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

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Abstract

Objectives—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.

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CONFLICT OF INTEREST
The authors declare no actual or potential competing financial interests.
DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the Statewide Planning and Research Cooperative System at the New York State Department of Health. Restrictions apply to the availability of these data, which were used under a Data Use Agreement for this study.
DISCLAIMER
The findings and conclusion in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
ETHICS STATEMENT
IRB approval was obtained through a NYSDOH protocol for this study.

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 $10,720 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 91.8% from 2009 ($27.2 million) to 2013 ($52.2 million). Inpatient admissions and costs rose more sharply over the study period for those with nonsevere 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.

Conclusion—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. Structured transition programs may aid in keeping this population in appropriate cardiac care as they move to adulthood.

Keywords

adolescents and young adults; congenital heart defects; hospital utilization; hospitalizations; inpatient cost

1 | INTRODUCTION

Because of advances in early life treatment, more than 85% of children with congenital heart defects (CHDs) will survive to adulthood (Hoffman & Kaplan, 2002). As a result, the number of adults living with CHDs has steadily increased, as have their hospitalizations and healthcare costs (Gilboa et al., 2016). From 2002 to 2012, total inpatient discharges among adults with CHD in the US increased 4%, while total inpatient charges rose 178% (Briston, Bradley, Sabanayagam, & Zaidi, 2016).

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 (M. Gurvitz et al., 2013). 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 (M. Z. Gurvitz et al., 2007; Yeung, Kay, Roosevelt, Brandon, & Yetman, 2008). 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, Agrawal, Lin, & Williams (2014) using statewide inpatient data from California, and they found that inpatient costs decreased with age while admissions to the emergency department increased with age. 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.

2 | METHODS

2.1 | 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. SPARCS captures hospitalizations for both NYS and out of state residents. 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, ninth 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 noncardiac/nonvascular 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 (Glidewell et al., 2018). A dichotomous severe (severe only) and nonsevere (shunt + valve, shunt, valve, and other) CHD categorization scheme was also employed for select analyses.

We obtained hospital inpatient cost transparency data from 2009 to 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 (New York State Department of Health, 2018). 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. Next, the inpatient cost for each hospitalization was adjusted to 2013 U.S. dollars by the Personal Health Care Index for hospital care to account for health care price changes and price inflation from year to year (Agency for Healthcare Research and Quality, 2020; Dunn, Grosse, & Zuvekas, 2018).

2.2 | 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 consider non-normality of inpatient cost, we used Kruskal–Wallis 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 noncardiac/nonvascular 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 (GEEs), 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* (Grömping, 2006; Halekoh, Højsgaard, & Yan, 2006). All statistical tests were two-tailed; a p-value <.05 was considered statistically significant.

3 | 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 $27,304 ($47,448) and $10,720 ($18,246) overall. Median (IQR) and mean (SD) LOS were 3.0 (4.0) and 5.7 (10.6) days per admission, respectively.

Median inpatient costs decreased with increasing age and were higher among males ($12,959) than females ($9,199). Although the majority of inpatient admissions were among females (53.9%), 22% were pregnancy-related. Median inpatient costs were also higher among those of other races than white and black. Private insurance was listed as the primary payer type for most admissions (65.1%), but costs were the highest for Medicare admissions (median cost: $12,170) compared to other primary payers listed (median costs range: $7,038–$11,296). Higher median inpatient admissions costs were seen with cardiac/vascular hospitalizations ($17,007) compared to noncardiac/nonvascular ($8,125), and for surgical hospitalizations ($21,425) compared to medical ($7,143).

Emergency visits comprised 55.1% of admissions and elective hospitalizations had the highest median cost ($16,359). Emergency department service was received in almost half of inpatient admissions among individuals with a CHD diagnosis; however, inpatient admissions without emergency department services ($14,181) incurred higher median costs than those with emergency department services ($8,158).

Overall hospitalization costs were higher among those with severe CHDs ($13,557) compared to nonsevere CHDs ($10,267), but cost trends were similar across individual and inpatient admission characteristics for those with severe and nonsevere defects. Inpatient admissions for individuals with severe defects comprised 17.1% of all admissions among our population. Compared to individuals with nonsevere CHD, individuals with severe CHDs 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 91.8%, from $27.2 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 83.0% from $6.3 million in 2009 to $11.5 million in 2013. Among individuals with nonsevere CHDs, inpatient admissions increased 54.8%, from 1,249 in 2009 to 1,933 in 2013, and total inpatient costs increased 94.4% from $21.0 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 noncardiac/nonvascular 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” ($305,408), “Tracheostomy with

Mechanical Ventilation 96+ Hours with Extensive Procedure or Extracorporeal Membrane Oxygenation" ($227,056), and "Cardiac Defibrillator and Heart Assist Implant" ($45,053).

After excluding pregnancy-related admissions, the top three noncardiac/nonvascular 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 noncardiac/nonvascular reasons by median inpatient costs, among those with 10 or more admissions, were "Tracheostomy with Mechanical Ventilation 96+ Hours without Extensive Procedure" ($115,923), "Dorsal and Lumbar Fusion Procedure For Curvature Of Back" ($59,573) and "Extensive Procedure Unrelated To Principal Diagnosis" ($51,245).

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

The GEE model constructed to estimate inpatient cost per admission had an overall marginal R^2 of 59.9%. The variables with the greatest contributions to the cost prediction model included LOS (70.9% of R^2), SOI (15.6% of R^2), and medical/surgical classification (6.4% of R^2; Table 3). In the model predicting inpatient cost per day, the overall marginal R^2 was 30.0% and the variables with the greatest contributions to cost prediction were medical/surgical classification (36.4% of R^2), cardiac/vascular classification (20.3% of R^2), and type of admission (14.2% of R^2). The average increase of inpatient cost per admission for every additional 1 day in LOS was $2,626. Males had higher inpatient cost per day compared to females. Individuals of other races had higher inpatient cost per admission compared to whites. 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 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 nonsevere CHDs (66.5%). The cost prediction contribution of medical/surgical classification was greater in individuals with nonsevere CHDs (8.4% of R^2) than in individuals with severe CHDs (4.0% of R^2) and among 20–30-year-olds (10.2% 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 1 day in LOS were $2,039 and $4,819 in individuals with nonsevere CHDs and severe CHDs and $3,252 and $1,945 in individuals aged 11–19 and 20–30 years. Primary payer type with highest cost per admission was private in individuals with nonsevere CHDs and other in individuals with severe CHDs. For both age groups, primary payer types of Medicaid and self-pay were associated with lower inpatient cost per admission. Inpatient admissions classified as cardiac/vascular, surgical, extreme SOI, and in NYC commonly incurred higher inpatient cost per admission in all stratified models.

4 | 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 (23.0% per year and 12.2% per year on average, respectively), after adjusting for the Personal Health Care Price Index for hospital care. 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 nonsevere CHDs compared to severe CHDs. Characteristics associated with higher costs per admission and per day overall were longer LOS, severe CHD, cardiac/vascular classification, surgical procedures, higher SOI, and admissions in NYC.

While inpatient admissions among adolescents and young adults with CHDs in NYS increased from 2009 to 2013, all-cause inpatient admissions for the same age group decreased by an average of 0.03% per year over the same time period. 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 (New York State Department of Health, 2012). The specialty care physician ratio per 1,000 enrollees in Medicaid Managed Care increased from 10.60 in 2010 to 12.16 in 2011 (New York State Department of Health, 2012). 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 (New York State Department of Health, 2012).

From 2009 to 2013, the number of inpatient admissions increased by over 20% among individuals with severe CHDs and by 55% among individuals with nonsevere CHDs. Greater inpatient care utilization among adolescents and young adults with CHDs may be related to the growing population of individuals living with CHDs overall (Briston et al., 2016). However, the role of survivorship is likely marginal given that the relative increase in inpatient admissions was larger among those with nonsevere CHDs. One plausible explanation could be changes in coding practices. We observed that inpatient admissions with nonsevere CHD codes identified in the secondary diagnosis fields increased over time while inpatient admissions with nonsevere CHD codes identified in the primary diagnosis field were relatively constant over time data not shown). Additionally, individuals with nonsevere 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 (M. Gurvitz et al., 2013; Kollengode, Daniels, & Zaidi, 2018; Yeung et al., 2008).

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 patterns, where approximately 55% of inpatient admissions begin as emergency department visits (Healthcare Cost and Utilization Project, 2017). 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 (M. Z. Gurvitz et al., 2007; Lu et al., 2014). Emergency hospitalizations among individuals with CHDs often occur after lapses in routine cardiac care (M. Gurvitz et al., 2013). 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.

Among those with nonsevere CHDs, we also found that the ratio of admissions per individual to the hospital directly was similar to the ratio for admissions through the emergency department (0.90 vs. 0.89). However, among those with severe CHDs, the ratio of admissions per individual to the hospital directly was greater than the ratio for admissions through the emergency department (1.37 vs. 1.11). 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 (M. Gurvitz et al., 2013; Kollengode et al., 2018).

Unsurprisingly, surgical admissions resulted in higher inpatient costs than medical admission. However, we found that the incidence proportions of surgical admissions were 0.44 and 0.60 for individuals with severe and nonsevere CHDs, respectively. 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 nonsevere CHDs, similar to a previous article that attributed their findings to improvements in diagnostic and therapeutic interventions (Bouma & Mulder, 2017). However, our findings may be influenced by CHD misclassification. For example, individuals with nonsevere CHDs may have been less likely to have a CHD diagnosis code or individuals without CHDs receiving noncongenital cardiac care may have been misdiagnosed as having CHDs.

Of inpatient admissions among adolescents and young adult women with CHDs, 22% were related to pregnancy, compared to 51.26% of inpatient admissions among all females aged

11–30 years in NYS between 2009 and 2013. 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 CHDs, between high-risk obstetrics, neonatology, anesthesiology, and CHD specialists (Canobbio et al., 2017).

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 (N. Y. C. Department of City Planning, 2011). 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 (Sommerhalter et al., 2017). 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, SOI 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 (Lu et al., 2014). 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, and further research could be done to explore why there are higher healthcare expenditures in certain HSAs compared to others (National Association of Community Health Center, 2017).

Several limitations should be considered. First, there may be errors in billing and coding of diseases which may have resulted in misclassification. The accuracy of using ICD codes to detect and classify individuals with CHDs from healthcare administrative data has been shown to be higher for those with moderate or complex CHDs (Khan et al., 2018). If individuals with noncongenital cardiac conditions were misclassified as having CHDs in our analysis, we may have overestimated the financial burden and healthcare utilization of those with CHDs. Second, our data do not include individuals managed as outpatients or exclusively in emergency departments. However, most individuals with CHDs may not access outpatient care due to loss of insurance and lack of care continuity (Raskind-Hood, Hogue, Overwyk, & Book, 2019). Additionally, nearly 5 million individuals live in the Primary Care Health Professional Shortage Areas in NYS (Bureau of Health Workforce, 2020). 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.

5 | CONCLUSIONS

This study found that inpatient costs were associated with several characteristics, including LOS, CHD severity, cardiac/vascular classification, surgical procedures, SOI, and hospital location. Increases in inpatient admissions and costs were greater among individuals with nonsevere CHDs compared to individuals with severe CHDs. Additionally, the majority of inpatient admissions were emergency admissions. Further research on the relationship between inpatient and outpatient visits may clarify whether some hospitalizations and emergency admissions are preventable through routine cardiac care in adolescence and early adulthood, especially for individuals with nonsevere CHDs. Structured transition programs targeted at adolescents with CHDs should promote continuity of appropriate care in this vulnerable population. These results provide an informative baseline for the health care needs of adolescents and young adults with CHDs in NYS.

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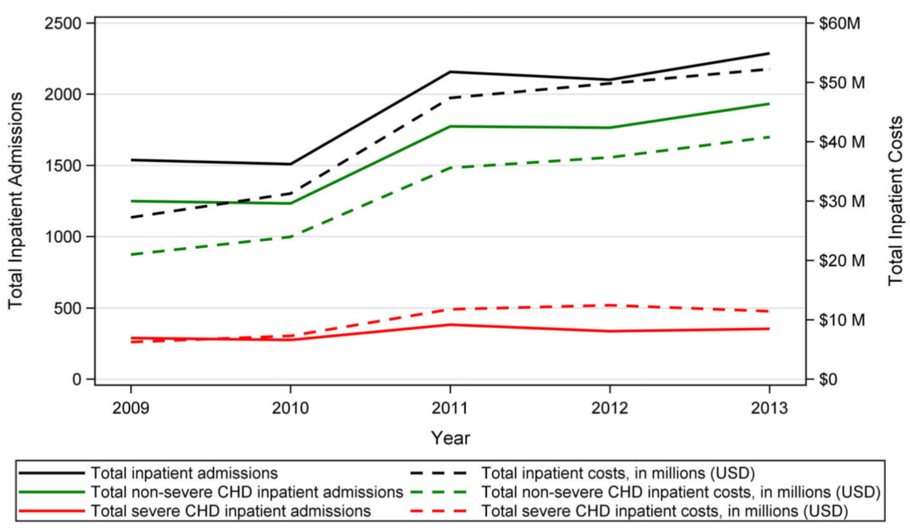

FIGURE 1.

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

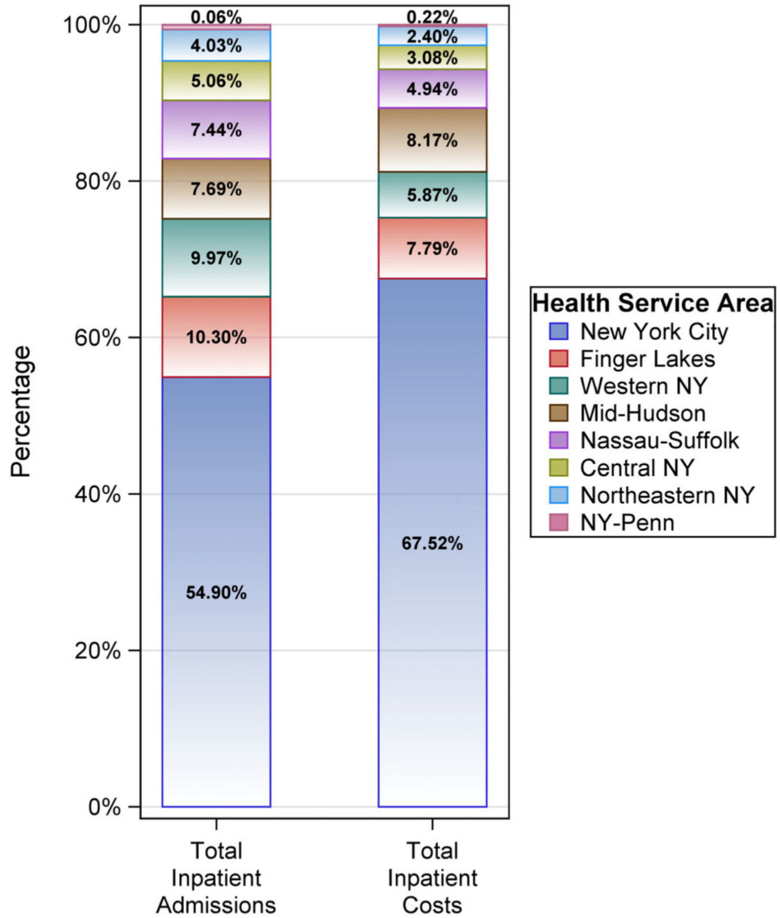

FIGURE 2.

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

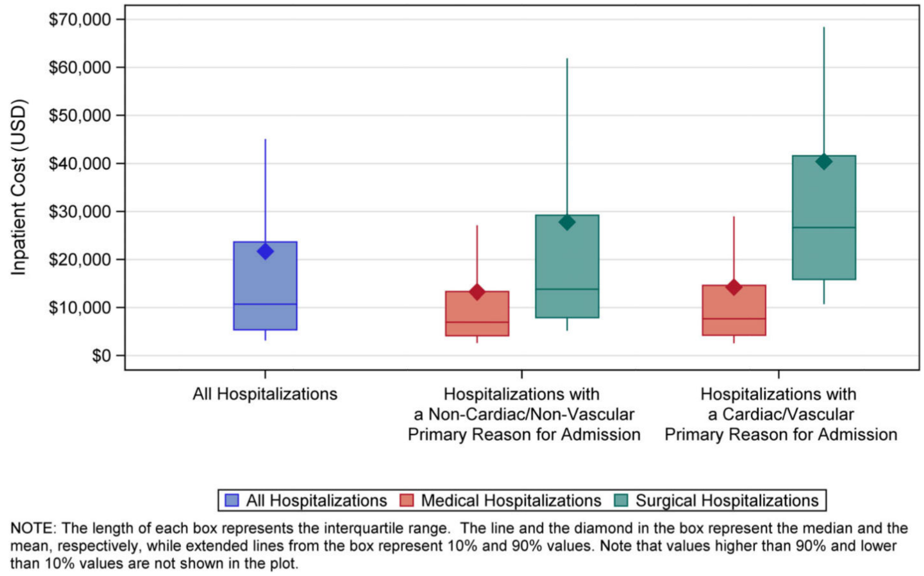

FIGURE 3.

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

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		Nonsevere	
	Admissions	Cost (USD)	Admissions	Cost (USD)	Admissions	Cost (USD)
	n (%)	Median (IQR)	*n* (%)	Median (IQR)	*n* (%)	Median (IQR)
Total	9,593	10,720 (18,246)	1,639	13,557 (25,030)	7,954	10,267 (16,957)
Individual characteristics						
Age at admission[a,b,c]						
11–13 years	1,234 (12.9)	13,916 (20,325)	259 (15.8)	15,599 (26,118)	975 (12.3)	13,461 (18,822)
14–16 years	1,294 (13.5)	13,633 (20,693)	268 (16.4)	16,325 (25,934)	1,026 (12.9)	12,682 (19,616)
17–19 years	1,331 (13.9)	11,069 (18,719)	306 (18.7)	12,413 (21,108)	1,025 (12.9)	10,752 (17,870)
20–30 years	5,734 (59.8)	9,502 (15,936)	806 (49.2)	11,882 (24,393)	4,928 (62.0)	9,201 (15,011)
Sex[a,b,c]						
Male	4,424 (46.1)	12,959 (22,240)	869 (53.0)	14,383 (26,764)	3,555 (44.7)	12,469 (21,142)
Female	5,169 (53.9)	9,199 (14,690)	770 (47.0)	12,049 (23,179)	4,399 (55.3)	8,922 (13,543)
Pregnancy-related[d,e,f]	1,154 (22.3)	5,802 (04,593)	79 (10.3)	5,398 (4,512)	1,075 (24.4)	5,832 (4,583)
Nonpregnancy-related[d,e,f]	4,015 (77.7)	11,645 (18,524)	691 (89.7)	14,083 (24,891)	3,324 (75.6)	11,368 (17,158)
Race[a,c]						
White	5,243 (54.7)	10,080 (17,897)	866 (52.8)	13,527 (24,042)	4,377 (55.0)	9,612 (16,734)
Black	1,702 (17.7)	10,391 (16,346)	308 (18.8)	12,642 (24,348)	1,394 (17.5)	9,979 (15,234)
Other	2,648 (27.6)	12,046 (19,730)	465 (28.4)	14,256 (27,129)	2,183 (27.5)	11,704 (18,556)
Ethnicity						
Hispanic	1,528 (15.9)	10,694 (17,689)	249 (15.2)	13,846 (24,268)	1,279 (16.1)	10,182 (16,462)
NonHispanic	7,795 (81.3)	10,951 (18,746)	1,362 (83.1)	13,613 (25,106)	6,433 (80.9)	10,485 (17,597)
Missing	270 (2.8)	6,050 (8,223)	28 (1.7)	4,171 (13,043)	242 (3.0)	6,110 (7,995)
CHD severity[a]						
Severe	1,639 (17.1)	13,557 (25,030)		—		—
Shunt	3,331 (34.7)	10,684 (15,387)		—		—
Shunt + valve	247 (2.6)	17,780 (29,326)		—		—

	Total		Severe		Nonsevere	
	Admissions	Cost (USD)	Admissions	Cost (USD)	Admissions	Cost (USD)
	***n* (%)**	**Median (IQR)**	***n* (%)**	**Median (IQR)**	***n* (%)**	**Median (IQR)**
Valve	1,969 (20.5)	11,837 (22,761)		—		—
Other	2,407 (25.1)	8,381 (14,102)		—		—
Inpatient admission characteristics						
Length of stay, median (IQR)	3 (4)		3 (5)		3 (4)	
Payer type[a,b,c]						
Private	6,246 (65.1)	11,296 (19,120)	1,030 (62.84)	14,229 (26,109)	5,216 (65.58)	10,761 (17,590)
Medicaid	1,763 (18.4)	9,443 (15,457)	306 (18.67)	11,755 (22,554)	1,457 (18.32)	9,125 (14,877)
Medicare	952 (9.9)	12,170 (18,287)	191 (11.65)	13,769 (21,631)	761 (9.57)	11,983 (17,890)
Self-pay	410 (4.3)	7,038 (14,117)	59 (3.6)	7,112 (25,605)	351 (4.41)	7,019 (12,725)
Other	222 (2.3)	9,481 (15,050)	53 (3.23)	12,217 (19,938)	169 (2.12)	8,239 (13,149)
Primary reason for hospitalization[a,b,c]						
Cardiac/vascular	3,780 (39.4)	17,007 (25,022)	864 (52.7)	20,708 (32,347)	2,916 (36.7)	16,083 (22,681)
Noncardiac/nonvascular	5,813 (60.6)	8,125 (11,611)	775 (47.3)	8,612 (12,428)	5,038 (63.3)	8,066 (11,429)
Medical/surgical APR DRG[a,b,c]						
Medical	6,030 (62.9)	7,143 (09,516)	998 (60.9)	7,672 (11,768)	5,032 (63.3)	7,044 (9,017)
Surgical	3,563 (37.1)	21,425 (26,115)	641 (39.1)	29,233 (33,255)	2,922 (36.7)	20,260 (24,549)
Admission type[a,b,c]						
Emergency	5,286 (55.1)	8,833 (13,564)	861 (52.5)	9,279 (15,190)	4,425 (55.6)	8,759 (12,834)
Urgent	1,108 (11.6)	8,849 (13,913)	196 (12.0)	9,749 (19,158)	912 (11.5)	8,710 (12,640)
Elective	3,156 (32.9)	16,359 (23,839)	574 (35.0)	23,799 (28,903)	2,582 (32.5)	15,256 (22,238)
Other	43 (0.5)	14,152 (20,244)	8 (0.5)	14,143 (12,767)	35 (0.4)	16,936 (26,311)
ED service[a,b,c]						
Yes	4,677 (48.8)	8,158 (11,766)	731 (44.6)	8,734 (14,993)	3,946 (49.6)	8,078 (11,337)
No	4,916 (51.3)	14,181 (23,049)	908 (55.4)	18,360 (28,941)	4,008 (50.4)	13,305 (21,636)
Hospital health service area (HSA)[a,b,c]						
Western NY	956 (10.0)	6,055 (08,354)	87 (5.3)	7,256 (9,257)	869 (10.9)	5,922 (7,823)
Finger Lakes	988 (10.3)	9,327 (16,096)	159 (9.7)	10,462 (25,494)	829 (10.4)	9,194 (15,470)

	Total		Severe		Nonsevere	
	Admissions	Cost (USD)	Admissions	Cost (USD)	Admissions	Cost (USD)
	n **(%)**	**Median (IQR)**	***n*** **(%)**	**Median (IQR)**	***n*** **(%)**	**Median (IQR)**
Central NY	485 (5.1)	6,548 (12,761)	112 (6.8)	5,856 (8,731)	373 (4.7)	6,608 (14,215)
NY-Penn	58 (0.6)	5,010 (07,004)	2 (0.1)	6,951 (9,643)	56 (0.7)	5,010 (6,705)
Northeastern NY	387 (4.0)	6,825 (12,192)	47 (2.9)	8,806 (14,287)	340 (4.3)	6,483 (12,070)
Mid-Hudson	738 (7.7)	11,128 (19,927)	82 (5.0)	10,849 (16,140)	656 (8.3)	11,145 (19,730)
NYC	5,267 (54.9)	13,646 (21,703)	1,085 (66.2)	16,460 (28,508)	4,182 (52.6)	12,919 (19,856)
Nassau-Suffolk	714 (7.4)	7,831 (10,545)	65 (4.0)	8,595 (15,312)	649 (8.2)	7,808 (10,347)

Note: For ethnicity, Kruskal–Wallis tests were performed excluding missing ethnicity.

Abbreviations: CHD, congenital heart defect; IQR, interquartile range; NY, New York; NYC, New York City; USD, United States dollar.

[a] Total—inpatient costs of the selected variable differed significantly ($p < .05$) according to Kruskal–Wallis tests.

[b] Severe—inpatient costs of the selected variable differed significantly ($p < .05$) according to Kruskal–Wallis tests.

[c] Nonsevere—inpatient costs of the selected variable differed significantly ($p < .05$) according to Kruskal–Wallis tests.

[d] Total—inpatients costs for pregnancy-related encounters under females differed significantly ($p < .05$) according to Kruskal–Wallis test.

[e] Severe—inpatients costs for pregnancy-related encounters under females differed significantly ($p < .05$) according to Kruskal–Wallis test.

[f] Nonsevere—Inpatients costs for pregnancy-related encounters under females differed significantly ($p < .05$) according to Kruskal–Wallis test.

TABLE 2

Top five 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	37,976	5	Heart and/or lung transplant	22	305,408	40
Percutaneous cardiovascular procedures without acute myocardial infarction	441	13,247	1	Tracheostomy with mechanical ventilation 96+ hr with extensive procedure or extracorporeal membrane oxygenation	21	227,056	37
Other cardiothoracic procedures	370	24,924	4	Cardiac defibrillator and Heart assist implant	112	45,053	3
Other vascular procedures	269	5,198	2	Cardiac valve procedures with cardiac catheterization	74	42,181	6
Cardiac arrhythmia and conduction disorders	269	15,690	1	Cardiac valve procedures without cardiac catheterization	479	37,976	5

Top noncardiac/nonvascular 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	5,683	2	Tracheostomy with mechanical ventilation 96+ hr without extensive procedure	15	115,923	33
Other pneumonia	178	6,921	3	Dorsal and lumbar fusion procedure for curvature of Back	58	59,573	4.5
Septicemia and disseminated infections	147	20,269	7	Extensive procedure unrelated to principal diagnosis	26	51,245	9
Sickle cell anemia crisis	132	11,172	6	Respiratory system diagnosis with ventilator support 96+ hr	28	48,928	16
Bipolar disorders	117	10,915	10	Infectious and parasitic diseases including HIV with operating room procedure	19	42,095	15

Abbreviations: HIV, human immunodeficiency virus; LOS, length of stay; USD, United States dollar.

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

TABLE 3

Model predicting inpatient costs among adolescents and adults with congenital heart defects (CHD): New York, 2009–2013

	Cost per admission		Cost per day		Cost per admission by severity				Cost per admission by age group			
					Nonsevere CHD		Severe CHD		Age 11–19		Age 20–30	
Characteristics	**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 (%)**
Length of stay[a,c,d,e,f]	2,626 (1962, 3,290)	70.9	—		2039 (1,509, 2,569)	66.5	4,819 (3,668, 5,969)	80.2	3,252 (2,456, 4,048)	76.1	1945 (1,155, 2,735)	60.8
Age at admission												
11–13 years (ref)		0.3		1.9		0.5		0.2	—		—	
14–16 years[b]	1,216 (−978, 3,411)		510 (75, 945)		1,336 (−1,103, 3,775)		−1,027 (−5,387, 3,333)					
17–19 years	1,653 (−1,410, 4,717)		156 (−198, 510)		−22 (−2,446, 2,402)		3,734 (−4,057, 11,525)					
20–30 years	−719 (−2,590, 1,153)		−227 (−520, 67)		−1,192 (−3,134, 751)		−495 (−4,723, 3,732)					
Sex												
Female (ref)		0.2		1.1		0.4		0.0		0.1		0.5
Male[b]	−703 (−2046, 640)		445 (245, 646)		214 (−757, 1,185)		−667 (−4,388, 3,054)		−1,513 (−3,819, 794)		354 (−1,187, 1895)	
Race												
White (ref)		0.3		0.8		0.3		0.2		0.3		0.3
Black	−41 (−1,487, 1,406)		−88 (−352, 175)		−334 (−1,606, 938)		712 (−3,489, 4,914)		−81 (−2,358, 2,196)		258 (−1,384, 1899)	
Other[a,c]	2,123 (355, 3,891)		38 (−249, 325)		1,675 (136, 3,215)		4,438 (−773, 9,648)		1,659 (−1,122, 4,441)		1,576 (−198, 3,351)	
Ethnicity												
Hispanic (ref)		0.1		0.8		0.1		0.1		0.1		0.2
NonHispanic	−1,209 (−2,921, 502)		−160 (−466, 145)		−891 (−2,476, 695)		−1,358 (−6,205, 3,488)		−1,124 (−3,815, 1,567)		−1,347 (−3,657, 963)	
Missing[a,b,c,f]	−3,279 (−6,189, −368)		−989 (−1,365, −613)		−2,514 (−4,695, −332)		−4,617 (−14,320, 5,086)		−8,529 (−21,845, 4,788)		−3,022 (−5,395, −649)	
CHD severity												
Severe (ref)		0.9		2.5	—		—			0.8		1.1
Shunt[a,b,e,f]	−5,283 (−7,457, −3,109)		−739 (−1,088, −391)						−6,879 (−10,323, −3,434)		−3,532 (−6,176, −888)	

Characteristics	Cost per admission		Cost per day		Cost per admission by severity: Nonsevere CHD		Cost per admission by severity: Severe CHD		Cost per admission by age group: Age 11–19		Cost per admission by age group: 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 (%)
Shunt + valve[b]	839 (−4,145, 5,823)		−962 (−1,679, −246)						2,285 (−4,461, 9,031)		−1,146 (−7,720, 5,429)	
Valve[a,b,e]	−2,946 (−5,125, −767)		−987 (−1,361, −614)						−3,708 (−6,919, −498)		−1,534 (−4,211, 1,143)	
Other[a,b,e,f]	−4,453 (−6,683, −2,224)		−971 (−1,328, −613)						−5,574 (−9,461, −1,687)		−3,484 (−5,931, −1,037)	
Payer type												
Medicaid (ref)		0.2		1.8		0.3		0.3		0.2		0.5
Medicare[a,b,f]	2,881 (302, 5,459)		540 (97, 983)		2,101 (−40, 4,243)		4,540 (−2,310, 11,389)		918 (−3,399, 5,234)		3,314 (59, 6,570)	
Private[a,b,c,f]	3,395 (1718, 5,073)		341 (86, 596)		3,254 (1819, 4,688)		4,259 (−970, 9,487)		2,713 (−583, 6,009)		2,978 (1,268, 4,688)	
Self-pay[a]	3,299 (839, 5,758)		−278 (−625, 70)		1,573 (−142, 3,289)		6,095 (−625, 12,815)		5,698 (−1,526, 12,921)		1,088 (−1,033, 3,208)	
Other[a,c,d,e]	5,952 (2,127, 9,777)		221 (−343, 786)		3,120 (276, 5,964)		13,483 (3,300, 23,666)		8,079 (954, 15,204)		1752 (−1,169, 4,673)	
Primary reason for hospitalization												
Noncardiac/nonvascular (ref)		2.0		20.3		1.7		1.8		1.2		3.2
Cardiac/vascular[a,b,c,d,e,f]	8,197 (6,872, 9,523)		2,105 (1896, 2,315)		6,479 (5,270, 7,688)		10,236 (7,206, 13,265)		7,498 (5,497, 9,499)		8,045 (6,420, 9,669)	
Hospitalization type												
Medical (ref)		6.4		36.4		8.4		4.0		4.3		10.2
Surgical[a,b,c,d,e,f]	16,101 (14,173, 18,030)		3,490 (3,253, 3,727)		15,567 (13,885, 17,250)		18,741 (13,934, 23,549)		17,962 (15,023, 20,902)		15,563 (13,357, 17,769)	
Severity of illness												
Minor (ref)		15.6		2.2		18.3		10.7		14.7		18.6
Moderate[a,b,c,e,f]	2,873 (1,229, 4,516)		−309 (−611, −7)		3,445 (2058, 4,832)		−303 (−2,766, 2,160)		2,624 (785, 4,464)		2,906 (1,193, 4,618)	
Major[a,b,c,e,f]	5,522 (2,458, 8,587)		−775 (−1,073, −477)		7,488 (4,953, 10,024)		10 (−4,461, 4,481)		4,715 (1,678, 7,751)		6,494 (3,032, 9,955)	

Characteristics	Cost per admission		Cost per day		Cost per admission by severity: Nonsevere CHD		Severe CHD		Cost per admission by age group: 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 (%)
Extreme[a,b,c,d,e,f]	32,949 (23,265, 42,633)		−479 (−842, −115)		33,773 (25,485, 42,062)		18,111 (5,566, 30,656)		33,076 (20,019, 46,134)		31,942 (21,962, 41,922)	
Admission type												
Emergency (ref)		0.5		14.2		0.6		0.7		0.4		0.7
Urgent	−909 (−3,663, 1845)		−5 (−376, 365)		−2,160 (−4,530, 210)		3,611 (−3,632, 10,854)		1,545 (−2,977, 6,066)		−1,468 (−4,457, 1,521)	
Elective[b]	401 (−2,413, 3,215)		1,376 (1,011, 1742)		−688 (−3,003, 1,626)		3,221 (−4,695, 11,137)		272 (−4,532, 5,076)		−815 (−3,707, 2077)	
Other[b]	2,580 (−2,145, 7,305)		1,532 (31, 3,034)		753 (−4,023, 5,530)		4,823 (−4,296, 13,942)		6,595 (−430, 13,620)		−378 (−6,439, 5,684)	
ED service												
No (ref)		0.5		7.8		0.5		0.6		0.3		0.9
Yes	694 (−1,201, 2,589)		−119 (−380, 142)		524 (−1,387, 2,436)		−212 (−5,069, 4,644)		1884 (−1,669, 5,436)		−820 (−2,792, 1,153)	
Hospital health service area (HSA)												
Western NY (ref)		1.9		10.1		2.3		1.2		1.5		3.0
Finger Lakes	−1,538 (−3,642, 566)		−136 (−561, 290)		−1,046 (−2,864, 771)		5,348 (−3,065, 13,761)		−793 (−4,625, 3,039)		−1,252 (−3,727, 1,222)	
Central NY	29 (−2,127, 2,186)		−225 (−651, 201)		349 (−1,497, 2,195)		6,968 (−1753, 15,690)		−255 (−5,022, 4,511)		−36 (−2,336, 2,264)	
NY-Penn[c]	−2,775 (−6,807, 1,257)		−174 (−899, 550)		−3,896 (−7,410, −381)		−1,121 (−29,976, 27,734)		1,689 (−7,115, 10,494)		−4,068 (−8,236, 100)	
Northeastern NY	750 (−1,438, 2,938)		173 (−283, 629)		627 (−1,198, 2,452)		7,009 (−3,976, 17,994)		−241 (−5,298, 4,816)		945 (−1,310, 3,201)	
Mid-Hudson[b,d]	−264 (−3,260, 2,733)		645 (258, 1,033)		1780 (−709, 4,268)		11,377 (1984, 20,769)		−4,622 (−11,744, 2,500)		1795 (−1,065, 4,656)	
NYC[a,b,c,d,e,f]	6,648 (4,802, 8,494)		1,636 (1,294, 1979)		6,312 (4,704, 7,919)		13,888 (5,982, 21,794)		7,848 (4,142, 11,555)		6,552 (4,501, 8,603)	
Nassau-Suffolk[b]	905 (−1,061, 2,871)		691 (240, 1,143)		745 (−975, 2,464)		6,940 (−2,296, 16,176)		1,011 (−3,334, 5,357)		1,198 (−891, 3,287)	

Abbreviations: β, coefficient; CI, confidence interval; ED, emergency department; NY, New York, NYC, New York City; SOI, severity of illness.

[a]Coefficients for predicting inpatient costs per admission are statistically significant (p <.05).

[b] Coefficients for predicting inpatient costs per day are statistically significant ($p < .05$).

[c] Severe CHD—coefficients for predicting inpatient costs per admission are statistically significant ($p < .05$).

[d] Nonsevere CHD—coefficients for predicting inpatient costs per admission are statistically significant ($p < .05$).

[e] Age 11–19—coefficients for predicting inpatient costs per admission are statistically significant ($p < .05$).

[f] Age 20–30—coefficients for predicting inpatient costs per admission are statistically significant ($p < .05$).