



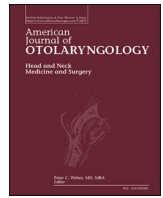
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Impact of COVID-19 on nationwide pediatric otolaryngology practice: Adenotonsillectomies (TA) and tonsil-related diagnoses trends[☆]

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ABSTRACT

Objectives/hypothesis: To determine the effects of the COVID-19 pandemic on Adenotonsillectomies (TA), Tonsil Related Cases (TC), and Peritonsillar Abscess (PTA) Trends.

Study design: Retrospective Cohort Study.

Methods: This is a retrospective cohort study using the Pediatric Health Information System® (PHIS) database, which consists of 51 children's hospitals. Regions were defined according to PHIS rules with at least five children's hospitals per region. We compared monthly total TA, TC, TC as a proportion of all hospital visits, and PTA from all encounters at each hospital from January 1, 2019, through December 31, 2021.

Results: Compared to 2019, April 2020 saw mean TC drop significantly from 371.62 to 68.37 ($p < 0.001$). Interestingly, June, September, and December 2020 had significantly higher mean TC compared to 2019. TC as a proportion of all hospital visits decreased significantly throughout the majority of 2021. Similarly, TA significantly decreased during 2020 and 2021 across all regions in the US, starting in March 2020 and this reduction in TA extended through the end of 2021 without any signs of recovery. PTA rates did not change significantly over the three years.

Conclusions: The pandemic-plagued 2020 saw a noticeable decrease in overall TC and TA but then rebounded quickly to even higher than pre-pandemic levels. However, this rebound halted for the majority of 2021 and subsequently decreased to lower than pre-pandemic levels, which differs from other communicable pathologies such as otitis media which decreased initially then recovered to pre-pandemic levels by Summer of 2021.

1. Introduction

Tonsillectomies have long been one of the most common surgical operations in pediatrics with over 500,000 operations performed each year in the United States alone [1]. Typically, the most common reason for a tonsillectomy (and subsequent adenoidectomy) is sleep disordered breathing or obstructive sleep apnea (OSA) [2]. However, tonsil-cases (TC) such as tonsillitis are also a common reason for tonsillectomies

and pediatric health care utilization [3]. For instance, tonsillitis takes up nearly 1.3 % of all outpatient visits [4].

The Covid-19 pandemic has led to monumental and long-lasting changes to healthcare and disease [5,6]. The subsequent behavioral changes, including both personal and government-associated distancing, have led to differences in how communicable diseases affect the population at large [7,8]. A paper published from Finland showed that social distancing associated with the pandemic led to a

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significant decrease in pediatric Emergency Room (ER) visits, a shorter influenza season, and a decrease in both influenza and respiratory syncytial virus (RSV) cases [8,9]. Our group recently published the effects of the pandemic on otitis media (OM), a communicable pathology in the pediatric population. Utilizing the Pediatric Health Information System® (PHIS) database, an established collection of diagnoses associated with 51 children's hospitals, we found that the mean proportion of OM cases per 100 hospital visits and myringotomy tube placements decreased substantially at the beginning of the pandemic, which then rebounded by summer of 2021 [10]. These results follow loosely the conclusions of a recent paper from Israel, which suggested that shortly after social distancing mandates were lifted, there was an increase in non-Covid-19 related infectious diseases [11]. Further, Australia also performed an analysis which also reported increased RSV diagnoses after public health directives were reduced in the wake of a downtrend of Covid-19 cases [12].

Of interest is the effect that Covid-19 behaviors may have on TC, TA, and PTAs. Social distancing clearly influences communicable diseases and as such social distancing and pandemic-related behavior could pose to be a barrier to worsening tonsillitis. Thus, what makes evaluating the trends of TC, TA, and PTAs fascinating is the mixed underlying pathophysiology. As stated, the two major reasons for a tonsillectomy (and adenoidectomy) are sleep related breathing disorder (or obstructive sleep apnea) – a non-communicable pathology – and recurrent tonsillitis. An interesting recent study performed by telephone questionnaire suggested that the social distancing behavior implemented led to a significant reduction in tonsillitis cases, however parents (70 %) were still interested in their children obtaining a TA if indicated. It should be noted that this study had a relatively low sample size ($n = 44$) [13]. Another study, from the United Kingdom, suggested that both tonsillitis and PTA presentations to the hospital were shifted to more outpatient management instead of admission, suggesting a change in care related to Covid-19 [14]. Importantly, tonsillitis has long been known to cause issues to both pediatric patients and their surrounding family, suggesting that there be a larger impetus to achieve surgical intervention even in the midst of a pandemic [15].

Thus, this analysis is meant to understand how social distancing related measures and behaviors affect tonsil pathology and intervention on a large-scale basis and to investigate whether there are geographical, demographical, or socioeconomic differences in the healthcare utilization associated with these pathologies. Further, we can examine and compare how this pathology differs from communicable and non-communicable diseases within the pandemic.

2. Methods

2.1. Data collection

This investigation is a retrospective cohort study using the Pediatric Health Information System® (PHIS) database. Custom queries were created by the principal investigator that specifically focused on tonsil related diagnosis, tonsil cases, and tonsillectomies from all encounters at each children's hospital from January 1, 2019, through December 31, 2021. Only “distinct” tonsil diagnoses were counted while similar redundant diagnoses codes for the same patient encounter were excluded. Total hospital encounters were collected as a denominator. The PHIS hospitals are 51 of the largest and most advanced children's hospitals in the US and constitute the most demanding standards of pediatric service. We collected clinic, inpatient, ambulatory, emergency department and observation data using ICD10 codes for peritonsillar abscesses (J36) and tonsil-related diagnoses (G47.3-G47.9, J03.0-J03.91, J35.0-J35.9). Regions were defined according to PHIS rules with at least five children's hospitals per region. We submitted to both Memorial Hermann Institutional Review Board and The University of Texas Health Science Center at Houston's Institutional Review Board and were granted exemption status.

2.2. Data analysis

The objective of this project is to analyze the effects and trends that the pandemic had on nationwide pediatric T&As, peritonsillar abscesses, and tonsil-related diagnoses. All monthly encounters during 2019, 2020, and 2021 were collected including the total monthly encounters to obtain the proportion of tonsil-related diagnoses. Each hospital's data were then grouped into regions as defined by PHIS to maintain the confidentiality of individual hospitals: Midwest, Northeast, South, and West. Statistical analyses were performed using the Analysis of Variance (ANOVA) to compare 2021 and 2020 data to pre-pandemic 2019 data for each month. P -value < 0.05 was considered statistically significant. In addition, we fitted multilevel linear or negative binomial regression models with hospitals nested within regions to assess the degree of association between the number or proportion of TC, TA, and PTPA and each month of the year. Each regression model was adjusted for the interaction effect between month and year. All statistical analyses were performed using R (version 4.0.3).

3. Results

3.1. Total tonsil cases in 2019 compared to 2020 and 2021

Compared to 2019, the year 2020 saw the start of a significant drop in overall TC. At the start of 2020, from January to February, there was no noticeable difference between TC compared to 2019, however in March there was a significant downtrend in cases (355.54 v. 262.48, $p < 0.05$). This decrease hit a dramatic nadir in April 2020 (371.62 v. 68.37, $p < 0.001$), but quickly rebounded by June 2020 (Fig. 1).

3.2. Tonsil cases as a proportion of all hospital visits

As a proportion of 100 hospital visits, the number of TC varied significantly in 2020 compared to 2019. For instance, the month of April 2020 saw a large decrease that quickly rebounded in May. Throughout the rest of the year, the rate of TC stayed relatively constant except in the months of June, September, and December for which 2020 had an increased rate of TC compared to 2019 (Fig. 2). This is largely different from 2021, for which the month of April saw a significant, sustained decrease in relative TC through December 2021 compared to 2019 and 2020, starting in the month of May 2021, as shown by regression analyses (Fig. 3). Regional variability was also the greatest starting Summer 2020 that persisted into Winter 2020, where the West and South regions had higher proportions of TC compared to the Midwest, followed by the lowest proportion of TC in the Northeast (Fig. 4). Regional TC trends were similar across the entirety of 2021 compared to 2020.

3.3. Total TA in 2019 compared to 2020 and 2021

When comparing TAs, the number of TA decreased significantly starting in the month of March 2020 and this difference was sustained throughout 2020 and 2021. At the nadir of April 2020, only a mean of 11.61 TA procedures were performed compared to 149.81 in April 2019 (Table 1). TA volumes recovered in May 2020 to mean of 86.17, followed by 131.29 in June 2020 at the peak. TA volumes never recovered to pre pandemic levels in 2021. In fact, only two months of June and December 2021 did the mean TA procedures surpass 100. On regression analyses, TA procedures were similarly low across all four regions in both 2020 and 2021 compared to 2019 (Fig. 5). The West region had the lowest number of TA procedures. Compared to pre pandemic volumes, the Northeast had the largest decline in TA volumes at 46.9 %, followed by the South at 46.6 %, West at 35.8 %, and the Midwest at 29.1 %. These declining trends in TA persisted throughout 2021 across all regions.

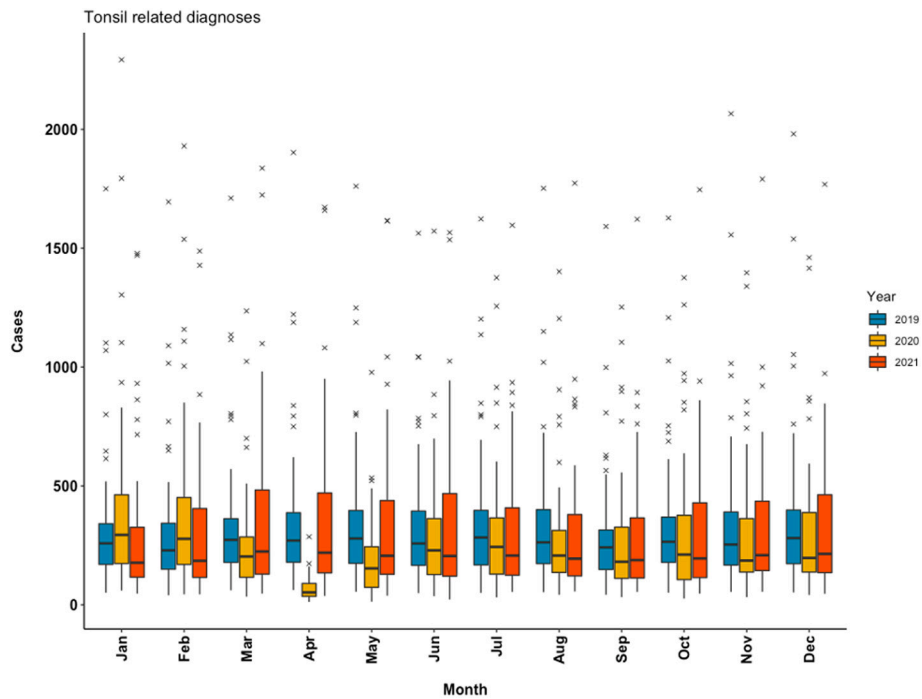


Fig. 1. Box plot of total tonsil cases for years 2019, 2020, and 2021 by month. The cross (x) denotes outliers (i.e., values above or below $Q3 \pm 3 \times (Q3 - Q1)$, where $Q1$ and $Q3$ represent the first and third quartiles, respectively).

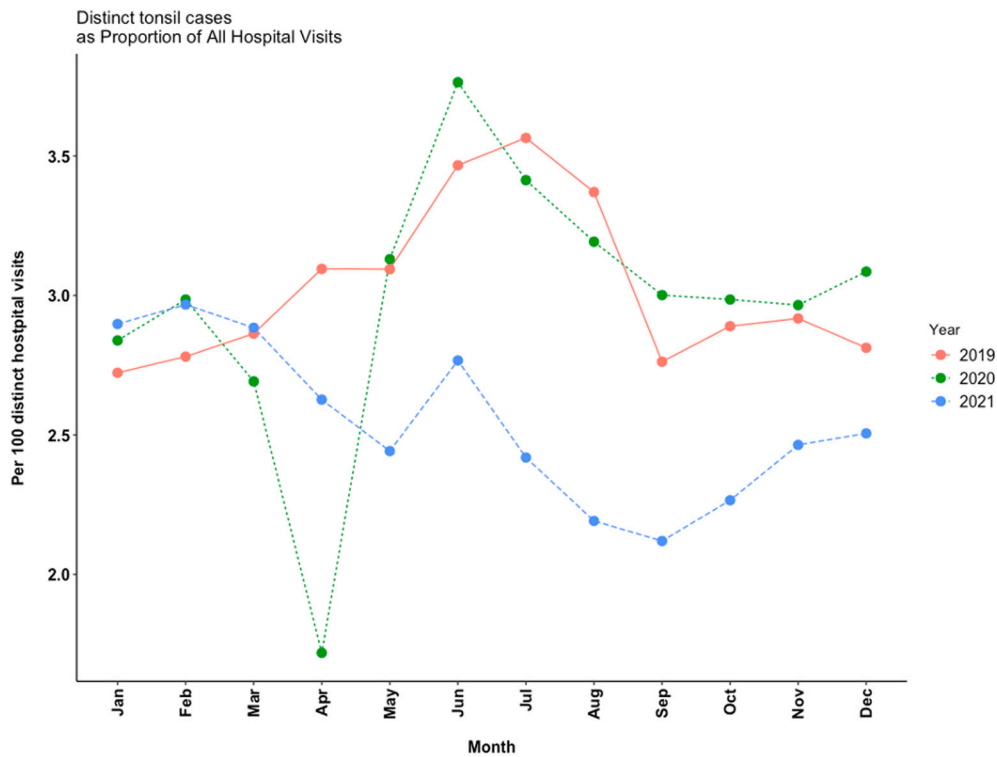


Fig. 2. Mean distinct tonsil cases per 100 hospital visits for years 2019, 2020, 2021 by month.

3.4. Total PTA in 2019 compared to 2020 and 2021

Throughout the country, the total number of PTAs did not differ between 2019, 2020, and 2021. The average rate of PTA per 100 hospital visits in 2019 was 1.56, with the highest rate in the West (Fig. 6). In 2020, the average rate of PTA per 100 hospital visits was 1.6, with the

South having the highest rate. In 2021, the average rate of PTA per 100 hospital visits was 1.4, with the South having the highest rate. Interestingly, while holistically there was no difference between the years, regionally, the Midwest had a statistically significant decrease in comparative rate of PTA ($p < 0.05$).

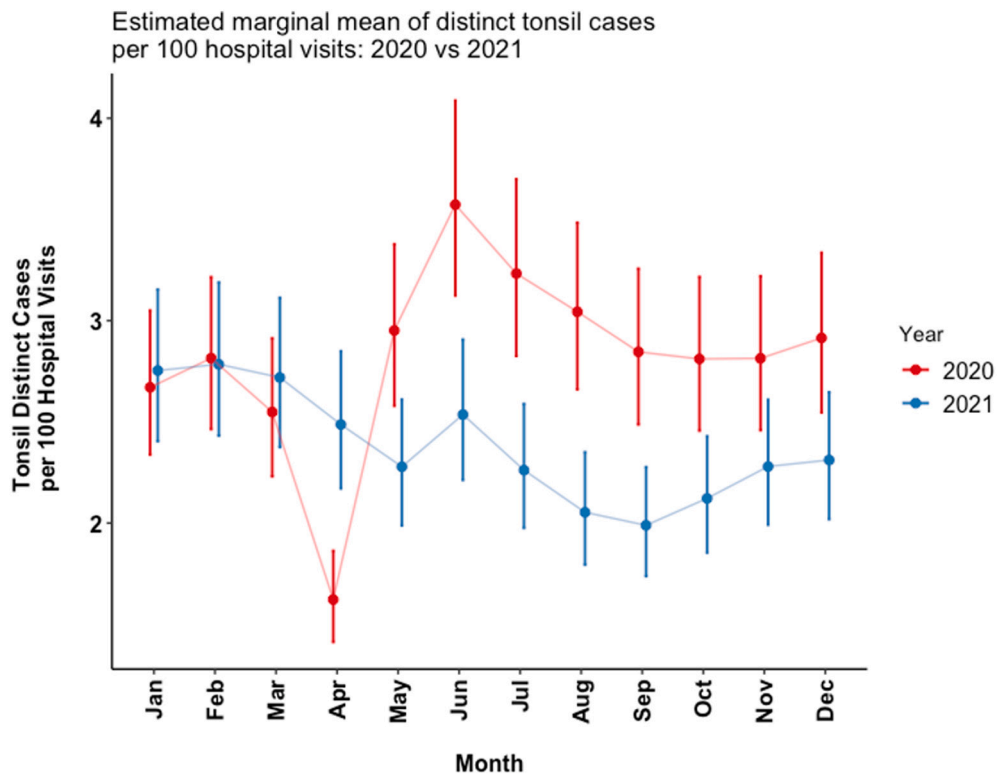


Fig. 3. Regression model analyses - proportion of tonsil cases per 100 hospital visits 2020 vs 2021.

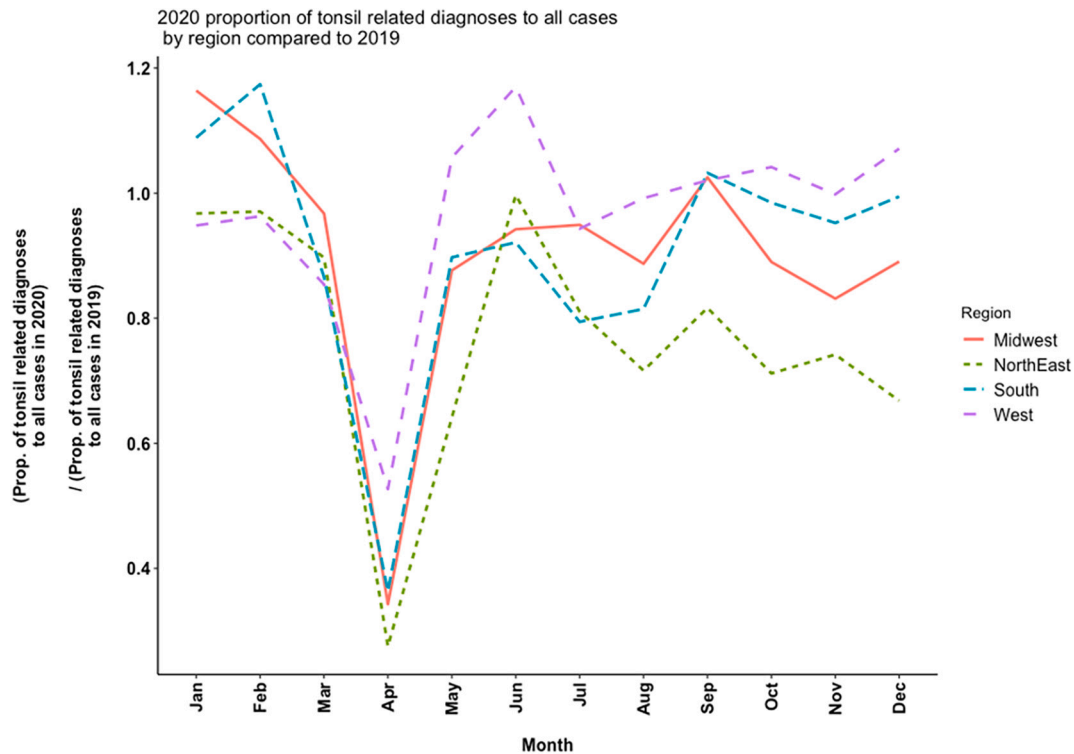


Fig. 4. Proportion of tonsil cases 2020 vs 2019 by region.

4. Discussion

This study's objective was to determine the effects of the COVID-19 pandemic on TC, TA, and PTA, one complication of acute tonsillitis. Given that the diagnosis rates and hospital presentations of well-known

communicable diseases decreased during the pandemic, it stands to reason that TC, TA, and PTAs should follow a similar trajectory. Overall, there was a significant decrease in total TC and TA procedures in March 2020 that persisted throughout the end of 2021. However, the year 2020 did not see a decrease in TC as a proportion of all hospital visits and in

Table 1
Tonsillectomy and adenoidectomy volume trends for 2019, 2020, and 2021 by month.

Month		2019 (N = 564)	2020 (N = 509)	2021 (N = 481)	Total (N = 1554)	p value
Jan	Number of TAs					0.003
	Mean	129.11	143.70	79.85	119.82	
	SD	96.02	99.31	53.24	90.40	
	Median	109.00	124.00	71.00	97.00	
	Q1, Q3	42.50, 168.50	57.50, 206.50	33.00, 112.00	44.00, 169.00	
	Range	15.00–371.00	21.00–379.00	3.00–204.00	3.00–379.00	
Feb	Number of TAs					0.008
	Mean	124.68	134.68	77.92	114.23	
	SD	99.51	95.71	57.82	90.31	
	Median	100.00	131.00	76.50	92.50	
	Q1, Q3	40.00, 180.50	52.00, 189.00	30.25, 107.00	38.50, 162.00	
	Range	8.00–389.00	19.00–404.00	4.00–290.00	4.00–404.00	
Mar	Number of TAs					<0.001
	Mean	144.30	82.30	93.72	107.46	
	SD	110.72	63.80	63.04	87.02	
	Median	124.00	71.00	84.50	84.50	
	Q1, Q3	54.00, 196.50	23.00, 116.50	41.50, 127.25	42.25, 148.50	
	Range	5.00–482.00	2.00–244.00	3.00–235.00	2.00–482.00	
Apr	Number of TAs					<0.001
	Mean	149.81	11.61	89.33	93.03	
	SD	115.45	11.95	62.47	98.40	
	Median	124.00	7.00	87.00	60.00	
	Q1, Q3	48.50, 220.50	4.00, 20.50	39.00, 125.00	19.00, 136.00	
	Range	10.00–465.00	1.00–54.00	7.00–271.00	1.00–465.00	
May	Number of TAs					0.001
	Mean	150.15	86.17	86.77	109.84	
	SD	117.46	80.64	67.04	96.91	
	Median	134.00	71.00	82.00	83.00	
	Q1, Q3	56.00, 215.00	24.75, 122.75	29.50, 114.50	34.50, 153.75	
	Range	6.00–517.00	3.00–368.00	6.00–277.00	3.00–517.00	
Jun	Number of TAs					0.032
	Mean	165.36	131.29	105.26	135.87	
	SD	125.35	102.35	76.93	107.05	
	Median	134.00	106.50	96.00	109.00	
	Q1, Q3	68.00, 233.50	43.75, 191.25	45.50, 142.00	49.75, 198.00	
	Range	17.00–500.00	14.00–419.00	8.00–325.00	8.00–500.00	
Jul	Number of TAs					0.003
	Mean	167.15	115.95	94.61	127.73	
	SD	126.75	85.77	80.03	104.94	
	Median	158.00	109.50	70.00	100.50	
	Q1, Q3	64.00, 221.50	38.00, 174.00	40.00, 117.00	47.75, 181.75	
	Range	13.00–574.00	10.00–349.00	3.00–362.00	3.00–574.00	
Aug	Number of TAs					<0.001
	Mean	152.49	95.62	83.46	112.35	
	SD	113.12	65.91	58.33	89.12	
	Median	129.00	93.50	76.00	97.00	
	Q1, Q3	58.00, 233.50	29.00, 149.50	36.00, 118.00	40.00, 158.50	
	Range	9.00–447.00	7.00–280.00	4.00–225.00	4.00–447.00	
Sep	Number of TAs					0.049
	Mean	109.60	83.62	75.88	90.57	
	SD	80.36	57.05	60.07	68.35	
	Median	96.00	78.00	73.00	78.50	
	Q1, Q3	38.50, 165.50	31.50, 127.50	36.00, 99.00	36.25, 132.25	
	Range	10.00–333.00	8.00–200.00	5.00–282.00	5.00–333.00	
Oct	Number of TAs					0.004
	Mean	128.81	85.33	81.20	99.63	
	SD	90.50	59.91	63.11	75.93	
	Median	113.00	75.00	63.00	84.00	
	Q1, Q3	50.50, 192.00	24.50, 132.50	34.00, 110.00	37.50, 147.50	
	Range	10.00–428.00	9.00–236.00	5.00–290.00	5.00–428.00	
Nov	Number of TAs					0.008
	Mean	139.00	86.07	98.27	109.05	
	SD	99.42	59.93	81.53	85.22	
	Median	117.00	83.00	77.00	96.50	
	Q1, Q3	54.00, 193.50	34.00, 131.25	45.00, 125.00	43.25, 141.50	
	Range	21.00–471.00	4.00–251.00	5.00–355.00	4.00–471.00	
Dec	Number of TAs					0.004
	Mean	149.57	86.14	110.10	116.68	
	SD	106.87	59.85	91.10	92.18	
	Median	132.00	86.00	79.00	102.00	
	Q1, Q3	56.50, 206.50	36.00, 124.75	42.25, 136.75	47.00, 165.00	
	Range	16.00–507.00	5.00–271.00	3.00–377.00	3.00–507.00	

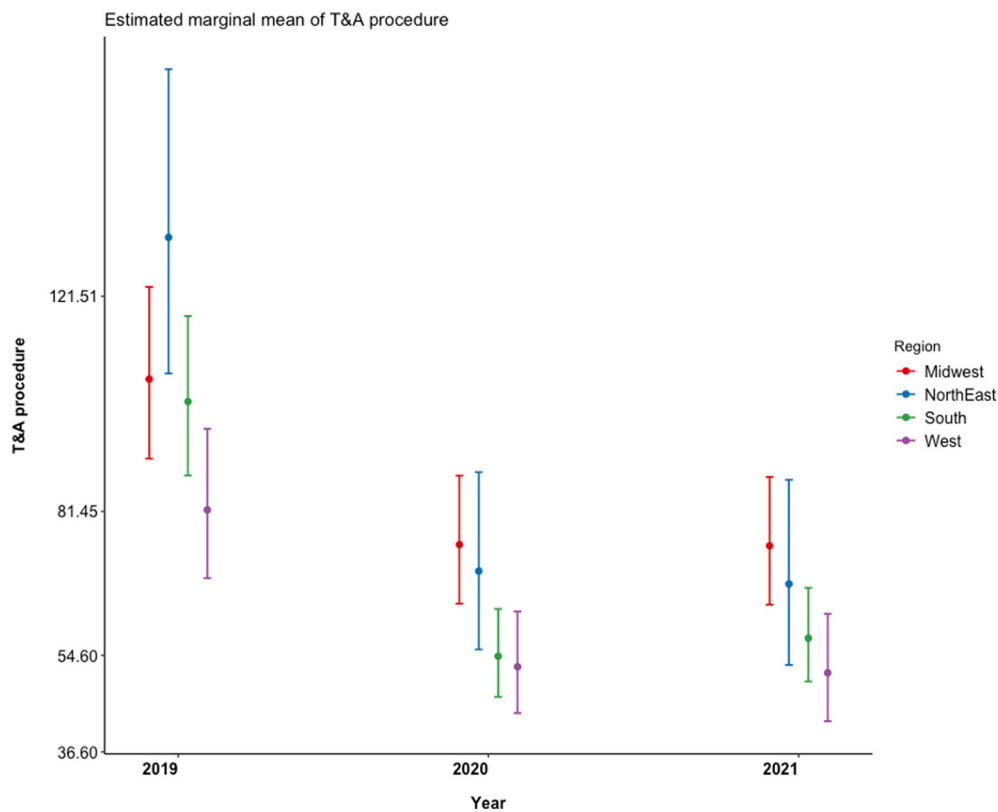


Fig. 5. Regression model analyses. TA procedures for years 2019, 2020, 2021 by region.

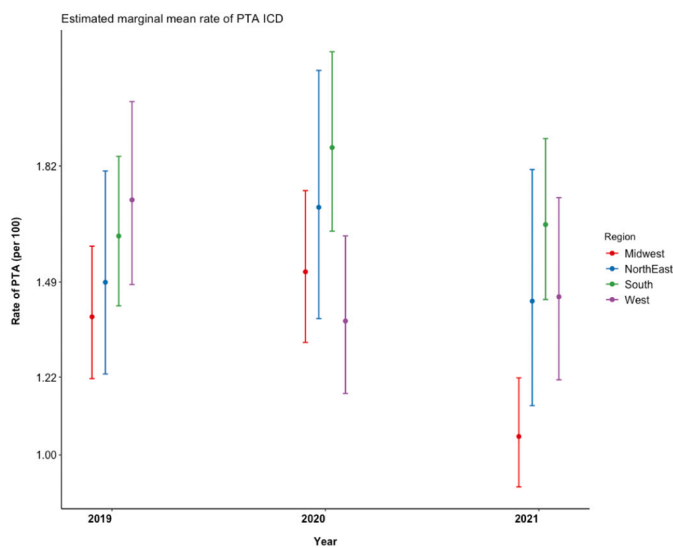


Fig. 6. Regression model analyses. Rate of PTA per 100 Hospital visits for years 2019, 2020, 2021 by region.

fact, June, September, and December months had an increased rate of TC in 2020 compared to 2019. It was not until March 2021 that a decline in relative TC was observed; this reduction did not recover through the end of 2021. Despite an overall decline in tonsil-related diagnoses, PTA rates did not change significantly throughout the three years. Regional differences were most pronounced in the Summer and Winter months of 2020, with the lowest TC in the Northeast. TA procedures were also significantly lower in 2020 and 2021, with the lowest raw total TA in the West, but the Northeast experienced the largest decline in TA at almost 50 % less volume for both 2020 and 2021.

Indications for pediatric tonsillectomy include obstructive sleep disordered breathing, recurrent tonsillitis, and obstructive sleep apnea diagnosed on polysomnography [16]. Paradise criteria for recurrent tonsillitis is defined by greater than six tonsil infections over the past year, five infections every year for two years, or three infections every year for past three years. The findings reported in this paper suggest that while overall TC decreased early in the pandemic, the actual rate of TC as a proportion of all hospital visits did not see an appreciable downturn until March of 2021. The reason for why overall TC did decrease could be the result of the response of social distancing mandates and day care closures as this would theoretically decrease the risk of obtaining diseases that stem from close personal contact, like tonsillitis. Another factor influencing tonsillitis transmission rates may be due to voluntary mask utilization in public places. Mandatory mask mandates were established during March 2020 and continued throughout 2021 [17]. Wearing masks is theorized to filter virus sized particles from entering the upper respiratory tract and has been linked with lower transmission of COVID-19 [18]. A study by Fischer et al. showed that at least 8 states boasted a 75 % or more mask adherence rate from April to June 2021 [17]. Therefore, it is plausible that a combined factor of wearing masks and social distancing measures decreased rates of many communicable diseases during the COVID 19 pandemic. This explains the declining rates of tympanostomy tube placement, as shown by the authors in a similar study, during the pandemic as children did not develop as many ear infections [10]. Further, decreased outpatient physician visits likely also contributed to declining tonsil cases during the COVID-19 pandemic. The total number of outpatient physician visits declined significantly during the pandemic and did not fully recover after restrictions were lifted [19]. Pediatrician and Otolaryngology outpatient visits especially did not recover as well as non-surgical subspecialties [19].

As stated prior, proportional TC did not exactly follow the trend of other communicable diseases such as URIs or OM [20,21]. In fact, while overall TC did decrease early in the pandemic, relative TC as a

proportion of all hospital visits did not follow the same trend of URIs/OM, which reduced early in the pandemic and then rebounded near the latter aspect of 2021. Prior to initiating this research, we expected tonsil cases to be impacted similarly to OM but to a lesser extent since most tonsil diagnoses are related to sleep disordered breathing and obstructive sleep apnea. While this was mostly true based on our study, the proportion of tonsil cases had a delayed reduction in cases (early 2021 instead of 2020) and persisted at lower-than-expected rates through December 2021. June, September, and December 2020 had higher TC than even pre pandemic. There are multiple theories about the reasoning behind this data. These trends in tonsil related diagnoses could be mirroring waves in Covid-19 case load as well as school sessions. For example, June 2020 was when travel was revived for many families and the start of summer vacation. September 2020 was also when many children resumed attending in-person schools [22]. December 2020 again was a popular travel month due to the holidays. The year 2021 also brought about many changes which may have influenced population health behaviors and local mandates. May 2021 was the first case of Delta variant followed by Omicron in November 2021, which was also around the same time the Covid-19 vaccine was offered to children 5 to 11 years of age [23,24]. Given all these changes, there could have been a behavioral change in healthcare utilization in that patients sought care elsewhere in the community rather than pediatric children's hospitals. However, all these theories do not completely explain why TC differed from other communicable diseases such as OM or URIs. Another theory could be that the Covid-19 pandemic, and the related behavioral modifications that ensued because of it, led to a long-lasting change in the pathophysiology of tonsil related cases that persisted throughout 2021.

Further, our study illustrated that the number of TA procedures also decreased significantly early in the pandemic, even if TC cases did not. The TA cases sustained their decrease relative to 2019 throughout 2020 and through the end of 2021. The reasoning behind these results is unclear. For one, it is clear that the cancellation of elective surgeries likely played a role on pediatric tonsil related cases during the COVID-19 pandemic early on as tonsillectomy is considered an elective surgery [25]. However, this does not explain why TA cases did not rebound once elective surgeries were implemented once again. This once again gives credence to the idea that there could have well been a difference in the underlying pathophysiology, and its resultant presentation and symptomatic spectrum, in TC or perhaps increased utilization outside of pediatric children's hospitals. Additionally, this data also argues against an article published prior, which suggested that even in the face of a pandemic, parents would still seek out tonsillectomies if indicated [13].

PTAs did not differ in rates throughout 2019–2021. PTAs are a common reason for presentation to the ED and are managed typically with a bedside drainage or antibiotics alone [26,27]. The reason for why PTAs did not differ during the pandemic is unclear, especially since overall TC declined, the rate of PTA was expected to decline as well. Since PTA present typically as a complication of acute tonsillitis, the pandemic could have affected access to care and timeliness of diagnoses or treatment which made these rates of PTA persist despite lower overall TC. Interestingly, analyses of patient demographics for PTA revealed increased black race and non-Hispanic ethnicity, as well as higher median household income ($p < 0.05$) compared to pre pandemic demographics. Insurance type did not differ significantly between the 3 years for those diagnosed with PTA.

This study is not without limitations. First, this data reflects the patient encounters of 51 Children's hospitals in 25 separate states and one district (Washington, DC), which may limit generalizability to local, state, regional, national, or international scales. As such, we are not able to include data from private practice, community hospitals, ambulatory surgery centers, or telemedicine visits. Additionally, any database entry is subject to both diagnostic and procedural coding errors. Furthermore, this is a cross-sectional study and does not imply causality. This remains the first US study to investigate the effects of Covid-19 on nationwide pediatric tonsil-related diseases and adenotonsillectomy procedures

across three consecutive years.

5. Conclusion

In conclusion, TC and TA decreased early in the pandemic, and TC increased relatively in several months in 2020. Proportion of TC then decreased significantly from May through December 2021 remaining at an all-time low. Despite relative increases in TC, TA procedures persistently stayed low without recovery for 2020 and 2021, which suggests that behavioral modifications related to the pandemic could have led to long-lasting change in the pathophysiology or healthcare utilization for TC. Future research could break down tonsil related diagnoses further into more specific subsets and compare these data across 2019 to include new data from 2022.

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None.

Declaration of competing interest

We have no conflicts of interests to disclose.

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We have none to report.

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