Cureus
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Factors Associated With Revision Palatine Tonsillectomy in Pediatric Patients

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Review began 09/29/2026
Review ended 10/27/2026
Published 11/01/2026

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DOI: 10.7759/cureus.118956

Abstract

Introduction

Revision tonsillectomy is uncommon but increasingly relevant as more surgeons adopt intracapsular techniques. As Current Procedural Terminology (CPT) coding does not allow for differentiation between intracapsular and extracapsular tonsillectomy, all pediatric cases must be considered collectively. We therefore aimed to explore whether demographic and/or clinical characteristics were associated with revision palatine tonsillectomy among children aged 17 years or younger, irrespective of surgical technique, to inform patient counseling.

Methods

A retrospective cohort study was conducted using the PearlDiver Mariner database, a national claims database including approximately half of Americans across private and federally funded insurance carriers from 2010-2023. Pediatric patients undergoing palatine tonsillectomy were identified by CPT codes and divided into revision and no-revision cohorts. Revision was defined as a subsequent tonsillectomy code recorded at least 30 days after the initial procedure. Demographics, comorbidities, and care setting were compared, and multivariable logistic regression identified factors independently associated with revision. Secondary outcomes included revision rates by geographic region and care setting.

Results

Of 1,493,209 pediatric tonsillectomy patients, 3,660 (0.25%) underwent revision. Revision patients were younger (mean 5.0 vs 7.2 years, p<0.001) and more often male (54.5% vs 48.9%, p<0.001), although male sex was not independently associated with revision after adjustment (OR 1.03, 95% CI 0.97-1.10). On multivariable analysis, each additional year of age was associated with lower odds of revision (OR 0.80, 95% CI 0.79-0.81). Higher odds of revision were observed for patients with trisomy 21 (OR 2.08, 95% CI 1.49-2.91; revision rate 1.1%), obesity (OR 1.80, 95% CI 1.66-1.94), and lymphoproliferative disorders (OR 1.90, 95% CI 1.21-2.98). Revision rates were highest in the Northeast (0.38%) and after tonsillectomy performed in the inpatient setting (0.70%) compared with the outpatient setting (0.24%).

Conclusion

In this large national cohort, revision tonsillectomy was rare. Younger age, obesity, trisomy 21, and lymphoproliferative disorders were independently associated with higher odds of revision, although absolute risk remained low in every subgroup. These findings may inform preoperative counseling. Whether these findings should alter surgical technique or perioperative management requires prospective study that distinguishes intracapsular from extracapsular techniques.

Categories: Otolaryngology, Pediatric Surgery, Pediatrics
Keywords: coblation, extracapsular tonsillectomy, intracapsular tonsillectomy, pediatric tonsillectomy, repeat tonsillectomy, repeat tonsillotomy, revision tonsillectomy, tonsillotomy

Introduction

Tonsillectomy and adenotonsillectomy (T&A) are among the most frequently performed pediatric surgeries in the United States, with an estimated 5 to 8 procedures per 1,000 children annually [1].

The traditional extracapsular tonsillectomy (ECT), in which the tonsil and its capsule are completely excised from the pharyngeal musculature, remains effective but is associated with notable postoperative morbidity, including pain and hemorrhage [2]. In recent years, intracapsular tonsillectomy (ICT) has gained popularity due to faster recovery, reduced postoperative pain, and decreased bleeding risk [3]. Using coblation or other microdebrider-based techniques, ICT removes the majority of tonsillar tissue while preserving a thin rim along the capsule to protect underlying muscle. However, this residual tissue carries the potential for

regrowth, which may necessitate revision tonsillectomy [4].

As ICT becomes more widely adopted, revision tonsillectomy, although rare, has become an increasingly relevant outcome of interest. Current literature reports reoperation rates ranging from 0.5% to 6.1%, with a meta-analysis in 2023 finding the reoperation rate after ICT to be 1.4% based upon six studies with a total of 7,720 patients [5,6]. In comparison, a 2017 meta-analysis reported hemorrhage-related revisit, readmission, or reoperation rates of 0.2% to 5.7% after total (extracapsular) tonsillectomy [7].

Previous studies have proposed several factors that may increase the likelihood of tonsillar regrowth requiring revision surgery, including younger age (<5 years), frequent upper respiratory infections, high dietary sugar intake, history of gastroesophageal reflux, comorbid allergic rhinitis or asthma, and indications for primary T&A of upper airway obstructive symptoms or middle ear disease [8-10]. Several of these factors, such as dietary sugar intake and frequency of upper respiratory infections, are not reliably captured in insurance claims databases such as the one used in this study. Because procedural codes do not differentiate between ECT and ICT, population-level data on revision tonsillectomy remain limited, and it is unknown which patient characteristics are associated with revision when all tonsillectomy techniques are considered together.

The present study utilizes a large national claims database to address this gap. Our primary aim was to explore whether demographic or clinical characteristics were associated with revision palatine tonsillectomy, defined as a repeat tonsillectomy code recorded at least 30 days after the initial tonsillectomy, among children 17 years or younger in the PearlDiver Mariner database from 2010-2023. All techniques were analyzed together because procedure codes do not distinguish ICT from ECT. Secondary aims were to describe revision rates by geographic region and care setting of the initial tonsillectomy and to assess the association between overall comorbidity burden, measured by the Charlson Comorbidity Index (CCI), and revision. Based on proposed mechanisms of residual lymphoid regrowth and persistent upper airway obstruction, we hypothesized that younger age, obesity, trisomy 21, and lymphoproliferative disorders (identified here by leukemia and lymphoma diagnosis codes; abnormal lymphoid proliferation could predispose to regrowth of residual tonsillar tissue after ICT) would be associated with higher odds of revision. Identifying such associations could serve to better inform preoperative patient counseling.

Materials And Methods

This retrospective cohort study utilized the PearlDiver Mariner database (PearlDiver Technologies, Colorado Springs, CO, USA), a commercially available, HIPAA-compliant national claims database encompassing more than 170 million de-identified patients across the United States. The database integrates inpatient and outpatient encounters from Medicare, Medicaid, and private insurance plans, with data mapped to standardized coding systems including the International Classification of Diseases, Ninth and Tenth Revisions (ICD-9/10) [11], and Current Procedural Terminology (CPT) codes [12]. Data were queried on September 17, 2025, from the Mariner dataset designated M170 ENT, which contains claims from January 1, 2010, through April 30, 2023. The codes used to identify revision tonsillectomy were not validated against medical records. In accordance with PearlDiver policy, cell counts between 1 and 10 are reported as ⩽10 to protect patient confidentiality. Institutional Review Board approval was obtained for this study. The study was reported in accordance with the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement.

Pediatric patients aged 17 years and younger who underwent palatine tonsillectomy between 2010 and 2023 were identified using CPT codes 42820, 42821, 42825, and 42826 (Table *1*). Cases of adenoidectomy were included when performed concurrently with tonsillectomy. The date of the initial tonsillectomy served as the index event for all subsequent analyses. The primary outcome was revision palatine tonsillectomy, defined as any subsequent tonsillectomy code, at any age, recorded at least 30 days after the index procedure to minimize inclusion of early returns for postoperative hemorrhage or miscoding. No procedure code is specific to revision tonsillectomy, so revision was identified by recurrence of the same procedure codes (Table *1*). Revision was defined by procedure code alone as the clinical criteria used to recommend revision, such as recurrent obstructive symptoms or recurrent tonsillitis, are not recorded in claims data. Patients were followed from initial tonsillectomy through April 30, 2023, the end of available data; no minimum follow-up was required, and no maximum interval to revision was imposed. Because Mariner is derived from provider-network claims rather than insurer enrollment files, continuous enrollment could not be required. Patients were included if they had at least one of these CPT codes recorded before age 18 years; no exclusion criteria were applied.

Variable	Code System	Codes
Palatine tonsillectomy (index)	CPT	42820, 42821 (tonsillectomy and adenoidectomy); 42825, 42826 (tonsillectomy, primary or secondary)
Revision tonsillectomy	CPT	Any of the above CPT codes recorded ≥30 days after the index procedure (at any age)
Obesity	ICD-9/10	ICD-9-CM 278.0, 278.00–278.03; ICD-10-CM E66.0–E66.9 (PearlDiver group DX-Obesity; includes overweight)
Trisomy 21	ICD-10	ICD-10-CM Q90.0, Q90.1, Q90.2
Lymphoproliferative disorders	ICD-9/10	PearlDiver groups DX-Leukemias and DX-NonHodgkinsLymphoma: ICD-9-CM 200, 202, 203.1, 203.8, 204–208, 238.79, 273.3, V10.6, V10.79; ICD-10-CM C82–C86, C88, C90.1, C91–C96, Z85.6, Z85.72, Z85.79
Obstructive sleep apnea	ICD-9/10	ICD-9-CM 327.23; ICD-10-CM G47.33
Tonsillitis	ICD-9/10	ICD-9-CM 463, 474.00, 474.02; ICD-10-CM J03.00, J03.01, J03.80, J03.81, J03.90, J03.91, J35.01, J35.03
Gastroesophageal reflux disease	ICD-9/10	ICD-9-CM 530.11, 530.81; ICD-10-CM K21.0, K21.00, K21.01, K21.9, P78.83

TABLE 1: ICD-9/10 and CPT codes used to define the study cohort, outcomes, and covariates

Revision was defined as recurrence of any palatine tonsillectomy CPT code at least 30 days after the initial procedure. Diagnosis codes were identified at any time in the patient's available claims, and the Charlson Comorbidity Index was calculated by the PearlDiver platform.

CPT: Current Procedural Terminology; ICD: International Classification of Diseases; CM: Clinical Modification.

Demographic variables included age, sex, geographic region (Midwest, Northeast, South, and West), and service location of the initial procedure (inpatient vs outpatient). Clinical variables identified by ICD-9/10 diagnosis codes (Table *1*) included comorbid obesity, trisomy 21, and lymphoproliferative disorders (defined by PearlDiver's predefined leukemia and lymphoma code groups). Obesity was identified by clinician-assigned diagnosis rather than body mass index (BMI) thresholds as height, weight, and BMI are not available in claims data. The code group used included overweight diagnoses as well (Table *1*). Surgical indication was approximated by diagnosis codes for obstructive sleep apnea (OSA) and tonsillitis and categorized as OSA only, tonsillitis only, both, or neither. All diagnosis codes were identified at any time in each patient's available claims, before or after the index procedure. Additionally, clinical variables included the CCI, a clinical tool used to quantify burden of comorbid disease and predict mortality risk with higher CCI values indicating a greater comorbidity burden and increased risk of adverse outcomes [13]. The CCI was calculated by the PearlDiver platform, which applies the original Charlson weights to comorbidities recorded in the two years preceding a patient's last record in the analyzed cohort; age points do not apply to a pediatric cohort. Insurance type, allergic rhinitis, and asthma were considered during study design but were not analyzed: the insurance plan subtype field was unknown for all patients in the extracted data, and allergic rhinitis and asthma were not included in the final query.

Descriptive statistics were used to compare demographic and clinical characteristics between patients with and without revision surgery. Categorical variables were analyzed using chi-squared tests with Yates' continuity correction; age was compared using Welch's t-test, and CCI scores were compared using the Mann-Whitney U test due to non-normal distribution. Multivariable logistic regression was performed to identify factors independently associated with revision tonsillectomy. The patient-level model included age (continuous, per year), sex (reference: female), geographic region (reference: Midwest), obesity, trisomy 21, lymphoproliferative disorders (each reference: absent), and CCI (continuous, per point). Additionally, the model was adjusted for gastroesophageal reflux disease (GERD) and surgical indication category (reference: neither OSA nor tonsillitis), though these were included as adjustment variables only, and their estimates are not reported. Service location was assessed descriptively and was not included in the model. Patients with unrecorded sex (n = 14) or region (n = 23,691) were retained as separate unknown categories, whose estimates are not shown; 27 patients with missing covariate values were excluded, leaving 1,493,182 patients in the model. No imputation was performed. Odds ratios (ORs) with 95% Wald confidence intervals (CIs) were reported, and statistical significance was defined as $p < 0.05$. Cohort construction and multivariable regression were performed within PearlDiver's Bellwether platform, which fits regression models in R (R

Foundation for Statistical Computing, Vienna, Austria) and has been widely used in prior otolaryngologic outcomes research. Bivariate tests were calculated from aggregate counts exported from Bellwether and verified in Python 3.13 (Python Software Foundation, Fredericksburg, VA, USA) (SciPy 1.18).

Results

A total of 1,493,209 pediatric patients in the database underwent palatine tonsillectomy between 2010 and 2023. Among these, 3,660 patients (0.25%) subsequently underwent revision tonsillectomy. Table 2 compares the demographic and clinical characteristics between pediatric patients with and without revision palatine tonsillectomy. Patients requiring revision were significantly younger at the time of their initial procedure (mean 5.0 ± 3.7 years) compared with those who did not require revision (7.2 ± 3.8 years, $p < 0.001$). Males comprised a greater proportion of the revision cohort than of the no-revision cohort (54.5% vs 48.9%, $p < 0.001$). All demographic and clinical characteristics differed significantly between cohorts with the exception of residence in the Midwest region. Sex was not recorded for 14 patients and region for 23,691 (1.6%) (Table 2).

Characteristic	Revision (n=3,660)	No Revision (n=1,489,549)	χ^2 (df = 1)	P value
Age, Mean ± SD, y	5.0 ± 3.7	7.2 ± 3.8	—	<0.001
Sex				
Male	1,996 (54.5)	728,529 (48.9)	46.02	<0.001
Female	1,664 (45.5)	761,006 (51.1)		
Not recorded	0 (0.0)	14 (<0.1)		
Region				
Midwest	985 (26.9)	417,498 (28.0)	2.20	0.138
Northeast	853 (23.3)	220,957 (14.8)	206.53	<0.001
South	1,383 (37.8)	626,128 (42.0)	26.87	<0.001
West	388 (10.6)	201,326 (13.5)	26.30	<0.001
Not recorded	51 (1.4)	23,640 (1.6)		
Service location				
Inpatient	154 (4.2)	21,906 (1.5)	186.03	<0.001
Outpatient	3,481 (95.1)	1,467,303 (98.5)	282.57	<0.001
Obesity				
Obese	924 (25.2)	262,858 (17.6)	144.43	<0.001
Non-obese	2,736 (74.8)	1,226,691 (82.4)		
Trisomy 21	36 (1.0)	3,189 (0.2)	96.78	<0.001
Lymphoproliferative disorders	20 (0.5)	3,298 (0.2)	15.96	<0.001

TABLE 2: Comparison of demographic and clinical characteristics between pediatric patients with and without revision palatine tonsillectomy

Bivariate analysis of patient demographics and comorbid conditions among pediatric patients (≤17 years) undergoing palatine tonsillectomy between 2010 and 2023. Revision occurred in 3,660 patients (0.25%) compared with 1,489,549 patients without revision. Values are expressed as n (%) unless otherwise indicated. p-values were calculated using χ^2 tests with Yates' continuity correction; each comparison is a 2 × 2 contingency test with 1 degree of freedom, in which individual region and service-location categories were compared against all remaining patients. Patients with unrecorded sex or region are shown as "Not recorded"; they were included among remaining patients in the region comparisons and excluded from the sex comparison. Service location was assigned per claim: patients with claims in more than one setting are counted in each row, and patients whose claims were coded only in other settings (office, clinic, other, or unknown) appear in neither row, so these rows do not sum to cohort totals. Obesity, trisomy 21, and lymphoproliferative disorders were identified from diagnosis codes recorded at any time (Table 1). Age is a continuous variable and was compared using Welch's t-test ($t = 35.9$, $p < 0.001$); χ^2 is therefore not applicable (—). All expected cell counts exceeded 5, so Fisher's exact test was not required; applied as a sensitivity check, it yielded concordant results for trisomy 21 ($p < 0.001$) and lymphoproliferative disorders ($p < 0.001$).

Regional variation was observed, with the Northeast demonstrating the highest revision rate (0.38%) and the

West the lowest (0.19%, p < 0.001). Revision rates were 0.24% in the Midwest and 0.22% in the South. Revision procedures were also more common following surgeries performed in the inpatient setting (0.70%) compared with outpatient (0.24%, p < 0.001). Revision rates declined with later index years, from 0.38% for procedures performed in 2010 to 0.14% for those performed in 2022.

Revision was also more common among patients with obesity (0.35% revision rate in children with obesity vs 0.22% in those without, p < 0.001), trisomy 21 (1.1% vs 0.24%, p < 0.001), and lymphoproliferative disorders (0.60% vs 0.24%, p < 0.001). Patients who required revision had slightly higher comorbidity scores, represented in Table *3* (mean CCI 0.31 ± 0.64 vs 0.23 ± 0.52, p < 0.001).

CCI Score	Revision (n=3,660)	No Revision (n=1,489,549)
0	2,704 (73.9%)	1,193,014 (80.1%)
1	832 (22.7%)	264,725 (17.8%)
2	91 (2.5%)	24,902 (1.7%)
≥3	33 (0.9%)	6,908 (0.5%)
Summary statistics		
Mean CCI	0.31	0.23
Median CCI	0	0
SD	0.64	0.52
Mean rank	793,769	746,489
Mann–Whitney U	2,553,252,739	
z (normal approximation)	9.56	
Overall p-value (Mann–Whitney U)		<0.001*

TABLE 3: Comparison of Charlson Comorbidity Index (CCI) scores between pediatric patients with and without revision palatine tonsillectomy

Values are presented as n (%). Distribution of CCI scores among patients who underwent revision (n = 3,660) compared with those without revision (n = 1,489,549). Patients requiring revision demonstrated a higher comorbidity burden (mean CCI 0.31 ± 0.64 vs 0.23 ± 0.52). Both groups had a median score of 0. Scores were compared using the Mann–Whitney U test with correction for ties: U = 2,553,252,739, z = 9.56, p < 0.001, with a mean rank of 793,769 in the revision cohort versus 746,489 in the no-revision cohort (rank-biserial correlation r = 0.06, indicating a small effect despite statistical significance). Scores of 3 or more are combined to comply with PearlDiver's suppression of counts between 1 and 10.

Using multivariable logistic regression, factors independently associated with revision were identified (Figure *1*). Increasing age was associated with lower odds of revision tonsillectomy (OR 0.80 per year, 95% CI 0.79-0.81, p < 0.001), indicating that younger children had higher odds of revision. Obesity (OR 1.80, 95% CI 1.66-1.94, p < 0.001), trisomy 21 (OR 2.08, 95% CI 1.49-2.91, p < 0.001), lymphoproliferative disorders (OR 1.90, 95% CI 1.21-2.98, p = 0.005), and higher CCI score (OR 1.08 per point, 95% CI 1.03-1.14, p = 0.003) were also independently associated with higher odds of revision. Compared to the Midwest, revision was more likely in the Northeast (OR 1.38, 95% CI 1.25-1.51, p < 0.001) and less likely in the South (OR 0.87, 95% CI 0.80-0.94, p < 0.001) and West (OR 0.86, 95% CI 0.76-0.97, p = 0.013). Male sex was not independently associated with increased odds of revision (OR 1.03, 95% CI 0.97-1.10, p = 0.36).

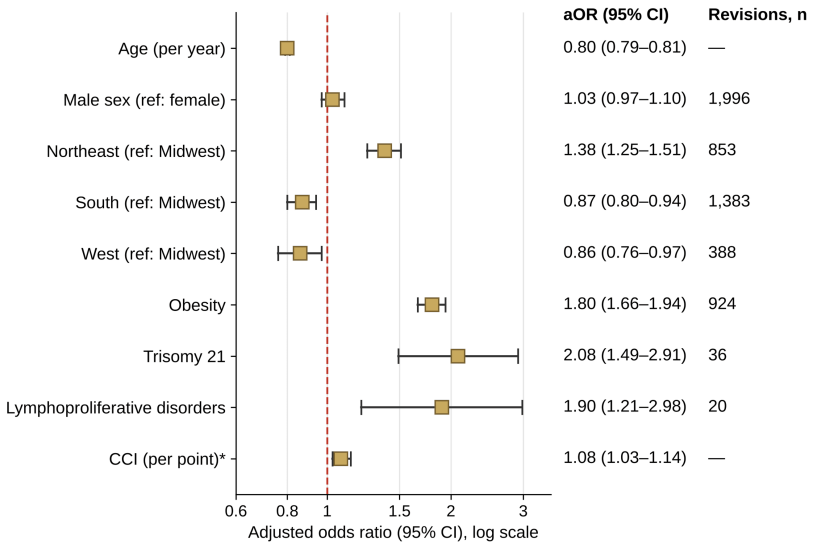


FIGURE 1: Multivariable logistic regression identifying factors independently associated with revision palatine tonsillectomy in pediatric patients

Odds ratios with 95% Wald confidence intervals are shown on a logarithmic scale for study variables in the multivariable model of revision tonsillectomy among pediatric patients (≤17 years) in the PearlDiver Mariner database from 2010–2023. Reference categories were female sex, Midwest region, and absence of each comorbidity. The model was additionally adjusted for GERD, surgical indication (OSA and tonsillitis codes), and unknown sex and region categories, but these estimates are not shown. Age and CCI were modeled as continuous variables. The number of revision events in each category is shown (n = 3,660 total revisions). Younger age, obesity, trisomy 21, and lymphoproliferative disorders were independently associated with increased odds of revision, whereas male sex was not significant. For every 1-point increase in CCI, the odds of revision tonsillectomy increase by about 8% (*). CCI was used as a comorbidity proxy, although it has not been specifically validated in pediatric populations.

GERD: gastroesophageal reflux disease; OSA: obstructive sleep apnea.

Discussion

In this large, national cohort of pediatric patients, revision palatine tonsillectomy was rare, occurring in 0.25% of patients. Younger age, obesity, trisomy 21, and lymphoproliferative disorders were independently associated with higher odds of coded revision on multivariable analysis. Absolute revision rates nonetheless remained low in each subgroup, ranging from 0.35% among children with obesity to approximately 1.1% in those with trisomy 21. These findings identify patient characteristics that could help inform preoperative counseling in pediatric tonsillectomy.

The overall revision rate of 0.25% is lower than published revision rates following ICT (0.5% to 6.1%) [5,6]. This likely reflects some element of dilution by ECT cases, which carry a lower risk of regrowth, but may also reflect under-ascertainment, as revisions performed after the study period, outside the networks contributing to the database, or coded differently or incorrectly may not be captured; the lower revision rates observed for later index years are consistent with truncated follow-up. The reported rate should be interpreted as a conservative estimate.

Consistent with prior studies in ICT, younger age at the time of the index procedure was strongly associated with revision [9]. Age was analyzed as a continuous variable, and as such, no single cutoff defined “younger” patients in this study. Each additional year of age at the index procedure was associated with approximately 20% lower odds of revision (OR 0.80), and patients undergoing revision were a mean of 5.0 years old at their index procedure as compared with 7.2 years among those who did not. One proposed explanation is that children under five years of age may be particularly susceptible due to the ongoing hypertrophic phase of lymphoid tissue growth, which peaks between four and eight years of age [10,14]. When intracapsular tonsillectomy is performed during this period, residual lymphoid tissue may regenerate, leading to symptomatic regrowth. Of note, however, a study in 2014 by Zhang et al. was unable to relate immune factors leading to increased tonsillar regrowth following ICT [15]. Surgical technique was not differentiated within our dataset, and young children may be more likely to undergo ICT, so the association between age and revision may in part reflect differences in technique rather than age alone. Regardless of mechanism, surgeons may consider discussing the possibility of revision when counseling families of younger children.

Although males comprised a slightly greater proportion of revision cases on bivariate analysis (54.5% vs 48.9%, $p < 0.001$), sex was not independently associated with revision on multivariable analysis (OR 1.03, 95% CI 0.97-1.10), and we do not consider this difference to be clinically significant or meaningful. This aligns with existing literature showing minimal differences in postoperative outcomes or complication rates by biological sex [16]. Accordingly, while demographic variation may exist, patient sex should not meaningfully influence surgical decision-making or follow-up protocols.

Several comorbidities were associated with higher odds of revision. Obesity, trisomy 21, and lymphoproliferative disorders each remained independently associated with revision after adjustment. The association between obesity and revision may be multifactorial, possibly reflecting both increased prevalence and persistence of OSA among obese children, as well as impaired wound healing and immune dysregulation that may promote tissue hypertrophy [17]. Of note, however, these mechanisms could not be assessed in our data. Trisomy 21 (Down syndrome) is characterized by craniofacial and airway abnormalities, hypotonia, and lymphoid hyperplasia - all factors that contribute to airway obstruction and recurrence of OSA symptoms following partial tonsillectomy [18-20]. Similarly, patients with Down syndrome have increased OSA recurrence rates regardless of adenotonsillectomy technique, further contributing to possible revision [21-23]. Moreover, children with trisomy 21 frequently exhibit obesity due to reduced resting metabolic rate, compounding the risk for revision surgery [18]. Estimates for trisomy 21 and lymphoproliferative disorders should be interpreted cautiously, as they were based upon a small number of revision events (36 and 20, respectively) and had correspondingly wide confidence intervals. Because the lymphoproliferative category was defined by leukemia and lymphoma codes, it also overlaps with the leukemia and lymphoma components of the CCI, which was included in the same model, although variance inflation was minimal (variance inflation factors 1.03 and 1.07, respectively).

Regional and care-setting differences were also observed. Compared with the Midwest, revision was more likely to occur in the Northeast (OR 1.38) and less likely in the South and West. Given that patient biology is unlikely to differ substantially across these regions, these differences are more plausibly linked to regional variations in practice habits and patterns or differences in claims capturing. Similarly, the higher revision rate following inpatient tonsillectomy (0.70% vs 0.24%) may reflect the tendency to select higher-risk patients for inpatient surgery rather than an effect of the care setting alone. Consequently, the overall revision rate and associations reported may not apply uniformly to individual practices, particularly those that perform predominantly ICT.

Most limitations of this study relate to the completeness and variability of claims data. First, as procedure codes do not distinguish ECT from ICT, the reported revision rate combines both surgical approaches and should not be used to estimate revision risk for a specific approach. Further, the proportion of each surgical approach may reflect surgeon preference, which could not be controlled for. Second, claims data do not capture important clinical confounders, including, but not limited to, tonsil size, surgical technique, and surgeon experience, and surgical indication could be approximated only by OSA and tonsillitis diagnosis codes. Additionally, the decision to perform revision is subject to provider practice and preference. Third, coding variations, indications for surgery, and diagnostic definitions of comorbidities often vary across providers. For example, obesity is likely under-coded and was identified with a predefined code group that includes overweight. BMI values were unavailable, so we could not confirm that coded patients met the conventional pediatric definition of obesity with a BMI at or above the 95th percentile for age and sex [24]. Trisomy 21 was identified only by ICD-10-CM codes Q90.0-Q90.2, omitting Q90.9 (Down syndrome, unspecified) and the ICD-9-CM code 758.0, so some affected children were likely classified as unaffected, which would bias its estimate toward the null. The lymphoproliferative disorder category, which combined leukemia and lymphoma codes, is broad and thus particularly susceptible to miscoding. Relatedly, revision codes cannot distinguish revision for regrowth from revision for other indications. The 30-day threshold, however, was intended to exclude early returns for hemorrhage. Fourth, revisions may be under-ascertained because procedures billed outside the networks contributing to the database are not captured and continuous enrollment could not be required. Because no minimum follow-up was imposed, patients with later index procedures had less time at risk, as reflected in the lower revision rates for later index years, whereas revision after ICT occurs a mean of 3.5 years after the primary procedure [9]; a time-to-event analysis accounting for censoring was not performed. Fifth, diagnosis codes were captured at any time, including after the index procedure, and patients undergoing revision likely have more healthcare encounters, creating more opportunities for codes to be recorded; this may inflate associations with comorbidities. For patients revised before age 18 years, the CCI look-back window may also have extended to the revision procedure. Sixth, the CCI has not been validated in pediatric populations specifically, age was modeled linearly, and no sensitivity analyses using alternative revision definitions or time windows were performed. Finally, these findings reflect an insured US population and therefore may not generalize to uninsured patients or to other countries, where geographic, sociocultural, and practice differences can influence revision rates. The study identifies associations only. No predictive model was developed or externally validated, the model explained little of the variation in revision (McFadden pseudo-R^2 0.06), and the findings therefore should not be used for individual risk prediction.

Taken together, our results indicate that revision tonsillectomy is an uncommon event, and that younger age, obesity, trisomy 21, and lymphoproliferative disorders are associated with higher odds of revision. Consistent with our primary aim, these associations, interpreted alongside the low absolute revision rates

observed, may help surgeons provide more informed preoperative counseling to pediatric patients and their families.

Conclusions

In our large national pediatric cohort, revision tonsillectomy was exceedingly rare, occurring in roughly 1 in 400 pediatric tonsillectomy patients. In this study, revision was identified by a repeat tonsillectomy procedure code at least 30 days after the initial procedure rather than by clinical criteria, obesity was identified by diagnosis codes rather than BMI thresholds, and age was analyzed continuously with each additional year of age associated with approximately 20% lower odds of revision. Younger age and comorbid obesity, trisomy 21, and lymphoproliferative disorders were independently associated with higher odds of revision surgery, although absolute risk remained low in all subgroups. Nonetheless, our findings may help guide preoperative counseling. Whether these patients would benefit from modification of surgical technique or close postoperative surveillance cannot be determined from this dataset alone and warrants prospective or registry-based studies distinguishing ICT from ECT and indications for surgery. Additionally, these data may serve to guide further prospective studies to identify additional risk factors or develop preventative strategies for these patients.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Acquisition, analysis, or interpretation of data: Elizabeth A. Lamberty, Brian W. Herrmann, Sarah A. Gitomer

Drafting of the manuscript: Elizabeth A. Lamberty

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Concept and design: Matthew J. Hill, Nicole Wershoven

Supervision: Brian W. Herrmann, Sarah A. Gitomer

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. COMIRB issued approval 24-1286. "Your COMIRB Initial Submission APP001-2 has been determined to be EXEMPT from IRB review. There is no requirement for continuing review and your study has not been given an expiration date.". **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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