



# Population-Based Study of Congenital Heart Disease and Revisits After Pediatric Tonsillectomy

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**Objective:** Accurate assessment of risk factors such as congenital heart disease (CHD) can aid in risk stratification of children presenting for surgery. Risk stratification is especially important in tonsillectomy ± adenoidectomy (T/A), a common pediatric procedure that is usually performed electively, but that has a high rate of adverse events. In this study, we examined the association of CHD with revisits after T/A.

**Methods:** We identified children who underwent T/A at hospitals and hospital-owned facilities during 2010 to 2014 using the State Inpatient Databases and State Ambulatory Surgery and Services Databases of Florida, Georgia, Iowa, New York, and Utah. We evaluated the association between CHD severity and the occurrence of an unplanned hospital readmission or ED visit within 30 days following discharge using multivariable logistic regression.

**Results:** The analysis included 244,598 patients, of whom 858 had minor or major CHD. In multivariable analysis, CHD was not associated with an increased risk of 30-day revisits (minor OR = 1.1; 95% CI: 0.8, 1.5;  $P = .65$ ; major OR = 1.2; 95% CI: 0.9, 1.6;  $P = .34$ ). Other comorbidities, including chromosomal anomalies (OR = 1.4; 95% CI: 1.2, 1.6;  $P < .001$ ), congenital airway anomalies (OR = 1.3; 95% CI: 1.03, 1.7;  $P = .03$ ), and neuromuscular impairment (OR = 1.4; 95% CI: 1.2, 1.7;  $P < .001$ ) predicted an increased likelihood of revisits.

**Conclusion:** Neither minor nor major CHD was independently associated with an increased risk of 30-day revisits among children undergoing T/A. Other characteristics, particularly non-cardiac comorbidities, socioeconomic status, and geographic region may be of greater utility for predicting revisit risk following pediatric T/A.

**Key Words:** Congenital heart disease, tonsillectomy, risk stratification.

**Level of Evidence:** 2b

## INTRODUCTION

With improved surgical techniques and treatment options, children with congenital heart disease (CHD) are increasingly surviving to older ages.<sup>1</sup> An accurate assessment of risk factors in children with CHD presenting for non-cardiac surgery can aid in risk stratification of these patients.<sup>2</sup> Although serious perioperative adverse events related to CHD have been reported, the independent association of CHD with post-discharge outcomes remains unclear. Studies of a variety of surgical procedures performed primarily in infants and young children have generally found CHD to be associated with a greater risk of adverse postsurgical outcomes, such as increased risk of

readmissions or prolonged postoperative stay.<sup>2–11</sup> One previous study has described an increased risk of respiratory complications after T/A in children with CHD.<sup>12</sup> Yet, studies of procedures performed primarily in older children (eg, posterior spinal fusion) have typically found no association between CHD and postoperative outcomes.<sup>13–17</sup> Because common pediatric surgical procedures vary by age, the overall association of CHD with adverse outcomes in pediatric surgery can be difficult to characterize.

Notably, most recent studies examining the impact of CHD on adverse outcomes in non-cardiac surgery have used the National Surgical Quality Improvement Program-Pediatric (NSQIP-P) database.<sup>2,3,5,7–11,13–17</sup> While this database contains standardized information on patient comorbidities and surgical complications, only a select group of procedures are sampled for inclusion. Tonsillectomy with or without adenoidectomy (T/A), for example, is a very common procedure with a high rate of revisits (7–15%),<sup>18,19</sup> but this procedure is not included in the NSQIP-P database. Therefore, conclusions about risks of CHD drawn from studies using the NSQIP-P may not apply to this surgical population.

Knowledge of CHD history can influence risk stratification, preoperative assessment, and anesthetic management. A patient with CHD considered at high risk for adverse outcomes might undergo the procedure at a specialist center or require a pediatric cardiac anesthesiologist to provide perioperative care.<sup>20,21</sup> Risk stratification is especially important in T/A, which is almost always

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performed electively, thereby permitting greater flexibility in case scheduling and planned disposition, but is associated with a high rate of adverse events related to pain, bleeding, nausea/vomiting, and respiratory depression, up to and including mortality.<sup>18,19,22,23</sup> In this study, we examined whether CHD is associated with a higher risk of unplanned revisits following T/A. We hypothesized that patients with minor or major CHD would have a higher rate of hospital readmission or emergency department (ED) visit within 30 days of T/A.

## METHODS

### *Study Population and Data Source*

This study was deemed exempt from review by the Institutional Review Board at Nationwide Children's Hospital. We used 2010 to 2014 data from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SID) and State Ambulatory Surgery and Services Databases (SASD) of Florida, Georgia, Iowa, New York, and Utah.<sup>24</sup> Data in the SID and SASD are derived from discharge summaries and abstracts created by hospitals and other health-care facilities for billing purposes. The SID and SASD are population-based databases that include, respectively, records of all inpatient admissions and outpatient surgeries performed at a hospital or hospital-owned facility in a state. In some states, outpatient procedures performed at non-hospital owned facilities are also included in the SASD.<sup>24</sup> We identified patients <18 years of age who underwent T/A at a hospital or hospital-owned facility. Patients undergoing T/A were identified by an International Classification of Diseases, 9th revision (ICD-9) code of 28.2 or 28.3 or a Current Procedural Terminology (CPT) code of 42820, 42821, 42825, or 42826. We excluded procedures performed at non-hospital owned freestanding institutions because these institutions were not consistently included in the SASD across the selected states. The primary outcome was unplanned (non-elective) hospital readmission or ED visit within 30 days following discharge.

### *Definitions of CHD and Other Patient Comorbidities*

Patients with CHD were identified by the presence of an ICD-9 code of 745.0–746.85, 746.87–746.9, or 747.0–747.4 on the index surgery discharge record.<sup>25</sup> Complexity of CHD was classified as none, minor, or major, and identified by presence of minor, major, or unclassified CHD diagnoses (Table I).<sup>25</sup> Patients were classified as having minor CHD if one of the minor defects was the only CHD diagnosis listed on their discharge record. Patients with more than one minor defect, a major CHD diagnosis, or any unclassified CHD diagnosis were categorized for our analysis as having major CHD. Because the SID and SASD do not explicitly specify whether CHD has been corrected, correction status was not included in the classification scheme. Based on past literature, we controlled for other comorbidities listed among the discharge diagnosis codes for the surgical encounter, including obstructive sleep

TABLE I.  
Classification of Congenital Heart Defects as Major or Minor, Based on ICD-9 Code (N = 858).

Type of heart defect	ICD-9 Code	N (%)
<b>Minor congenital heart defects</b>		
Atrial septal defects	745.5	272 (32%)
Ventricle septal defects	745.4	177 (21%)
Patent ductus arteriosus	747.0	75 (9%)
Pulmonary stenosis	747.3, 747.31, 747.32, 747.39	31 (4%) <sup>†</sup>
Aortic stenosis	746.3	
<b>Major congenital heart defects</b>		
Coarctation of the aorta	747.10	30 (4%)
Transposition of the great artery	745.10	30 (4%)
Tetralogy of Fallot	745.2	28 (3%)
Hypoplastic left heart syndrome	746.7	13 (2%)
Pulmonary atresia	746.01	24 (3%)*
Total anomalous pulmonary venous return	747.41	
Tricuspid Atresia	746.1	
Truncus arteriosus	745.0	
Double-outlet ventricle	745.11	
Single ventricle	745.3	
Ebstein's anomaly	746.2	
Aortic interruption/atresia/stenosis	747.11, 747.22	
<b>Unclassified congenital heart defect</b>		302 (35%)

ICD-9 = International Classification of Diseases, 9<sup>th</sup> revision  
\*Categories Pulmonary atresia through Aortic interruption/atresia/stenosis collapsed to maintain confidentiality, due to incidence of ≤10.

apnea (ICD-9 327.23), chromosomal anomaly (ICD-9 758), congenital airway anomaly (ICD-9 748), and neuromuscular impairment (ICD-9 318, 330, 334, 335, 343, 359, 740-742, 754-756).<sup>6,26</sup>

### *Statistical Analysis*

Continuous variables were expressed as a median with interquartile range (IQR) and were compared between groups (defined by presence and severity of CHD) using rank-sum tests. Categorical variables were expressed as a count with proportion and compared between groups using Chi-square tests or Fisher's exact tests, as applicable. For the primary analysis, we used multivariable mixed effects logistic regression models to evaluate the risk of unplanned revisits according to CHD presence and severity. These models included a hospital-level random intercept effect to account for the clustering of patients within hospitals. Covariates included the following characteristics at the time of surgery: age (0–3, 4–9, or 10–17), gender, insurance status (public, private, or other), ambulatory procedure, the facility location (state and whether the facility was in a rural or urban area), year of surgery, surgery type (tonsillectomy alone vs. tonsillectomy and adenoidectomy), national median household income quartile of the patient's ZIP code of residence, and the comorbidities listed above.<sup>6,22,26,27</sup> As a secondary analysis, we stratified patients according to inpatient status and evaluated the risk of an unplanned

hospital revisit within these subpopulations using multivariable mixed effects logistic regression.

In further analysis, we examined the incidence of common reasons for revisit within 30 days, including pain (ICD-9 = 338.18, 338.19, 338.28, 780.96, 784.00, 784.1), bleeding (ICD-9 = 784.7, 784.8, 998.1, 998.11), nausea/vomiting (ICD-9 = 787.0, 787.01, 787.02, 787.03, 787.04), fever (ICD-9 = 780.6, 780.61, 780.62), and dehydration (ICD-9 = 276.51). Rates of revisits for these reasons were compared between patients with and without CHD using Chi-square tests. Statistical analysis was performed using

Stata/IC 14.2 (StataCorp, LP, College Station, TX) with two-tailed  $P < .05$  considered statistically significant.

## RESULTS

We identified 246,703 patients age < 18 years who underwent T/A in a hospital or hospital-owned facility in Florida, Georgia, Iowa, New York, or Utah in 2010 to 2014. We excluded 2105 patients missing information on length of stay. Of the remaining 244,598 patients (median age: 6 years [IQR: 4, 9]; 50% male/50% female), 431 (0.2%) had minor CHD and 427 (0.2%) had major CHD. Specific

TABLE II.  
Patient and Procedural Characteristics and Outcomes in Children Undergoing Tonsillectomy ± Adenoidectomy, According to Presence and Severity of Congenital Heart Disease (N = 244,598).

Characteristics	Severity of congenital heart disease			P-value*	
	None (N = 243,740) N (%)	Minor (N = 431) N (%)	Major (N = 427) N (%)	None vs. Minor	None vs. Major
Readmission or ED visit	18,289 (8%)	46 (11%)	48 (11%)	.01	.003
Age					
0-3 years	58,754 (24%)	217 (50%)	157 (37%)	<.001	<.001
4-9 years	130,419 (54%)	169 (39%)	202 (47%)		
10-17 years	54,567 (22%)	45 (10%)	68 (16%)		
Female	121,295 (50%)	211 (49%)	202 (47%)	.74	.31
Insurance status					
Private	123,450 (51%)	192 (45%)	198 (46%)	.02	.12
Public	107,501 (44%)	220 (51%)	209 (49%)		
Other	12,542 (5%)	19 (4%)	19 (4%)		
Median household income quartile by ZIP code					
1 Poorest	59,996 (25%)	115 (27%)	108 (26%)	.12	.68
2	68,051 (28%)	112 (26%)	112 (27%)		
3	66,558 (28%)	104 (24%)	112 (27%)		
4 Wealthiest	45,624 (19%)	96 (22%)	88 (21%)		
Comorbidities					
Obstructive sleep apnea	56,090 (23%)	227 (53%)	192 (45%)	<.001	<.001
Chromosomal anomaly	1661 (1%)	140 (32%)	102 (24%)	<.001	<.001
Congenital airway anomaly	585 (0.2%)	25 (6%)	†	<.001	<.001
Neuromuscular impairment	1359 (1%)	36 (8%)	34 (8%)	<.001	<.001
Tonsillectomy alone	25,375 (10%)	56 (13%)	46 (11%)	.08	.81
Inpatient	11,000 (5%)	126 (29%)	122 (29%)	<.001	<.001
Facility State					
Florida	62,691 (26%)	118 (27%)	114 (27%)	.02	.15
Georgia	46,991 (19%)	95 (22%)	85 (20%)		
Iowa	22,391 (9%)	21 (5%)	41 (10%)		
New York	76,483 (31%)	129 (30%)	112 (26%)		
Utah	35,184 (14%)	68 (16%)	75 (18%)		
Rural location	20,536 (8%)	23 (5%)	32 (8%)	.02	.50
Year of surgery					
2010	48,349 (20%)	82 (19%)	88 (21%)	.02	.12
2011	55,436 (23%)	77 (18%)	85 (20%)		
2012	50,637 (21%)	92 (21%)	75 (18%)		
2013	47,700 (20%)	84 (19%)	92 (22%)		
2014	41,618 (17%)	96 (22%)	87 (20%)		

ED = emergency department; IQR = interquartile range.

\*P-values are based on the Chi-square statistic.

†Category counts not listed to maintain confidentiality, due to incidence of ≤10.

TABLE III.  
Patient and Procedural Characteristics and Outcomes in Children Undergoing Inpatient Tonsillectomy ± Adenoidectomy, According to Presence and Severity of Congenital Heart Disease (N = 11,248).

Characteristics	Severity of congenital heart disease			P-value*	
	None (N = 11,000) N (%)	Minor (N = 126) N (%)	Major (N = 122) N (%)	None vs. Minor	None vs. Major
Readmission or ED visit	1,164 (11%)	13 (10%)	23 (19%)	.92	.003
Age					
0-3 years	5,868 (53%)	82 (65%)	62 (51%)	.02	.56
4-9 years	3,661 (33%)	34 (27%)	46 (38%)		
10-17 years	1,471 (13%)	‡	14 (11%)		
Female	4,563 (41%)	57 (45%)	57 (47%)	.36	.40
Insurance status					
Private	3,904 (36%)	43 (34%)	45 (37%)	.42	.86
Public	6,666 (61%)	81 (64%)	71 (59%)		
Other	420 (4%)	†	†		
Median household income quartile by ZIP code					
1 Poorest	3,492 (34%)	43 (35%)	41 (35%)	.93	.40
2	2,271 (22%)	24 (19%)	18 (15%)		
3	2,277 (22%)	28 (23%)	28 (24%)		
4 Wealthiest	2,367 (23%)	29 (23%)	30 (26%)		
Comorbidities					
Obstructive sleep apnea	7,567 (69%)	101 (80%)	93 (76%)	.006	.08
Chromosomal anomaly	485 (4%)	64 (51%)	51 (42%)	<.001	<.001
Congenital airway anomaly	235 (2%)	14 (11%)	†	<.001	<.001
Neuromuscular impairment	540 (5%)	18 (14%)	24 (20%)	<.001	<.001
Tonsillectomy alone	1,034 (9%)	13 (10%)	12 (10%)	.73	.87
Facility State					
Florida	3,894 (35%)	34 (27%)	30 (25%)	<.001	<.001
Georgia	939 (8%)	24 (19%)	15 (12%)		
Iowa	258 (2%)	†	†		
New York	5,377 (49%)	45 (36%)	51 (42%)		
Utah	532 (5%)	19 (15%)	20 (16%)		
Rural location	342 (3%)	†	†	.59	.03
Year of surgery					
2010	2,229 (20%)	25 (20%)	28 (23%)	.13	.77
2011	2,502 (23%)	18 (14%)	26 (21%)		
2012	2,162 (20%)	24 (19%)	19 (16%)		
2013	2,190 (20%)	30 (24%)	26 (21%)		
2014	1,917 (17%)	29 (23%)	23 (19%)		

ED = emergency department; IQR = interquartile range.

\*P-values are based on the Chi-square statistic when counts are ≥5 and Fisher's exact test when <5.

†Category counts not listed to maintain confidentiality, due to incidence of ≤10.

diagnoses among patients with CHD are described in Table I. Obstructive sleep apnea was a common comorbidity (23%), while chromosomal anomalies (1%), neuromuscular impairment (1%), and congenital airway anomalies (0.3%) were relatively rare. In the overall cohort, 18,383 patients (8%) had at least one revisit within 30 days of discharge. Among the 21,591 total revisits, 18,855 (87%) were ED visits and 2,736 (13%) were hospital revisits. Among the 18,383 patients with a revisit, 2714 (15%) had multiple revisits within 30 days.

On bivariate analysis, 8% of patients without CHD had at least one revisit, as compared to 11% of patients

with minor CHD ( $P = .01$ ) and 11% of patients with major CHD ( $P = .003$ ). Patient and procedural characteristics are compared according to severity of CHD in Table II. Patients with CHD were generally younger, and more often had comorbidities including obstructive sleep apnea, chromosomal anomalies, congenital airway anomalies, and neuromuscular impairment. Patients with CHD were also more likely to have public insurance, although they did not differ from patients without CHD with regard to the median household income in their ZIP code of residence. Patients with CHD were more likely to undergo inpatient procedures and less likely to undergo tonsillectomy

TABLE IV.  
Patient and procedural characteristics and outcomes in children undergoing outpatient tonsillectomy ± adenoidectomy, according to presence and severity of congenital heart disease (N = 233,350).

Characteristics	Severity of congenital heart disease			P-value*	
	None (N = 232,740)	Minor (N = 350)	Major (N = 350)	None vs. Minor	None vs. Major
	N (%)	N (%)	N (%)		
Readmission or ED visit	17,125 (7%)	33 (11%)	25 (8%)	.02	.58
Age					
0–3 years	52,826 (23%)	135 (44%)	95 (31%)	<.001	<.001
4–9 years	126,758 (54%)	135 (44%)	156 (51%)		
10–17 years	53,096 (23%)	35 (11%)	54 (18%)		
Female	116,732 (50%)	154 (20%)	145 (48%)	.91	.36
Insurance status					
Private	119,546 (51%)	149 (49%)	153 (50%)	.67	.75
Public	100,835 (43%)	139 (46%)	138 (45%)		
Other	12,122 (5%)	17 (6%)	14 (5%)		
Median household income quartile by ZIP code					
1 Poorest	56,504 (25%)	72 (24%)	67 (22%)	.43	.71
2	65,780 (29%)	88 (29%)	94 (31%)		
3	64,281 (28%)	76 (25%)	84 (28%)		
4 Wealthiest	43,257 (19%)	67 (22%)	58 (19%)		
Comorbidities					
Obstructive sleep apnea	48,523 (21%)	126 (41%)	99 (32%)	<.001	<.001
Chromosomal anomaly	1176 (1%)	76 (25%)	51 (17%)	<.001	<.001
Congenital airway anomaly	350 (0.2%)	11 (4%)	†	<.001	.078
Neuromuscular impairment	819 (0.4%)	18 (6%)	†	<.001	<.001
Tonsillectomy alone	24,341 (10%)	43 (14%)	34 (11%)	.04	.70
Facility State					
Florida	58,797 (25%)	84 (28%)	84 (28%)	.07	.002
Georgia	46,052 (20%)	71 (23%)	70 (23%)		
Iowa	22,133 (10%)	17 (6%)	35 (11%)		
New York	71,106 (31%)	84 (28%)	61 (20%)		
Utah	34,652 (15%)	49 (16%)	55 (18%)		
Rural location	20,194 (9%)	18 (6%)	24 (8%)	.08	.63
Year of surgery					
2010	46,120 (20%)	57 (19%)	60 (20%)	.14	.21
2011	52,934 (23%)	59 (19%)	59 (19%)		
2012	48,475 (21%)	68 (22%)	56 (18%)		
2013	45,510 (20%)	54 (18%)	66 (22%)		
2014	39,701 (17%)	67 (22%)	64 (21%)		

ED = emergency department; IQR = interquartile range.

\*P-values are based on the Chi-square statistic when counts are ≥5 and Fisher's exact test when <5.

†Category counts not listed to maintain confidentiality, due to incidence of ≤10.

without adenoidectomy. When examining inpatient (Table III) and outpatient (Table IV) procedures separately, in both groups patients with CHD more often had comorbidities. In the outpatient group, patients with CHD were still generally younger, but in the inpatient group, this trend only held for patients with minor CHD. Additionally, among both inpatients and outpatients, neither insurance coverage nor zip code-level median household income varied between patients with and without CHD.

In multivariable analysis (Table V), CHD severity was not associated with an increased risk of 30-day

revisits (minor CHD OR = 1.1; 95% CI: 0.8, 1.5; *P* = .65; major CHD OR = 1.2; 95% CI: 0.9, 1.6; *P* = .34). When considering other comorbidities, chromosomal anomalies (OR = 1.4; 95% CI: 1.2, 1.6; *P* < .001), congenital airway anomalies (OR = 1.3; 95% CI: 1.03, 1.7; *P* = .03), and neuromuscular impairment (OR = 1.4; 95% CI: 1.2, 1.7; *P* < .001) were associated with an increased risk of 30-day revisits, but obstructive sleep apnea was not (OR = 1.0; 95% CI: 1.0, 1.0; *P* = .88). Compared to patients aged 0 to 3 years, patients aged 4 to 9 years had a decreased risk of complications (OR = 0.9; 95% CI: 0.8, 0.9; *P* < .001),

TABLE V.  
Mixed Effects Logistic Regression Model for Occurrence of  
Readmission or Emergency Department Visit Following Pediatric  
Tonsillectomy ± Adenoidectomy (N = 240,774).

Characteristics	OR	95% CI	P-value
CHD complexity			
None	Ref.		
Minor	1.08	(0.79, 1.48)	.65
Major	1.17	(0.85, 1.61)	.34
Age			
0–3 years	Ref.		
4–9 years	0.86	(0.83, 0.89)	<.001
10–17 years	1.16	(1.10, 1.21)	<.001
Female	0.99	(0.96, 1.02)	.47
Insurance status			
Private	Ref.		
Public	1.79	(1.73, 1.85)	<.001
Other	1.27	(1.17, 1.37)	<.001
Median household income quartile by ZIP code			
1 Poorest	Ref.		
2	0.94	(0.90, 0.98)	.007
3	0.84	(0.80, 0.88)	<.001
4 Wealthiest	0.72	(0.68, 0.77)	<.001
Comorbidities			
Obstructive sleep apnea	1.00	(0.96, 1.04)	.88
Chromosomal anomaly	1.41	(1.21, 1.63)	<.001
Congenital airway anomaly	1.32	(1.03, 1.69)	.03
Neuromuscular impairment	1.40	(1.18, 1.65)	<.001
Tonsillectomy alone	1.12	(1.07, 1.18)	<.001
Inpatient	1.15	(1.06, 1.23)	<.001
Facility State			
Utah	Ref.		
Florida	2.51	(2.04, 3.09)	<.001
Georgia	3.34	(2.70, 4.11)	<.001
Iowa	2.39	(1.92, 2.98)	<.001
New York	3.04	(2.49, 3.72)	<.001
Rural location of facility	0.94	(0.88, 1.01)	.10
Year of surgery			
2010	Ref.		
2011	1.08	(1.03, 1.14)	.001
2012	1.13	(1.08, 1.19)	<.001
2013	1.15	(1.09, 1.21)	<.001
2014	1.20	(1.14, 1.26)	<.001

CHD = congenital heart disease; CI = confidence interval; OR = odds ratio.

whereas patients aged 10 to 17 years had an increased risk (OR = 1.2; 95% CI: 1.1, 1.2;  $P < .001$ ). Compared to private insurance, public insurance and other coverage were associated with an increased risk of revisits. Residence in wealthier ZIP codes was associated with a decreased risk of revisits. Inpatient status and undergoing surgery in a more recent year were also associated with increased risk of 30-day revisits, while undergoing tonsillectomy without adenoidectomy was associated with

increased risk. Compared to patients with procedures performed in Utah, patients who underwent procedures in the other states examined had significantly higher rates of 30-day revisits. The likelihood ratio test showed that revisit rates differed at the hospital level ( $\chi^2 = 1629$ ,  $P < .001$ ). When patients with one unclassified CHD diagnosis were reclassified as having minor CHD, CHD severity was still not associated with an increased risk of 30-day revisits (minor CHD OR = 1.1; 95% CI: 0.8, 1.4;  $P = .65$ ; major CHD OR = 1.4; 95% CI: 0.9, 2.2;  $P = .18$ ). In a supplemental analysis of 198,057 patients treated in New York, Florida, Georgia, and Iowa who also had available data on race/ethnicity, we found that, after adjustment for all patient and procedural characteristics previously described, as compared to non-Hispanic white patients, black patients (OR = 1.0; 95% CI: 1.0, 1.0;  $P = .91$ ) or Hispanic patients (OR = 1.0; 1.0, 1.1;  $P = .17$ ) did not have a change in revisit risk. However, patients of other race/ethnicity (OR = 0.9; 95% CI: 0.8, 0.96;  $P = .001$ ) had a lower revisit risk.

When patients were stratified according to inpatient status (Table VI), CHD severity was still not associated with an increased risk of 30-day revisits for either inpatients (minor CHD OR = 0.8; 95% CI: 0.4, 1.4;  $P = .44$ ; major CHD OR = 1.5; 95% CI: 0.9, 2.4;  $P = .15$ ) or outpatients (minor CHD OR = 1.3; 95% CI: 0.9, 1.8;  $P = .22$ ; major CHD OR = 1.0; 95% CI: 0.7, 1.5;  $P = .99$ ). Compared to patients age 0 to 3, patients age 4 to 9 years still had a decreased risk of revisits in the outpatient population, but not in the inpatient population; patients age 10 to 17 still had an increased risk of revisits in both groups. Median household income quartile and year of surgery were still associated with revisits in the outpatient population, but not in the inpatient population. Neuromuscular impairment was only associated with revisits in the inpatient population, while congenital airway anomaly was no longer associated with revisit risk in either subpopulation.

Reasons for revisits are summarized according to the presence of CHD in Table VII. In the overall cohort, reasons for revisit included bleeding (23%), dehydration (20%), pain (18%), fever (12%), and nausea (11%). Bleeding was a more common reason for patients without CHD (23%) than for patients with CHD (14%;  $P = .03$ ). Patients with CHD were more likely to return for an unplanned visit for reasons other than bleeding, dehydration, pain, nausea, or fever (47%) compared to patients without CHD (34%;  $P = .004$ ). Among patients with CHD who revisited for other reasons, 25 (45%) revisits were potentially related to the patient's CHD.

## DISCUSSION

Proposed risk scores for pediatric surgery have specifically included CHD as a marker of increased risk for adverse outcomes.<sup>28–30</sup> However, the association between CHD and outcomes such as unplanned revisits may vary by procedure and patient population. We have evaluated the association of CHD with revisits after T/A, a common

TABLE VI.  
Mixed Effects Logistic Regression Model for Occurrence of Readmission or Emergency Department Visit Following Pediatric Tonsillectomy ± Adenoidectomy, Stratified by Inpatient Status (N = 240,774).

Characteristics	Inpatient (N = 10,637)			Outpatient (N = 230,137)		
	OR	95% CI	P-value	OR	95% CI	P-value
CHD complexity						
None	Ref.			Ref.		
Minor	0.79	(0.43, 1.44)	0.44	1.26	(0.87, 1.83)	.22
Major	1.45	(0.87, 2.43)	0.15	1.00	(0.66, 1.52)	.99
Age						
0–3 years	Ref.			Ref.		
4–9 years	0.95	(0.82, 1.10)	0.47	0.85	(0.82, 0.89)	<.001
10–17 years	1.29	(1.07, 1.56)	0.008	1.14	(1.09, 1.20)	<.001
Female	1.01	(0.89, 1.15)	0.88	0.99	(0.96, 1.02)	.43
Insurance status						
Private	Ref.			Ref.		
Public	1.44	(1.24, 1.67)	<0.001	1.81	(1.75, 1.88)	<.001
Other	1.14	(0.79, 1.64)	0.50	1.27	(1.17, 1.38)	<.001
Median household income quartile by ZIP code						
1 Poorest	Ref.			Ref.		
2	1.06	(0.89, 1.26)	0.54	0.94	(0.90, 0.98)	.003
3	1.08	(0.90, 1.30)	0.41	0.83	(0.79, 0.87)	<.001
4 Wealthiest	0.91	(0.73, 1.13)	0.39	0.71	(0.67, 0.76)	<.001
Comorbidities						
Obstructive sleep apnea	1.05	(0.90, 1.22)	0.55	1.00	(0.96, 1.04)	.99
Chromosomal anomaly	1.44	(1.10, 1.87)	0.007	1.37	(1.14, 1.64)	.001
Congenital airway anomaly	1.28	(0.88, 1.88)	0.20	1.37	(0.98, 1.90)	.06
Neuromuscular impairment	1.61	(1.25, 2.07)	<0.001	1.22	(0.98, 1.55)	.08
Tonsillectomy alone	0.99	(0.79, 1.25)	0.96	1.13	(1.07, 1.19)	<.001
Facility State						
Utah	Ref.			Ref.		
Florida	2.28	(1.18, 4.38)	0.01	2.47	(2.00, 3.05)	<.001
Georgia	2.55	(1.24, 5.24)	0.01	3.30	(2.67, 4.08)	<.001
Iowa	1.50	(0.66, 3.37)	0.33	2.40	(1.92, 2.99)	<.001
New York	2.58	(1.35, 4.94)	0.004	2.99	(2.44, 3.67)	<.001
Rural location of facility	1.45	(1.04, 2.03)	0.03	0.93	(0.87, 0.99)	.04
Year of surgery						
2010	Ref.			Ref.		
2011	0.92	(0.76, 1.12)	0.40	1.10	(1.04, 1.16)	<.001
2012	1.02	(0.83, 1.24)	0.87	1.15	(1.09, 1.21)	<.001
2013	0.97	(0.80, 1.19)	0.78	1.17	(1.11, 1.23)	<.001
2014	1.10	(0.89, 1.34)	0.37	1.21	(1.14, 1.28)	<.001

CHD = congenital heart disease; CI = confidence interval; OR = odds ratio.

pediatric procedure with a high rate of revisits that has been excluded from many past studies exploring the contribution of CHD to adverse postoperative outcomes. Our findings suggest that neither minor nor major CHD are independently associated with an increased risk of hospital readmissions or ED visits among children undergoing T/A. This finding suggests that characteristics other than CHD may be more useful for predicting the risk of revisit following T/A. In particular, toddler or adolescent age group, non-cardiac comorbidities (such as chromosomal anomalies, congenital airway anomalies, or neuromuscular

impairment), procedural characteristics (such as undergoing tonsillectomy with adenoidectomy), and low socioeconomic status (use of public insurance or low median household income in the ZIP code of residence) may be better predictors of revisit risk.

One previous study has described an increased risk of respiratory complications after T/A in children with CHD.<sup>3</sup> However, considering a broader outcome of all unplanned revisits, we did not find that CHD independently contributed to revisit risk after this procedure. Our findings add to a previous study which found that

TABLE VII.

Reasons for Readmission or Emergency Department Visit Among Children Undergoing Tonsillectomy ± Adenoidectomy, According to Presence of Congenital Heart Disease (N = 21,591)\*.

Reasons for revisit	No CHD (N = 21,471)	CHD (N = 120)	P-value <sup>†</sup>
Bleeding	4840 (23%)	17 (14%)	.03
Dehydration	4290 (20%)	18 (15%)	.17
Pain	3889 (18%)	17 (14%)	.26
Fever	2556 (12%)	13 (11%)	.72
Nausea/vomiting	2300 (11%)	13 (11%)	.97
None of the above	7326 (34%)	56 (47%)	.004

\*Total number of readmissions or emergency department visits within 30 days.

<sup>†</sup>P-values are based on the Chi-square statistic.

CHD = congenital heart disease.

ambulatory procedures can be safely performed in children with CHD with a relatively low rate of unanticipated hospital admissions immediately following surgery.<sup>31</sup> Our results are also similar to prior studies reporting no excess risk of postoperative complications due to CHD, which have explored procedures other than T/A using the NSQIP-P registry.<sup>13–17</sup> In line with these studies, our analytic sample included a population of relatively older children, with a median age of 6 years. Meanwhile, the association of CHD with revisit risk appears strongest in studies that focus on younger children.<sup>2–11</sup>

Although our study found no excess revisit risk due to CHD, it is important to note that pediatric health care providers typically take additional precautions when treating a patient with known CHD. Institutional practices may include specific algorithms for treating patients known to have CHD, and the success of current practices at mitigating risk could account for the lack of association between CHD and unplanned revisits. As T/A is primarily an elective procedure, institutions are able to plan appropriate accommodations for patients with CHD. For example, our institution previously reported our practice of scheduling patients with CHD to undergo T/A in the main operating rooms as opposed to the ambulatory surgery center.<sup>32</sup>

The overall revisit rate in our study was 8%, which falls within the range of revisit rates reported by previous studies (7–15%).<sup>18,19</sup> When examining reasons for revisits, patients with CHD were less likely than patients without CHD to have revisits due to bleeding, but similarly likely to have revisits due to pain, nausea/vomiting, dehydration, or fever. Patients with CHD also had fewer overall revisits attributed to one of these causes, a significant proportion of which may have been related to their cardiac comorbidity. Despite the differences in reasons for revisit, the overall rate of unplanned revisits did not differ by CHD presence or severity.

The conclusions from our study are subject to several limitations. First, in comparison to previous studies using the NSQIP-P database, some variables are unavailable in the HCUP state databases. This includes American Society of Anesthesiologists (ASA) status and use of inotropic support. However, even without controlling for these more granular measures of comorbidity, we found that

CHD was not independently associated with an increased risk of revisits after T/A. Second, the NSQIP-P contains information on specific comorbidities identified in the patient medical record by trained raters. By contrast, when using the HCUP, comorbidities had to be identified by ICD-9 codes, which are less accurate. Because we identified CHD using ICD-9 codes listed for the index procedure, under-reporting of CHD may have limited identification of these patients.<sup>25</sup> As with any study using administrative data, the identification of CHD and other comorbidities was dependent on the correct entry of diagnosis codes, leading to potential misclassification error. Such misclassification could have biased the association between CHD and adverse outcomes after tonsillectomy. Additionally, because ICD-9 codes do not indicate whether CHD has been corrected, our measure of CHD severity does not adequately capture patients' functional status. Finally, this study was limited by the lack of information on specific institutional practices related to performing T/A in patients with CHD. Without this information, we can only conclude that there is no excess risk of unplanned revisits due to CHD given the institutional practices existing at the time of data collection.

## CONCLUSION

In sum, our analysis of a large multi-state data set found no excess risk of 30-day revisits associated with CHD in children undergoing T/A. This provides further evidence for the safety of non-cardiac elective surgery performed in children with CHD. Furthermore, because this finding is for a common pediatric surgery not included in the NSQIP-P, these results indicate caution when generalizing risk scoring systems developed from the NSQIP-P to procedures or populations not sampled in this database. With the mix of common pediatric procedures varying by patient age, accounting for age and procedure may be important for refining predictive models for surgical risk in children.

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