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Otolaryngology in the face of A pandemic

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Although infrequent, pandemics are serious public health concerns with unpredictable courses. The COVID-19 pandemic began over 2 years ago and is far from over. This pandemic has spread rapidly throughout the world and led to several million deaths, making it commonly compared to the deadly Spanish influenza pandemic. Policy and safety measures are constantly being adapted to reduce transmission rates. The pandemic places stress on all healthcare workers, but especially otolaryngology providers due to their direct contact with airway connected cavities. This puts them at higher risk for infection and has impacted inpatient and outpatient otolaryngology care, as well as education, research, and mental health.

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Introduction

In December 2019, the first reported incidence of the novel upper respiratory infection known as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was reported in Wuhan, China.\textsuperscript{1} One month later, the disease caused by SARS-CoV-2, known as COVID-19, had reached the United States (US) when the first confirmed case was documented in northern Washington. By March 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic.\textsuperscript{2} This declaration urges us to think back to previous pandemics and their impact on healthcare, society, and the economy.

Multiple pandemics have occurred throughout history, ranging from gastrointestinal to respiratory illnesses. One of the most notable pathogens is Yersinia pestis which led to 3 plague pandemics. The deadliest was the Black Death which originated in East Asia and swept through Europe in the early 14th century.\textsuperscript{3} In addition to Yersinia pestis, Vibrio cholera has also lead to multiple pandemics. Originally endemic to Asia, Vibrio cholera began to spread from India to other regions of the world in 1817.\textsuperscript{4} In more recent years, viral upper respiratory illnesses have become some of the most difficult to contain. These respiratory pandemics have been caused by 2 predominant viral pathogens, Influenza and Coronavirus. The first influenza pandemic occurred in 1510 and several have followed since then. The one most often discussed is the Spanish influenza of 1918 (aka “Spanish Flu”) which caused 50-100 million deaths.\textsuperscript{5} In 2002, an outbreak of Coronavirus, known as SARS-CoV-1, occurred in over 29 countries.\textsuperscript{6} Coronavirus again became a global health concern when SARS-CoV-2 emerged in 2020 and led to the current pandemic. It is common for surges in infection rates to occur throughout the duration of a pandemic which enables it to last for several years without fully resolving. For instance, the Spanish Flu had 3 waves of illness in the spring, fall, and winter.

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of 1918 with peak mortality during the second surge. Similarly, as the current pandemic has progressed, surges in COVID-19 infections have occurred due to the emergence of new SARS-CoV-2 variants. The Delta variant was first identified in India in December 2020 and the Omicron variant followed in Botswana in November 2021.

Prior pandemics, including the Black Death and Spanish Flu, occurred before the development of antimicrobials or advancements in vaccines.5 Initially, Influenza was thought to be bacterial in nature, therefore the vaccines first created for the Spanish Flu were essentially ineffective. However, administration of vaccines still positively influenced the public because it helped mitigate anxiety and provided hope that the pandemic would soon end.9 It was during the Spanish Flu that public health officials first implemented strict social distancing measures, such as school closures and gathering bans, to reduce mortality rates.7 In addition to these more aggressive interventions, campaigns regarding hygiene, such as coughing into a handkerchief and hand washing, were employed.5,6 By 1925, all states in the US were participating in a national disease reporting system through which they were required to report certain diseases to the United States Public Health Service. This mandatory reporting allowed for the development of sophisticated surveillance techniques and better organized public health efforts. A large part of the public health response to the current pandemic implemented strategies used in the past, such as extensive lockdowns, travel restrictions, social distancing, and quarantining in order to limit the spread of COVID-19. However, there have been many more advances in science and public health since then that have improved our ability to manage these diseases; for example, today we can deploy antivirals, antibiotics, immune-modulating drugs, oxygen, and ventilators to treat COVID-19 and its related complications whereas in the past patients were treated for symptoms simply with aspirin and oxygen.8

In addition to the global impact on public health, pandemics have strongly influenced the economy. Before the Black Death, Europe was over-populated which led to workers settling for low wages due to fear of being easily replaced.5 However, the onset of the Black Death caused severe labor shortages due to increased mortality associated with the plague and lower income citizens suddenly found themselves in high demand. As a result, these workers were in a novel position of having the leverage to demand better working conditions and pay. This shift in the power dynamic eventually led to the Peasants’ Revolt in 1381.5 These events resulted in significant reform of the established socioeconomic structure that diminished the disparities between upper-and lower-income citizens. Similar labor shortages were seen in 1918, when the young male workforce was depleted due to deaths from the Spanish Flu and World War I.5 Women began to fill that void and joined the workforce in roles that were not previously open to them.9 This increase in economic power inspired women to actively advocate for women’s rights and helped gain momentum for the women’s suffrage movement.9 Similar labor shortages were seen during the current COVID-19 pandemic. Specifically, there was a large shortage of healthcare workers as a result of nosocomial COVID-19 infections, and with the combination of an overload of COVID-19 patients in the hospital, this put extreme strain on the healthcare system as a whole. Over the course of the pandemic, national and global lockdowns led to economic instability, supply chain issues, and some of the highest documented rates of unemployment.10

COVID-19 is the first disease to muster a global healthcare response since the Spanish Flu. Similar to previous respiratory pandemics, COVID-19 is spread from human to human via contact droplets and aerosols.11,12 Mucosal surfaces and saliva are sites that have a higher viral load.13 As a result, otolaryngology was quickly determined to be a high-risk specialty given the close proximity to mucosal surfaces and the upper aerodigestive tract during standard clinical examinations and procedures.14,15 However, despite the increased risks of exposure, otolaryngologists were also in high demand due to common COVID-19 symptoms requiring their expertise, such as anosmia, dysgeusia, and airway compromise. As a result, the otolaryngology community responded globally with the rapid development of guidelines and protocols that allowed us to safely provide care for patients during the pandemic.

Impact on inpatient care

In January 2020, when the first case of COVID-19 was documented in the US, healthcare professionals knew very little about the transmissibility and extent of disease it could cause. Due to the novelty of the virus, protocols were constantly evolving and the approach to patient care was ever-changing. This added to the difficulty otolaryngologists faced when attempting to balance the proper precautions needed to keep themselves safe and providing quality patient care that did not compromise outcomes.

As the incidence of COVID-19 grew, hospitals became increasingly overwhelmed by the number of patients who required medical attention. This led to hospitals becoming a nidus for infections, putting healthcare workers and hospitalized patients at increased risk. One institution reported an incidence of hospital-acquired COVID-19 in 29% of healthcare professionals and 12% of hospitalized patients.16 This demand on the healthcare system resulted in multiple unforeseen effects on otolaryngology care.

Visitation restrictions and supply shortages

Throughout the course of the pandemic, visitation policies were constantly changing and highly dependent on local infection rates. However, at the onset of the pandemic, many institutions restricted visitation altogether.17 These restrictions impacted patients both mentally and emotionally, especially for cancer patients whose levels of depression and anxiety increased during the pandemic.18 When families were eventually permitted to visit the hospital,
strict protocols were enforced to limit viral transmission, including masking and social distancing.

Currently, the Centers for Disease Control and Prevention (CDC) and the WHO recommend wearing N95 masks, gloves, gowns, and eye protection, as well as having established donning and doffing stations, when providers are working with COVID-19 positive patients.\(^{10,20}\) However, at the onset of the pandemic, there was a high demand for personal protective equipment (PPE) but limited access to these supplies due to supply chain shortages related to the economic impact of the pandemic.\(^{21}\) In response to these shortages, guidelines were established to instruct healthcare workers on how to reuse masks designed for single use in order to extend the lifespan of N95 masks.\(^{21}\) As the supply of N95 masks rose to meet the demand over time, providers were able to return to using them as originally intended.

PPE is especially important for aerosolizing procedures, which is defined as those that generate small (< 5-10 um) aerosols that can travel greater than 2 meters. The following is a list of procedures commonly used in otolaryngology that are considered aerosolizing: surgical procedures using (CO\(_2\)) laser vaporization, electrocautery, endotracheal procedures, nasal surgery, nasal packing for epistaxis, oropharyngeal surgeries, mastoid surgeries, endoscopic functional sinus surgery, bronchoscopy, sputum induction, manual ventilation, and nebulized or aerosol therapy.\(^{22,23}\) It is important to note that our understanding of aerosolizing procedures has evolved over the course of the pandemic. For instance, it was initially thought that flexible laryngoscopy was an aerosolization procedure. However, research has now shown that it is actually the potential reactions that the exam may evoke that are aerosolizing, including coughing, sneezing, and even phonating during the exam.\(^{2}\) This is because any time air is forced over a respiratory mucosal surface, it will generate more respiratory particles.\(^{24}\) As such, although some procedures may not be aerosol-generating in and of themselves, because it is unpredictable how patients may react during the procedure, many otolaryngologists adopted treating all of these procedures as potentially aerosol-generating.

**Impact on perioperative care and protocols**

As access to PPE improved and physicians became better equipped to treat COVID-19 positive patients, new perioperative protocols were established to ensure patient and healthcare worker safety.\(^{25}\) Most recommendations included: (1) obtaining preoperative COVID-19 testing, (2) limiting the number of personnel involved in the procedure, (3) performing aerosolizing procedures in a controlled environment with negative pressure capabilities if possible, and (4) wearing PPE that defends against airborne transmission.\(^{1,26-29}\) Fortunately, literature published since the start of the pandemic has demonstrated that adherence to these safety recommendations is effective at decreasing the spread of infection.\(^{25,30,31}\)

In the beginning of the pandemic, in order to limit viral transmission and conserve surgical resources, non-urgent operative procedures were canceled.\(^{12,33}\) As resources became more available and our knowledge of how to protect healthcare workers against COVID-19, surgical volume began to increase, but with new preoperative testing protocols.\(^{34}\) Over the course of the pandemic, recommendations regarding preoperative testing constantly changed depending on local infection rates and testing capabilities. At our institution, testing was initially provided on the day of surgery. However, as surgical volume increased, testing facilities were overwhelmed which forced the institution to transition to testing 3 days prior to surgery with a mandatory interim quarantine that was dependent on an honor system. Eventually, the institution only required testing 5 days before surgery, but these recommendations continue to evolve.

With the increase in preoperative COVID testing, there followed the need for protocols to guide how to proceed for patients who tested positive for COVID-19, both symptomatic and asymptomatic. Generally speaking, it was recommended to delay elective surgeries until a patient was no longer infectious and demonstrated recovery from COVID-19. According to the CDC, patients were deemed non-infectious if the patient was asymptomatic and had 2 negative COVID-19 tests 24-hours apart.\(^{35}\) More lenient guidelines were implemented by some hospital systems which defined patients to be not infectious when it had been (1) at least 72 hours since resolution of a fever and respiratory symptoms and (2) at least 7 days since symptoms first appeared.\(^{36}\) However, as with everything else during the pandemic, these policies have constantly been evolving over the last 2 years. Initial recommendations at our institution delayed rescheduling cases up to 2-3 months after the initial positive test. However, today this has decreased to waiting up to 6 weeks after a positive COVID-19 test before undergoing elective surgery, as it was found that risks of perioperative mortality were greatest within 6 weeks of COVID-19 onset.\(^{37}\) Additional guidelines can be seen in Table 1.\(^{38}\) If a COVID-19 positive patient needed urgent surgical care, maximal precautions were taken to protect providers, such as using extensive PPE, including N95 facial mask, disposable long sleeve waterproof gowns, double pair of gloves, head caps, and shoe covers, as well as and having designated COVID-19 operating rooms, that were ideally negative pressure rooms closest to the entrance to minimize contamination.\(^{39}\)

Various types of COVID-19 tests have been developed as the pandemic has progressed. The first was a PCR test created in February 2020 that was designed to detect the presence of viral RNA.\(^{40}\) A few months later, a rapid antigen test was developed to detect viral surface proteins and was able to provide results much faster and be administered at home, but did have increased rate of false negatives compared the PCR test.\(^{41}\) As such, many hospitals required PCR testing due to its higher sensitivity and ability to detect early infection. However, the main downside to PCR testing is the longer processing time compared to the rapid
antigen test. The rapid implementation of these protocols was widely accepted by hospital personnel. However, these tests were subject to providing a false sense of security due to the potential for false negative results and patients becoming infected between testing and surgery. Ultimately, de-implementation of these practices may be difficult, however, as healthcare workers have become accustomed to the sense of security that this objective measure provides.

There were shifts observed in the prioritization of cases when resources became scarce during the pandemic. Each of the subspecialty otolaryngology societies produced guidelines for triaging which conditions required emergent operative management and which conditions could be safely delayed until further testing was performed or resources were available. Many of these guidelines will be further discussed in subsequent articles in this issue. Ultimately, instead of giving preference to the sickest patients who required lifesaving interventions, triaging switched to prioritizing patients for whom the greatest number of quality life years could be salvaged. However, a slightly different trend was observed for the triaging of head and neck cancer patients. While timing of care is traditionally equal for patients of all stages of cancer, during the pandemic those with early-stage tumors were postponed in order to prioritize patients with late-stage tumors.

Impact on otolaryngology inpatient consultations

Throughout the pandemic, there was a shift in otolaryngology consultations. At one institution in New York City (NYC), the overall number of monthly otolaryngology consults remained the same, but there was an increase in the proportion of intensive care unit (ICU) consults compared to emergency department (ED) and floor consults. The majority of the consults were for management of respiratory distress, new facial and neck masses, dysphagia, and epistaxis. This suggested that many of the consults seen in the ED were either able to be appropriately addressed by the ED providers, redirected to the outpatient setting, or that patients were simply not presenting to the ED at all. This was an interesting paradigm shift in ED otolaryngology consults during the pandemic, but further investigation is warranted to determine both why and whether this is a durable change. Not all institutions, however, experienced similar changes in otolaryngology consults. An institution in Pittsburgh experienced a 22% decrease in the number of overall monthly consults, with a large decrease in craniofacial trauma. The decrease in craniofacial trauma in Pittsburgh was mainly thought to be due to adherence to social distancing measures. At the beginning of the pandemic, the institution in Pittsburgh implemented several treatment algorithms for common otolaryngologic complaints including head and neck masses (Figure 1), airway concerns (Figure 2), and epistaxis (Figure 3). Regardless of the volume of consultations received, many institutions similarly adapted treatment algorithms for the management of otolaryngology consultations aimed to decrease unnecessary exposures. For instance, the American laryngology community recommended only performing flexible laryngoscopy in critical cases where findings had an immediate impact on patient care.

Impact on outpatient care

The effects of COVID-19 on otolaryngology practices were not limited to the inpatient setting. In addition to surgeries being canceled due to a scarcity of PPE, many otolaryngology clinics were closed at the onset of the pandemic. This was in part due to the degree of perceived risk involved in performing a basic head and neck exam and the ability to inadvertently cause aerosolization.

Patients had an increasingly difficult time gaining access to otolaryngology providers as more clinics closed during the pandemic. Unfortunately, even after clinics were

### Table 1 Guidelines for delaying elective surgeries after positive COVID-19 test adapted from American Society of Anesthesiologists’ Joint Statement

| Time between COVID-19 infection and surgery with respect to minimizing post-operative complications | Four wk for an asymptomatic patient or recovery from only mild, non-respiratory symptoms. Six wk for a symptomatic patient (eg, cough, dyspnea) who did not require hospitalization. Eight to 10 wk for a symptomatic patient who is diabetic, immunocompromised, or hospitalized. Twelve wk for a patient who was admitted to an intensive care unit due to COVID-19 infection. |
| Time from COVID infection to surgery for patients severely ill or immunocompromised | At least 10 d and up to 20 d have passed since symptoms first appeared. At least 24 h have passed since the last fever without the use of fever-reducing medications. Symptoms (eg, cough, shortness of breath) have improved. |
| Time from COVID infection to surgery for patients with mild to moderate symptoms and NOT immunocompromised | At least 10 d have passed since symptoms first appeared. At least 24 h have passed since last fever without the use of fever-reducing medications. Symptoms (eg, cough, shortness of breath) have improved. |
Figure 1  Algorithm for management of of head and neck mass. (image reprinted with permission from Dharmarajan H, Belsky MA, Anderson JL, Sridharan S. Otolaryngology Consult Protocols in the Setting of COVID-19: The University of Pittsburgh Approach. Annals of Otology, Rhinology and Laryngology. 2022;131(1). doi:10.1177/00034894211005937). Abbreviations: EMR = electronic medical record; PAPR = powered air purifying respirator; OR = operating room; DL = direct laryngoscopy; FNA = fine needle aspiration; CT = computed tomography.

Figure 2  Algorithm for management of airway evaluation. (image reprinted with permission from Dharmarajan H, Belsky MA, Anderson JL, Sridharan S. Otolaryngology Consult Protocols in the Setting of COVID-19: The University of Pittsburgh Approach. Annals of Otology, Rhinology and Laryngology. 2022;131(1). doi:10.1177/00034894211005937). Abbreviations: PPE = personal protective equipment; H&P = history and physical exam; FFL = flexible fiberoptic laryngoscopy.

re-opened, patients still struggled to be seen due to a decrease in the number of available appointments and prioritization of patients with urgent or semi-urgent chief complaints.1,2,51 For those patients who were able to be seen, rigorous screening measures were implemented, including questionnaires regarding symptoms, temperature checks, and masking requirements.2,52 Furthermore, in an effort to facilitate social distancing, patients were not permitted to bring any supporting family or friends to clinic visits which was mentally and emotionally taxing for patients.51

There were many logistical challenges to safely re-open ambulatory clinics. Several of these challenges included (1) rearranging waiting room space and check-in/check-out procedures in order to limit the number of patients in the waiting rooms, (2) staggering appointments to enhance social distancing protocols, and (3) using physical barriers at check-in desks to limit the exchange of respiratory droplets.2,51,52 Unnecessary objects, such as informational pamphlets and 3-D anatomical models, were removed from examination rooms to allow for efficient
disinfection of rooms between patients. Additionally, due to the frequency of aerosol-generating procedures performed in otolaryngology, protocols were implemented to allow for adequate air exchange to occur in the rooms which helped with decontamination. This often required rooms to be closed for upwards of an hour, impacting the overall workflow and volume of patients who could be seen in 1 day. As knowledge regarding COVID-19 transmissibility increased, many clinics opted to upgrade their clinic spaces with improved ventilation systems that allowed for quicker air turnover, which significantly decreased shutdown times and allowed for more patient visits. The majority of these changes remain in place today and will likely continue beyond the pandemic. However, as the pandemic continues, COVID-19 fatigue surrounding these precautions has set in. While recommendations to mask and gown, as well as frequent hand washing, remain in place, many providers have followed them less stringently, compared to the beginning of the pandemic.

Another major change that occurred in the outpatient setting during the pandemic was the implementation of telemedicine. As an alternative to in-person visits, telemedicine was quickly adopted to limit COVID-19 exposure while maintaining uninterrupted quality care. This will be discussed in greater detail in a different article of this issue. The COVID-19 pandemic continues to influence inpatient and outpatient otolaryngology practices. As our knowledge of the pandemic evolves and different variants are identified, we continue to adapt how to maintain appropriate precautions while still providing quality care that will not compromise patient outcomes. The impact of the pandemic on otolaryngology will likely persist for many years, and we are still in the nascent stage of our understanding.

**Impact on education**

In addition to affecting patient care, the pandemic greatly impacted otolaryngology resident education. Resident training was disrupted when otolaryngology residents were deployed to non-traditional roles in order to cover other services in the midst of staffing shortages. In response, the American Board of Otolaryngology Head and Neck Surgery (ABOHNS) changed the board eligibility requirements. Rather than the required 6 months, PGY-1 residents were now only required to rotate on an otolaryngology service for 3 months in order to complete their first year of residency. In addition, the ABOHNS allowed for the months spent caring for COVID-19 patients to count towards board eligibility.

This increased flexibility in board eligibility requirements allowed for programs to enact the necessary precautions to decrease the risk of resident exposure to COVID-19. One system that programs implemented to decrease resident exposure and risk was by transitioning to a platoon system, whereby half the residents were present for clinical duties and the other half were performing educational activities from the safety of their homes. This ensured that if a resident became symptomatic, transmission to the rest of the resident complement would be limited. However, the
designated time at home made it difficult for residents to be engaged in on-site educational activities and prompted the expansion of virtual education. In an unprecedented fashion, pre-recorded lectures, step-by-step videos, and online workshops were shared amongst institutions across the country to help hone surgical skills while hands-on experience was restricted. In addition, videoconferencing became popular which allowed for multi-institutional virtual journal clubs, lecture series, and observation of live surgeries. As most in-person didactics transitioned to the virtual platform, continued participation in educational sessions, such as multidisciplinary head and neck oncology conferences and grand rounds was possible.

Although virtual education provided a way to enhance resident training during the pandemic, it was unable to provide vital, hands-on clinical and operative experiences. The cancelation of elective surgeries, as well as decreased resident involvement in procedures, significantly limited operative opportunities for residents. Sixty percent of residents described losing more than 6 months of their training, and some reported up to 10-12 months of lost time. In web-based surveys, residents reported spending less time in the hospital, decreased clinical duties, lower surgical volume, and having less procedural independence than before the pandemic. Additionally, 55% of residents felt that the pandemic had a negative impact on their ability to secure a job or fellowship after training. Over time, hybrid models were developed to combine both virtual and in-person education. According to a program director survey, these models were beneficial for junior residents, and because of this success, these models are likely to remain throughout the pandemic’s duration, and may even continue after. Despite these efforts to optimize resident education during the pandemic, it is clear that residents feel their training has been significantly impacted, at least in the short-term. The long-term impact of the pandemic on resident training and education is yet to be elucidated.

In addition to resident training, the pandemic also significantly affected medical student education. In past years, rotations at various institutions were highly encouraged, especially for students without a home otolaryngology program. During the pandemic, students were no longer permitted to rotate at outside institutions, which impacted their education and exposure to otolaryngology. This also limited students’ abilities to demonstrate their strengths in-person which can negatively affect applicants’ match potentials. One trend resulting from these restrictions has been a significant increase in the number of students matching at their home programs from 22% to 30% in 2020 and 2021, respectively. There were additional stresses when applying to residency during the COVID-19 pandemic, as this was the first time students had to interview over Zoom and were not able to visit prospective institutions. In a cross-sectional survey of otolaryngology applicants, participants reported that the move to virtual interviews increased the number of programs they applied to and the number of interviews they planned to attend.

In fact, the average number of residency programs applied to for otolaryngology applicants increased from an average of 69 to 79 between 2019 and 2021. As our response to the pandemic and our understanding of the potential impact on medical education has evolved, the ACGME has now allowed students in the 2022 otolaryngology match to do one away rotation. It is unclear at this time how restrictions on away rotations will change in the future.

**Impact on research**

COVID-19 presented a unique research opportunity for otolaryngologists given its direct impact in otolaryngology and the increased shift in available time for academic endeavors during the initial shut-down. During the pandemic, there were over 3 times as many COVID-19 publications (759 publications) compared to publications on other popular otolaryngology topics, such as sensorineural hearing loss (237), obstructive sleep apnea (175), otitis media (167), and chronic sinusitis (120). This is in stark contrast to the Spanish Flu in which no articles regarding the pandemic were published in the major otolaryngology journals during that time. During the COVID-19 pandemic, there was a 42% increase in the number of otolaryngology publications in general. Some of the highest increases in subspecialty publications were rhinology and laryngology (51% and 72%, respectively). However, other types of research were negatively impacted during the pandemic including the majority of animal studies and clinical trials being halted at its onset. In a survey of American rhinologists, 36% of 71% respondents reported their otolaryngology research labs were not able to continue employing hired personnel with full salary due to loss of funding. However, as the pandemic has progressed over the last 2 years, labs have been slowly returning to baseline productivity with re-engagement in animal studies and clinical trials.

**Impact on mental health**

The constantly changing policies and unknown future of the COVID-19 pandemic has been exhausting for all physicians. Caring for patients who may be COVID-19 positive and the fear of becoming infected themselves has impacted the mental health of practicing otolaryngologists. In one survey assessing resident wellness, 24% of residents reported some level of burnout and more than half of respondents reported increased stress and anxiety during the pandemic. Interestingly, PGY-2 otolaryngology residents had higher rates of self-reported burnout compared to other years. Another survey assessing attending physicians’ and residents’ mental health found similar results with 22% reporting burnout, 48% reporting anxiety, 11% reporting depression, and 60% reporting distress. The effects of COVID-19 impacted all otolaryngologists alike, with increased levels of distress shown to directly correlate with increased COVID-19 infection rates in the area. However, when assessing burnout, residents reported
higher rates of burnout compared to attendings.\textsuperscript{71,72} Despite these negative impacts on physician well-being, efforts have shown that providing sufficient training and education regarding COVID-19, as well as adequate amounts of PPE, significantly reduced rates of anxiety and depression among otolaryngology providers.\textsuperscript{73}

**Conclusion**

Global pandemics have plagued our world for millennia. However, the current pandemic was unlike any prior pandemics, largely in part due to current advances in technology, the internet, and access to misinformation across the globe. We have become accustomed to a world that is more easily accessible through global travel, but in a pandemic where transmissibility was high and need for social isolation and quarantine was paramount, we were unable to take part. As the pandemic persisted and became heavily politicized, there was an unprecedented impact on the economic, political, and healthcare landscapes. Although we have increased our knowledge and understanding of how to manage this disease, the extent of the pandemic’s impact on our clinical practices, resident education, and mental health in otolaryngology are likely long-lasting and yet to be fully elucidated. However, as we continue to expand our scientific understanding of the disease process and improve global vaccine uptake, in addition to continued adherence to recommended safety guidelines, we will continue to adapt and find ways to stay safe without compromising optimal care for our patients.

**Disclosures**

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**References**

1. Couloigner V, Schmerber S, Nicollas R, et al: COVID-19 and ENT surgery. Euro Ann Otorhinolaryngol 137, 2020. doi:10.1016/j.anorl.2020.04.012.

2. Benito DA, Pasick L, Mulcahy CF, et al: Local spikes in COVID-19 cases: Recommendations for maintaining otolaryngology clinic operations. Am J Otolaryngol 41, 2020. doi:10.1016/j.amjotol.2020.102688.

3. Sampath S, Khedr A, Qamar S, et al. Pandemics throughout the history. cureus. Published online 2021. doi:10.7759/cureus.18136

4. el Magd EAA: Covid-19 vs. Spanish Flu. Scholarly J Otolaryngol 4, 2020. doi:10.32474/SJOT.2020.04.000199.

5. Patterson GE, McIntyre KM, Clough HE, Rushton J. Societal impacts of pandemics: comparing COVID-19 with history to focus our response, frontiers in public health. 2021;9. doi:10.3389/fpubh.2021.630449

6. Schwartz JL: The Spanish flu, epidemics, and the turn to biomedical responses. Am J Public Health 108, 2018. doi:10.2105/AJPH.2018.305581.

7. Tones N: Destroyer and teacher: Managing the masses during the 1918-1919 influenza pandemic. Public Health Rep 125(3), 2010 SUPPL. doi:10.1177/003335491012503308.

8. Billings M. The medical and scientific conceptions of influenza. Published February 2005. Available at: https://virus.stanford.edu/uda/index.html. Accessed March 10, 2022.

9. Blackburn C, Parker G, Wendelbo M: How the 1918 flu pandemic helped advance women’s rights. Smithsonian Magazine. Published online 2, 2018. March Available at: https://www.smithsonianmag.com/history/how-1918-flu-pandemic-helped-advance-womens-rights-180968311/ Accessed March 10, 2022.

10. Congressional Research Service Unemployment rates during the COVID-19 pandemic. Published 2020, 2021. August Available at: https://sgp.fas.org/hrs/crss/R46554.pdf. Accessed March 20, 2022.

11. Zuo M, Huang Y: Expert recommendations for tracheal intubation in critically ill patients with coronavirus disease 2019 (Version 1.0). Chinese J Anesthesiol 40, 2020. doi:10.3760/cma.j.cn131073.20200218.00307.

12. Foster P, Cheung T, Craft P, et al: Novel approach to reduce transmission of COVID-19 during tracheostomy. J Am Coll Surg 230, 2020. doi:10.1016/j.jamcollsurg.2020.04.014.

13. Atakorallaya DS, Ratnayake RK: Oral Mucosa, Saliva, and COVID-19 infection in oral health care. Front Med 8, 2021. doi:10.3389/fmed.2021.656926.

14. Vukkadala N, Qian ZJ, Holsinger FC, Patel ZM, Rosenthal E: COVID-19 and the otolaryngologist: preliminary evidence-based review. Laryngoscope 130, 2020. doi:10.1002/lary.28672.

15. Chan JYK, Wong EWY, Lam W: Practical aspects of otolaryngologic clinical services during the 2019 novel coronavirus epidemic: an experience in Hong KONG. JAMA Otolaryngol 146, 2020. doi:10.1001/jamaoto.2020.0488.

16. Wang D, Hu B, Hu C, et al: Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA - J Am Med Assoc 323, 2020. doi:10.1001/jama.2020.1585.

17. Andrist E, Clarke RG, Harding M. Paved with good intentions: hospital visitation restrictions in the age of coronavirus disease 2019+. pediatric critical care medicine. Published online 2020. doi:10.1097/PCC.0000000000002506

18. Salehi O, Alarcon SV, Vega EA, et al: COVID-19’s impact on cancer care: increased emotional stress in patients and high risk of provider burnout. J Gastrointest Surg, 2021 Published online. doi:10.1007/s11605-021-05052-y.

19. World Health Organization (WHO) Rational use of personal protective equipment for COVID-19 and considerations during severe shortages: interim guidance. Published December 23, 2020. Available at: https://www.who.int/iris/handle/10665/358033 Accessed March 20, 2022.

20. Interim CDC: Infection prevention and control recommendations for patients with suspected or confirmed coronavirus disease 2019 (COVID-19) in healthcare settings. Centers Dis Control Prevent 2:1–11, 2020.

21. Emanuel EJ, Persad G, Upshur R, et al: Fair allocation of scarce medical resources in the time of covid-19. N Engl J Med 382, 2020. doi:10.1056/nejmsb2005114.

22. Thamboo A, Lea J, Sommer DD, et al: Clinical evidence based review and recommendations of aerosol generating medical procedures in otolaryngology - Head and neck surgery during the COVID-19 pandemic. J Otolaryngol 49, 2020. doi:10.1186/s40463-020-00425-6.

23. Kozin ED, 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 41:1163–1174, 2020. doi:10.1097/MAO.0000000000002868.

24. Klompas M, Baker M, Rhee C: What is an aerosol-generating procedure? JAMA Surg 156:113, 2021. doi:10.1001/jamasurg.2020.6643.
25. Aodeng S, Wang W, Chen Y, et al: Safety and efficacy of tracheotomy for critically ill patients with coronavirus disease 2019 (COVID-19) in Wuhan: A case series of 14 patients. Eur J Cardiothorac Surg 58, 2020. doi: 10.1093/ejcts/ezaa312.

26. Radhakrishnan S, Perumbally HA, Surya S, et al: Guidelines for surgical tracheostomy and tracheostomy tube change during the covid-19 pandemic: A review article. Ind J Otolaryngol Head Neck Surg 72(3), 2020. doi: 10.1007/s12070-020-01893-y.

27. Harrison L RJ. Tracheostomy guidance during the COVID-19 pandemic for surgical tracheostomy and tracheostomy tube change during the COVID-19 pandemic. ENTUK. Published online 2020.

28. Kalita S, Gogoi B, Khaund G, et al, Optimizing airway surgery in COVID 19 era. indian journal of otolaryngology and head and neck surgery. Published online 2021.

29. Seto WH, Tsang D, Yang RWH, et al: Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 361, 2003. doi:10.1016/S0140-6736(03)13168-6.

30. Chao TN, Harbison SP, Braslow BM, et al: Outcomes after tracheostomy in COVID-19 patients. Ann Surg 272, 2020. doi:10.1097/SLA.S000000000001466.

31. Yeung E, Hopkins P, Auzinger G, et al: Challenges of tracheostomy in COVID-19 patients in a tertiary centre in inner city London. Int J Oral Maxillofac Surg 49, 2020. doi:10.1111/joms.2020.08.007.

32. Crozby DL, Sharma A. Insights on otolaryngology residency training during the COVID-19 pandemic. otolaryngology - head and neck surgery (United States). 2020;163. doi:10.1177/1945998020922502.

33. Bandi F, Karlikostas A, Mella J, et al: Strategies to overcome limitations in Otolaryngology residency training during the COVID-19 pandemic. Eur Arch Otorhinolaryngol 277, 2020. doi:10.1007/s00405-020-06228-9.

34. Sarawathula A, Gourin CG, Stewart CM: National trends in US otolaryngology surgical volume during the early COVID-19 pandemic. JAMA Otolaryngol 147, 2021. doi:10.1001/jamaoto.2020.5472.

35. Centers for Disease Control and Prevention. Interim Guidance for Managing Healthcare Personnel with SARS-CoV-2 Infection or Exposure to SARS-CoV-2.

36. Anesthesia Patient Safety Foundation Preoperative covid testing: examples from around the U.S. Published, 2020. November 11 Available at: https://www.apsf.org/novel-coronavirus-covid-19-resource-center/preoperative-covid-testing-examples-from-around-the-us/ Accessed January 20, 2022.

37. Lobo D, Devys JM: Timing of surgery following SARS-CoV-2 infection: an international prospective cohort study. Anaesthesia 77, 2022. doi:10.1111/anae.15540.

38. American Society of Anesthesiologists, Anesthesia Patient Safety Foundation ASA and APSF joint statement on elective surgery and anesthesia for patients after COVID-19 Infection. Published, 2021. March 9Available at: https://www.asahq.org/about-asa/newsroom/news-releases/2021/03/asa-and-apsf-joint-statement-on-elective-surgery-and-anesthesia-for-patients-after-covid-19-infection-rv Accessed February 1, 2022.

39. Coccolini F, Perrone G, Chiarugi M, et al: Surgery in COVID-19 patients: Operational directives. World J Emergency Surg 15, 2020. doi:10.1186/s13017-020-00307-2.

40. Centers for Disease Control and Prevention. CDC Diagnostic tests for COVID-19. Published, 2021. August 7Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/testing.html Accessed January 20, 2022.

41. Drug Administration, Coronavirus, U.S. Food COVID-19 update: FDA authorizes first antigen test to help in the rapid detection of the virus that causes COVID-19 in patients. Published, 2020. May 9Available at: https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-first-antigen-test-help-rapid-detection-virus-causes Accessed January 20, 2022.

42. Kavanagh PG, Callanan D, Connolly C, et al: Pre-operative testing for SARS-CoV-2 and outcomes in otolaryngology surgery during the pandemic: A multi-center experience. Laryngoscope Investig Otolaryngol 6, 2021. doi:10.1002/ito.2613.

43. Penney JA, Doron SL. Finding the off-ramp: Rethinking severe acute respiratory coronavirus virus 2 (SARS-CoV-2) preoperative screening. Infection Control & Hospital Epidemiology. Published online January 6, 2022. doi:10.1017/ice.2022.2.

44. Brindle ME, Doherty G, Lillemoe K, et al: Approaching surgical triage during the COVID-19 pandemic. Ann Surg 272, 2020. doi:10.1097/SLA.S000000000003992.

45. Yuen E, Fote G, Horwich P, et al: Head and neck cancer care in the COVID-19 pandemic: A brief update. Oral Oncol 105, 2020. doi:10.1016/j.oraloncology.2020.104738.

46. Kielar M, Depurba R, Agnyaziak M, et al: The COVID-19 pandemic as a factor of hospital staff compliance with the rules of hand hygiene: Assessment of the usefulness of the “Clean Care is a Safer Care” program as a tool to enhance compliance with hand hygiene principles in hospitals. J Prevent Med Hygiene 62, 2021. doi:10.15167/2421-4248/jpmh2021.62.1.1603

47. Shomorony A, Chern A, Long SM, et al: Essential inpatient otolaryngology: what COVID-19 has revealed. Eur Arch Otorhinolaryngol, 2021 Published online. doi:10.1007/s00405-021-06963-7.

48. Dharmarajan H, Belsky MA, Anderson JL, et al: Otolaryngology consult protocols in the setting of COVID-19: The university of pittsburgh approach. Ann Otol, Rhinol Laryngol 131, 2022. 10.1177/00034849210105937.

49. Rameau A, Young VVN, Amin MR, Sulica L. Flexible laryngoscopy and COVID-19, otolaryngology - head and neck surgery (United States). 2020;162. doi:10.1177/1945998020921399.

50. Kaniz ED, Remenschneider AK, Blevins NH, et al: American neurotology society, American otolaryngologic society, and American academy of otolaryngology - head and neck foundation guide to enhance otologic and neurotologic care during the COVID-19 pandemic. Otol Neurotol 41, 2020 official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. doi:10.1097/MAO.0000000000002868.

51. Maza-Solano JM, Plazas-Mayor G, Jiménez-Luna A, et al: Strategies for the practice of otolaryngology and head and neck surgery during the monitoring phase of COVID-19. Acta Otorrinolaringol Esp 71, 2020. doi:10.1016/j.otorri.2020.05.001.

52. Chan Y, Angel D, Aron M, et al: CSO (Canadian society of otolaryngology – head & neck surgery) position paper on return to Otolaryngology – head & neck surgery clinic practice during the covid-19 pandemic in Canada. J Otolaryngol 49, 2020. doi:10.1186/s40463-020-00466-x.

53. Garvey M, Joerger G, Furr S: Gastroenterology procedures generate aerosols: An air quality turnover solution to mitigate covid-19’s propagation risk. Int J Environ Res Public Health 17, 2020. doi:3.390/jipers/72338780.

54. Huang VW, Imam SA, Nguyen SA: Telehealth in the times of SARS-CoV-2 infection for the otolaryngologist. World J Otorhinolaryngol 6, 2020. doi:10.1016/j.wjolr.2020.04.008.

55. Ramirez AV, Ojeaga M, Espinoza V, et al. Telemedicine in minority and socioeconomically disadvantaged communities amidst COVID-19 pandemic. otolaryngology - head and neck surgery (United States). 2021;164. doi:10.1177/1945998020947667.

56. Nussenbaum B. Extension of Temporary Changes to Board Eligibility Requirement. American Board of Otolaryngology - Head and Neck Surgery.

57. Sánchez-Gómez S, Maza-Solano JM, López Flórez L, et al: Impacto de la pandemia COVID-19 en la formación de los residentes de otorrinolaringología. Acta Otorrinolaringológica Española. Published online, 2021 October. doi:10.1016/j.otorri.2021.09.001.

58. Chou DW, Staltari G, Mullen M, et al: Otolaryngology resident wellness, training, and education in the early phase of the COVID-19 pandemic. Ann Otol, Rhinol Laryngol 130, 2021. doi:10.1177/0003484920987194.

59. Guo T, Kiong KL, Yao CMKL, et al. Impact of the COVID-19 pandemic on otolaryngology trainee education. head and neck. 2020;42. doi:10.1002/hed.26368.
60. Chénard-Roy J, Guitton MI, Thuot F: Online residency training during the COVID-19 pandemic: a national survey of otolaryngology head and neck surgery program directors. J Otolaryngol 50, 2021. doi:10.1186/s40463-021-00546-6.

61. Bernstein JD, Harmon M, Watson D. COVID-19 and the otolaryngology residency match: rising incidence of home matches. the laryngoscope. Published online January 21, 2022. doi:10.1002/lary.30028

62. Xie DX, Hillel AT, Ward BK: Otolaryngology residency match during the COVID-19 pandemic: what happens next? JAMA Otolaryngol 146, 2020. doi:10.1001/jamaoto.2020.1078.

63. Izreig S, Torabi SJ, Kasle DA, Rahmati RW, Manes RP: Otolaryngology match 2020-21: survey of prospective applicants in the setting of COVID-19. Annals of Otology. Rhino Laryngol 130:450–458, 2021. doi:10.1177/0003489420952470.

64. Hamaker AE. Will otolaryngology match numbers continue to rise?. ENTtoday. Published, 2020. February 7 Available at https://www.enttoday.org/article/will-otolaryngology-match-numbers-continue-to-rise/ Accessed March 10, 2022.

65. Tan JL, Lim MY, Lee SYC, et al: Impact of COVID-19 on a tertiary otolaryngology practice in Singapore. Ann Acad Med, Singapore 49, 2020. doi:10.47102/annals-acadmedsg.2020214.

66. Djoutsop OM, Mbougo JV, Kamounye US: Global head and neck surgery research during the COVID pandemic: A bibliometric analysis. Ann Med Surg 68, 2021. doi:10.1016/j.amsu.2021.102555.

67. Denneny JC. Emerging from the pandemic with lessons learned to impact change. American academy of otolaryngology- head and neck surgery. Published May 27, 2020. Available at: https://bulletin.entnet.org/home/article/21247878/emerging-from-the-pandemic-with-lessons-learned-to-impact-change. Accessed December 19, 2021

68. Trecca EMC, Marano PG, Gelardi M, et al: The impact of covid-19 on the Italian academic production. Acta Biomedica 92, 2021. doi:10.23750/abm.v92i2.11557.

69. Grayson JW, McCormick JP, Thompson HM, Miller PL, Cho DY, Woodworth SARS-CoV-2 pandemic impact on rhinology research: A survey of the American Rhinologic Society. Am J Otolaryngol 41, 2020. doi:10.1016/j.amjoto.2020.102617.

70. Batra PS, LoSavio PS, Michaelides E, et al. Management of the clinical and academic mission in an urban otolaryngology department during the covid-19 global crisis. otolaryngology - head and neck surgery (United States). 2020;163. doi:10.1177/0194599820929613.

71. Civantos AM, Byrnes Y, Chang C, et al: Mental health among otolaryngology resident and attending physicians during the COVID-19 pandemic: National study. Head Neck. Vol 42, 2020. doi:10.1002/hed.26292.

72. Prasad A, Civantos AM, Byrnes Y, et al: Snapshot impact of COVID-19 on mental wellness in nonphysician otolaryngology health care workers: A national study. OTO Open 4, 2020. doi:10.1177/2473974X20948835.

73. Vallée M, Kutchukian S, Pradère B, et al: Prospective and observational study of COVID-19’s impact on mental health and training of young surgeons in France. Br J Surg 107, 2020. doi:10.1002/bjs.11947.