2299-5564)
46-64	406 (7.4)	17,246 (1085)	9790 (4822-21,243)	231,510 (17.4)	9864 (30)	6067 (3548-10,940)
≥65	1417 (25.9)	16,512 (536)				6339 (3716-11,034)
Private	2733 (30.1)	39,184 (1518)	12,589 (4100-39,369)	519,702 (23.3)	8235 (21)	4771 (2737-8950)
<1	1256 (46.0)	58,253 (2972)	17,949 (2264-64,140)	25,480 (4.9)	8145 (195)	1408 (815-3799)
1-3	138 (5.1)	45,611 (6334)	26,423 (4534-50,346)	6323 (1.2)	6217 (255)	2455 (1452-4828)
4-17	158 (5.8)	44,677 (6266)	31,219 (8882-51,650)	27,327 (5.3)	8499 (134)	3864 (2313-6910)
18-45	501 (18.3)	15,907 (984)	8468 (4633-18,854)	205,253 (39.5)	5912 (23)	3870 (2495-6178)
46-64	589 (21.6)	18,688 (865)	11,063 (5928-25,373)	204,924 (39.4)	10,190 (31)	6668 (3825-11,716)
≥65	91 (3.3)	17,503 (2083)	10,452 (5311-21,794)	50,395 (9.7)	9903 (66)	6128 (3301-11,409)
Other[d]	739 (8.2)	21,251 (1613)	6978 (2840-24,441)	239,943 (10.7)	7503 (25)	4490 (2591-8145)
<1	275 (37.2)	26,304 (3504)	4144 (1307-28,045)	9656 (4.0)	3466 (112)	1091 (714-2271)
1-3	33 (4.5)	46,353 (15,820)	36,341 (3155-50,883)	1645 (0.7)	5322 (423)	2396 (1533-4304)

	Hospitalizations including a congenital heart defect diagnosis			Hospitalizations not including a congenital heart defect diagnosis		
	N (%)	Mean cost[b]	Median cost[b] (25th–75th percentile)	*N*	Mean cost[b]	Median cost[b] (25th–75th percentile)
4-17	31 (4.2)	39,252 (6197)	37,425 (10,420-50,825)	7459 (3.1)	8724 (246)	3695 (2291-6677)
18-45	187 (25.3)	14,660 (1483)	6697 (3682-16,629)	120,997 (50.4)	6265 (31)	3889 (2401-6592)
46-64	186 (25.1)	14,669 (1294)	8274 (4877-18,287)	85,272 (35.5)	9377 (46)	5963 (3491-10,662)
≥65	27 (3.7)	9434 (1753)	6135 (4880-11,047)	14,914 (6.2)	9075 (88)	6025 (3376-11,161)
Missing	128 (1.4)			26,717 (1.2)		

[a] Excludes hospitalizations missing age, hospital charges, hospitalizations of out of state residents, and normal newborn births.

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

[c] Other race includes Hispanic, Asian or Pacific Islander, Native American, and other race.

[d] Other payer includes self-pay, no charge, and other payer.