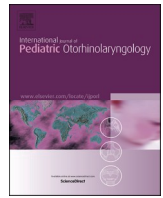




Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Impact of the novel coronavirus on surgical practices at a tertiary pediatric hospital: A 3 year cross-sectional study

Ashley M. Lloyd^{a,*}, Hengameh K. Behzadpour^b, Habib G. Zalzal^b, Ishwarya S. Mamidi^c, Hannah R. Crowder^c, Claire M. Lawlor^b, Diego Preciado^b, Brian K. Reilly^b

^a Division of Otolaryngology, George Washington University Hospital, 900 23rd Street NW, Washington, DC, 20037, USA

^b Department of Otolaryngology, Children's National Hospital, 111 Michigan Ave NW, Washington, DC, 20010, USA

^c George Washington University School of Medicine & Health Sciences, 2300 I Street NW, Washington, DC, 20052, USA

ARTICLE INFO

Keywords:
Coronavirus
Pediatric otolaryngology
Surgery
COVID-19

ABSTRACT

Objective: The novel coronavirus (COVID-19) forced unprecedented changes in pediatric otolaryngology workflow in the early pandemic, particularly due to the postponement of elective procedures. In turn, this has impacted timely treatment of patients and ability to train residents and fellows. The objective is to characterize how surgical practices in pediatric otolaryngology have been impacted by the pandemic through a cross sectional analysis over three years.

Methods: This cross-sectional study focuses on patients who underwent surgical procedures within the department of otolaryngology at a single tertiary pediatric hospital. Descriptive statistical analysis was used to compare subsets of patients from pre-pandemic in 2019, early-pandemic in 2020, and late-pandemic in 2021.

Results: Operative volume decreased by 87.57% in the early pandemic and 36.86% in the late pandemic. In the early pandemic, the greatest decreases were seen in airway reconstruction (100%), adenotonsillectomy (96.4%), adenoidectomy (94.7%), myringotomy with tympanostomy tube insertion (94.6%), frenulectomy (94.1%), and sinonasal procedures (93.3%), while in the late-pandemic adenotonsillectomy (42.4%) and myringotomy with tympanostomy tube insertion (70.1%) remained reduced when compared to pre-pandemic volume. Increased average case lengths in the early-pandemic (78.28 ± 51.95 min) and late-pandemic (71.91 ± 70.76 min) were observed when compared to pre-pandemic (52.26 ± 39.20 min) ($p < 0.001$). An increased proportion of multidisciplinary cases were completed in 2020 and 2021 ($p < 0.001$). In the 2020, 25% of cases were completed without trainee involvement. There was an overall decrease in case numbers for trainees and increase in cases without their involvement when compared to 2019 and 2021.

Conclusion: The COVID-19 pandemic resulted in a decrease in pediatric otolaryngology surgical procedures, particularly at the onset of the pandemic. While surgical trainees saw a dramatic reduction in case numbers early on, one year into the pandemic case volume is increasing and trending to pre-pandemic numbers. More complex cases, as represented by patients requiring longer operative times, inpatient status, and more frequently multidisciplinary care, were seen in the early pandemic, while drastic reductions were seen in routine outpatient procedures.

1. Introduction

The novel coronavirus (COVID-19) has greatly impacted operative procedures and hospital protocols, reducing surgical case volumes across the country to historical lows [1]. As COVID-19 cases in the United States increased throughout March 2020, postponement of elective surgeries became a priority in an attempt to further control

disease spread and increase availability of hospital resources and staffing for patients requiring care for COVID-19. Ultimately, the Center for Medicare and Medical Services released the recommendation to postpone elective surgeries on March 18, 2020 [2]. With these recommendations in mind, elective procedures were postponed at our institution beginning March 18, 2020, leading to a downstream overall reduction in surgical volume in the early pandemic. On April 7, 2020, a tier system to

* Corresponding author. George Washington University Hospital, 900 23rd Street NW, Washington, DC, 20037, USA.

E-mail address: ashleylloyd@gwu.edu (A.M. Lloyd).

<https://doi.org/10.1016/j.ijporl.2021.110923>

Received 11 May 2021; Received in revised form 9 August 2021; Accepted 11 September 2021

Available online 13 September 2021

0165-5876/© 2021 Elsevier B.V. All rights reserved.

guide treatment priority was released, which offered guidance on resuming elective cases [2].

At our institution, the following procedures were deemed necessary: operative laryngoscopy and/or bronchoscopy that could not wait beyond 6 weeks, tracheostomy, post-operative tonsillectomy bleeding or other surgical complications, foreign body aspiration, any battery foreign body, active abscess non-responsive to medical treatment, complications of otitis media or sinusitis, and biopsies and/or resection for head and neck cancer management. Non-battery nasal or ear foreign body were first attempted in-office, then brought to the operating room on an as-needed basis. Other procedures were scheduled at the discretion of the surgeon if delaying for 6–8 weeks could result in adverse effects.

In a survey across several large United States hospital systems, a 35% reduction in overall surgical volumes across specialties was seen from March 2020 through July 2020 compared to years prior, with up to 77% reduction in pediatric otolaryngology head and neck cases [1,3]. Delays in care, either due to perceived risks by patients themselves or due to hospital-wide reductions in non-urgent cases, may lead to negative outcomes for patients and surgical case backlogs for providers [4,5]. The downstream consequences may also lead to reduced case volume for surgical trainees. Otolaryngology residents in the United States must complete a minimum number of certain cases deemed key indicator cases to graduate. A subset of these key indicator cases, including 20 airway cases (pediatric and adult), 22 bronchoscopies, 40 ethmoidectomies, and 7 congenital neck masses, are cases that are often completed on pediatric patients or during a pediatric otolaryngology rotation for those residents [6]. At the onset of the pandemic, recommendations were made to reduce elective airway procedures, many of which comprise otolaryngology training [7]. A reduction in overall surgical volume may impact resident ability to meet residency key indicator criteria [8].

Further studies suggest that surgical trainees have had significant reductions in their ability to participate in both emergency and non-emergency cases since the onset of the pandemic [9]. In a survey of pediatric otolaryngology fellowship directors, 86.3% reported some continued surgical procedures at their institution, yet 77.2% felt COVID-19 was causing a significant impact on overall fellowship experience and 68.2% felt implemented changes could have a mild or moderate impact on ability to become a well-trained pediatric otolaryngologist [10]. Decreased operative exposure and experience for pediatric otolaryngology surgical trainees, in particular, may lead to decreased comfort in complex operative procedures such as correction of craniofacial abnormalities, cochlear implantation, laryngotracheal reconstruction, and excision of larger lymphatic malformations [11].

Despite deviation from traditional training, as time has progressed elective surgeries have been able to resume throughout the country with certain limitations. On December 3, 2020 the Center for Disease Control released a statement recommending healthcare workers and residents of long term care facilities receive the first doses of the COVID-19 vaccine and as of April 21, 2021 all Americans over age 16 years old became eligible for vaccination [12]. This, combined with increased availability of rapid COVID-19 testing, has likely played a role in the resumption of elective surgical procedures.

With the rapidly changing health climate of the United States in mind, the objective of this study is to assess the impact of the COVID-19 pandemic on otolaryngology surgical volume at our pediatric institution both at the immediate onset and one year into the pandemic. Our goal is to further characterize surgical trends and explore the impact of the COVID-19 pandemic on surgical trainees.

2. Materials and methods

This cross-sectional study was completed with permission from the Office for the Protection of Human Subjects and Institutional Review Board at a single tertiary pediatric hospital, Children's National Medical Center, in Washington, DC. An internal surgical billing dataset for

procedures completed during three time-frames was obtained. Data from March 18, 2019 through April 18, 2019 made up the pre-pandemic subset, while data from March 18, 2020 through April 18, 2020, corresponding to the first month of shutdown of elective surgical procedures, made up the early-pandemic subset, and data from March 18, 2021 through April 18, 2021 made up the late-pandemic subset. Data extracted included date of procedure, description of procedure, length of procedure, American Society of Anesthesiologist (ASA) classification, and type of admission (outpatient, observation, or inpatient). Demographics, including age, gender, body mass index (BMI), and comorbidities were collected. Comorbidities were categorized into the following: prematurity, genetic, pulmonary, cardiac, severe obstructive sleep apnea, developmental delay, and carcinoma. Involvement of a surgical assist (resident, fellow, or both) was noted. Cases were classified as multi-disciplinary if a single patient underwent procedures from multiple departments under a single anesthetic.

The surgical procedures for each patient were reviewed and categorized. Each procedure was listed as part of one or more of the following groups: adenoidectomy, tonsillectomy, adenotonsillectomy, diagnostic direct laryngoscopy with bronchoscopy, direct laryngoscopy with bronchoscopy with operative intervention, cochlear implant, myringotomy with tympanostomy tube placement, tracheostomy, exam under anesthesia, soft tissue mass resection, incision and drainage of abscess, mastoidectomy and/or tympanoplasty, sinonasal procedure, frenulectomy, or airway reconstruction. Exam under anesthesia consists of an ear exam under anesthesia with removal of impacted cerumen and/or ear foreign body, nasal exam under anesthesia without further intervention, sleep endoscopy, and any other procedure requiring anesthesia not better suited for any other category. Neck masses including branchial cleft cysts, thyroidectomy, and lymph node biopsies were categorized under soft tissue resection. Incision and drainage of abscess included both neck and peritonsillar abscesses which were accessed externally or intraorally.

Descriptive statistical analysis was completed using *Microsoft Excel* (2020 Microsoft Corporation) and *R Statistical Program* (RStudio: Integrated Development for R. RStudio, PBC, Boston, MA). Patients were divided into two groups regarding the year they underwent surgery (2020 COVID year versus 2019 non-COVID year). Chi-square analysis was performed for nominal data with Pearson's correlation, while independent samples t-tests were performed for interval data. Statistical significance was defined as $p \leq 0.05$ [13].

3. Results

3.1. Demographics

A total of 771 patients were analyzed in this cohort, with 43.2% females, average age of 71.34 months, and average BMI of 19.36. While in 2019 77% of patients were classified as ASA I or II, in 2020 and 2021 these represented 55.5% and 68% respectively. Demographic data for each subset analyzed is represented in [Table 1](#). There is no statistical significance in gender between subsets ($p = 0.518$).

3.2. Surgical volume

At the initial onset of the pandemic, from March 18, 2020 through April 18, 2020, 56 patients underwent 61 otolaryngology procedures under general anesthesia, a significant decrease compared to the 433 patients who underwent 491 procedures one year prior, from March 18, 2019 through April 18, 2019. In the following year, operative volume began to increase with 282 patients and 310 unique procedures completed in the department from March 18, 2021 through April 18, 2021. [Fig. 1](#) reflects trends in surgical frequency by week during the study time frame. When procedures were observed overall, adenotonsillectomy and myringotomy with tympanostomy tube insertion had significant decreases in 2020 and remained decreased when compared

Table 1
Demographics.

	2019 (N = 433)	2020 (N = 56)	2021 (N = 282)	P value
Age (months), mean (SD)	67.73 (57.45)	52.88 (55.79)	80.55 (69.59)	0.002
Female, n (%)	182 (42)	28 (50)	159 (56)	0.52
BMI, mean (SD)	19.02 (5.61)	18.20 (4.87)	20.17 (6.26)	0.009
ASA, %				<0.001
I	22	12.5	16	
II	55	43	52	
III	18	21	23	
IV	1.4	12.5	1.8	
IE	1.1	7	2.5	
IIE	1.6	2	2.5	
IIIE	0.7	0	1.4	
IVE	0.2	2	0.7	
Comorbidities, %				<0.001
None	73	70	54	
One	18	18	23	
Two	8	13	23	

*P values were obtained from two-sample t-test test for continuous data and Chi-square/Fisher's exact test for binary and categorical data.

to pre-pandemic volume. Need for tracheostomy placement was unchanged across all subsets.

Prior to the pandemic, the majority of procedures were scheduled outpatient procedures. In 2019, 284 patients (66%) had outpatient surgery, 81 patients (19%) required overnight observation, and 68

patients (16%) required inpatient admission. Early in the pandemic there was a reduction in patients requiring either outpatient surgery or post-surgical observation, 15 and 30 patients respectively (27%, 23%), in comparison to the 28 patients who required inpatient surgery (50%). By late-pandemic in 2021, the number of inpatient procedures returned to pre-pandemic volume. However, the extent of recovery did not hold true for outpatient or observational procedures, at 168 and 45 respectively. There was a statistically significant increase in case length both in the early-pandemic (78.28 ± 51.95 min) and late-pandemic (71.91 ± 70.76 min) when compared to average case length pre-pandemic (52.26 ± 39.20 min) ($p < 0.001$). Multidisciplinary cases made up 3% of cases in 2019, 11% of cases in 2020, and 10% of cases in 2021 ($p < 0.001$).

Of the patients treated in 2020, 36 (64.3%) had preoperative COVID-19 testing, resulting in 2 (3.6%) positive results, while all patients treated in 2021 had either pre-operative negative COVID-19 testing within 72 hours or met the hospital policy for exclusion of need for additional testing. Patients with positive COVID-19 result were not required to undergo repeat testing if their surgery was >28 days but <90 days of prior positive test. There were no patients in the late-pandemic subset who tested positive for COVID-19 prior to their operative procedure.

3.3. Surgical trainee involvement

Table 2 outlines the distribution of trainee involvement. The overall number of cases with trainee participation was dramatically decreased in 2020, early in the pandemic, with 25% of cases completed by attending surgeon only. However, by 2021 this trend began to reverse, with only 10% of cases uncovered by a resident or fellow.

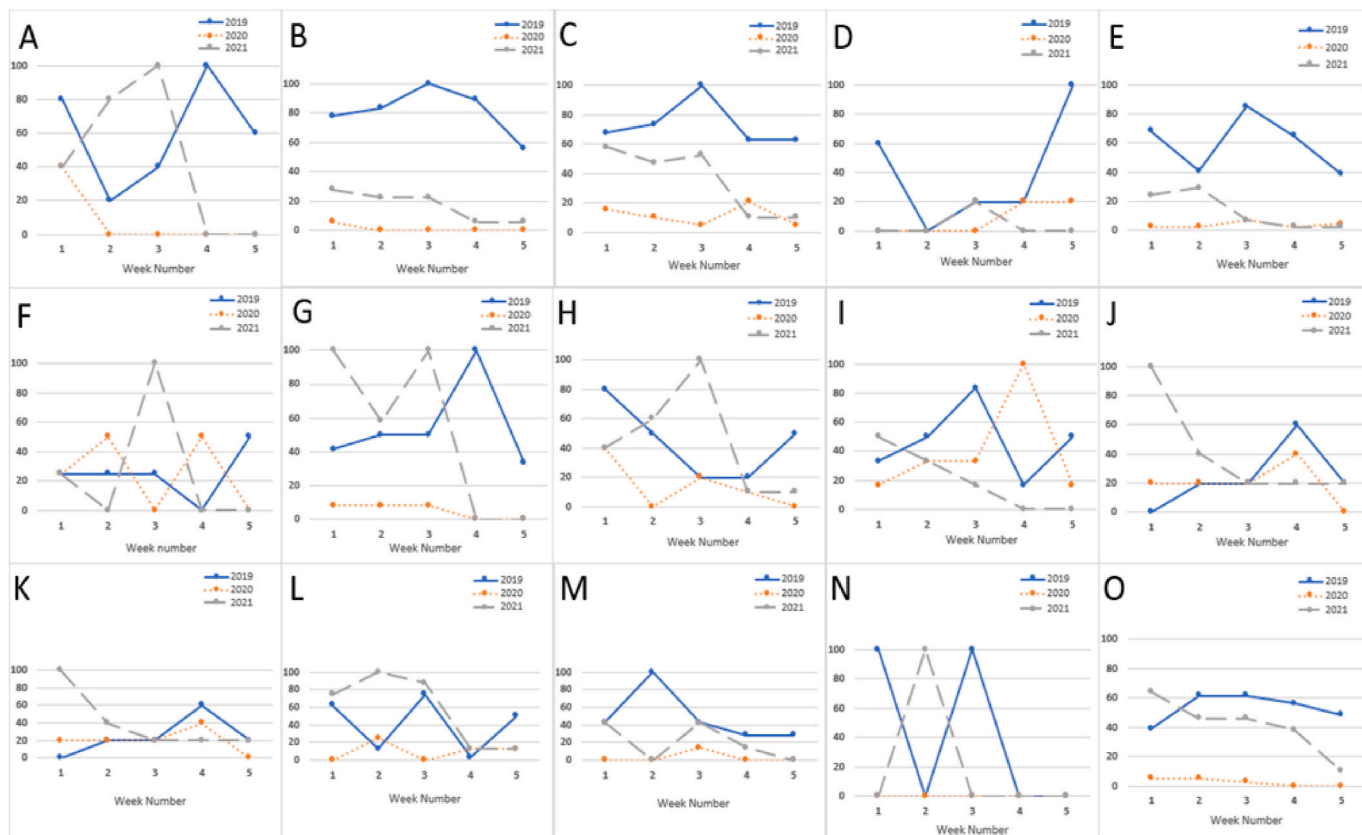


Fig. 1. Weekly Surgery Volume Trends 2019–2021 by Case Type. Weekly rates of surgical procedures from 2019, 2020, 2021. Case percentages were calculated with 2019 as reference point. A, Tonsillectomy. B, Adenoidectomy. C, Direct Laryngoscopy Bronchoscopy without intervention. D, Cochlear Implant. E, Myringotomy with Tympanostomy Tube placement. F, Tracheostomy. G, Exam Under Anesthesia. H, Soft tissue mass resection. I, Incision and Drainage of abscess. J, Mastoidectomy and/or tympanoplasty. K, Sinonasal. L, Direct Laryngoscopy Bronchoscopy with intervention. M, Frenulectomy. N, Airway reconstruction. O, Adenotonsillectomy.

Table 2
Involvement of surgical assist.

	2019	2020	2021	P value
None , n (%)	65 (15)	14 (25)	27 (10)	<0.001
Resident , n (%)	203 (47)	17 (30)	164 (58)	
Fellow , n (%)	148 (34)	22 (39)	50 (18)	
Both , n (%)	18 (4)	3 (5)	41 (15)	

*P values were obtained from two-sample *t*-test test for continuous data and Chi-square/Fisher's exact test for binary and categorical data.

4. Discussion

The cancellation and postponement of elective pediatric otolaryngology procedures resulted in a significant decrease in overall cases during the one-month period analyzed immediately after the onset of the pandemic. Overall there was an 87.57% decrease in surgical volume in the early pandemic. The most commonly completed procedures in the department in 2019, adenotonsillectomy and bilateral myringotomy with tympanostomy tube insertion, demonstrated >94% decrease in 2020, representing a shift from outpatient procedures to procedures on inpatients or those requiring a postoperative inpatient admission. By 2021 the surgical volume began to increase, in contrast to 2019 with 36.86% volume decrease. Interestingly, the number of procedures performed on inpatients returned to pre-pandemic volume, but outpatient procedures, including adenotonsillectomy and bilateral myringotomy with tympanostomy tube insertion, remained lower. This is not surprising due to lockdown precautions put in place, such as transitioning to virtual school and eliminating daycare, which may have lowered viral exposure for children. Viral infections serve as one of the main factors for recurrent infection ultimately requiring surgical intervention.

While in 2020 we noted a decrease in diagnostic and interventional airway procedures, by 2021 these numbers had returned to pre-pandemic numbers. There were more cases of direct laryngoscopy bronchoscopy with intervention in 2021 when compared to 2019, which could have been due to a backlog of patients from the early pandemic who required airway procedures whose cases were deemed non-emergent. Although tracheostomy is an aerosolizing procedure, we did not observe a change in the number completed across subsets, likely due to the underlying indication for tracheostomy placement. Airway reconstruction procedures were not completed in the early pandemic due to their longer operative time, direct exposure to the airway for the surgical team, and requirement of postoperative ICU admission, but it was possible to resume these procedures as the pandemic progressed with improved COVID-19 testing and precautions.

Multiple factors may have contributed to longer average case lengths in 2020 and 2021. Longer cases may imply more complex patients, more complex procedures, or a combination. Our cohort saw an increase in patients with multiple medical comorbidities, higher ASA classification, and a higher proportion of multidisciplinary cases in the pandemic years, which likely contributed to our longer case lengths. Multidisciplinary cases are commonly coordinated at our facility in order to complete multiple procedures under a single session of anesthesia with the aim to decrease lifetime anesthetic for a single pediatric patient. These combination cases reduce the need for multiple pre-operative COVID-19 tests for a single patient, as well as reduced airway manipulation by the anesthesia team.

Although patients undergoing operative procedures typically require negative pre-operative COVID-19 testing, allowances were made for emergent cases regardless of COVID-19 positivity. Of note, one patient in the early-pandemic required immediate surgical treatments for a neck abscess on two separate occasions, despite being COVID-19 positive. Appropriate airborne precautions were taken for these cases, including Powered Air Purifying Respirator (PAPR), and the involvement of only the most senior surgeon, the attending physician, in order to reduce potential exposure of the surgical team. In the late-pandemic there were

no patients who tested COVID-19 positive requiring immediate surgical intervention.

Resident and fellow surgical involvement was unquestionably interrupted in the early-pandemic. Not only was there an overall reduction in total cases in March 2020, but there was also an increase in cases that were completed without the assistance of a resident or fellow. In 2019 15% of cases were completed without an assist compared to 25% in 2020. Lack of rapid testing in the early pandemic likely contributed to decreased trainee participation due to the goal of the most experienced surgeon participating in the case to both decrease exposure and expedite completion. In 2020 there were surgical cases completed without trainees due to unknown or positive COVID-19 status of the patient. By 2021, only 10% of cases were completed without trainee involvement. This was likely due to increased availability of COVID-19 testing, adequate Personal Protective Equipment (PPE), and vaccinations.

With the reduction of cases in mind in the early-pandemic, there were concerns regarding adequate training for pediatric otolaryngology fellows due to absence of required cases and further occasions to demonstrate leadership. Fellows experienced a reduction in complex cases, such as laryngotracheal reconstructions and airway intervention procedures, whereas residents had a reduction in common otolaryngology procedures. Involvement of both a resident and fellow implies a teaching opportunity, which is an important component of pediatric otolaryngology fellowship training. In the early-pandemic there were only three cases with both a resident and fellow involved, but by 2021 there were 41 cases with both trainees involved. At our institution we are continuing to see an increase in surgical volume and educational opportunities trending to pre-pandemic levels.

This study is limited to a single tertiary pediatric institution. It is cross-sectional in nature and focuses on one month time frames in each respective year, which may not capture the full impact of the pandemic. Given the fluidity of COVID-19 restrictions and guidelines due to case increases throughout the country, increased study length and multi-institutional involvement could further illustrate the impact of this disease on pediatric otolaryngology surgery.

5. Conclusion

The COVID-19 pandemic resulted in a significant decrease in pediatric otolaryngology surgical volumes in the immediate month following the onset of the pandemic. With increases in availability of personal protective equipment, preoperative COVID-19 testing, and availability of vaccines to providers, trends in surgical volumes are beginning to return to pre-pandemic levels. This study highlights the increase in complex otolaryngology procedures with decrease in routine outpatient procedures seen in response to the pandemic. Future studies may further quantify the long-term impact on surgical trainees due to the significant reduction in pediatric otolaryngology cases at the immediate onset of the pandemic.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

- [1] G. Berlin, D. Bueno, K. Gibler, J. Schulz, Cutting through the COVID-19 surgical backlog, Published October 2, 2020, <https://www.mckinsey.com/industries/h/healthcare-systems-and-services/our-insights/cutting-through-the-covid-19-surgical-backlog#>. (Accessed 17 January 2021).
- [2] Non-Emergent, Elective medical Services, and treatment recommendations, Centers.Medicare.Medicaid.Serv. (April 7, 2020). <https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf>. (Accessed 17 January 2021).
- [3] H.N. Kuhar, A. Heilingoetter, M. Bergman, N. Worobetz, T. Chiang, L. Matrkra, Otolaryngology in the time of corona: assessing operative impact and risk during

- the COVID-19 crisis, *Otolaryngol Neck Surg* 163 (2) (2020) 307–315, <https://doi.org/10.1177/0194599820930214>.
- [4] J.I. Billig, E.D. Sears, The compounding access problem for surgical care: innovations in the post-COVID Era [published online ahead of print, 2020 May 20], *Ann. Surg.* (2020), <https://doi.org/10.1097/SLA.0000000000004085>, 10.1097/SLA.0000000000004085.
- [5] M. Lazzarini, E. Barbi, A. Apicella, F. Marchetti, F. Cardinale, G. Trobia, Delayed access or provision of care in Italy resulting from fear of COVID-19, *Lancet Child Adolesc Health* 4 (5) (2020) e10–e11, [https://doi.org/10.1016/S2352-4642\(20\)30108-5](https://doi.org/10.1016/S2352-4642(20)30108-5).
- [6] Accreditation Council of Graduate Medical Education, Required minimum number of key indicator procedures for graduating residents review committee for otolaryngology, March 2013, in: http://www.acgme.org/Portals/0/PFAssets/ProgramResources/280_Required_Minimum_Number_of_Key_Indicator_Procedures.pdf (Accessed 1 November 2020).
- [7] D.V. Bann, V.A. Patel, R. Saadi, et al., Best practice recommendations for pediatric otolaryngology during the COVID-19 pandemic, *Otolaryngology-Head Neck Surg.* (Tokyo) 162 (6) (2020) 783–794, <https://doi.org/10.1177/0194599820921393>.
- [8] R.K. Gurgel, B.R. Cardon, C.M. Allen, et al., Evaluating gender parity in operative experience for otolaryngology residencies in the United States, *Laryngoscope* 130 (7) (2020) 1651–1656, <https://doi.org/10.1002/lary.28306>.
- [9] E.C. Ellison, K. Spanknebel, S.C. Stain, et al., Impact of the COVID-19 pandemic on surgical training and learner well-being: report of a survey of general surgery and other surgical specialty Educators [published online ahead of print, 2020 sep 12], *J. Am. Coll. Surg.* 231 (6) (2020) 613–626, <https://doi.org/10.1016/j.jamcollsurg.2020.08.766>.
- [10] J. Johnson, M.T. Chung, J. Stathakios, N. Gonik, B. Siegel, The impact of the COVID-19 pandemic on fellowship training: a national survey of pediatric otolaryngology fellowship directors, *Int. J. Pediatr. Otorhinolaryngol.* 136 (2020 Sep) 110217, <https://doi.org/10.1016/j.ijporl.2020.110217>. Epub 2020 Jun 23. PMID: 32797806; PMCID: PMC7308764.
- [11] K. Kerscher, A. Tabaei, R. Ward, J. Haddad Jr., E. Grunstein, The residency experience in pediatric otolaryngology, *Laryngoscope* 118 (4) (2008 Apr) 718–722, <https://doi.org/10.1097/MLG.0b013e3181620847>. PMID: 18176338.
- [12] How CDC is making COVID-19 vaccine recommendations, Centers of Disease Control and Prevention (April 28, 2021). <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations.html>. (Accessed 29 April 2021).
- [13] RStudio Team, R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria, 2020. URL, <http://www.R-project.org/>.