International Survey of Operative Practices for Otologists and Neurotologists During the COVID-19 Crisis

*†Sarah E. Ridge, *Divya A. Chari, *Elliott D. Kozin, ‡Aaron K. Remenschneider, §Oliver F. Adunka, ||Miguel Aristegui, ¶Wai Tsz Chang, **††‡‡Yen-Fu Cheng, §§Jong Woo Chung, *Michael S. Cohen, *Matthew G. Crowson, ||||Justin S. Golub, ¶¶Ophir Handzel, ***Brandon Isaacson, †††Arunachalam Iyer, ‡‡‡Seiji Kakehata, §§§Daniele Marchioni, ||||||João Flávio Nogueira, ¶¶¶****Nirmal Patel, *Alicia M. Quesnel, †Alejandro Rivas, ††††Shakeel R. Saeed, ‡‡‡‡Richard Salzman, *Felipe Santos, §§§§Alexander J. Saxby, ||||||||Muaaz Tarabichi, ¶¶¶¶*****Nicolas Verhaert, †††††Robert Vincent, ‡‡‡‡‡George Wanna, §§§§§Stephan Wolpert, and *Daniel J. Lee

**Department of Otolaryngology – Head and Neck Surgery, Massachusetts Eye and Ear, Harvard Medical School, Boston, Massachusetts; †Department of Otolaryngology – Head and Neck Surgery, University Hospitals Cleveland Medical Center, Cleveland, Ohio; ‡Department of Otolaryngology – Head and Neck Surgery, University of Massachusetts Medical Center, Worcester, Massachusetts; §Department of Otolaryngology – Head and Neck Surgery, The Ohio State University Wexner Medical Center, Columbus, Ohio; ||Department of Otorhinolaryngology, Hospital General Universitario Gregorio Marañón, Madrid, Spain; ¶Department of Otorhinolaryngology, Head and Neck Surgery, The Chinese University of Hong Kong, Hong Kong; **Department of Medical Research, Taipei Veterans General Hospital; ††Department of Otolaryngology – Head and Neck Surgery, Taipei Veterans General Hospital; ‡‡School of Medicine, National Yang-Ming University, Taipei, Taiwan; §§Department of Otorhinolaryngology – Head and Neck Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea; ||||Department of Otolaryngology – Head and Neck Surgery, Columbia University Vagelos College of Physicians and Surgeons, New York-Presbyterian/Columbia University Irving Medical Center, New York; ¶¶Department of Otolaryngology/Head, Neck and Maxillofacial Surgery, Tel-Aviv Sourasky Medical Center, Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel; ***Department of Otolaryngology – Head and Neck Surgery, University of Texas Southwestern Medical Center, Dallas, Texas; †††Department of Otorhinolaryngology, University of Glasgow, University Hospital Monklands, Scotland, United Kingdom; ‡‡‡Department of Otolaryngology – Head and Neck Surgery, Yamagata University Faculty of Medicine, Japan; §§§Department of Otorhinolaryngology – Head and Neck Surgery, University Hospital of Verona, Verona, Italy; ||||||Sinus & Oto Centro-Hospital Geral de Fortaleza, Rua Dr. José Furtado, Fortaleza, Brazil; ¶¶¶Royal North Shore Hospital, Division of Otolaryngology Head and Neck surgery, Discipline of Surgery, Sydney Medical School, University of Sydney; ****Department of Otolaryngology Head and Neck Surgery, Faculty of Medicine and Health Science, Macquarie University, Sydney, Australia; ††††Royal National Throat Nose and Ear Hospital, University College London Ear Institute, University College London, London, United Kingdom; ‡‡‡‡Department of Otorhinolaryngology and Head and Neck Surgery, Faculty of Medicine and Dentistry, Palacky University Olomouc and University Hospital Olomouc, Czech Republic; §§§§Royal Prince Alfred Hospital, University of Sydney, Sydney, Australia; ||||||||Tarabichi Stammberger Ear and Sinus Institute, Dubai, United Arab Emirates; ¶¶¶¶Department of Otolaryngology, Head and Neck Surgery, University Hospitals Leuven; *****KU Leuven, Department of Neurosciences, ExpORL, Belgium; †††††Causse Ear Clinic, Colombiers, France; ‡‡‡‡‡Department of Otolaryngology – Head and Neck Surgery, New York Eye and Ear Infirmary of Mount Sinai and Mount Sinai Beth Israel, Icahn School of Medicine at Mount Sinai, New York, NY; and §§§§§Department of Otorhinolaryngology – Head and Neck Surgery, University of Tuebingen, Tuebingen, Germany*

Address correspondence and reprint requests to Daniel J. Lee, M.D., 243 Charles Street, Boston, MA 02114; E-mail: Daniel_Lee@meei.harvard.edu

The authors disclose no funding and conflicts of interest.

Supplemental digital content is available in the text.

DOI: 10.1097/MAO.0000000000003219

Objective: To investigate the influence of the COVID-19 pandemic on operative practices of otology and neurotology providers internationally.

Study Design: Cross-sectional survey.

Methods: A 78-question survey was distributed to otologists and neurotologists between May 12, 2020 and June 8, 2020

to assess the impact of the pandemic on surgical practices. Sections within the survey delineated time periods: prior to the crisis, onset of the crisis, during the crisis, postcrisis transition.

Results: Of 396 survey respondents, 284 participants from 38 countries met inclusion criteria.

Respondents were 16.9% female and 82.4% male, with a most common age range of 40 to 49 years (36.3%). 69.8% of participants had been in practice for over 10 years and most respondents worked in an academic medical center (79.2%). The average operative weekly caseload was 5.3 (SD 3.9) per surgeon prior to the crisis, 0.7 (SD 1.2) during the COVID-19 crisis, and 3.5 (SD 3.3) for those who had begun a postcrisis transition at the time of survey administration ($p < 0.001$). 71.5% of providers did not perform an elective otologic or neurotologic operative procedure during the initial crisis period. 49.8% reported modifying their surgical technique due to the COVID-19 pandemic. Use of powered air-purifying respirators and filtering facepiece 2 or 3 (FFP2/FFP3) respirators were in minimal supply for 66.9% and 62.3% of respondents, respectively.

Conclusion: The COVID-19 pandemic impacted the otology and neurotology community globally, resulting in significant changes in operative volume and case selection. Modification of surgical technique and shortages of personal protective equipment were frequently reported. **Key Words:** Aerosol generating procedure—Coronavirus—Endoscope—Exoscope—Mastoidectomy—N95—Neurotologic surgery—Otologic surgery—Pandemic—PAPR—Personal protective equipment—PPE—SARS CoV-2—Severe acute respiratory syndrome.

Otol Neurotol **42:**1275–1284, 2021.

The COVID-19 outbreak, caused by the novel coronavirus SARS-CoV-2, has resulted in unprecedented changes to the modern healthcare landscape. In March of 2020, the World Health Organization categorized COVID-19 as a global pandemic and encouraged hospitals to prepare and protect healthcare workers (1). Institutions adapted quickly to meet the needs of employees and patients, often while facing workforce changes, decreased revenue, and shortages of equipment and testing supplies (2). Policies and practice patterns changed drastically, with many hospitals discontinuing elective operative procedures (3).

The SARS-CoV-2 virus is transmitted through aerosols and droplets, and high viral loads are present in the nasopharynx for both symptomatic and asymptomatic individuals (4). Viral loads of the middle ear and mastoid cells have not been well established, but respiratory viruses, including rhinovirus, respiratory syncytial virus, influenza, parainfluenza, and other coronavirus subtypes have been identified in middle ear fluid samples from children (5–7). SARS-CoV-2 has been identified in cadaveric temporal bone specimens of recently deceased individuals infected with COVID-19 (8). Surgeons performing temporal bone procedures may therefore be at increased risk for occupational exposure, and should wear enhanced personal protective equipment (PPE) when performing high-risk procedures (9,10).

Options for enhanced PPE include N95 or filtering facepiece 2 or 3 (FFP2/FFP3) respirators, face shields, and powered air-purifying respirators (PAPR). Additional recommendations to minimize nosocomial spread in the operating room include draping over the surgical field (e.g., use of an ''ototent'') (11,12) to isolate particulate matter, using alternative visualization techniques (endoscopes and exoscopes) to enable use of full PPE, operating in negative pressure rooms, and decreasing the number of personnel in the OR, particularly during intubation and extubation (9,13,14). The degree to which otology and neurotology providers implemented these recommended practices in the setting of COVID-19 remains unknown.

This survey study aims to investigate the effects of the COVID-19 crisis on surgical practices for otology and neurotology providers internationally (SDC, http://links.lww.com/MAO/B281), including operative caseload and case selection, modification of surgical techniques, and availability and use of PPE and PAPR. This survey also served as a platform for respondents to share lessons learned during the COVID-19 crisis and during the postcrisis transition.

MATERIALS AND METHODS

Survey Design

The research study and survey were approved by the Partners Healthcare Institutional Review Board (protocol number 2020P001245). A 78-question survey was created and hosted on the cloud-based survey software SurveyMonkey (www.surveymonkey.com). Questions regarding operative caseload, case selection, modification of surgical techniques, and availability and use of PPE and PAPR were divided into the following sections to delineate time periods (Fig. 1):

- *Prior to the crisis*: The period describing baseline practices, before any policy changes were implemented in response to the COVID-19 pandemic.
- *Onset of the crisis*: The period over which institutional policy changes were implemented in response to increasing concerns over the safety of staff members, patients, and the general public.
- *During the crisis*: The period during which a new steady-state routine was reached under acute crisis conditions, with fewer policy changes occurring.
- *Postcrisis transition*: The period over which some of the limitations imposed by *initial* policy changes were relaxed in order to resume elements of precrisis practices. (Note: This describes the time period after the *initial acute crisis period* and does not imply that the COVID-19 pandemic has resolved.)

Survey Administration

The survey was distributed by the study collaborators to otologists and neurotologists within their international professional networks, including providers within the United States,

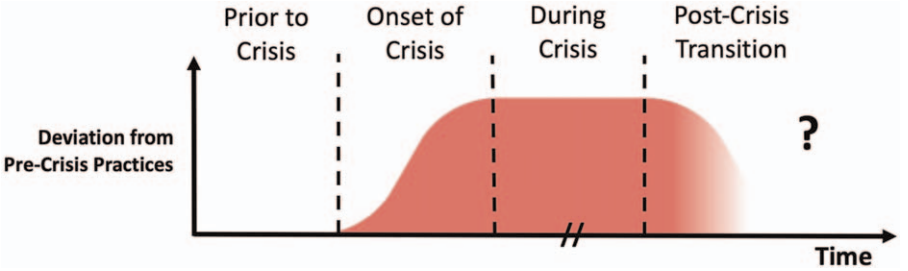

FIG. 1. COVID-19 healthcare response timeline. Visual representation of framework used to investigate changes to operative practices and personal protective equipment use over the course of the initial COVID-19 outbreak. There was likely a deviation from precrisis practices during the onset of the crisis, while a new steady-state routine was likely reached during the crisis. The postcrisis transition likely saw a reversal of some of the initial policy changes, bringing practice patterns closer to precrisis conditions. The future of practice patterns is unknown.

via e-mail beginning on May 12, 2020. The survey was also included in the American Neurotology Society/American Otological Society biannual email, which was distributed to 670 society members on May 15, 2020. Response rates could not be obtained using these methods. The survey closed on June 8, 2020. Informed consent was obtained from each respondent and information was collected anonymously.

Data Analysis

Responses were excluded from data analysis if the respondent 1) did not agree to participate in research, 2) was not a provider of otology or neurotology care, 3) was a resident physician, or 4) completed only the introductory or demographic portions of the survey. All other responses were analyzed, including those from partially complete surveys. Data were cleaned by reformatting or recategorizing responses where appropriate. Practice locations were classified using World Bank regions (15).

Statistical Analysis

Data were tabulated using Excel (Microsoft Corp). Descriptive statistics and statistical analysis were performed using SPSS (SPSS Software, IBM Corp). A one-way repeated measures analysis of variance was used to compare the operative caseload between defined periods. A Huynh-Feldt correction was used due to a significant Mauchly's test of sphericity ($p < 0.05$) and a Greenhouse-Geisser epsilon > 0.75. A chi-square test was used to investigate the relationship between PAPR use during the COVID-19 crisis and global region or practice environment. Statistical significance was set at $p < 0.05$ for all tests.

RESULTS

Demographic Information

A total of 396 responses were collected and 112 respondents were excluded based on the criteria outlined above. Demographic information from the remaining 284 respondents is represented in Table 1 and Figure 2. Respondents were 16.9% female (N = 48) and 82.4% male (N = 234), with a most common age range of 40 to 49 years. The majority of respondents had been practicing medicine for over 10 years (69.8%, N = 198) and the most common practice environment was an academic or university-affiliated medical center (79.2%, N = 225). Respondents from 38 countries participated in the survey. Within the United States, respondents were located in 21 states.

Operative Caseload and Case Selection

Operative caseload refers to the approximate number of otologic and neurotologic operative procedures performed per week by attending-level respondents with operative practices. Prior to the COVID-19 pandemic, physicians reported an average operative caseload of 5.3 (SD 3.9) cases per week per surgeon, which decreased to 0.7 (SD 1.2) cases per week during the COVID-19 crisis (Fig. 3). Indeed, 34.5% of respondents (N = 86) did not perform any otologic or neurotologic operative procedure (emergent/urgent, time-sensitive, or elective) during the COVID-19 crisis. With regard to elective procedures, 96.2% of respondents (N = 255) reported a significant decrease in elective operative procedures at their institution due to the COVID-19 pandemic and 71.5% of providers (N = 178) did not perform an elective otologic or neurotologic operative procedure during the crisis.

53.1% of respondents (N = 121) reported that a postcrisis transition had begun at their institution at the time of survey completion. Respondents who had begun to transition to a postcrisis time period reported an average operative caseload of 3.5 (SD 3.3) cases per week (Fig. 3). In the postcrisis time frame, the number of respondents who had not performed any otologic or neurotologic operative procedure decreased to 12.5% (N = 15). Elective operative procedures had significantly increased for 77.7% of respondents (N = 94), while 27.5% of providers (N = 33) indicated that they had not performed an elective otologic or neurotologic operative procedure during the postcrisis transition.

The change in operative caseload over the three time periods (Fig. 3) was found to be significant ($F[1.8, 204.8] = 158.8$, $p < 0.001$). Operative caseload was not significantly different among geographic region ($F[7.6, 202.5] = 1.7$, $p > 0.05$), academic practice environment ($F[1.8, 206.1] = 1.8$, $p > 0.05$), or private practice environment ($F[1.9, 204.1] = 0.527$, $p > 0.05$).

TABLE 1. *Respondent characteristics*

	#	%
Training status or years of practice		
Otology/neurotology fellow	16	5.6
1–5 years of practice	35	12.3
5–10 years of practice	35	12.3
10–20 years of practice	97	34.2
>20 years of practice	101	35.6
Scope of practice		
Otology	260	91.5
Neurotology	154	54.2
Comprehensive otolaryngology	95	33.5
Pediatric otolaryngology	96	33.8
Other	19	6.7
Practice environment		
Academic or university medical center	225	79.2
Private medical center	98	34.5
Nonacademic public hospital	26	9.2
Government facility	18	6.3
Other	5	1.8
Academic title		
Chairman of Otolaryngology department	51	18.0
Chief of Otolaryngology division, Department of Surgery	16	5.6
Chief of Otology and Neurotology division or section	47	16.5
Fellowship Program Director	11	3.9
Academic positions		
Professor	32	11.3
Associate Professor	62	21.8
Assistant Professor	33	11.6
Instructor	20	7.0
N/A	42	14.8
Other	26	9.2
Age		
18–29	4	1.4
30–39	58	20.4
40–49	103	36.3
50–59	86	30.3
60–69	28	9.9
70–79	5	1.8
Gender		
Female	48	16.9
Male	234	82.4
Prefer to self-describe	2	0.7

Figure 4 illustrates the timeline of changes in elective operative caseload per country and global region. Countries in East Asia (China, Japan, and Taiwan) reported an early onset of the COVID-19 crisis, while countries in Europe and North America reported a later onset on average. Of note, two respondents, both from Taiwan, reported that the COVID-19 pandemic had not affected their operative or clinical practice, likely due to a strict regulation policy and the low number of confirmed COVID-19 cases (16,17).

Operative Practices

Approximately half of respondents (49.8%, N = 126) reported modifying their surgical technique due to the COVID-19 crisis. Respondents had the option to describe these techniques in a follow-up free response question. Responses included using enhanced PPE (PAPR, goggles, or face shields), using an alternative draping technique to create a protective tent around the patient, and avoiding aerosol generating procedures (AGPs) such as suctioning or drilling. More specifically, respondents reported using transcanal endoscopic ear surgery to gain access to relevant structures and avoid the need for drilling of the mastoid cavity. Some surgeons reported using endoscopes and exoscopes in place of microscopes, as these are more compatible with eye-covering PPE (9). Others reported decreasing the number of personnel in the OR; 36.8% (N = 93) of respondents did not allow any trainees to participate in the operative setting. In fact, only 2.8% (N = 7) of respondents indicated that medical students were allowed to participate in the operative setting during the COVID-19 crisis, while 44.7% (N = 113) indicated that residents were allowed to participate. Many reported using local anesthesia where possible to avoid the need for intubation and extubation, which are considered AGPs. Approximately one-fifth of providers worked at an institution that imposed a minimum time requirement between intubation and the start of surgery (18.7%, N = 47), or extubation and transport to the recovery room (21.4%, N = 54), with an average delay of 20-minute following either intubation and extubation. About half of the respondents had a negative pressure operating room available to them at their institution (49.6%, N = 115).

Almost all respondents had access to SARS-CoV-2 PCR testing (97.4%, N = 226), and about half of respondents reported receiving results in less than 24 hours (52.2%, N = 118). About half of respondents had access to antibody testing (N = 113, 48.7%). Most respondents reported testing patients once preoperatively (65.1%, N = 151), while 15.9% reported testing twice (N = 37) due to concerns about the false negative rate of testing, and 6.5% (N = 15) reported that patients were not typically tested preoperatively at their institution.

Personal Protective Equipment

Prior to the COVID-19 crisis, 80.3% (N = 228) of providers had never used an N95/FFP2 or FFP3 respirator. During the COVID-19 crisis, about half of the providers (48.3%, N = 114) reported that they were required to wear one of these respirators during all operative procedures, and about three-quarters of respondents reported that these masks were required for AGPs (75.4%, N = 178) or operative procedures in which the patient had a presumed or confirmed SARS-CoV-2 infection (76.7%, N = 181). However, these respirators were in minimal or no supply for the majority of respondents (66.9%, N = 158). 42.0% (N = 99) of respondents had not had a fit test for these masks and, of those who had taken a fit test, 10.2% (N = 14) had not passed the test.

Prior to the COVID-19 crisis, 98.2% of providers (N = 279) had never used a PAPR. There was wide

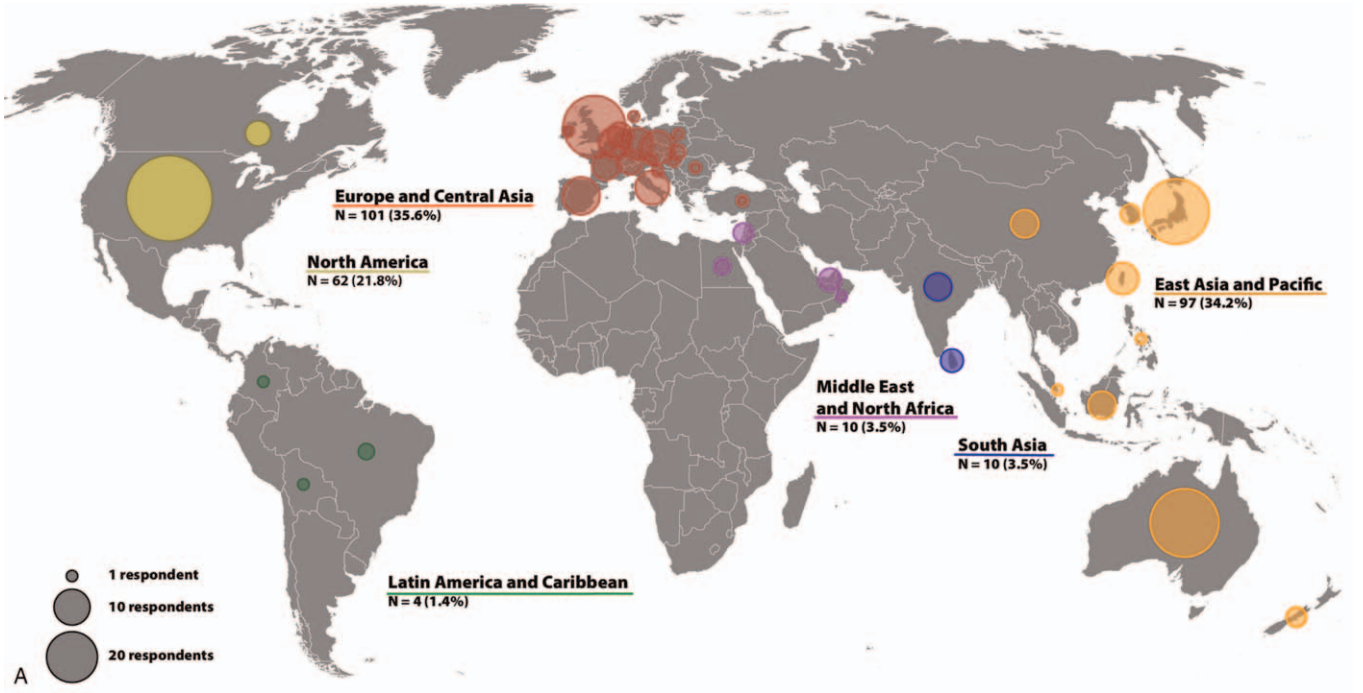

FIG. 2. Proportional symbol map showing survey respondents geographic location *A*, internationally and *B*, within the United States.

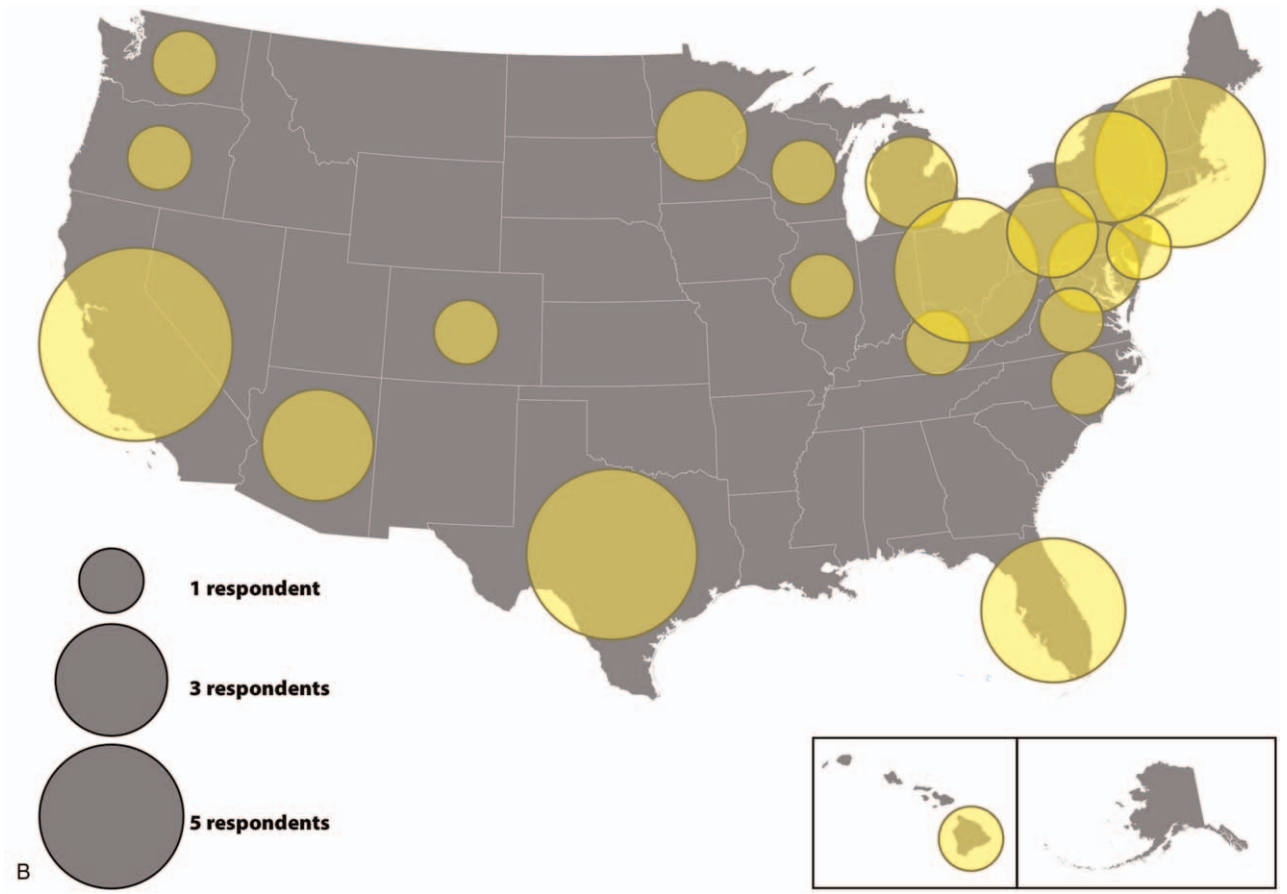

FIG. 2. (Continued).

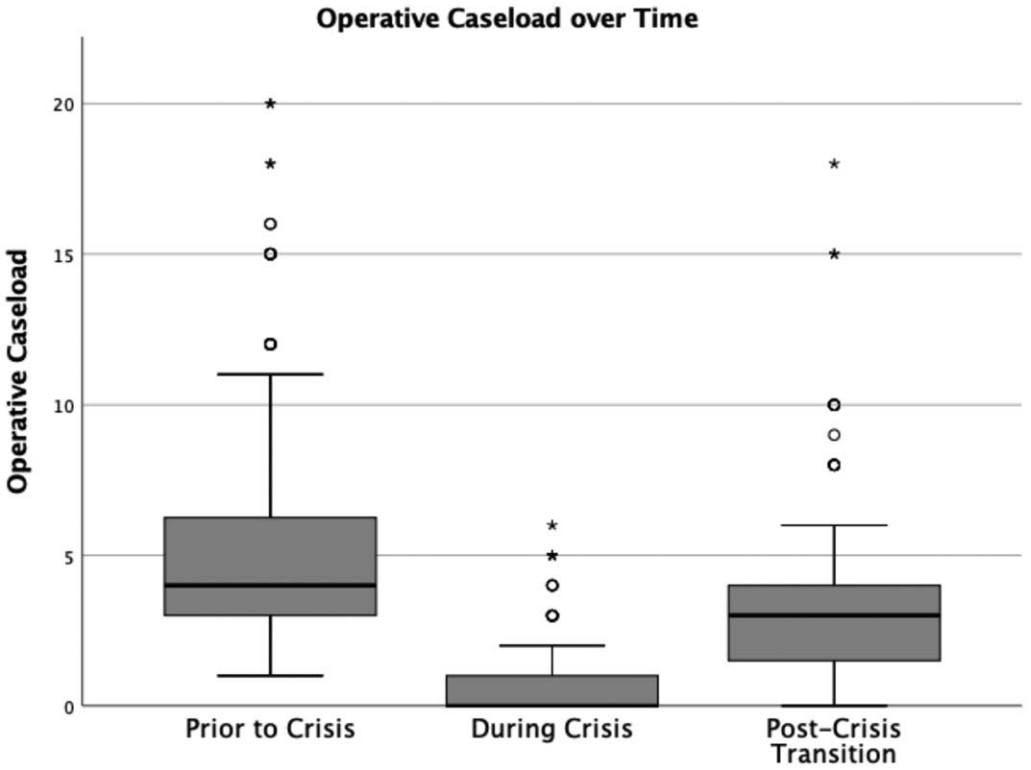

FIG. 3. Boxplot depicting change to weekly operative caseload over the course of the initial COVID-19 outbreak. The box represents the interquartile range, while the line represents the median. Mild outliers (values between 1.5 and 3 times the interquartile range) and extreme outliers (values which are 3 or more times the interquartile range) are represented with circles and stars, respectively. One extreme outlier is not shown for scaling purposes.

variability in PAPR availability and protocols surrounding PAPR use. PAPR was in minimal or no supply for 62.3% of respondents (N = 147) and 42.8% of respondents (N = 101) said that PAPR was never made available at their institution. One-third of respondents (33.5%, N = 79) indicated that PAPR was permitted under some circumstances, such as AGPs, prolonged exposure to a patient with a presumed or confirmed SARS-CoV-2 infection, or if a fit test for a N95/FFP2 or FFP3 respirator mask failed. One respondent reported that their department does not allow PAPR to be used, but a colleague had purchased one for themselves and was using it surreptitiously. About half of respondents said they planned to use a PAPR in the future if they were to perform a high-risk AGP in a presumed or confirmed positive patient (47.0%, N = 111), and many others expressed that they would use PAPR if it were available or permitted at their institution. Despite these responses, only 12.7% (N = 30) of respondents had use a PAPR during the COVID-19 crisis, and there was not a significant relationship between PAPR use and geographic region (X^2 [5, N = 236] = 5.22, $p > 0.05$), academic practice environment (X^2 [1, N = 236] = 0.175, $p > 0.05$), or private practice environment (X^2 [1, N = 236] = 1.37, $p > 0.05$). Information regarding PAPR use during the COVID-19 pandemic in these 30 respondents is presented in Table 2. A total of 23 respondents described their experience while operating with a PAPR, reporting trouble with communication, reduced ability to use a microscope, impaired view, high temperature, and interference with a headlight.

DISCUSSION

The healthcare landscape has been severely impacted by the COVID-19 pandemic, which has resulted in approximately 187.8 million cases and 4 million deaths worldwide as of July 2021 (18). Our international survey results demonstrated a significant decrease in the number of surgical cases performed by otologists and neurotologists during the initial onset of the COVID-19 pandemic (96.2%, N = 255). At the onset of the COVID-19 pandemic in early 2020, guidelines across the world encouraged postponing elective procedures and performing only emergency procedures or oncologic cases under some conditions (19–22). Perhaps unsurprisingly, a sharp decline was noted in the number of surgical cases reported immediately following the onset of the COVID-19 crisis. In the subsequent months, however, surgical volume appeared to increase; in the ''postcrisis transition'' time period of this survey, 87.5% (N = 105) of respondents reported performing some otologic or

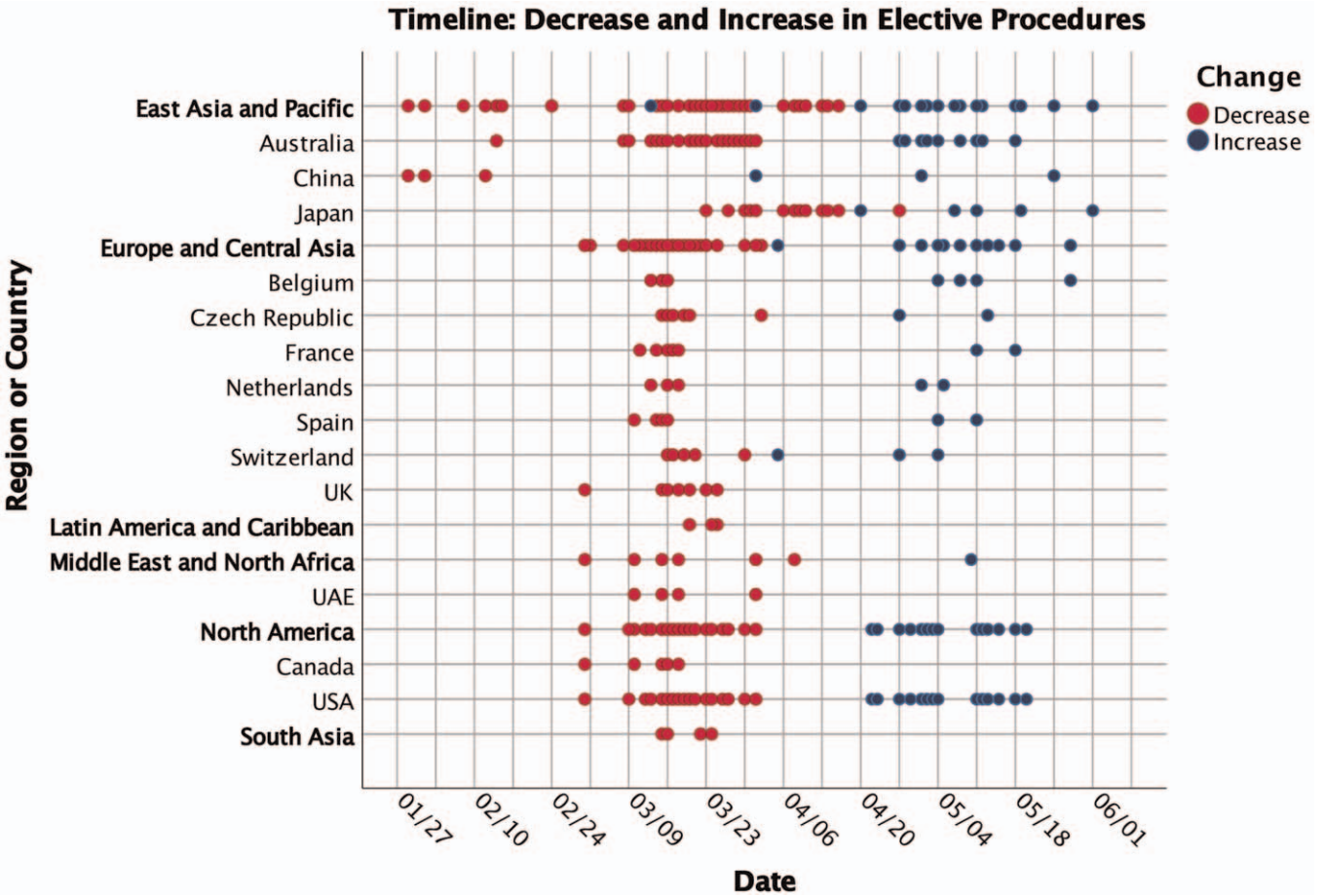

FIG. 4. Decrease and increase in elective procedures. Respondents were asked whether there had been a significant decrease in elective operative procedures at their institution during the onset of the COVID-19 pandemic as compared to the precrisis time period, and whether there had been a subsequent increase from nadir at the time of survey completion. This figure shows a timeline of the approximate dates on which these changes occurred, by geographic region or country. Countries with three or fewer responses are not shown.

neurotologic procedures. Indeed, by the time of survey completion between May 15 and June 8, 77.7% of respondents (N = 94) reported that their operative volume had increased compared to during the initial onset of the pandemic.

Though no literature has been published quantifying changes in caseload or case selection on an international scale or within the otology and neurotology subspecialty, our findings are consistent with reports from other subspecialties. A North American survey found that 96.3% of responding otolaryngologists had canceled elective cases (23), and a hospital in Belgium had a 79.5% decrease in otolaryngology and maxillofacial cases during the crisis (24). We speculate that the initial dramatic decrease in surgical volume observed internationally was due to unknown factors related to viral transmissibility and risk of nosocomial infection, particularly in otologic surgery. As more knowledge was obtained and disseminated about the COVID-19 virus and rates of infection were reported for various geographic regions, practitioners began to reopen their surgical practices, corresponding to the increase in surgical volume at later time periods.

Guidelines both domestically and internationally have suggested modifying surgical practices to increase safety for healthcare workers during the COVID-19 pandemic (9,13,14). In our study, about half of respondents (49.8%, N = 126) reported modifying their surgical technique. Many reported using an altered draping technique to create a protective tent around the patient. Studies have demonstrated reduced particle dispersion using this technique (11,12,25,26) and this method has been recommended by the British Society of Otology for its potential to limit aerosolization of tissues (27). Approximately half of respondents (49.6%, N = 115) reported that a negative pressure operating room was available to them at their institution, though this has been recommended in cases where COVID-19 status is positive or unknown (28) or during intubation/extubation (29). Some guidelines have suggested that intubation and extubation be performed with only one anesthesia provider and one assistant in the OR, and that other personnel enter the OR only after

TABLE 2. *Experience with powered air-purifying respirators (PAPRs) during the COVID-19 crisis*

PAPR used during the COVID-19 pandemic	#	%
Formal training received		
Yes	20	66.7
No	10	33.3
Source		
Institution	29	96.7
Self	2	6.7
Assistant use of PAPR		
Yes	25	83.3
No	4	13.3
Sometimes	1	3.3
Reasoning		
AGP	25	83.3
Other respirators unavailable	4	13.3
Poor fit of other respirators	3	10.0
Additional respiratory PPE used		
None	11	36.7
Surgical mask	5	16.7
N95/FFP2/FFP3	13	43.3
Type of PAPR		
Half mask	4	13.3
Full mask	26	86.7
Setting		
OR	20	66.7
Clinic	3	10.0
Both	7	23.3

AGP indicates aerosol generating procedure; PAPR, powered air-purifying respirators; PPE, personal protective equipment.

adequate air exchange has occurred. This waiting period is typically between 15 and 30 minutes (30,31). Only one-fifth of providers worked at an institution which imposed a minimum time requirement between intubation and the start of surgery (18.7%, N = 47), or extubation and transport to the recovery room (21.4%, N = 54), with an average delay of approximately 20 minutes for both procedures. Several respondents reported using endoscopes or exoscopes in place of an operating microscope during the COVID-19 crisis. Transcanal endoscopic ear surgery can be used to access the middle ear without the need for bony drilling, thereby avoiding aerosol generation (32,33). Both endoscopes and exoscopes allow surgeons to perform heads-up surgery that utilizes an eye-level monitor, rather than viewing the surgical field through binoculars that can be difficult to use with eye-covering PPE such as masks, hoods, and visors. These are therefore recommended as alternatives to the operating microscope in trained surgeons who find that enhanced PPE interferes with their ability to perform microscopic ear surgery (27,34–36).

Minimizing the number of personnel in the operating room may be an important safety measure (27,34). In our study, 44.7% (N = 113) of respondents allowed resident participation during the COVID-19 crisis. This is in contrast to a multi-institutional study from North America which found that 91.8% of institutions continued to utilize residents in the operating room for otolaryngologic surgeries, though this was only when their involvement was absolutely necessary (23). We believe this difference may be due to the nature of otologic procedures, which largely can be completed by a single surgeon. It is possible that the COVID-19 pandemic has had lasting consequences for trainees, who had a decrease in OR involvement during the crisis and may have been excluded from some high-risk cases due to protective policies or lack of necessary PPE (37).

Interestingly, most respondents indicated that patients were tested for the SARS-CoV-2 virus only once preoperatively (65.1%, N = 151), despite the limitations of current PCR testing and concern for false negatives (38). 15.9% (N = 37) indicated that patients were tested twice preoperatively, while 6.5% (N = 15) indicated that patients were not typically tested at all preoperatively. At the time of survey completion, there was no consensus on the timing or number of tests for preoperative SARS-CoV-2 testing, and criteria varied between hospitals (27,34).

PAPR represents another option for enhanced PPE to be worn during high-risk procedures. However, PAPR use remains controversial when performing sterile procedures due to concerns of surgical field contamination from unfiltered exhaust, although this has not been experimentally demonstrated (39). Additionally, PAPRs are more expensive than other respirators, are difficult to decontaminate, and may contaminate the wearer if doffed improperly (40). These concerns may explain why 42.8% of respondents (N = 101) reported that PAPR use was never made available at their institution and 62.3% of respondents (N = 147) reported that PAPR was in minimal or no supply at their institution. Though some publications recommend using a respirator for all procedures (27,28), wearing a respirator during high-risk procedures is highly recommended across guidelines (21,41,42). Despite this, these respirators were in minimal or no supply for the majority of respondents (66.9%, N = 158).

Despite these limitations, many publications and association guidelines recommend PAPR as an option when performing high-risk AGPs, especially in a patient with a suspected or confirmed COVID-19 infection, or when other respirators fit improperly (41,43,13). Importantly, about half of respondents said they planned to use a PAPR in the future if they were to perform a high-risk AGP in a presumed or confirmed positive patient (47.0%, N = 111), and many other respondents expressed that they would use PAPR if it were available or permitted at their institution. Some had taken to purchasing a PAPR for themselves if it was not provided by their institution, and one respondent had a colleague who was using PAPR despite policies against its use. Difficulty with communication was reported in the survey population, which is consistent with a study that shows a decrease in speech intelligibility while wearing a PAPR (44). These data and anecdotal reports illustrate a desire for PAPR access within the otology and neurotology community. Respondents seem to view PAPR as an important tool

for personal safety at this time, but report issues with accessibility and institutional policy. Overall, only 12.7% (N = 30) of respondents had use a PAPR during the COVID-19 crisis, and there was not a significant relationship between PAPR use and geographic region or practice environment. Interestingly, a third of respondents who had used a PAPR had not received formal training (33.3%, N = 10), an important part of PAPR safety. This is consistent with a UK study which found that 40% of respondents had not attended a PPE donning and doffing course (45). Additionally, 98.2% of providers (N = 279) had never used a PAPR prior to the COVID-19 pandemic. These data point to a possible gap in training for safe PAPR use and a lack of previous experience with these devices.

Limitations of this study include recall and nonresponse bias. Survey fatigue may have contributed to the number of participants who did not complete the survey in full. The majority of respondents were from academic health centers in North America, Europe and Central Asia, and East Asia and the Pacific. Perspectives from these geographical locations are therefore more heavily represented. An unknown proportion of respondents were a convenience sample, so results should not be extrapolated to a generalized population. The time periods defined in this study may not be applicable to all countries. For example, at the time of survey completion, some countries may not have experienced a postcrisis transition. Furthermore, physicians made a subjective determination about the time period based on guidelines provided in the survey and thus answers may not be consistent among providers within a given geographic region. While survey data were collected from both the operative and clinical setting, this study reports results of the changes in operative volume and does not address changes made in the clinical setting. Future studies analyzing the effects of the COVID-19 pandemic on clinical practices are in process.

The results of this survey illustrate the significant impact of the COVID-19 crisis on otologic and neurotologic care globally, including changes in caseload, case selection, timing of proposed care, and modification of surgical technique. Furthermore, while the requirements for PPE have increased, respirators were in minimal or no supply for the majority of respondents at the time of survey completion. As COVID-19 infection rates have continued to fluctuate since the first surge and viral variants have emerged (46,47), providers will need to remain vigilant to ensure their own safety and that of the public. Routine preoperative testing of surgical patients is mandated at most institutions and has reduced the risk of COVID-19 transmission but there is variability in the sensitivity and specificity of these assays. We hope that insights from this survey will prove useful to inform safe practice recommendations moving forward.

Acknowledgments: The authors would like to thank the survey respondents and study collaborators, as well as Eric Puma for his contributions.

REFERENCES

1. WHO. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020.
2. Grimm CA. *Office of inspector general hospital experiences responding to the COVID-19 Pandemic. Results of a National Pulse*. 2020.
3. Diaz A, Sarac BA, Schoenbrunner AR, Janis JE, Pawlik TM. Elective surgery in the time of COVID-19. *Am J Surg* 2020;219:900–2.
4. Zou L, Ruan F, Huang M, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N Engl J Med* 2020;382:1177–9.
5. Pitkaranta A, Virolainen A, Jero J, Arruda E, Hayden FG. Detection of rhinovirus, respiratory syncytial virus, and coronavirus infections in acute otitis media by reverse transcriptase polymerase chain reaction. *Pediatrics* 1998;102:291–5.
6. Heikkinen T, Thint M, Chonmaitree T. Prevalence of various respiratory viruses in the middle ear during acute otitis media. *N Engl J Med* 1999;340:260–4.
7. Pitkaranta A, Jero J, Arruda E, Virolainen A, Hayden FG. Polymerase chain reaction-based detection of rhinovirus, respiratory syncytial virus, and coronavirus in otitis media with effusion. *J Pediatr* 1998;133:390–4.
8. Frazier KM, Hooper JE, Mostafa HH, Stewart CM. SARS-CoV-2 virus isolated from the mastoid and middle ear. *JAMA Otolaryngol Neck Surg* 2020;146:964–6.
9. Kozin AED, Remenschneider AK, Blevins NH, et al. American Neurotology Society, American Otological Society, and American Academy of Otolaryngology – head and neck foundation guide to enhance otologic and neurotologic care during the COVID-19 pandemic. *Otol Neurotol* 2020;41:1163–74.
10. Lagos AE, Ramos PH, Andrade T. Protection for otolaryngologic surgery in the COVID-19 pandemic. *OTO Open* 2020;4: 2473974X2093473. doi 10.1177/2473974x20934734.
11. Chari DA, Workman AD, Chen JX, et al. Aerosol dispersion during mastoidectomy and custom mitigation strategies for otologic surgery in the COVID-19 era. *Otolaryngol – Head Neck Surg (United States)* 2020;164:67–73.
12. Chen JX, Workman AD, Chari DA, et al. Demonstration and mitigation of aerosol and particle dispersion during mastoidectomy relevant to the COVID-19 era. *Otol Neurotol* 2020;41:1230–9.
13. AAOHN. Guidance for Return to Practice for Otolaryngology-Head and Neck Surgery – Part One. American Academy of Otolaryngology – Head and Neck Surgery®.
14. British Society of Otology. Guidance for Undertaking Otological Procedures During COVID-19 Pandemic.
15. World Bank: Country and Lending Groups. World Bank Data.
16. Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan. *JAMA* 2020;323:1341–2.
17. Steinbrook R. Contact tracing, testing, and control of COVID-19-learning from Taiwan. *JAMA Intern Med* 2020;180:1163–4.
18. Coronavirus Map: Tracking the Global Outbreak. The New York Times.
19. Ralli M, Minni A, Candelori F, Cialente F, Greco A, de Vincentiis M. Effects of COVID-19 pandemic on otolaryngology surgery in Italy: the experience of our university hospital. *Otolaryngol – Head Neck Surg (United States)* 2020;163:86–8.
20. Lee AKF, Cho RHW, Lau EHL, et al. Mitigation of head and neck cancer service disruption during COVID-19 in Hong Kong through telehealth and multi-institutional collaboration. *Head Neck* 2020;42:1454–9.
21. Couloigner V, Schmerber S, Nicollas R, et al. COVID-19 and ENT surgery. *Eur Ann Otorhinolaryngol Head Neck Dis* 2020;137:161–6.
22. Lavinsky J, Kosugi EM, Baptistella E, et al. An update on COVID-19 for the otorhinolaryngologist – a Brazilian Association of Otolaryngology and Cervicofacial Surgery (ABORL-CCF) Position Statement. *Braz J Otorhinolaryngol* 2020;86:273–80.
23. Wickemeyer JL, Billings KR, Valika TS. Evolving management of COVID-19: a multi-institutional otolaryngology perspective. *Otolaryngol – Head Neck Surg (United States)* 2020;163:259–64.

24. Farid Y, Schettino M, Kapila AK, et al. Decrease in surgical activity in the COVID-19 pandemic: an economic crisis. *Br J Surg* 2020;107:e300. doi 10.1002/bjs.11738.
25. Matava CT, Yu J, Denning S. Clear plastic drapes may be effective at limiting aerosolization and droplet spray during extubation: implications for COVID-19. *Can J Anesth* 2020;67:902–4.
26. David AP, Jiam NT, Reither JM, Gurrola JG, Aghi M, El-Sayed IH. Endoscopic skull base and transoral surgery during the COVID-19 pandemic: minimizing droplet spread with a negative-pressure otolaryngology viral isolation drape (NOVID). *Head Neck* 2020;42:1577–82.
27. Rea P, Ray J, Lloyd S, Saeed S. *A Graduated Return to the Provision of Elective ENT Services during the COVID-19 Pandemic*. 2020.
28. Kowalski LP, Sanabria A, Ridge JA, et al. COVID-19 pandemic: effects and evidence-based recommendations for otolaryngology and head and neck surgery practice. *Head Neck* 2020;42:1259–67.
29. Pandey AS, Ringer AJ, Rai AT, et al. Minimizing SARS-CoV-2 exposure when performing surgical interventions during the COVID-19 pandemic. *J Neurointerv Surg* 2020;12:643–7.
30. Wald SH, Arthofer R, Semple AK, Bhorik A, Lu AC. Determination of length of time for ''Post- Aerosol Pause'' for patients under investigation or positive for COVID-19. *Anesth Analg* 2020;131:e94–6.
31. London M. Coronavirus Disease 2019 (COVID-19): Anesthetic Concerns, Including Airway Management and Infection Control. UpToDate.
32. Hu Y, Teh BM, Hurtado G, Yao X, Huang J, Shen Y. Can endoscopic ear surgery replace microscopic surgery in the treatment of acquired cholesteatoma? A contemporary review. *Int J Pediatr Otorhinolaryngol* 2020;131:109872.
33. Miller KA, Fina M, Lee DJ. Principles of pediatric endoscopic ear surgery. *Otolaryngol Clin North Am* 2019;52:825–45.
34. Krajewska (Wojciechowska) J, Krajewski W, Zub K, Zatoński T. Review of practical recommendations for otolaryngologists and head and neck surgeons during the COVID-19 pandemic. *Auris Nasus Larynx* 2020;47:544–58.
35. Gordon SA, Deep NL, Jethanamest D. Exoscope and personal protective equipment use for otologic surgery in the era of COVID-19. *Otolaryngol Head Neck Surg* 2020;163:179–81.
36. Topsakal V, Rompaey V, Kuhweide R, et al. Prioritizing otological surgery during the COVID-19 pandemic. *B-ENT* 2020;16:55–8.
37. Park JS, El-Sayed IH, Young VVN, Pletcher SD. Development of clinical care guidelines for faculty and residents in the era of COVID-19. *Head Neck* 2020;42:1403–8.
38. Woloshin S, Patel N, Kesselheim AS. False negative tests for SARS-CoV-2 infection—challenges and implications. *N Engl J Med* 2020;383:e38. doi 10.1056/nejmp2015897.
39. Howard RA, Lathrop GW, Powell N. Sterile field contamination from powered air-purifying respirators (PAPRs) versus contamination from surgical masks. *Am J Infect Control* 2020;48:153–6.
40. Lammers MJW, Lea J, Westerberg BD. Guidance for otolaryngology health care workers performing aerosol generating medical procedures during the COVID-19 pandemic. *J Otolaryngol Head Neck Surg* 2020;49:36. doi:10.1186/s40463-020-00429-2.
41. Saadi RA, Bann DV, Patel VA, Goldenberg D, May J, Isildak H. A commentary on safety precautions for otologic surgery during the COVID-19 pandemic. *Otolaryngol – Head Neck Surg (United States)* 2020;162:797–9.
42. Bann DV, Patel VA, Saadi R, et al. Impact of coronavirus (COVID-19) on otolaryngologic surgery: brief commentary. *Head Neck* 2020;42:1227–34.
43. Summary Table of Suspected and Confirmed COVID-19 Patient PPE Guidance (3/22/2020).
44. Kempfle JS, Panda A, Hottin M, et al. Effect of powered air-purifying respirators on speech recognition among health care workers. *Otolaryngol – Head Neck Surg (United States)* 2020;164:87–90.
45. O'Donoghue G, Swift A. *Synopsis of PPE Survey Results for the COVID-19 Pandemic*. 2020.
46. WHO. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-13 July [2020].
47. MGH Institute for Technology Assessment. COVID-19 Simulator.