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ORIGINAL RESEARCH

Association of Insurance Status With Emergent Versus Nonemergent Hospital Encounters Among Adults With Congenital Heart Disease

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BACKGROUND: Although the number of hospital visits has exponentially increased for adults with congenital heart disease (CHD) over the past few decades, the relationship between insurance status and hospital encounter type remains unknown. The purpose of this study was to evaluate the association between insurance status and emergent versus nonemergent encounters among adults with CHD ≥18 years old.

METHODS AND RESULTS: We used California Office of Statewide Health Planning and Development Database from January 2005 to December 2015 to determine the trends of insurance status and encounters and the association of insurance status on encounter type among adults with CHD. A total 58 359 nonpregnancy encounters were identified in 6077 patients with CHD. From 2005 to 2015, the number of uninsured encounters decreased by 38%, whereas government insured encounters increased by 124% and private by 79%. Overall, there was a significantly higher proportion of emergent than nonemergent encounters associated with uninsured status (13.0% versus 1.8%; $P<0.0001$), whereas the proportion of nonemergent encounters associated with private insurance was higher than emergent encounters (35.8% versus 62.4%; $P<0.0001$). When individual patients with CHD became uninsured, they were ≈5 times more likely to experience an emergent encounter ($P<0.0001$); upon changing from uninsured to insured, they were significantly less likely to have an emergent encounter ($P<0.001$). After multivariate adjustment, uninsured status exhibited the highest odds of an emergent rather than nonemergent encounter compared with all other covariates (adjusted odds ratio, 9.20; 95% CI, 7.83–10.8; $P<0.0001$).

CONCLUSIONS: Efforts to enhance the ability to obtain and maintain insurance throughout the lifetime of patients with CHD might result in meaningful reductions in emergent encounters and a more efficient use of resources.

Key Words: congenital heart disease ■ health disparities ■ health policy and outcomes research ■ health services research

Substantial evidence exists to show that lack of insurance is associated with increased morbidity and mortality.[1,2] Insurance coverage increases access to preventive and ambulatory care, which can directly maintain or improve health.[1,3–5] However, the evidence on the effects of insurance on the use of ambulatory and emergent encounters has been quite mixed.[6–11] Although most of these services fulfill critical health needs, some of them also represent low-value care or may reflect poor outpatient care.[9,12] Understanding the impact of insurance on these services is particularly important for adults with chronic childhood preexisting conditions like congenital heart disease (CHD), a vulnerable high-cost population.[13–15] Knowledge about this can add evidence to inform national conversations about important policies such as

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CLINICAL PERSPECTIVE

What Is New?

- We determined the association of insurance status on the type of hospital encounters among adults with congenital heart disease in California.
- From 2005 to 2015, the number of uninsured congenital heart disease encounters decreased while the government and privately insured encounters increased; however, there was a substantially higher emergent:nonemergent encounter ratio among uninsured rather than insured patients, even after adjusting for covariates.
- This difference in the emergent:nonemergent encounter ratio was because of the higher proportion of emergent encounters among the uninsured and higher nonemergent encounters among the privately insured; compared with those insured, uninsured patients had significantly more encounters for noncardiac diagnoses and nondiscretionary emergent conditions.

What Are the Clinical Implications?

- Our results could inform important national discussions related to health policies especially related to the preexisting condition clause and Medicaid expansion.
- When individual patients with congenital heart disease became uninsured, they were ≈5 times more likely to experience an emergent encounter whereas they were significantly less likely to have an emergent encounter when they became insured.
- Our findings suggest that efforts to enhance the ability to obtain and maintain insurance throughout the lifetime for patients with congenital heart disease might result in meaningful reductions in emergency encounters and a more efficient use of resources.

Nonstandard Abbreviations and Acronyms

OSHPD	Office of Statewide Health Planning and Development Database

Medicaid expansion and tangible influences of preventing or allowing denial of insurance for patients with preexisting conditions.

There are ≈1.6 million adults with CHD living in the United States, and their numbers are increasing by 40 000 to 50 000/year because of improving pediatric CHD care.[16–19] The number of hospitalizations for adults with CHD in the United States has more than doubled from 1998 to 2010, and mean hospital charges have increased 127%.[15] Yeung et al have demonstrated that a lapse in medical care for more than 2 years for adults with CHD is associated with a 3 times higher likelihood of requiring urgent cardiac intervention.[20] Loss of insurance is often cited as one of the common reasons for lapse in care for these patients.[21] Despite this, there are no data about the effects of insurance status (uninsured, government insurance, or private insurance) on the types of hospital encounters, whether emergent or nonemergent. This information could not only help policymakers make appropriate insurance coverage related decisions but would also allow the CHD care team to help patients with their own practical financial decisions.

We leveraged a large California hospital encounter database to identify all encounters among adults with CHD over an 11-year period. We compared the types of hospital encounters (emergent or nonemergent) among adults with CHD based on their type of insurance during those encounters.

METHODS

The data that support the findings of this study are available from the corresponding author on reasonable request. The data source is the Office of Statewide Health Planning and Development Database (OSHPD). OSHPD collects and makes publicly available performance, financial, use, patient characteristics, and service data from nearly 7000 California licensed health facilities. This study used previously collected deidentified data and was, therefore, exempted from institutional review board approval.

We retrospectively examined all encounters in the OSHPD database between January 1, 2005, and December 31, 2015. All the encounters were further classified as emergent (for encounters associated with emergency department [ED] visits or admissions from the ED) and nonemergent (for encounters at hospital based or free-standing ambulatory surgery center or admissions from ambulatory surgery center). An ambulatory surgery procedure is defined as those procedures performed on an outpatient basis in the general operating rooms, ambulatory surgery rooms, endoscopy units, or cardiac catheterization laboratories of a hospital or a freestanding ambulatory surgery center. We took this approach in identifying nonemergent encounters because patients with CHD often require elective procedures such as cardiac catheterizations or ablations during routine surveillance monitoring and these nonemergent procedures are often performed to potentially reduce the need for emergent interventions and admissions. Any admissions that were not from the ED or the ambulatory surgery center were excluded.

We also excluded any pregnancy- or delivery-related encounters.

The *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes for CHD were used to identify patients with a CHD diagnosis (Data S1 and Table S1). For patients with codes for >1 CHD diagnosis, we used the hierarchical algorithm proposed by Broberg et al[22] to designate 1 condition per patient as the principal CHD diagnosis. As described earlier,[13,22–24] we excluded *ICD-9* codes that have lower specificity for CHD, including atrial septal defect, bicuspid aortic valve, aortic stenosis, congenital mitral valve disease, anomalous coronary arteries, and unspecified congenital anomalies. The remaining patients with CHD were categorized using the American Heart Association/American College of Cardiology anatomic classification[25] as (1) complex CHD, defined by the presence of Eisenmenger (for those with a concomitant CHD diagnosis code and pulmonary arterial hypertension), univentricular heart defects (including hypoplastic left heart syndrome), transposition of the great arteries, tetralogy of Fallot, truncus arteriosus, and endocardial cushion defects; (2) moderately complex CHD, defined by the presence of Ebstein anomaly, coarctation of aorta, anomalies of the pulmonary artery, anomalies of the pulmonary valve, anomalies of the tricuspid valve, unspecified septal defects, anomalies of the great vein, subaortic stenosis, and aortic anomalies; and (3) simple CHD, defined by the presence of ventricular septal defect and patent ductus arteriosus. Once a CHD diagnosis was determined, all encounters for those patients throughout the study period were evaluated.

For each encounter for a patient with CHD, baseline characteristics were assessed. These included age, sex, race, income, and comorbidities. Medical comorbidities were identified from the *ICD-9* diagnosis codes previously described in the literature and categorized as cardiac or noncardiac (Data S1).[18,19] Insurance status during an encounter was determined based on the OSHPD database assignment of the payer defined as the type of entity or organization expected to pay the greatest share of the patient's bill. Each encounter was categorized as uninsured, government insurance (such as Medicare Part A, B, Medicaid [Medi-Cal] or other federal or nonfederal government programs) or private insurance (eg, preferred provider organization, point of service, health maintenance organization, Blue Cross/Blue Shield, and commercial insurance company). The OSHPD database included a record linkage number that can be used to identify sequential visits for a patient within California, even if those visits occur at a different facility or setting (inpatient, ED, or ambulatory surgery) than the index encounter. We used this record linkage number to track encounters for each patient with CHD and determine if there was a change in insurance status during those encounters. Hospital volumes were calculated from the total number of inpatient, ED, and ambulatory surgery visits across each year. Annual hospital volumes were categorized by quartiles of median.

The OSHPD database includes a variable listing the Agency for Healthcare Research and Quality's single-level Clinical Classification System code for the primary diagnosis.[26] The Clinical Classification System system provides a way to classify diagnoses and procedures into a limited number of categories by aggregating individual *ICD-9* codes into broad diagnosis and procedure groups to facilitate statistical analysis and reporting. We used these single-level Clinical Classification System codes to determine the first diagnosis in the database, which is referred to as the primary diagnosis during an encounter. Encounters with Clinical Classification System codes 96–108 or 213 were determined to have a primary cardiac diagnosis, whereas all other encounters were considered noncardiac. We identified candidate diagnoses that were associated with serious or painful illnesses and injuries and that are highly likely to prompt patients to seek care in an ED, regardless of their insurance status and of their underlying CHD. These diagnoses (such as fracture or other injuries, poisoning, appendicitis, foreign body, bowel obstruction, others) were used to identify the nondiscretionary diagnoses for the ED visits, as described previously by Mulcahy et al.[27] Because our patient population had adults up to 65 years age (whereas Mulcahy et al only included adults up to 26 years of age), we also added acute myocardial infarction to our list of nondiscretionary emergent encounters.

Statistical Analysis

Data were analyzed from April 4, 2019, through November 1, 2020. Continuous variables are presented as mean± SD or median and interquartile range as appropriate, and categorical variables are presented as percentages. A Student *t* test or Kruskal-Wallis rank test as appropriate was used for comparisons of continuous variables and Pearson chi-square test for categorical variables. Generalized linear regression models were used to analyze trends and compare them by encounter and insurance types. Logistic regression was used to determine the association of change in insurance status for a patient with CHD and the type of encounters. Multivariate logistic regression was used to examine the association of insurance status on the type of encounters, after adjusting for the covariates. Statistical analyses were performed using Stata (version 14; StataCorp, College Station, TX) and SAS (version 9.4; SAS Institute, Inc., Cary, NC).

RESULTS

Study Population

Between January 2005 and December 2015, there were a total of 72 609 246 encounters for patients 18 to 65 years old. A total of 2 732 821 pregnancy-related encounters were excluded. Of the remaining 69 876 425 encounters, 58 359 were identified among 6077 patients with CHD. Of all the encounters among patients with CHD, 48 225 (83%) were emergent. Of these emergent encounters, 39 038 (81%) were ED encounters alone whereas 9187 (19%) ED encounters resulted in an admission. Of all the CHD encounters, 6460 (11%) were in uninsured patients, 28 544 (49%) involved patients with government insurance, and 23 355 (40%) came from patients with private insurance. Of 6077 patients with CHD, 5910 had more than 1 encounter of any type during the study period; 4, 389 (74.3%) had a change in their insurance status between encounters.

Baseline Characteristics

Baseline characteristics during encounters among patients with CHD are compared by their insurance status in Table. Encounters with government insurance were significantly more likely among patients who were 18 to 40 years old, female, Black, and those who had complex CHD when compared with the uninsured or privately insured encounters. On the other hand, when compared with insured encounters, uninsured ones were more common among those 51 to 65 years age, Hispanic, Asian, and other races/ethnicities and simple CHD, and less common among those with comorbidities.

Trends by Types of Encounters and Insurance Status

From 2005 to 2015, the total number of encounters for patients with CHD increased by 90% ($P<0.0001$) with a significantly higher increase in emergent than nonemergent encounters (103% versus 45%; $P<0.0001$) (Figure 1). When evaluating the trends by insurance status, the proportion of uninsured encounters for adults with CHD decreased by 38%, whereas the government and private insured encounters increased by 124% and 79%, respectively. The differences in trends across years were highly significant when comparing uninsured with any other insurance-related encounters ($P<0.0001$) (Figure 2). Throughout the study period, the ratio of emergent to nonemergent encounters remained significantly higher among uninsured (average ratio 35.7; 95% CI, 34.8–36.6) compared with those with government insurance (average ratio 2.69; 95% CI, 2.65–2.73; $P=0.007$) and those privately insured (average ratio 6.86; 95% CI, 6.7–6.9; $P=0.010$) (Figure 3). The P value for interaction between insurance status and the emergent to nonemergent encounter ratio over the years was 0.0005.

The absolute numbers of all, emergent and nonemergent encounters by insurance status is shown in Figures S1A through S1C. Overall, there was a significantly higher proportion of emergent than nonemergent encounters associated with uninsured status (13.0% versus 1.8%; $P<0.0001$), and the proportion of nonemergent encounters associated with private insurance was significantly higher than emergent encounters (35.8% versus 62.4%; $P<0.0001$) (Figure 4). On changing the insurance status from government insurance to uninsured, patients with CHD were ≈5 times more likely to experience an emergent encounter ($P<0.0001$) (Figure 5). On the other hand, upon changing from uninsured to government or private insurance, they were 0.46 and 0.14 times respectively less likely to have an emergent encounter ($P<0.0001$).

Factors Associated With Emergent Versus Nonemergent Encounters

After adjusting for baseline covariates, factors significantly associated with higher odds of emergent over nonemergent encounters among patients with CHD included female sex, Black race, government insurance and uninsured status, higher hospital volumes, and the presence of any comorbidity (cardiac or noncardiac), whereas older age, Asian and other race (Native American and any race included within the "Other Race" category of the OSHPD database), and higher income were associated with significantly lower odds (Figure 6). Of all the variables, uninsured status exhibited the largest magnitude of effect when compared with private insurance. The type of CHD was not significantly associated with the type of encounter. When compared with patients with CHD with any type of insurance (government or private), an uninsured adult patient with CHD had a >6-fold adjusted odds of an emergent encounter (adjusted odds ratio, 6.42; 95% CI, 5.48–7.53; $P<0.0001$).

Primary Diagnosis for Encounters

A primary noncardiac diagnosis was more common among emergent than nonemergent encounters (82.8% versus 66.1%; $P<0.0001$). Similarly, a primary noncardiac diagnosis was more common among uninsured than government or privately insured encounters (Figure 7A), irrespective of the type of CHD or encounter type.

For emergent encounters, there were no differences in the prevalence of nondiscretionary diagnosis by insurance status for all and patients with simple CHD. On the other hand, uninsured encounters among patients with moderately complex and complex CHD had a significantly higher prevalence of nondiscretionary diagnoses than insured encounters (Figure 7B).

Table. Baseline Characteristics During Hospital Encounters Among Adults With CHD by Insurance Type, 2005 to 2015

Baseline characteristics	Uninsured encounters (n=6460)	Government-insured encounters (n=28 544)	Private-insured encounters (23 355)	*P* value
Age, y, mean±SD	38.6 ± 13.7	35.5 ± 12.3	38.4 ± 13.3	<0.0001
Age group				<0.0001
18–30 y	2362 (36.6)	11 978 (42.0)	8137 (34.8)	
31–40 y	1367 (21.2)	7217 (25.3)	4891 (20.9)	
41–50 y	947 (14.7)	5027 (17.6)	4925 (21.1)	
51–65 y	1784 (27.6)	4322 (15.1)	5402 (23.1)	
Female sex*	2848 (44.1)	17 999 (63.1)	13 644 (58.4)	<0.0001
Race/ethnicity*				<0.0001
White	2854 (44.2)	14 877 (52.1)	13 686 (58.6)	
Black	609 (9.4)	3478 (12.2)	2071 (8.87)	
Hispanic	2198 (34.0)	7851 (27.5)	4802 (20.6)	
Asian	457 (7.1)	939 (3.3)	1558 (6.7)	
Others††	271 (4.2)	1026 (3.6)	744 (3.2)	<0.0001
Annual income, US$, median (25th, 75th)	57 364.0 (45 749.0, 75 090.0)	53 080.0 (43 117.0, 69 828.0)	63 656.0 (51 094.0, 81 277.0)	<0.0001
Annual hospital visits, median (25th, 75th)†				<0.0001
Quartile 1, 1571 (940, 2168)	25 (0.39)	226 (0.79)	170 (0.73)	
Quartile 2 8078 (2550, 14 125)	223 (3.45)	1346 (4.72)	775 (3.32)	
Quartile 3 28 090 (20 115, 35 329)	1502 (23.3)	6342 (22.2)	4663 (19.9)	
Quartile 4 62 561 (47 686, 82 667)	4710 (72.9)	20 630 (72.3)	17 747 (75.9)	
Type of congenital heart disease				<0.0001
Complex	1102 (17.1)	6986 (24.5)	5196 (22.3)	
Moderately complex	1815 (28.1)	9583 (33.6)	9182 (39.1)	
Simple	3543 (54.9)	11 975 (41.9)	8977 (38.4)	
Comorbidities				
Any	1272 (19.7)	9490 (33.3)	8538 (36.6)	<0.0001
Cardiovascular	645 (9.98)	5416 (18.9)	5947 (25.5)	<0.0001
Noncardiovascular	900 (13.9)	7034 (24.6)	5920 (25.4)	<0.0001
Emergent encounters	6284 (97.3)	24 913 (87.3)	17 028 (72.9)	<0.0001
Nonemergent encounters	176 (2.72)	3631 (12.7)	6327 (27.1)	<0.0001

CHD indicates congenital heart disease.
*Have some missing values.
†Quartiles are classified based on the median annual hospital visits.
††Other refers to Native American and any race included within the "Other Race" category of the OSHPD database.

DISCUSSION

Using more than 58 000 encounters in California over a 11-year period, we found that uninsured adults with CHD had a substantially higher odds of emergent as opposed to nonemergent hospital encounters when compared with those with either government or private insurance, even after adjusting for potential confounders and mediators. This was likely owing to the increased proportion of emergent encounters among the uninsured and also higher proportion of nonemergent encounters among the privately insured. Furthermore, we observed that upon becoming uninsured, patients with CHD were ≈5 times more likely to experience an emergent encounter, whereas they were significantly less likely to have an emergent encounter after becoming insured. Although the majority of encounters among these adults with CHD were primarily for noncardiac diagnoses, uninsured patients had more encounters for noncardiac diagnoses than the insured. Also, nondiscretionary emergent encounters were significantly more common among the uninsured

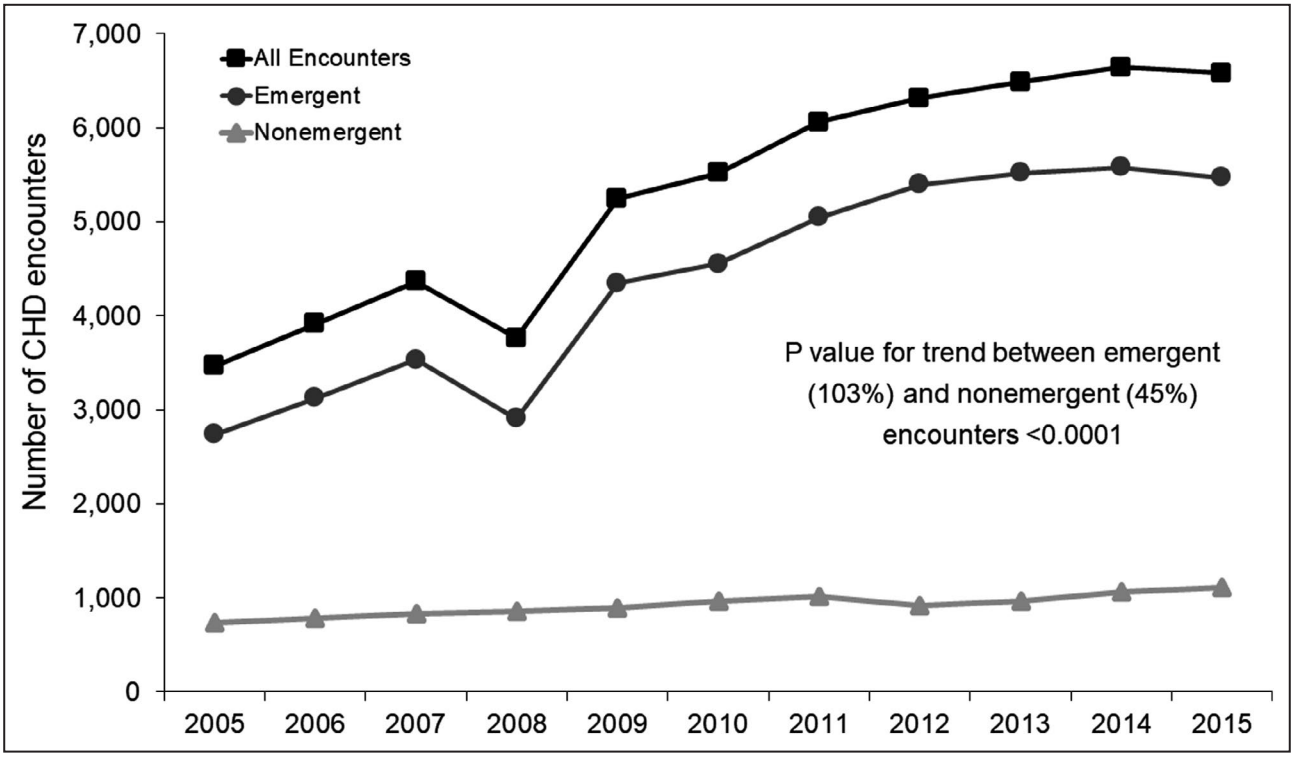

Figure 1. Trends in the number of encounters, 2005 to 2015.
Black indicates all types of encounters; dark grey, patients with emergent encounters; and light grey, patients with nonemergent encounters. CHD indicates congenital heart disease.

compared with those insured, especially among adults with complex and moderately complex CHD. These findings suggest that having insurance might result in reductions in emergency encounters for both cardiac and noncardiac conditions and a more efficient use of healthcare resources among adults with a preexisting chronic childhood conditions such as CHD.

Prior studies have described the increasing numbers of encounters among adults with CHD for all hospitalizations, ED visits, admissions from the ED, or for heart failure admissions.[15,23,28–30] In this study, in addition to the emergent encounters, we also described the trends in nonemergent hospital encounters especially related to ambulatory surgical center encounters, given the higher expected prevalence of such encounters in these patients given their underlying disease course. We observed an increasing number of encounters over time for both emergent and nonemergent encounters, albeit a much greater increase for emergent encounters. Of note, only about a fifth of the ED visits in our California-level study resulted in admissions compared with more than half in a prior national ED database.[30] This could be because of the much younger age in our study (mean age 38 versus 50 years) and differences in the types of CHD defects included. In particular, we excluded those with mitral and aortic valve abnormalities and those with coronary anomalies as the related *ICD* codes can be difficult if not impossible to differentiate from other acquired conditions (especially in the elderly) – these types of lesions accounted for a bulk of encounters in the prior study.[22,31]

The overall numbers of uninsured encounters significantly decreased over the study period, whereas the numbers of those with government and private insurance more than doubled. This finding likely reflects the impact of health policy changes in California during the study period. The Patient Protection and Affordable Care Act (ACA) implemented between 2010 and 2014[32] expanded Medicaid as well as removed the "preexisting" condition clause. This likely allowed more patients with CHD to have obtain insurance during our study period. Although we did not directly calculate the changes in insurance rates over time among adults with CHD, our findings still provide indirect evidence of the impact of the ACA on insurance status among California adults with CHD and are consistent with analyses of prior national survey and hospital claims data.[27,33] In addition to the changes in coverage, we also found changes in the type of services used for patients with CHD, consistent with other studies evaluating all young adults.[27,33] Interestingly, although the ratio of emergent to nonemergent encounters remained high for the uninsured throughout the study period, we noticed that the ratio declined after 2011,

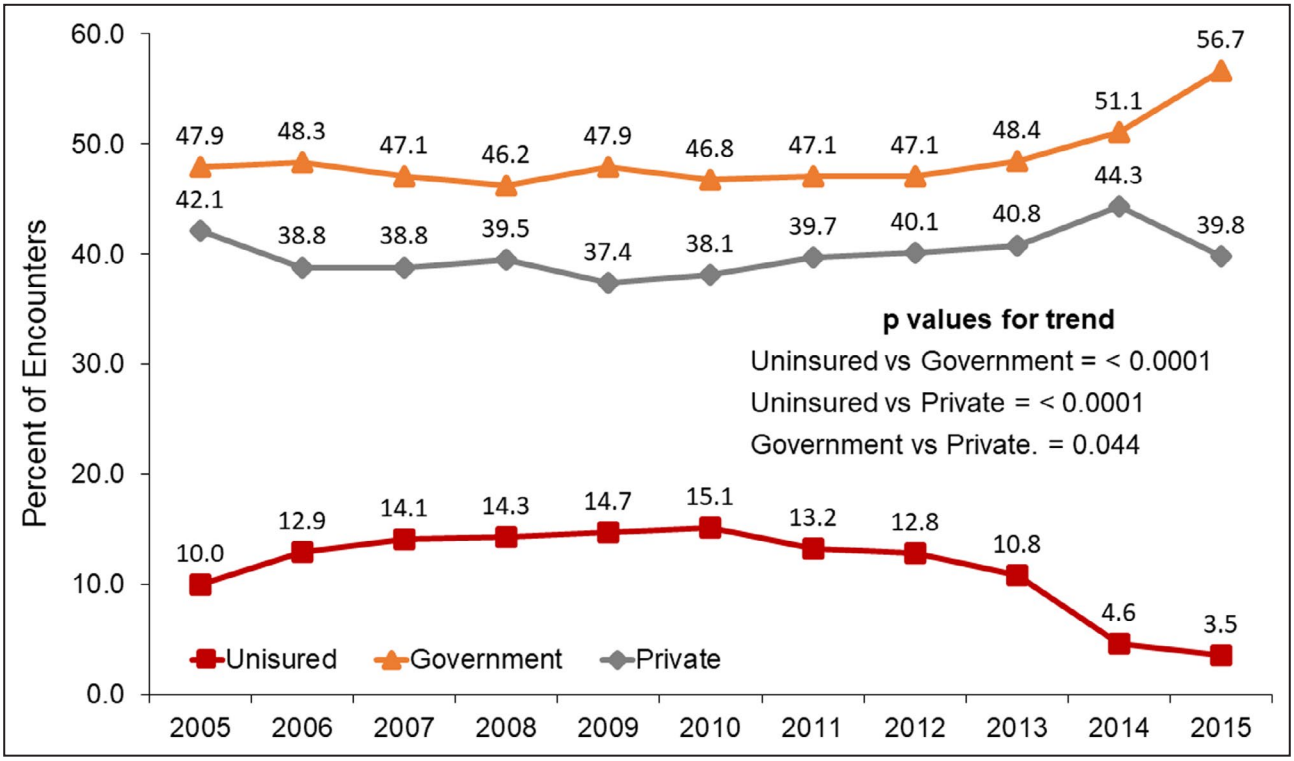

Figure 2. Trends in the percentage of encounters by insurance type, 2005 to 2015.
Red squares indicates percentage of uninsured encounters; orange triangles indicate government insured encounters; and grey diamonds are privately insured encounters.

coincident with initiation of the ACA. It could be likely that the sicker patients with CHD might have taken advantage of the Medicaid expansion provision under ACA, resulting in fewer emergent encounters among uninsured patients who were less sick or had less complex CHD and hence the declining ratio in them. Since 2015, California has continued to support and adopt the ACA, especially the Medicaid expansion provision under the ACA. Between 2015 and 2019, the overall proportion of uninsured population in California has continued to be lower and stable than before 2014 (at ≈10% versus 24% before 2014), Medicaid has remained higher and stable (at 21% versus 11% before 2014) and those on employer-based insurance have increased only slightly (58% versus 53% before 2014).[32] Based on this, we hypothesize that the absolute numbers of uninsured patients with CHD in California may have remained lower since 2015 (compared with before 2014), thus resulting in lower but persistent disparities in encounter types by insurance status. However, future studies evaluating the impact of various policy changes on the types of health service use, especially for a vulnerable population like those with CHD, are warranted to help further inform national policies.

Prior data regarding the impact of insurance coverage on emergency visits has shown mixed findings. Evidence from Oregon and Illinois have shown an increase in ED use or all-cause hospitalization with Medicaid expansion.[6,10,11] On the other hand, evidence from Massachusetts, some other states, and a nationally representative ED visit database have shown no change or a decrease in ED use or hospitalization from the ED with the adoption of universal coverage.[7,8,12] Our observations in this study are more consistent with the latter, given that patients in our study were more likely to have emergent encounters when their insurance status changed from insured to uninsured and vice versa. One of the likely reasons for this could be that insured adults with CHD had better access to ambulatory care than those uninsured and timely outpatient care could prevent some of the emergent admissions. This is a plausible explanation, as it has been shown that gaps in ambulatory care for patients with CHD result in a greater need for urgent interventions.[20] On the other hand, patients with good ambulatory CHD care would be expected to have more nonemergent encounters for procedures that keep their disease under control, such as elective admissions for arrhythmia ablations or device insertions. Additionally, having insurance might not only increase access to CHD specific care but could also increase access to care for other medical conditions and thus may lead to less reliance on ED. Furthermore, we observed that not only uninsured but also patients with government insurance are more

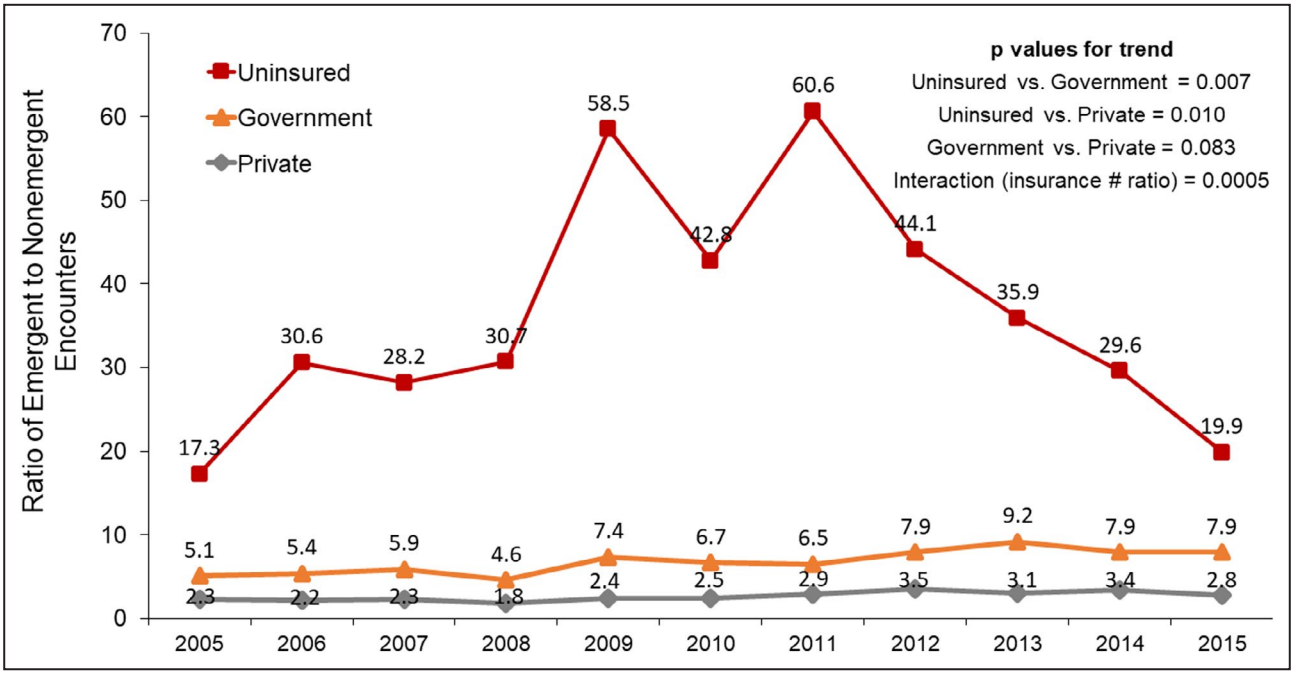

Figure 3. Trends in the ratio of emergent to nonemergent encounters by insurance type among adults with congenital heart disease, 2005 to 2015.
Red squares indicates ratio for uninsured encounters; orange triangles indicate government-insured encounters; and grey diamonds are privately insured encounters.

likely than the privately insured to have disparities in the type of hospital encounters, with more emergent encounters when the insurance status of a patient with CHD changes from private to government insurance. Future studies evaluating the impact of the extent of insurance coverage (such as share of out-of-pocket costs) could shed light on the effect of financial hardships on these patients.

Our data further highlight the impact of insurance on the primary reasons for hospital encounters among patients with CHD. Similar to a prior study from Germany and one from a US national ED database,[30,34] we found a higher prevalence of noncardiac than cardiac diagnosis during hospital encounters for all patients with CHD. This highlights the multisystem challenges faced by patients with this complex cardiac condition, irrespective of their insurance status. Guidelines thus recommend comprehensive CHD centers for multidisciplinary care by both CHD specialists as well as noncardiologists to be able to meet the complex needs of these patients. Uninsured adults in our study, however, had a much higher prevalence of noncardiac and nondiscretionary diagnoses (during emergent encounters) than those insured, especially among those with moderately complex or complex CHD. This suggests that the uninsured patients are likely avoiding care unless necessary and relying on ED when they need care. On the other hand, insured patients might have easier access to other services, such as urgent care or same-day physician appointments for some of their needs. Furthermore, uninsured emergency encounters incur additional uncompensated costs for the hospitals and ED providers, especially for nondiscretionary diagnoses, which are relatively less sensitive to insurance status. Mulcahy et al[27] estimated that coverage expansion under the ACA led to 22 072 additional ED visits among young adults that were covered by private insurance after the ACA compared with before. This resulted in the transfer of $147 million in ED and hospital costs to private insurance pools, thus minimizing the hospital losses that would have resulted if these visits were for uninsured patients.

In addition to insurance status, we identified other patient characteristics that were associated with higher odds of emergent than nonemergent encounters. Those with female sex and Black race were more likely to have government insurance, and, after adjusting for all the covariates, they were noted to have a significantly higher proportion of emergent encounters. Although data on sex and racial differences in healthcare use remain limited (especially among adults), our findings about racial differences are similar to another study that demonstrated important health disparities based on sex and race.[35] Interestingly, in our study, whereas the presence of cardiac or noncardiac comorbidities was independently associated with higher odds of emergent encounters, the type of CHD was not significant. This likely reflects the heterogeneity of CHD, and the different

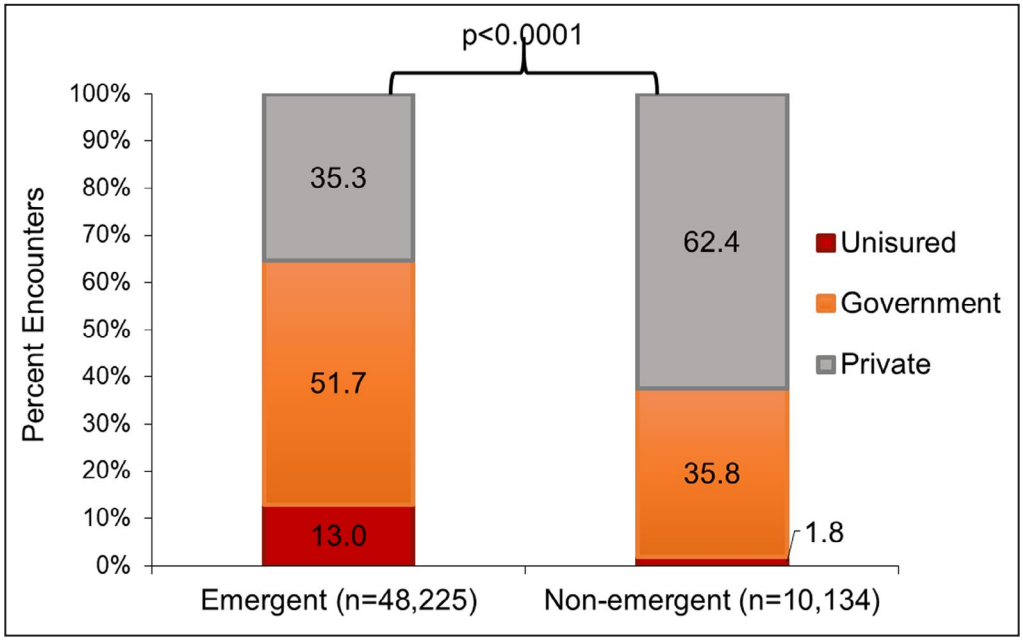

Figure 4. Proportion of emergent and nonemergent encounters by insurance status.
Red bars indicate percent of uninsured encounters; orange indicates percentage of government insured encounters; and grey is privately insured encounters.

clinical and physiologic consequences of CHD, even among patients with similar anatomical lesions. Thus, clinicians caring for these patients should likely focus more on using an anatomical-physiological classification of CHD, as recommended by the American Heart Association/American College of Cardiology guidelines

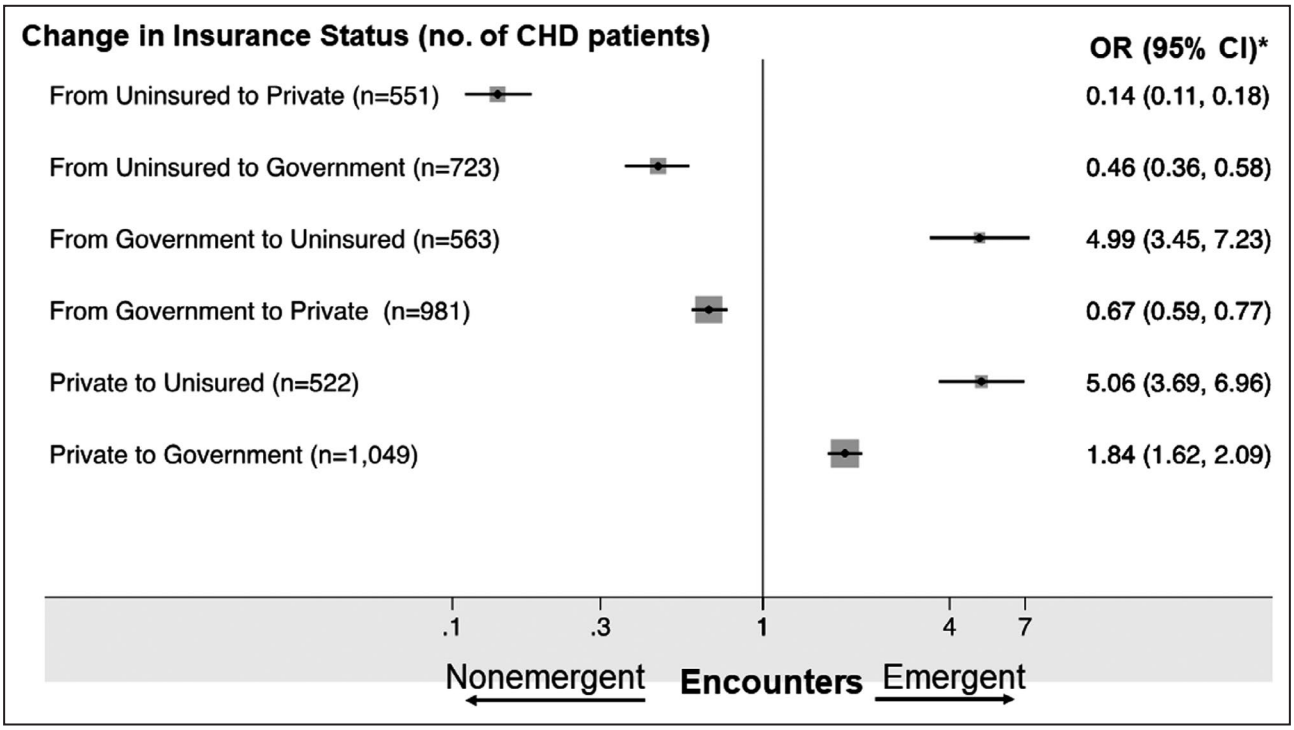

Figure 5. Odds of emergent to nonemergent encounters with change in insurance status among adults with congenital heart disease (CHD) in California, 2005 to 2015.
OR indicates odds ratio. *All *P* values are <0.0001. Grey square is centered at the adjusted odds ratio (black dots) and the line represents 95% CI. The area of the square is proportional to the weight of the corresponding variable.

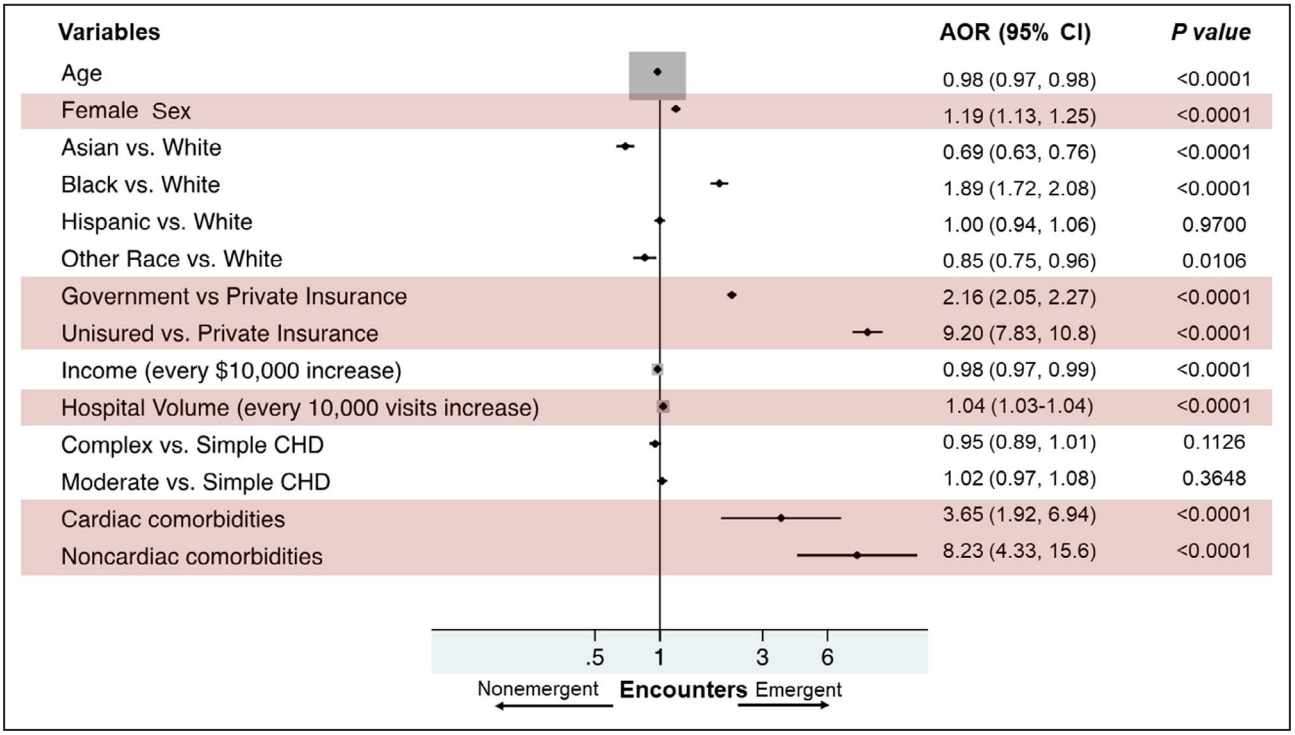

Figure 6. Factors associated with emergent versus nonemergent encounters among adults with congenital heart disease (CHD).
AOR indicates adjusted odds ratio (adjusted for all the characteristics listed in the figure).

and less so on lesion categories alone.[25] Other factors such as age, patient income, and hospital volumes based on annual visits had modest but significant associations with the type of encounters. Further detailed studies to understand the impact of these factors on hospital encounter type might be helpful. Interestingly, we observed that the median income of patients with uninsured encounters was similar to those with government insurance. Although the exact reasons are unknown but could be likely that the insurance information is less well documented or high premiums might have resulted in less patients opting for an insurance plan.

Limitations

This study has several limitations, primarily intrinsic to its retrospective nature and the use of an administrative database.[36] The *ICD-9* codes have imperfect sensitivity and specificity, and CHD may have been incorrectly coded. Because of this, we excluded patients with atrial septal defect, because it is known that coding for atrial septal defect versus patent foramen ovale is frequently incorrect.[22,31] Likewise, we excluded some other CHD diagnoses with nonspecific *ICD* codes and thus believe that we have a sample of patients with CHD with higher specificity for CHD than previous studies using administrative databases. Similarly, the comorbidities and primary diagnoses for which *ICD-9* codes were used could also have been imperfectly coded. But we used codes that have been previously used and validated in other studies. We analyzed all encounters of patients with a primary or secondary CHD diagnosis, but it is likely that comorbid CHD is not consistently coded and thus we may not have measured all the encounters. However, the miscoding of CHD is most likely to result in nondifferential misclassification in all insurance and encounter groups, and thus would tend to bias the results toward the null. Also, these limitations might be partially compensated for by the large size of the OSHPD database and a uniform representation of all regions of California. Clinical detail is often missing from administrative databases; thus, inherent patient differences, and variations in clinical presentation and characteristics could not be studied. The hospital nature of this database did not allow us to capture out-of-hospital encounters or intensity and quality of care before the encounters. Hence, we were unable to directly measure the association of insurance status on type of encounters by the quantity or quality of outpatient care. Currently, there is no existing database that includes information across all care settings (outpatient and inpatient) for patients with all insurance types (including the uninsured). Thus, we used the best currently available resource. Finally, further study using nationwide samples might provide data that could be more generalizable, although state-level data could be more informative about the impact of state-level policy

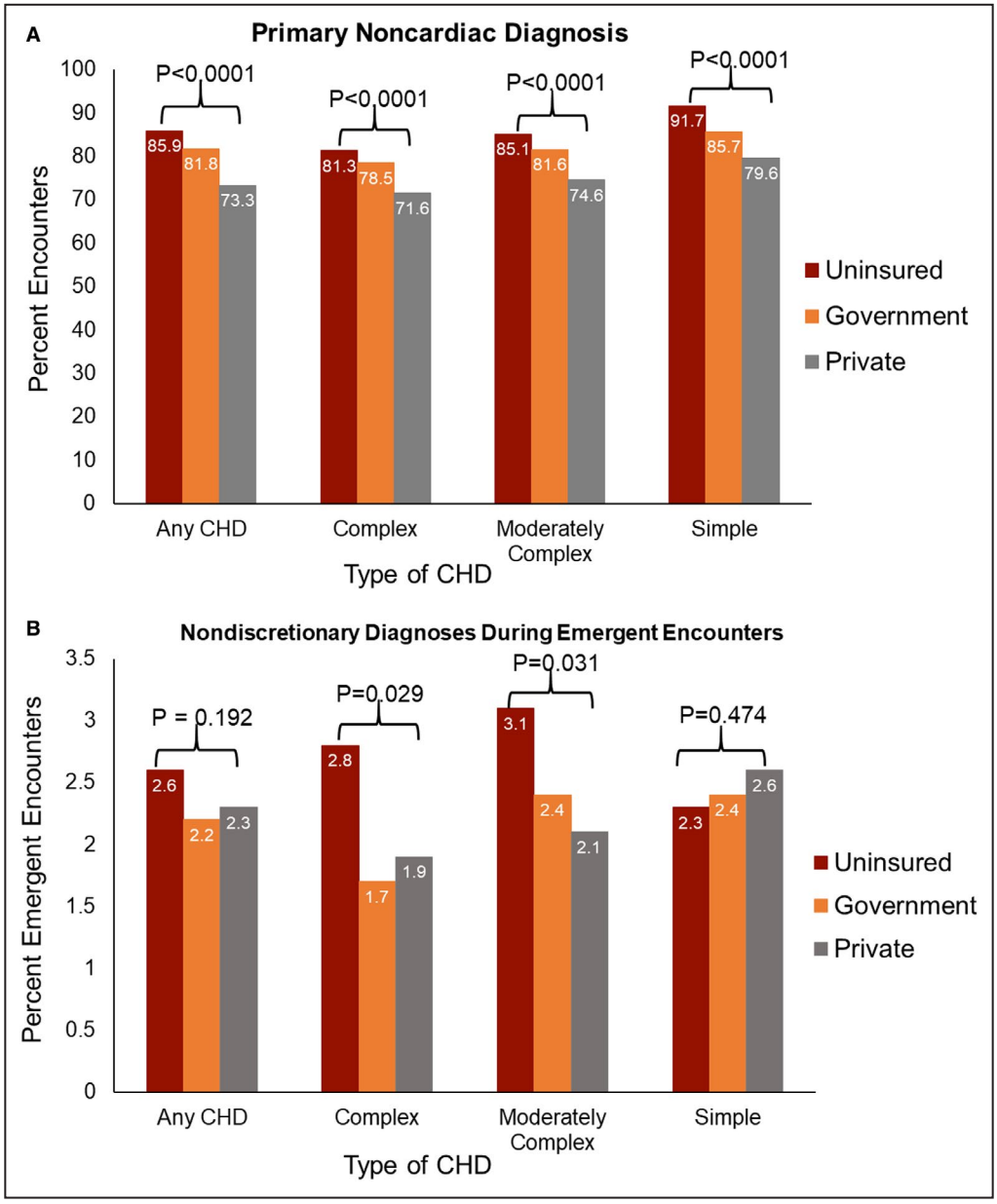

Figure 7. Prevalence of primary noncardiac (A) and nondiscretionary (B) diagnoses by type of congenital heart disease (CHD).
Red bars indicate percent of uninsured encounters; orange indicates percentage of government insured encounters; and grey bars are privately insured encounters. *P* value compares the prevalence of primary diagnoses among various insurance types. Complex CHD includes Eisenmenger, univentricular heart defects, transposition of the great arteries, tetralogy of Fallot, truncus arteriosus, and endocardial cushion defects. Moderately complex CHD includes Ebstein anomaly, coarctation of aorta, anomalies of the pulmonary artery, anomalies of the pulmonary valve, anomalies of the tricuspid valve, unspecified septal defects, anomalies of the great vein, subaortic stenosis and aortic anomalies. Simple CHD includes ventricular septal defect and patent ductus arteriosus.

changes on the type of care and outcomes. Finally, because the OSHPD data do not provide information about the actual costs of care, we were not able to evaluate the impact of insufficient insurance and associated medical bills (eg, copays, deductibles) on type of encounters.

In summary, our study builds on past work to help understand how insurance status affects the types of hospital encounters albeit for patients with chronic childhood disease, specifically those with CHD. As this population is more likely to use care and have more adverse outcomes compared with the general population,

a better understanding of what affects their care is vital and can also provide insight into other complex chronic disease populations. Insurance-related policies, especially Medicaid expansion and preexisting condition clause, are in particular critical health policy decisions that significantly affects the care we provide to adults with chronic childhood conditions, like CHD.

CONCLUSIONS

In this study of nearly all hospital encounters in California during a 11-year period, adult patients with CHD when uninsured had substantially more emergent versus nonemergent encounters than when insured, with evidence of a persistent disparity over time. Our findings suggest that efforts to enhance the ability to obtain and maintain insurance throughout the lifetime for patients with CHD might result in meaningful reductions in emergency encounters and a more efficient use of resources.

ARTICLE INFORMATION

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Supplementary Material

Data S1
Table S1
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SUPPLEMENTAL MATERIAL

Data S1.

Supplemental Methods

Identifying congenital heart disease (CHD) cohort:

Patients were identified as having CHD if they had a diagnosis code for any CHD lesion per International Classification of Disease, Ninth Revision (ICD-9) codes as listed below. If an ICD-9 code for CHD was present on any inpatient or outpatient claim at any billing position during the period of enrollment, these patients were then considered to have CHD. For patients with codes for more than one CHD diagnosis, we used the hierarchical algorithm proposed by Broberg et al.[22] to designate one condition per patient as their principal CHD diagnosis. We excluded ICD codes that have lower specificity for CHD, including atrial septal defect, bicuspid aortic valve, aortic stenosis, congenital mitral valve disease, anomalous coronary arteries and unspecified congenital anomalies. We also excluded any patients who had pregnancy or delivery related claims during the study period in order to avoid inclusion of pregnant women with fetuses affected by CHD.

Table S1. Types of Congenital Heart Disease (CHD) Lesions and their ICD-9 codes.

	ICD 9 codes
Complex lesions	
Eisenmenger (CHD code AND cyanosis)	782.5 PLUS other congenital code (782.5+745-747)
Hypoplastic left heart syndrome	746.7
Common ventricle	745.3
Transposition Complex	745.10, 745.11, 745.12, 745.19
Tetralogy of Fallot	745.2
Truncus Arteriosus	745.0
Endocardial Cushion Defect	745.60, 745.61,745.69
Moderately complex lesions	
Ebstein's Anomaly	746.2
Aortic Coarctation	747.10
Anomalies of the Pulmonary Artery (except pulmonary atresia)	747.31, 747.39
Anomalies of the Pulmonary Valve	746.0, 746.02, 746.09
Anomalies of the Tricuspid valve	746.1
Anomalies of Veins	747.4, 747.41, 747.42
Unspecified Defect of Septal Closure	745.9
Subaortic stenosis	746.81
Aortic anomalies	747.29
Simple CHD	
Ventricular septal defect	745.4
Patent ductus arteriosus	747.0

CHD – congenital heart disease, ICD – International classification of disease

Identifying Comorbidities: Several tools are available to identify comorbidities in administrative data. To estimate comorbidity rates, we modified the types of comorbidities listed in the Agency for Healthcare Research and Quality (AHRQ) Elixhauser comorbidity measures.[37] We made this modification because the AHRQ measure does not include some conditions that are important in CHD care (e.g., arrhythmias) and to combine some conditions for ease of presentation (e.g., combining diabetes with and without complications). First, the revised version of the Elixhauser comorbidities was modified to obtain 21 conditions. These modifications included; excluding valvular disorders (since CHD patients often have valvular problems as their inherent structural abnormality), combining two types of diabetes (diabetes with complication and diabetes without complication) into one condition (diabetes); combining two types of anemia (blood loss anemia and deficiency anemia) into one condition (anemia), combining neurodegenerative disorders and paralysis into one condition (neurologic disorder), combining psychosis and depression into one condition (psychiatric disorder), combining alcohol and drug use into one condition (substance abuse), and combining all types of tumors like lymphoma, metastasis and solid tumors into one condition (any tumor). Finally, four conditions were added: coronary artery disease [CAD] (410.x, 414.0x, 414.2x, 414.3x, 414.8x, 414.9x, I21.XX, I22.X, I25); stroke (431, 434, 436, 438, I61, I63, I64, I69); atrial or ventricular arrhythmias (427.31, 427.32, I48.0, I48.1, 427.41, 427.42, 427.5, I46.9, I49.01, I49.02) and hypercholesterolemia (272.0, 272.2, 272.4, E78.0, E78.2, E78.4).[38,39]

In sum, we assessed for the presence of a total of 25 comorbidities. We classified these into 2 categories:

- *Cardiac comorbidities:* congestive heart failure (CHF), arrhythmias, pulmonary circulation disorders, hypertension, hypercholesterolemia, coronary artery disease (CAD), peripheral vascular disorders (PVD), and stroke

- *Noncardiac comorbidities*: diabetes, obesity, neurologic disorder, hypothyroidism, liver disease, peptic ulcer, acquired immunodeficiency syndrome (AIDS), any tumor, rheumatoid arthritis/collagen vascular disease, coagulopathy, weight loss, fluid and electrolyte disorders, anemia, renal disease, substance abuse, psychiatric disorder and chronic pulmonary disease.

Figure S1. Trends in the numbers of all encounters (IA), emergent encounters (IB) and nonemergent encounters (IC) by insurance status, 2005-2015.

Red square indicates uninsured encounters; orange triangle indicate government insured encounters, and grey diamond are privately insured encounters