Inpatient admissions and costs for adolescents and young adults with congenital heart defects in New York, 2009-2013

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Abstract

Background Most individuals born with congenital heart defects (CHDs) survive to adulthood, but healthcare utilization patterns for adolescents and adults with CHDs have not been well described. We sought to characterize the healthcare utilization patterns and associated costs for adolescents and young adults with CHDs.

Methods We examined 2009-2013 New York State inpatient admissions of individuals ages 11-30 years with ≥1 CHD diagnosis codes recorded during any admission. We conducted multivariate linear regression using generalized estimating equations to examine associations between inpatient costs and sociodemographic and clinical variables.

Results We identified 5,100 unique individuals with 9,593 corresponding hospitalizations over the study period. Median inpatient cost and length of stay (LOS) were $10,307 and 3.0 days per admission, respectively; 55.1% were emergency admissions. Admission volume increased 48.7% from 2009 (1,538 admissions) to 2013 (2,287 admissions), while total inpatient costs increased 111.2% from 2009 ($24.7 million) to 2013 ($52.2 million). Inpatient admissions and costs rose more sharply over the study period for those with non-severe CHDs compared to severe CHDs. Characteristics associated with higher costs were longer LOS, severe CHD, cardiac/vascular hospitalization classification, surgical procedures, greater severity of illness, and admission in New York City.

Conclusions This study provides an informative baseline of health care utilization patterns and associated costs among adolescents and young adults with CHDs in New York State.

Background

Because of advances in early life treatment, more than 85 percent of children with congenital heart defects (CHDs) will survive to adulthood (1). As a result, the number of adults living with CHDs has steadily increased, as have their hospitalizations and healthcare costs (2). From 2002 to 2012, total inpatient discharges among adults with CHD in the US increased 4%, while total inpatient charges rose 178% (3).

Few studies have characterized healthcare utilization trends for adolescents and young adults with CHDs. Ideally, individuals with CHDs should transition from pediatric to adult-centered cardiac care as they age out of adolescence and into young adulthood. However, gaps in cardiac care become increasingly common as individuals with CHDs age. In one study, a >3-year gap in care was identified for 42% of adults with CHD, and the mean age at first gap was reported as 19.9 years (4). Lapses in cardiac care for individuals with CHDs have been linked to a number of adverse outcomes, including increased risk of requiring urgent cardiac intervention and an increased likelihood of returning for care via the emergency room (5, 6). Because the adverse outcomes associated with lapses in care may impact healthcare utilization and cost, it is important to characterize healthcare utilization patterns for the transitional population comprising adolescents and young adults with CHDs. One such study was performed by Lu et al. using statewide inpatient data from California, and they found that inpatient costs decreased with age while admissions to the emergency department increased with age (7). However, findings from California may not be generalizable to other areas of the country, and further research is necessary to fully capture trends in healthcare utilization and costs for this population. For this study, we sought to characterize inpatient admissions and costs among adolescents and young adults with CHDs in New York State (NYS). In addition, we determined clinical and sociodemographic factors associated with increased inpatient costs.

Methods

Study Population and Data Sources. The legislatively mandated Statewide Planning and Research Cooperative System (SPARCS) database contains hospital discharge data for all acute care hospital admissions in NYS, excluding admissions to psychiatric and federal hospitals. Using 2009–2013 SPARCS data, we identified all individuals with ≥1 CHD diagnosis codes recorded during any inpatient admission during the time period and who were between 11 and 30 years of age at the time of admission; hereafter referred to as "adolescents and young adults with CHD". Eligible CHD diagnosis codes included International Classification of Diseases, 9th revision, Clinical Modification (ICD–9-CM) codes: V13.65, 648.5, and 745.XX–747.XX, excluding 746.86 (congenital heart block), 747.32 (pulmonary arteriovenous malformation), 747.5 (absence or hypoplasia of umbilical artery), 747.6X (other anomalies of peripheral vascular system), and 747.8X (other specified anomalies of the circulatory system).

For this analysis, we included all inpatient admissions in SPARCS occurring between 2009 and 2013 for the identified cohort, regardless of whether a CHD diagnosis code was recorded for the specific admission. For all inpatient admissions we extracted age at admission, sex, race, ethnicity, admission type, information on which admissions had emergency department service prior to the inpatient stay, hospital health service area (HSA), all ICD–9-CM diagnosis codes, length of stay (LOS), primary payment sources, and total charges. We also extracted the SPARCS All Patient Refined Diagnosis Related Group codes, or hospitalization classification codes, on primary reason for admission, severity of illness (SOI) [range: 1 (minor severity) to 4 (extreme severity)], and hospitalization type (medical or surgical). We collapsed the primary reason for admission into mutually exclusive cardiac/vascular and non-cardiac/non-vascular categories.. HSAs are geographical subdivisions of NYS within which the care facility is located, assigned by SPARCS based on facility county. The eight HSAs for New York are Western NY, Finger Lakes, Central NY, NY-Penn, Northeastern NY, Mid-Hudson, New York City (NYC), and Nassau-Suffolk. Eligible CHD ICD–9-CM diagnosis codes for each person were categorized into five hierarchical, mutually exclusive severity groups (from top to bottom of hierarchy: severe, shunt + valve, shunt, valve, and other) considering anatomy and hemodynamic severity (8). A dichotomous severe (severe only) and non-severe (shunt + valve, shunt, valve, and other) CHD categorization scheme was also employed for select analyses.

We obtained hospital inpatient cost transparency data from 2009–2013 for NYS from the New York State Department of Health (NYSDOH)'s Open Data site, a government initiative designed to improve access to NYSDOH datasets (9). New York hospitals are required to report financial and statistical information under NYS Public Health Law, Article 28. This dataset contains information on mean and median charges (amounts billed by the hospital when claims were submitted), mean and median costs (expenses incurred in the production of hospital services received), and the total number of admissions by discharge year, facility, primary reason for hospitalization, SOI, and medical/surgical classification).

We calculated the ratio of cost to charge (RCC) for each combination of discharge year, facility, primary reason for hospitalization, and SOI level using cost and charge information from the hospital cost transparency dataset. The inpatient cost for each hospitalization was then calculated as the product of the inpatient charge reported by SPARCS and the RCC for the discharge year, facility, primary reason for hospitalization, and SOI level that corresponded to that inpatient admission.

Data Analysis. We calculated summary statistics, including means with standard deviations (SD) and medians with interquartile ranges (IQR), for inpatient admissions, charges, costs and LOS, across selected demographic and clinical characteristics. To account for multiple admissions per individual, we used Friedman's chi-square tests to investigate whether inpatient costs differed by selected variables.

To depict the relationship between inpatient admissions and inpatient costs by region, we calculated the proportion of inpatient admissions and inpatient costs within each HSA. We also determined the top five cardiac/vascular and non-cardiac/non-vascular primary reasons for hospitalization, ranked by both median inpatient costs as well as the number of inpatient admissions.

We examined the relationship between inpatient costs, our outcome of interest, and sociodemographic and clinical variables using generalized estimating equations (GEE), with an independent correlation structure, to account for potential correlation between admissions for the same individual. We examined the proportion of inpatient costs explained by each explanatory variable in our model. We also constructed GEE models predicting inpatient costs by day, by CHD severity, and by age group. All analyses were performed using SAS 9.4 and the R packages *geepack* and *relaimpo (*10, 11). All statistical tests were 2-tailed; a p-value < 0.05 was considered statistically significant.

Results

Table 1 provides summary statistics for inpatient admissions, costs and LOS among adolescents and young adults with CHDs by selected characteristics for 2009–2013, overall and stratified by CHD severity. We identified 5,100 unique individuals with 9,593 corresponding admissions (6,889 admissions (72%) had a documented CHD) during the study period. Of all individuals, 1,780 (35%) had more than one admission during the study period, totaling 6,273 admissions. Median (IQR) charges and costs per admission, respectively, were $26,111 ($45,403) and $10,307 ($17,486) overall. Median (IQR) and mean (SD) LOS were 3.0 (4.0) and 5.7 (10.6) days per admission, respectively.

Median inpatient costs increased with decreasing age and were higher among males ($12,402) than females ($8,793). Although the majority of inpatient admissions were among females (53.9%), 22% were pregnancy-related. Private insurance was listed as the primary payer type for most admissions (65.1%), but costs were the highest for Medicare admissions (median cost: $11,888) compared to other primary payers listed (median costs range: $6,741 to $10,844). Higher median inpatient admissions costs were seen with cardiac/vascular hospitalizations ($16,141) compared to non-cardiac/non-vascular ($7,777), and for surgical hospitalizations ($20,626) compared to medical ($6,861).

Emergency visits comprised 55.1% of admissions and elective hospitalizations had the highest median cost ($15,614). Emergency department service was received in almost half of inpatient admissions among individuals with a CHD diagnosis; however, inpatient admissions without emergency department services ($13,507) incurred higher median costs than those with emergency department services ($7,825).

Overall hospitalization costs were higher among those with severe CHDs ($12,993) compared to non-severe CHDs ($9,845), but cost trends were similar across individual and inpatient admission characteristics for those with severe and non-severe defects. Inpatient admissions for individuals with severe defects comprised 17.1% of all admissions among our population. Compared to individuals with non-severe CHD, individuals with severe CHD had a lower proportion of admissions among individuals in the 20–30 year old age group (49.2% vs 62.0%) and with emergency department service (44.6% vs 49.6%), and a higher proportion of admissions categorized as cardiac/vascular (52.7% vs 36.7%) and in NYC (66.2% vs 52.6%).

Figure 1 displays total inpatient admissions and costs for each year from 2009 to 2013. Total admissions increased 48.7% from 1,538 in 2009 to 2,287 in 2013, while total inpatient costs increased 111.2%, from $24.7 million in 2009 to $52.2 million in 2013. Among individuals with severe CHDs, inpatient admissions increased 22.5% from 2009 to

2013, while total inpatient costs increased 101.5% from $5.7 million in 2009 to $11.5 million in 2013. Among individuals with non-severe CHDs, inpatient admissions increased 54.8%, from 1,249 in 2009 to 1,933 in 2013, and total inpatient costs increased 114.1% from $19.0 million in 2009 to $40.8 million in 2013. Areas with larger proportions of inpatient admissions generally had higher total inpatient costs (Figure 2). The NYC HSA accounted for 54.9% of inpatient admissions and 67.5% of the inpatient costs.

Table 2 shows the top cardiac/vascular and non-cardiac/non-vascular primary reasons for hospitalization, for inpatient admissions, excluding pregnancy-related admissions, ranked by the number of inpatient admissions and by median inpatient costs among those with 10 or more admissions. The top three cardiac/vascular reasons by number of admissions were “Cardiac Valve Procedures without Cardiac Catheterization" (n = 479), “Percutaneous Cardiovascular Procedures without Acute Myocardial Infarction” (n = 441), and “Other Cardiothoracic Procedures” (n = 370). The top three cardiac/vascular reasons by median inpatient cost were “Heart and/or Lung Transplant” ($291,932), “Tracheostomy with Mechanical Ventilation 96+ Hours with Extensive Procedure or Extracorporeal Membrane Oxygenation” ($222,168), and “Cardiac Defibrillator and Heart Assist Implant” ($43,251).

After excluding pregnancy-related admissions, the top three non-cardiac/non-vascular primary reasons for hospitalization by number of admissions were “Seizure” (n = 188), “Other Pneumonia” (n = 178), and “Septicemia and Disseminated Infections” (n = 147). The top three non-cardiac/non-vascular reasons by median inpatient costs, among those with 10 or more admissions, were “Tracheostomy with Mechanical Ventilation 96+ Hours without Extensive Procedure” ($108,323), “Dorsal and Lumbar Fusion Procedure For Curvature Of Back” ($56,610) and “Extensive Procedure Unrelated To Principal Diagnosis” ($50,046).

Overall, inpatient cost distributions were right-skewed, and inpatient costs for cardiac/vascular admissions were higher than the costs for non-cardiac/non-vascular admissions (Figure 3). For both cardiac/vascular and non-cardiac/non-vascular admissions, inpatient costs for surgical admissions were higher than for medical admissions, with that difference greater for cardiac/vascular admissions than for non-cardiac/non-vascular admissions.

The GEE model constructed to estimate inpatient cost per admission had an overall marginal R^2 of 59.6%. The variables with the greatest contributions to the cost prediction model included LOS (71.1% of R^2), SOI (15.6% of R^2), and medical/surgical classification (6.3% of R^2) (Table 3). In the model predicting inpatient cost per day, the overall marginal R^2 was 29.2% and the variables with the greatest contributions to cost prediction were medical/surgical classification (36.7% of R^2), cardiac/vascular classification (20.0% of R^2) and type of admission (14.1% of R^2). The average increase of inpatient cost per admission for every additional one day in LOS was $2,543. Males had higher inpatient cost per day compared to females. Individuals with the severe and shunt + valve CHD severity categories had higher inpatient costs per admission than individuals in the other categories. However, individuals with severe CHDs had higher inpatient costs per day than individual in any other CHD severity category. Medicaid as primary payer was significantly associated with lower inpatient cost (per admission and per day). Inpatient admissions with cardiac/vascular or surgical classifications resulted in higher inpatient cost (per hospitalization and per day). Inpatient admissions with extreme SOI incurred higher inpatient cost per admission, while admissions with minor or moderate SOI resulted in higher inpatient cost per day. Additionally, elective or other admissions resulted in higher inpatient cost per day.

After stratifying models by CHD severity and age at encounter, the variables with the greatest contributions to cost per admission prediction models were SOI, LOS, and medical/surgical classification (Table 3). The contribution of LOS to cost prediction was greater in individuals with severe CHDs (80.2% of R^2) than in individuals with non-severe

CHDs (66.7%). The cost prediction contribution of medical/surgical classification was greater in non-severe CHD individuals (8.3% of R^2) than in severe CHD individuals (4.0% of R^2) and among 20–30-year-olds (10.1% of R^2) compared to 11–19-year-olds (4.3% of R^2). The average increases of inpatient cost per admission for every additional one day in LOS were $1,974 and $4,669 in individuals with non-severe CHDs and severe CHDs and $3,146 and $1,866 in individuals aged 11–19 and 20–30 years. Primary payer type with highest cost per admission was private in individuals with non-severe CHDs and other in individuals with severe CHDs. For both age groups, primary payer types of Medicare, self-pay, or other, compared to Medicaid, were all associated with lower inpatient cost per admission. Cardiac/vascular primary reason for hospitalization and extreme SOI were commonly associated with higher inpatient cost per admission in all stratified models. Inpatient admissions classified as surgical and in NYC incurred higher inpatient cost per admission for both non-severe and severe CHDs. Admissions in Northeastern NY had the highest inpatient costs for both 11–19 year-olds and 20–30 year-olds.

Discussion

We evaluated contemporary trends in inpatient admissions and costs among adolescents and young adults with CHDs. We found that both inpatient admissions and inpatient costs in this population increased from 2009 through 2013, but that inpatient costs grew faster than inpatient admissions (27.8% per year and 12.2% per year on average, respectively), even after adjusting for inflation. We also found that the majority of inpatient admission types were emergency and number of inpatient admissions increased more among adolescents and young adults with non-severe CHD compared to severe CHD. Characteristics associated with higher costs per admission and per day overall were longer LOS, severe CHD, cardiac/vascular classification, surgical procedures, higher severity of illness, and admissions in NYC.

While inpatient admissions increased in NYS from 2009 to 2013, nationwide, the total number of inpatient admissions decreased by 1.4% per year and the cost per hospital stay increased by 4.4% per year, on average, over the same time period (12). In our analysis, the largest increase in inpatient admissions and costs occurred between 2010 and 2011. Data from our analysis does not allow us to determine why these increases occurred, but several factors may have influenced the changes. The Affordable Care Act was signed into law in 2010, which reduced the number of people without health insurance by implementing the pre-existing condition insurance plan extension and extension of dependent coverage for young adults. Additionally, NYS's Medicaid Section 1115 Medicaid Redesign Team Waiver has made efforts to improve healthcare access for the Medicaid population and expand coverage to additional low income NYS residents with resources generated through managed care efficiencies. For example, the Medicaid managed care had a 12.6% increase in enrollment from 2010 to 2012 and geographic coverage of mandatory enrollment expanded to 57 of the state's 62 counties (13). The specialty care physician ratio per 1,000 enrollees in Medicaid Managed Care increased from 10.60 in 2010 to 12.16 in 2011 [13]. Moreover, Family Health Plus, a public health insurance program for adults aged 19 to 64 whose incomes are too high to qualify for Medicaid, had an 11% increase in enrollment from 2010 to 2012 by expanding coverage, simplifying the eligibility process, and eliminating the resource test for applicants (13).

From 2009 to 2013, the number of inpatient admissions increased by over 20% among individuals with severe CHDs and by 55% among individuals with non-severe CHDs. Greater inpatient care utilization among adolescents and young adults with CHDs may be related to the growing population of individuals living with CHD overall (3). However, the role of survivorship is likely marginal given that the relative increase in inpatient admissions was larger among those with non-severe CHDs. Additionally, individuals with non-severe CHDs, compared to severe CHDs, may

be more likely to drop out of routine cardiac care, which may result in more adverse, yet preventable, outcomes requiring hospitalization (4, 5, 14).

Over half of the inpatient admissions identified from 2009 to 2013 in this analysis were categorized as emergency admissions, and this rate varied by age and CHD severity. This is similar to national trends, where approximately 55% of inpatient admissions begin as emergency department visits (15). In our study, the proportions of inpatient admissions classified as emergency varied by age. Among younger age groups, emergency admissions comprised 48.2% of all admissions, compared to 59.8% for individuals aged 20–30 years. Increasing rates of emergency admissions by age in this population is consistent with previous findings (6, 7). Emergency hospitalizations among individuals with CHDs often occur after lapses in routine cardiac care (4). Because many individuals with CHDs are lost to cardiac care as they move through adolescence to adulthood, our finding that adults with CHDs are presenting as emergency admissions more frequently than their younger counterparts may point to the need for structured transition programs aimed at keeping this population in appropriate cardiac care as they move to adulthood. We also found that slightly more individuals with non-severe CHDs (49.6%) were admitted to hospitals through the emergency department than were those with severe CHDs (44.6%). As previous studies have identified CHD complexity as a predictor of maintaining continuous care, designing targeted transition programs for those with less severe CHDs may also be needed (4, 14).

Unsurprisingly, surgical admissions resulted in higher inpatient costs than medical admission. However, we found that the proportion of surgical admissions was similar for both severe and non-severe CHD cases in our study (39.1% vs. 36.7% among all admissions; 55.3% vs 57.8% among cardiac/vascular admissions). We hypothesize that our findings may reflect a reduction in subsequent cardiac surgeries in individuals with severe CHDs and an increase in cardiac surgeries in individuals with non-severe CHDs over time, similar to a previous finding that attributed their findings to improvements in diagnostic and therapeutic interventions (16).

Over 20% of inpatient admissions among adolescents and young adult women with CHD were related to pregnancy. As pregnancy in this population can carry risks of adverse maternal and fetal outcomes, the American Heart Association recommends multispecialty collaborative care during pregnancy for women with complex CHD, between high-risk obstetrics, neonatology, anesthesiology, and CHD specialists (17).

Most inpatient admissions (54.9%) and costs (67.5%) occurred in the NYC HSA. However, the NYC HSA population comprised only 42.2% of the overall NYS population in 2010 (18). The disproportionate number of inpatient admissions of CHD cases in NYC may, in part, be attributed to a large percentage of cardiac care centers in this area (19). Similarly, the disproportionately higher inpatient costs in this area may be the result of treating sicker individuals and performing more complex diagnostic and therapeutic procedures than the rest of the state. Lending support to these claims, two-thirds of admissions among severe cases occurred in NYC and almost half of NYC admissions were categorized as surgical, compared to an average of just under a third of admissions across all other HSAs. However, after adjusting for CHD severity and other factors, in overall models, NYC still had the highest costs per admission and per day.

LOS, severity of illness and medical/surgical hospitalization designation were the three strongest predictors of inpatient cost across all cost prediction models, though LOS was over twice as strong as any other predictor. In a previous study, surgery was also identified as a significant predictor of inpatient costs (7). Though most primary predictors of inpatient cost in our study are unmodifiable, HSA and emergency department care are two factors that could be targeted for intervention to reduce healthcare expenditures. Keeping individuals with CHDs in routine

cardiac care through targeted transition programs may reduce emergency admissions [18], and further research could be done to explore why there are higher healthcare expenditures in certain HSAs compared to others (20).

Several limitations should be considered. First, there may be errors in billing and coding of diseases which may have resulted in misclassification. Second, our data do not include individuals managed as outpatients or exclusively in emergency departments. Third, missing patient information may have led to errors de-duplicating the data at the patient level to identify unique individuals. Finally, patterns identified in NYS may not reflect patterns in other parts of the country due to differences in the patient population and healthcare access.

Conclusions

This study found that inpatient costs were associated with several characteristics, including LOS, CHD severity, cardiac/vascular classification, surgical procedures, severity of illness, and hospital location. Increases in inpatient admissions and costs were greater among non-severe CHD individuals compared to severe CHD individuals. Additionally, the majority of inpatient admissions were emergency admissions. Further research, linking inpatient admissions to outpatient visits, may help clarify whether routine cardiac care in adolescence and early adulthood and formal transition from adolescent to adult cardiac care, especially for non-severe CHD individuals, can prevent some hospitalizations and emergency admissions. These results provide an informative baseline for the health care needs of adolescents and young adults with CHD in NYS.

Declarations

Availability of data and materials: The data that support the findings of this study are available from the New York State Department of Health Statewide Planning and Research Cooperative System (SPARCS), but restrictions apply to the availability for of these data, which were used under an agreement for the current study and so are not publicly available.

Ethics approval: IRB approval was obtained through a NYSDOH protocol for this study.

Consent for publication: Not applicable

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Authors' contributions: WH, KS, and AV made substantial contributions to the implementation study design. WH and CM were involved in data acquisition, analysis and/or interpretation. WH and KS drafted the manuscript and contributed to subsequent revisions. SF and KD provided critical input into writing. GL, AZ, and DH provided expertise in CHD categorization. All authors critically reviewed the manuscript and provided feedback. All authors have read and approved the manuscript.

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Tables

Table 1: Inpatient admissions and costs among adolescents and young adults with congenital heart defects (CHD), by selected characteristics: New York, 2009-2013

	Total		Severe		Non-Severe	
	Admissions	Cost (USD)	Admissions	Cost (USD)	Admissions	Cost (USD)
	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)
Total	9,593	10,307 (17,486)	1,639	12,993 (23,741)	7,954	9,845 (16,269)
Individual characteristics						
Age at admission						
11-13 years	1,234 (12.9)	13,270 (19,521)	259 (15.8)	15,003 (25,083)	975 (12.3)	12,932 (18,250)
14-16 years	1,294 (13.5)	13,137 (19,676)	268 (16.4)	15,330 (25,761)	1,026 (12.9)	12,291 (18,982)
17-19 years	1,331 (13.9)	10,707 (17,893)	306 (18.7)	11,957 (20,257)	1,025 (12.9)	10,287 (17,089)
20-30 years	5,734 (59.8)	9,142 (15,543)	806 (49.2)	11,540 (23,625)	4,928 (62.0)	8,859 (14,641)
Sex[a,b]						
Male	4,424 (46.1)	12,402 (21,230)	869 (53.0)	14,018 (25,528)	3,555 (44.7)	11,993 (20,560)
Female	5,169 (53.9)	8,793 (14,207)	770 (47.0)	11,586 (21,975)	4,399 (55.3)	8,611 (12,973)
Pregnancy-related[d,e]	1,154 (22.3)	5,555 (04,389)	79 (10.3)	5,235 (4,417)	1,075 (24.4)	5,585 (4,405)
Non-pregnancy-related[d,e]	4,015 (77.7)	11,189 (17,724)	691 (89.7)	13,466 (23,992)	3,324 (75.6)	10,908 (16,413)
Race[a,c]						
White	5,243 (54.7)	9,629 (17,140)	866 (52.8)	12,826 (23,044)	4,377 (55.0)	9,224 (15,962)
Black	1,702 (17.7)	10,083 (15,817)	308 (18.8)	12,202 (23,093)	1,394 (17.5)	9,653 (14,864)
Other	2,648 (27.6)	11,607 (18,955)	465 (28.4)	13,673 (25,903)	2,183 (27.5)	11,298 (18,116)
Ethnicity[a,c]						
Hispanic	1,528 (15.9)	10,347 (17,130)	249 (15.2)	13,182 (23,887)	1,279 (16.1)	9,791 (15,540)
Non-Hispanic	7,795 (81.3)	10,571 (17,947)	1,362 (83.1)	13,057 (23,899)	6,433 (80.9)	10,076 (16,764)
Missing	270 (2.8)	5,755 (07,648)	28 (1.7)	4,136 (12,232)	242 (3.0)	5,862 (7,542)
CHD Severity[a]						
Severe	1,639 (17.1)	12,993 (23,741)	-		-	
Shunt	3,331 (34.7)	10,174 (14,909)				
Shunt + Valve	247 (2.6)	17,228 (26,186)				
Valve	1,969 (20.5)	11,254 (21,850)				
Other	2,407 (25.1)	8,109 (13,608)				
Inpatient admission characteristics						
Length of Stay, median (IQR)	3 (4)		3 (5)		3 (4)	
Payer Type[a,b,c]						
Private	6,246 (65.1)	10,844 (18,341)	1,030 (62.84)	13,801 (24,867)	5,216 (65.58)	10,369 (17,058)
Medicaid	1,763 (18.4)	9,084 (15,069)	306 (18.67)	11,520 (21,467)	1,457 (18.32)	8,781 (14,266)
Medicare	952 (9.9)	11,888	191 (11.65)	13,587 (20,766)	761 (9.57)	11,641 (17,427)

		(18,172)				
Self-pay	410 (4.3)	6,741 (12,771)	59 (3.6)	6,702 (24,046)	351 (4.41)	6,780 (12,350)
Other	222 (2.3)	9,000 (14,223)	53 (3.23)	11,416 (19,079)	169 (2.12)	7,619 (12,407)
Primary reason for hospitalization [a,b,c]						
Cardiac/vascular	3,780 (39.4)	16,141 (23,730)	864 (52.7)	19,561 (31,385)	2,916 (36.7)	15,265 (21,809)
Non-cardiac/non-vascular	5,813 (60.6)	7,777 (11,206)	775 (47.3)	8,272 (12,248)	5,038 (63.3)	7,737 (11,069)
Medical/Surgical APR DRG[a,b,c]						
Medical	6,030 (62.9)	6,861 (09,209)	998 (60.9)	7,366 (11,116)	5,032 (63.3)	6,779 (8,686)
Surgical	3,563 (37.1)	20,626 (24,980)	641 (39.1)	27,313 (32,682)	2,922 (36.7)	19,447 (23,456)
Admission Type[a,b,c]						
Emergency	5,286 (55.1)	8,475 (12,957)	861 (52.5)	8,820 (14,889)	4,425 (55.6)	8,411 (12,455)
Urgent	1,108 (11.6)	8,532 (13,726)	196 (12.0)	9,192 (18,822)	912 (11.5)	8,301 (12,557)
Elective	3,156 (32.9)	15,614 (23,056)	574 (35.0)	22,610 (17,877)	2,582 (32.5)	14,623 (21,353)
Other	43 (0.5)	13,224 (20,196)	8 (0.5)	13,029 (11,142)	35 (0.4)	16,936 (26,132)
ED service[a,b,c]						
Yes	4,677 (48.8)	7,825 (11,377)	731 (44.6)	8,298 (14,265)	3,946 (49.6)	7,732 (10,811)
No	4,916 (51.3)	13,507 (22,128)	908 (55.4)	17,466 (27,979)	4,008 (50.4)	12,904 (20,532)
Hospital Health Service Area (HSA)[a,b,c]						
Western NY	956 (10.0)	5,883 (08,042)	87 (5.3)	7,003 (9,134)	869 (10.9)	5,683 (7,668)
Finger Lakes	988 (10.3)	8,944 (15,546)	159 (9.7)	10,462 (23,865)	829 (10.4)	8,901 (14,972)
Central NY	485 (5.1)	6,266 (12,504)	112 (6.8)	5,714 (8,337)	373 (4.7)	6,442 (13,451)
NY-Penn	58 (0.6)	4,814 (06,640)	2 (0.1)	6,882 (9,783)	56 (0.7)	4,814 (6,316)
Northeastern NY	387 (4.0)	6,612 (11,780)	47 (2.9)	8,298 (13,134)	340 (4.3)	6,187 (11,493)
Mid-Hudson	738 (7.7)	10,834 (18,893)	82 (5.0)	10,488 (15,307)	656 (8.3)	10,896 (19,036)
NYC	5,267 (54.9)	13,075 (20,578)	1,085 (66.2)	15,435 (27,153)	4,182 (52.6)	12,461 (19,177)
Nassau-Suffolk	714 (7.4)	7,424 (10,114)	65 (4.0)	8,190 (15,275)	649 (8.2)	7,367 (9,803)

CHD=Congenital Heart Defect, USD=United States Dollar, IQR= Interquartile Range, NY=New York, NYC= New York City

[a,b,c] Inpatient costs of the selected variable (a: Total, b: Severe, and c: non-Severe) differed significantly ($p<0.05$) according to Friedman's chi-square tests.

[d,e] Inpatients costs for pregnancy-related encounters under females (d: Total and e: non-Severe) differed significantly ($p<0.05$) according to Friedman's chi-square test.

Table 2: Top 5 Primary reasons for hospitalization among adolescents and young adults with congenital heart defects (CHD), ranked by number of inpatient admissions and median inpatient costs: New York, 2009-2013

Top cardiac/vascular reasons for hospitalization[a]							
Ranked by number of inpatient admissions				Ranked by median inpatient costs			
	n	Median Cost (USD)	Median LOS (days)		n	Median Cost (USD)	Median LOS (days)
Cardiac Valve Procedures without Cardiac Catheterization	479	36,194	5	Heart and/or Lung Transplant	22	291,932	40
Percutaneous Cardiovascular Procedures without Acute Myocardial Infarction	441	12,741	1	Tracheostomy with Mechanical Ventilation 96+ Hours with Extensive Procedure or Extracorporeal Membrane Oxygenation	21	222,168	37
Other Cardiothoracic Procedures	370	23,509	4	Cardiac Defibrillator and Heart Assist Implant	112	43,251	3
Other Vascular Procedures	269	5,096	2	Cardiac Valve Procedures with Cardiac Catheterization	74	40,725	6
Cardiac Arrhythmia and Conduction Disorders	269	14,777	1	Cardiac Valve Procedures without Cardiac Catheterization	479	36,194	5
Top non-cardiac/non-vascular reasons for hospitalizations[a]							
Ranked by number of inpatient admissions				**Ranked by median inpatient costs**			
	n	Median Cost (USD)	Median LOS (days)		n	Median Cost (USD)	Median LOS (days)
Seizure	188	5,601	2	Tracheostomy with Mechanical Ventilation 96+ Hours without Extensive Procedure	15	108,323	33
Other Pneumonia	178	6,540	3	Dorsal and Lumbar Fusion Procedure for Curvature Of Back	58	56,610	4.5
Septicemia and Disseminated Infections	147	19,755	7	Extensive Procedure Unrelated to Principal Diagnosis	26	50,046	9
Sickle Cell Anemia Crisis	132	10,282	6	Respiratory System Diagnosis with Ventilator Support 96+ Hours	28	47,283	16
Bipolar Disorders	117	10,320	10	Infectious and Parasitic Diseases Including HIV with Operating Room Procedure	19	41,189	15

USD=United States Dollar, LOS= Length of Stay, HIV= Human Immunodeficiency Virus

[a]Among classifications with ≥10 admissions and excluding pregnancy-related hospitalizations

ble 3. Model predicting inpatient costs among adolescents and adults with congenital heart defects (CHD): New York, 2013

haracteristics	Cost per Admission		Cost per Day		Cost per Admission by Severity				Cost per Admission by Age Group			
					Non-Severe CHD		Severe CHD		Age 11-19		Age 20-30	
	β (95% CI)	R^2 (%)	β (95% CI)	R^2 (%)	β (95% CI)	R^2 (%)	β (95% CI)	R^2 (%)	β (95% CI)	R^2 (%)	β (95% CI)	R^2 (%)
ength of Stay[a,c,d,e,f]	2543 (1898, 3188)	71.1	-		1974 (1456, 2491)	66.7	4669 (3549, 5789)	80.2	3146 (2382, 3911)	76.2	1886 (1107, 2666)	61.0
ge at admission												
11-13 years (Ref)		0.3		1.9		0.5		0.2	-		-	
14-16 years[b]	1243 (-902, 3388)		513 (86, 940)		1335 (-1072, 3742)		-831 (-5108, 3445)					
17-19 years	1628 (-1330, 4585)		156 (-184, 497)		-101 (-2449, 2246)		4045 (-3476, 11566)					
20-30 years	-652 (-2472, 1168)		-201 (-485, 83)		-1181 (-3075, 714)		-174 (-4354, 4006)					
ex												
Female (Ref)		0.2		1.2		0.4		0.0		0.1		0.5
Male[b]	-674 (-1972, 625)		441 (246, 636)		190 (-752, 1132)		-497 (-4090, 3095)		-1418 (-3634, 798)		323 (-1200, 1845)	
ace												
White (Ref)		0.3		0.8		0.3		0.3		0.3		0.3
Black	-15 (-1412, 1382)		-69 (-325, 188)		-329 (-1559, 900)		879 (-3254, 5012)		-61 (-2274, 2152)		280 (-1305, 1865)	
Other[a,c]	2209 (490, 3929)		76 (-205, 357)		1772 (259, 3285)		4487 (-531, 9505)		1807 (-896, 4511)		1648 (-92, 3388)	
thnicity												
Hispanic (Ref)		0.1		0.8		0.1		0.1		0.1		0.2
Non-Hispanic	-1115 (-2792, 562)		-131 (-429, 167)		-772 (-2315, 771)		-1449 (-6258, 3360)		-1074 (-3666, 1517)		-1233 (-3522, 1056)	
Missing[a,b,c,f]	-3330 (-6124, -537)		-977 (-1340, -614)		-2553 (-4630, -476)		-4856 (-14393, 4680)		-8551 (-21279, 4177)		-3024 (-5329, -719)	
HD Severity												
Severe (Ref)		0.9		2.5	-		-			0.7		1.1
Shunt[a,b]	-5128 (-7239, -3016)		-710 (-1050, -371)						1967 (-1457, 5390)		-836 (-2756, 1085)	
Shunt + Valve[b]	917 (-4101, 5934)		-927 (-1622, -231)						-48 (-4686, 4590)		-188 (-2414, 2037)	
Valve[a,b]	-2802 (-4922, -682)		-938 (-1302, -574)						-645 (-4378, 3088)		-1188 (-3589, 1214)	
Other[a,b]	-4250 (-6410, -2090)		-909 (-1256, -562)						1666 (-6880, 10212)		-3978 (-8030, 75)	
ayer Type												
Medicaid (Ref)		0.2		1.9		0.3		0.3		0.2		0.5
Medicare[a,b,c,e,f]	2991 (455, 5528)		544 (109, 979)		2216 (132, 4300)		4688 (-2085, 11462)		-6568 (-9890, -3245)		-3513 (-6128, -898)	
Private[a,b,c]	3411 (1785, 5038)		344 (94, 594)		3264 (1870, 4657)		4303 (-773, 9379)		2326 (-4467, 9119)		-998 (-7571, 5575)	
	3186		-284		1490		6085		-5295		-3355	

Self-pay[a,e,f]	(781, 5592)		(-620, 52)		(-162, 3142)		(-459, 12628)		(-9026, -1565)		(-5777, -933)	
Other[a,c,d,e]	5808 (2080, 9536)		207 (-340, 754)		3151 (356, 5946)		12859 (2993, 22726)		-3476 (-6584, -368)		-1495 (-4138, 1148)	
rimary reason for ospitalization												
Non-cardiac/non-ascular (Ref)		1.9		20		1.7		1.8		1.2		3.2
Cardiac/vascular[a,b,c,d,e,f]	7821 (6537, 9105)		1989 (1785, 2192)		6178 (5005, 7351)		9722 (6791, 12654)		7062 (5131, 8994)		7733 (6131, 9336)	
ospitalization Type												
Medical (Ref)		6.3		36.7		8.3		4.0		4.3		10.1
Surgical[a,b,c,d]	15518 (13653, 17383)		3362 (3132, 3593)		14950 (13319, 16582)		18369 (13671, 23066)		5604 (-1496, 12705)		1034 (-1041, 3108)	
everity of Illness												
Minor (Ref)		15.6		2.2		18.3		10.7		14.7		18.5
Moderate[a,c,e,f]	2766 (1169, 4364)		-275 (-569, 19)		3317 (1968, 4666)		-260 (-2647, 2127)		2515 (746, 4284)		2815 (1139, 4490)	
Major[a,b,c,e,f]	5266 (2283, 8249)		-724 (-1013, -436)		7190 (4719, 9661)		-99 (-4430, 4232)		4516 (1587, 7445)		6203 (2801, 9605)	
Extreme[a,b,c,d,e,f]	31848 (22435, 41262)		-435 (-786, -85)		32587 (24502, 40671)		17668 (5348, 29988)		32105 (19546, 44664)		30795 (21026, 40565)	
dmission Type												
Emergency (Ref)		0.5		14.1		0.6		0.7		0.4		0.6
Urgent	-784 (-3487, 1920)		6 (-358, 371)		-2062 (-4384, 259)		3937 (-3195, 11069)		1615 (-2777, 6006)		-1332 (-4298, 1635)	
Elective[b]	317 (-2402, 3035)		1313 (956, 1671)		-731 (-2985, 1523)		2950 (-4649, 10550)		239 (-4384, 4862)		-865 (-3688, 1957)	
Other[b]	2658 (-1949, 7266)		1409 (1, 2817)		851 (-3702, 5405)		4919 (-3625, 13464)		6690 (-115, 13496)		-403 (-6015, 5209)	
D service												
No (Ref)		0.5		7.8		0.5		0.6		0.3		0.9
Yes	694 (-1143, 2530)		-112 (-367, 144)		496 (-1362, 2354)		-42 (-4702, 4618)		-207 (-5131, 4717)		771 (-1422, 2964)	
ospital Health Service rea (HSA)												
Western NY (Ref)		1.9		10.1		2.3		1.2		1.5		3.0
Finger Lakes	-1441 (-3480, 599)		-106 (-521, 310)		-958 (-2730, 814)		5172 (-2969, 13313)		-4418 (-11317, 2481)		1602 (-1207, 4410)	
Central NY[e,f]	-12 (-2104, 2080)		-217 (-632, 197)		294 (-1518, 2105)		6792 (-1594, 15178)		7598 (3983, 11213)		6196 (4197, 8196)	
NY-Penn	-2713 (-6629, 1202)		-172 (-870, 527)		-3775 (-7192, -359)		-965 (-29075, 27145)		965 (-3282, 5213)		1025 (-1014, 3063)	
Northeastern NY[f]	637 (-1488, 2763)		167 (-279, 614)		534 (-1243, 2310)		6722 (-3917, 17361)		17341 (14503, 20179)		14986 (12837, 17134)	
Mid-Hudson[b,d,f]	-332 (-3252,		619 (240,		1679 (-749,		10878 (1715,		1171 (-3056,		3393 (172,	

	2588)		998)		4107)		20041)		5399)		6613)	
NYC[a,b,c,d,e]	6332 (4538, 8124)		1567 (1235, 1900)		6033 (4459, 7608)		13250 (5614, 20886)		7681 (719, 14643)		1894 (-980, 4769)	
Nassau-Suffolk[b,f]	783 (-1128, 2694)		658 (221, 1096)		651 (-1030, 2332)		6608 (-2303, 15520)		2770 (-430, 5970)		3006 (1331, 4681)	

Coefficient, CI=Confidence Interval, SOI=Severity of Illness, ED=Emergency Department, NY= New York, NYC=New York City

efficients for predicting inpatient costs per admission are statistically significant ($p < 0.05$).

efficients for predicting inpatient costs per day are statistically significant ($p < 0.05$).

,e,f Coefficients for predicting inpatient costs per admission are statistically significant ($p < 0.05$) (c: severe CHD, d: non-severe CHD, e: age 11-19, and f: age 20-30).

Figures

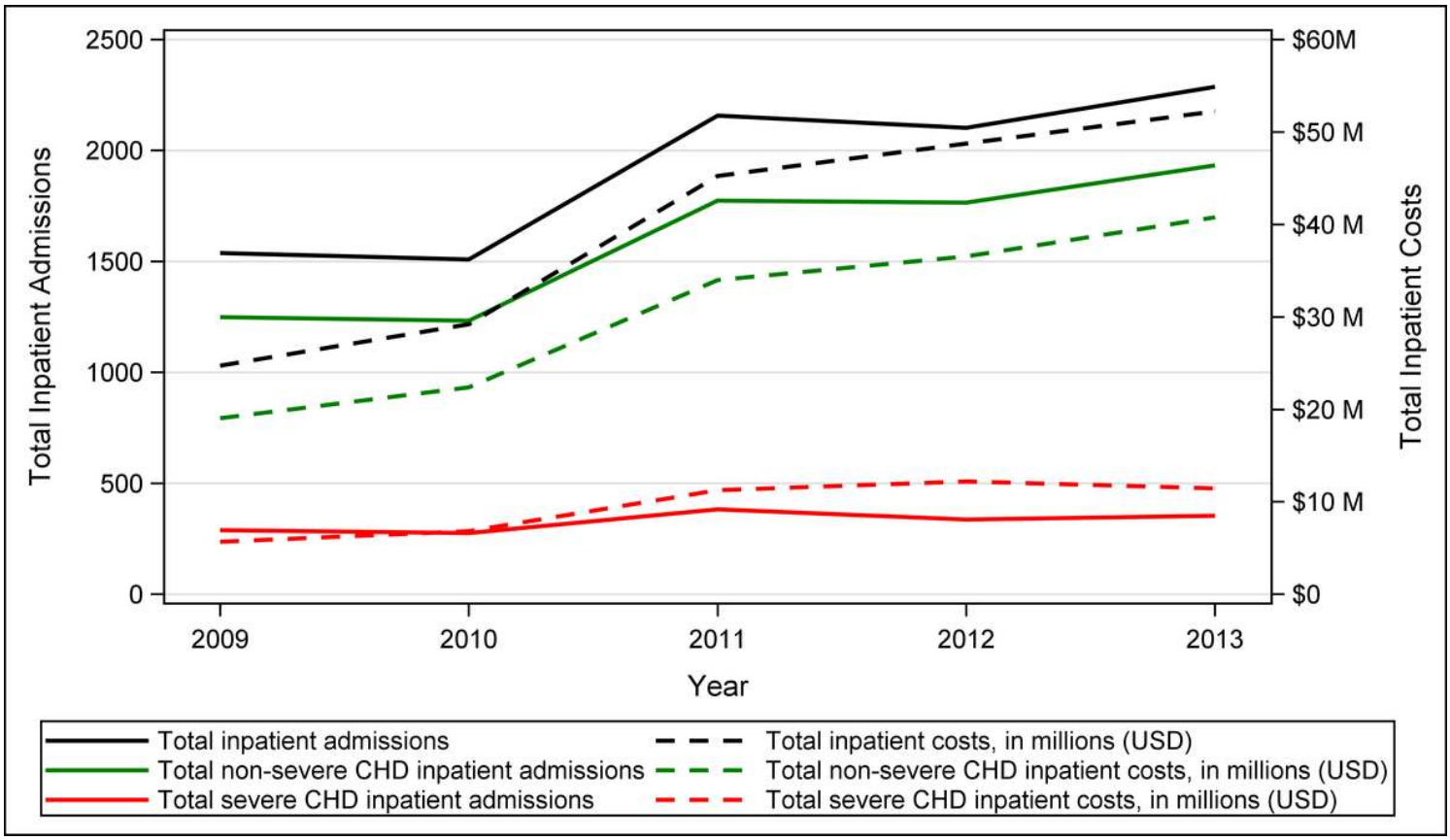

Figure 1

Inpatient admissions and costs among adolescents and young adults with congenital heart defects (CHD): New York, 2009-2013

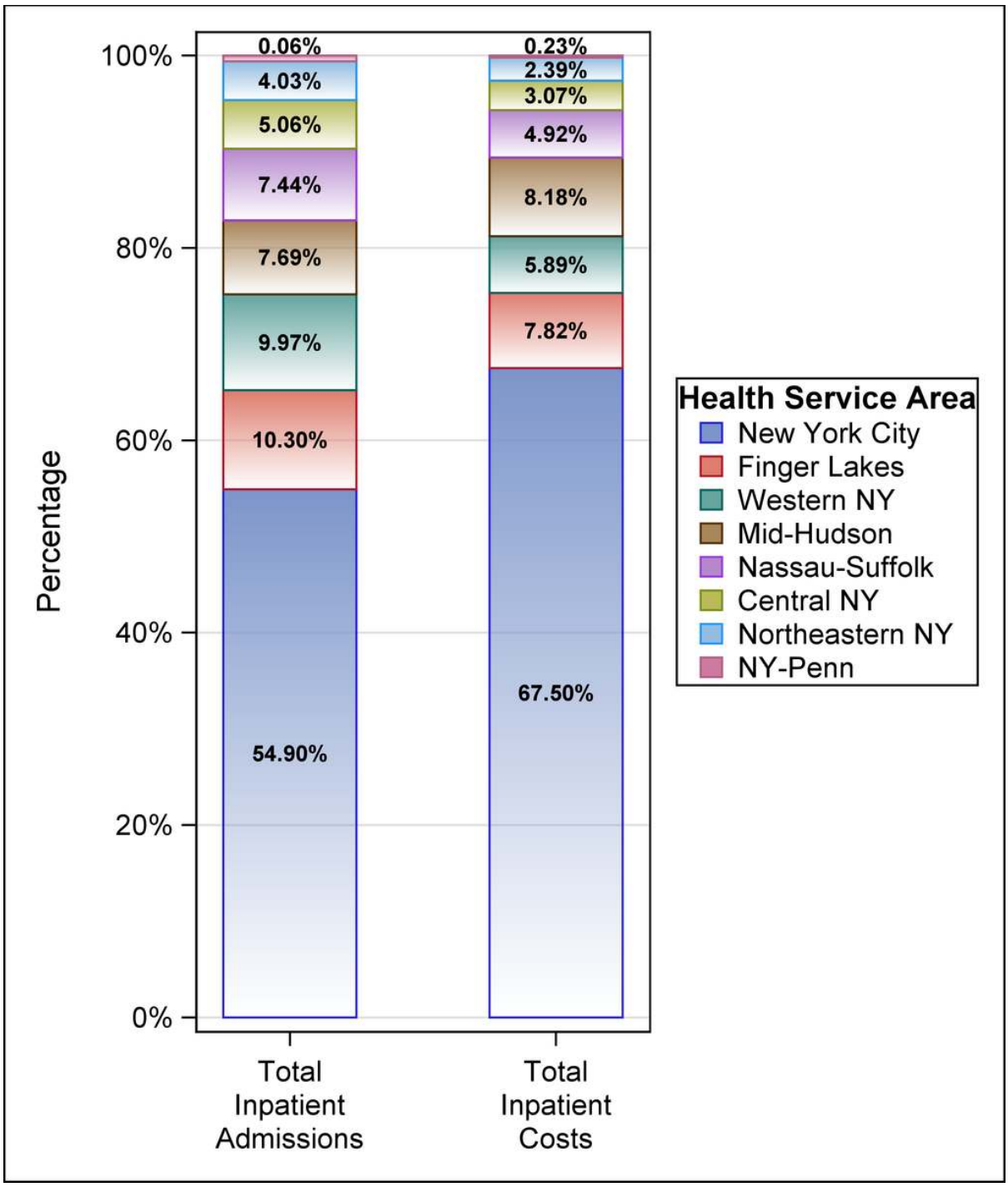

Figure 2

Proportion of inpatient admissions and costs among adolescents and young adults with congenital heart defects (CHD) by health service area: New York, 2009-2013

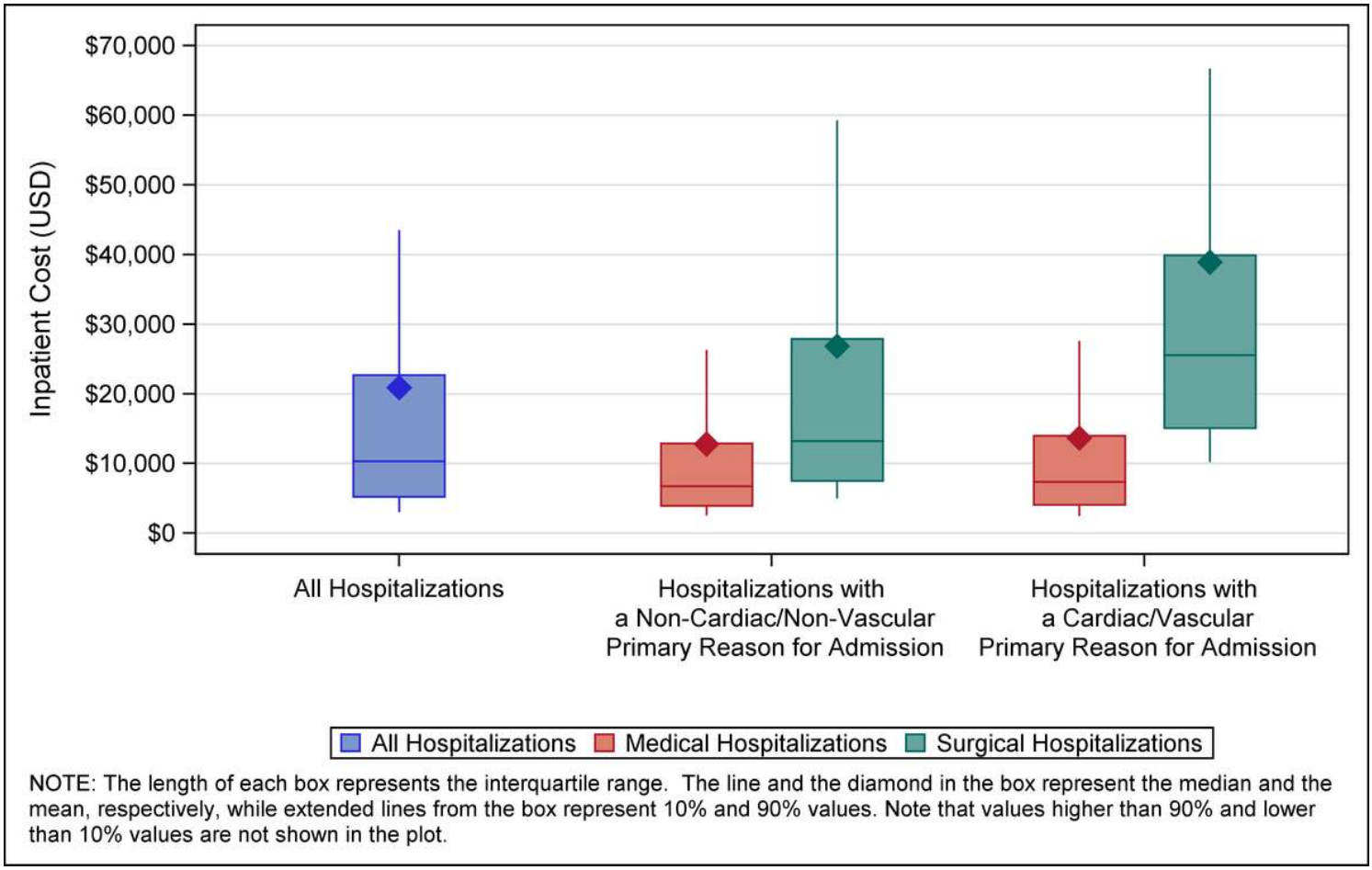

Figure 3

Inpatient costs stratified by primary reason for hospitalization among adolescents and adults with congenital heart defects (CHD): New York, 2009-2013