

Telemedicine and Telementoring in Rhinology, Otology, and Laryngology: A Scoping Review

OTO Open
 2022, Vol. 6(1) 1–14
 © The Authors 2022
 Article reuse guidelines:
sagepub.com/journals-permissions
 DOI: 10.1177/2473974X211072791
<http://oto-open.org>


Angela Yang, BS¹, Dayoung Kim, BA¹, Peter H. Hwang, MD¹,
 and Matt Lechner, MD, PhD¹

Abstract

Objective. Telemedicine and telementoring have had a significant boost across all medical and surgical specialties over the last decade and especially during the COVID-19 pandemic. The aim of this scoping review is to synthesize the current use of telemedicine and telementoring in otorhinolaryngology and head and neck surgery.

Data Sources. PubMed and Cochrane Library.

Review Methods. A scoping review search was conducted, which identified 469 articles. Following full-text screening by 2 researchers, 173 articles were eligible for inclusion and further categorized via relevant subdomains.

Conclusions. Virtual encounters and telementoring are the 2 main applications of telemedicine in otolaryngology. These applications can be classified into 7 subdomains. Different ear, nose, and throat subspecialties utilized certain telemedicine applications more than others; for example, almost all articles on patient engagement tools are rhinology based. Overall, telemedicine is feasible, showing similar concordance when compared with traditional methods; it is also cost-effective, with high patient and provider satisfaction.

Implications for Practice. Telemedicine in otorhinolaryngology has been widely employed during the COVID-19 pandemic and has a huge potential, especially with regard to its distributing quality care to rural areas. However, it is important to note that with current exponential use, it is equally crucial to ensure security and privacy and integrate HIPAA-compliant systems (Health Insurance Portability and Accountability Act) in the big data era. It is expected that many more applications developed during the pandemic are here to stay and will be refined in years to come.

Keywords

telemedicine, telehealth, rhinology, otolaryngology, otology, audiology, laryngology

Received October 22, 2021; accepted December 16, 2021.

Telemedicine is not a novel concept and has long been utilized across medical specialties, since the development of information and communication technologies (ICT), which are defined as “digital technologies that facilitate the electronic capture, processing, storage, and exchange of information.”¹ The World Health Organization has adopted the following broad description of telemedicine, having recognized that there is not a single definitive definition: “the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities.”² Modern telemedicine approaches often encompass algorithms to aid in diagnosis and treatment. These approaches have paved the way toward the application of artificial intelligence and other exciting developments.

Importantly, telemedicine has had a boost during the COVID-19 pandemic, and otolaryngology is considered one of the highest-risk health care specialties with regard to exposure of staff and contraction and spread of SARS-CoV-2. Many endoscopic examinations and surgical procedures in otolaryngology are considered aerosol generating,³ with an increased risk of viral transmission. Expansion of technology-centered remote delivery of care, where feasible and safe, has never been more needed than now. Hence, telemedicine has been in the spotlight during the COVID-19 pandemic, as utilizing the various forms of ICT has become an important way of providing health care from a distance, especially for high-risk patient groups seeking to minimize unnecessary exposures.

¹Department of Otolaryngology–Head and Neck Surgery, School of Medicine, Stanford University, Stanford, California, USA

Corresponding Author:

Matt Lechner, MD, PhD, UCL Cancer Institute, University College London, London, United Kingdom; UCL Division of Surgery and Interventional Science, University College London, London, United Kingdom; ENT Department, Barts Health NHS Trust, London, United Kingdom.
 Email: m.lechner@ucl.ac.uk



Regardless of the current trend that has accelerated the adoption of telemedicine, its development in the specialty of otorhinolaryngology–head and neck surgery has been slow: it was first described in 1994,⁴ with the number of publications increasing steadily over the years.

With this in mind, we aim to provide an up-to-date evaluation of the various applications of telemedicine in otorhinolaryngology–head and neck surgery. However, due to the broad nature of the question and the fact that the quality of published data is limited and heterogenous, a systematic review could not be performed; hence, a scoping review was conducted.

Materials and Methods

For methodology, we followed the PRISMA-ScR checklist⁵ (Preferred Reporting Items for Systematic Reviews and Meta-analyses Extension for Scoping Reviews).

Information Sources and Search Strategy

Articles were searched in the PubMed database with the following thread of keywords:

(telem* [tw] OR telehealth [tw] OR “tele-medicine” [tw] OR “tele-health” [tw] OR “e-consult” [tw] OR “e-consultation” [tw] OR econsult* [tw] OR telediagnos* [tw] OR “tele-diagnostics” [tw] OR telemedicine [mesh] OR “video consult” [tw] OR “video consultation” [tw] OR “Video consultations” [tw] OR “Video visit” [tw] OR “video visits” [tw] OR “tele mentoring” [tw] OR telemen* [tw] OR ((mentor* [ti] OR mentoring [mesh]) AND (telem* [ti] OR “telemedicine” [mesh]))) AND (“Otolaryngology” [Mesh] OR “Otorhinolaryngologic Surgical Procedures” [Mesh] OR “Otorhinolaryngologic Diseases” [Mesh] OR “Otologic Surgical Procedures” [Mesh] OR “Nasal Surgical Procedures” [Mesh] OR “Audiology” [Mesh] OR ent [ti] OR otolaryngolo* [ti] OR sinus* [ti] OR rhinolog* [ti]) AND English [lang] NOT (“animals” [mesh] NOT “humans” [mesh]).

Articles were also searched in the Cochrane Library databases with the following thread of keywords: telemedicine AND ENT; telemedicine AND otolaryngology; telehealth AND ENT; telehealth AND otolaryngology. The date of the last search was December 15, 2020.

Eligibility Criteria

Eligibility criteria were peer-reviewed studies that described the application of telemedicine in the otolaryngology specialty. Due to the scarcity of available literature, no restrictions were set on patient demographics and study design; thus, case reports were also included. Research articles that did not describe the application of telemedicine in the field of otolaryngology were excluded. Reviews, editorials, commentaries, and all other nonresearch trial articles on telemedicine in otolaryngology were excluded.

Selection of Sources of Evidence

Search results from databases were downloaded and uploaded to Covidence, an online organizer platform where duplicates were removed. Using the eligibility criteria, 2 reviewers (A.Y. and D.K.) independently screened the titles and abstracts of all included articles. For full-text screening, the 2 reviewers independently screened the articles, and conflicts were resolved by discussion. The final full-text screened cohort was confirmed with a third reviewer (M.L.).

Data Extraction

Eligible full-text articles were read independently by the 2 reviewers to extract information regarding year published, study design, subspecialty, type of telemedicine, disease of focus diagnosis/prognosis, participant number/sample size, and outcomes. Level of evidence was determined by study design (1, randomized controlled study; 2, prospective cohort study, controlled study; 3, retrospective controlled study; 4, case report, case series).

Results

The search yielded 469 results, and after removal of duplicates, 461 were eligible for initial screening. All titles and abstracts were screened. An overall 408 articles were eligible for full-text screening. A total of 235 articles were excluded as they did not fit the inclusion criteria: article type was not original research; article did not focus on application of telemedicine in otolaryngology; or there was no full text available or no access. Full-text review was performed on the remaining 173 articles, and data were extracted (**Figure 1**).

Of all studies that fit the inclusion criteria, 18 focused on rhinology or skull base surgery, 33 on laryngology/head and neck surgery, 35 on comprehensive otolaryngology–head and neck surgery, 85 on otology or audiology subspecialty, 1 on maxillofacial surgery, and 1 on multiple subspecialties. In general, there has been a significant increase in the annual number of articles published on telemedicine in otolaryngology overall and for subspecialties (**Figure 2**).

For ease of review, we classified the articles per the approach used for telemedicine.

Virtual Encounters

A total of 164 articles were identified. Virtual encounters (VEs) were defined as consultations held by telephone- or video-based platforms (with real-time audio and/or visual communication with minimal latency) and store-and-forward telepractice services. These commonly included clinical assessments with the patients presenting to an ear, nose, and throat (ENT) specialist while connected from a remote site, and they encompass tele-screening, tele-rehabilitation, and post-operative follow-up via patient engagement tools. Applications of VE were classified into 5 subdomains: patient-physician interaction (Supplemental Table 1a and 1b, available online), physician-physician interaction (Supplemental Tables S2a and S2b), patient engagement tools (Supplemental Tables S3a and

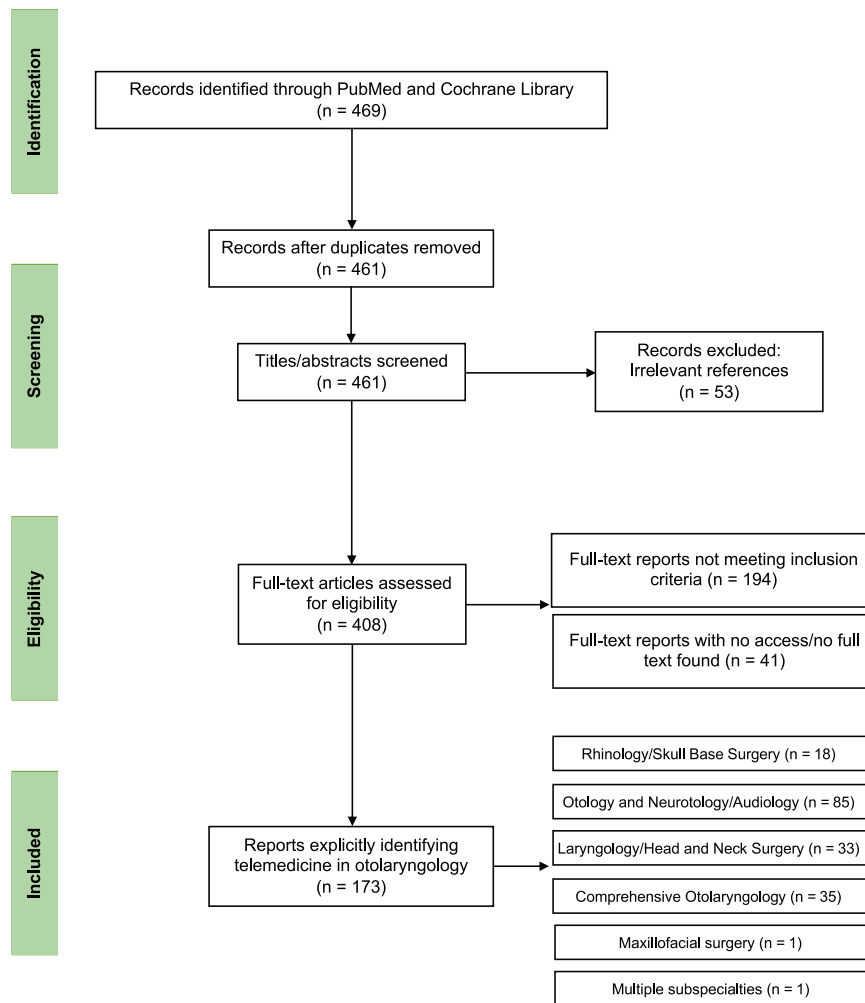


Figure 1. Search strategy flowchart.

S3b), tele-screening (Supplemental Tables S4a and S4b), and tele-rehabilitation (Supplemental Table S5a and S5b). Most studies focused on feasibility⁶⁻⁷⁵ or investigated concordance rates^{4,76-151} between ≥ 2 cohorts, while a few examined the cost savings.¹⁵²⁻¹⁵⁴

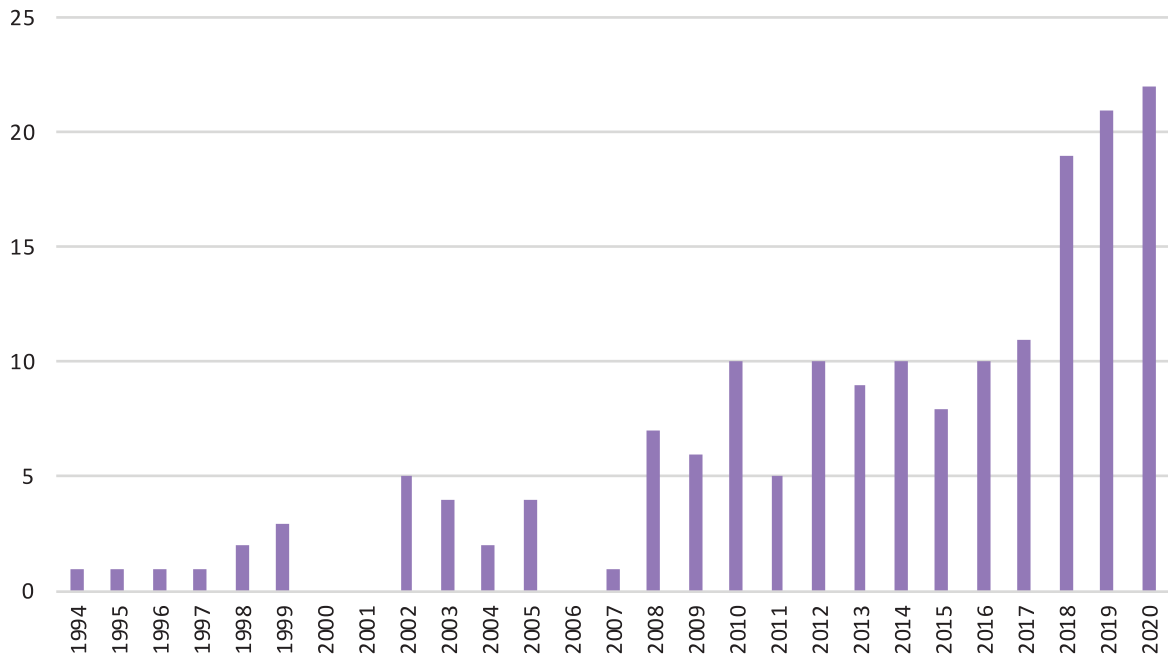
Physician-Patient Interaction. Prior to COVID-19, studies and case reports demonstrated the feasibility of remote tele-visits^{15,16,23,70} and sufficiency in providing patients with preliminary diagnoses, reducing referral wait time, allowing for postoperative tele-follow-up visits, or preventing unnecessary in-person otolaryngology visits.^{7,8,11,13,68,155}

A major theme identified was antibiotic prescription patterns in the course of tele-management. For treatment of sinusitis, feasibility of VE was supported in literature,^{14,83-85} but results on prescription patterns were contradicting. Some studies reported that physicians were more likely to prescribe antibiotics during tele-visits as compared with face-to-face (FTF) visits,⁸³ while others noted the opposite.^{84,85} One study found no significant difference among methods of visit in adherence to antibiotic prescription guidelines.¹⁵⁰ For management of acute respiratory tract infections, a group of researchers noted that patient satisfaction was highest in those

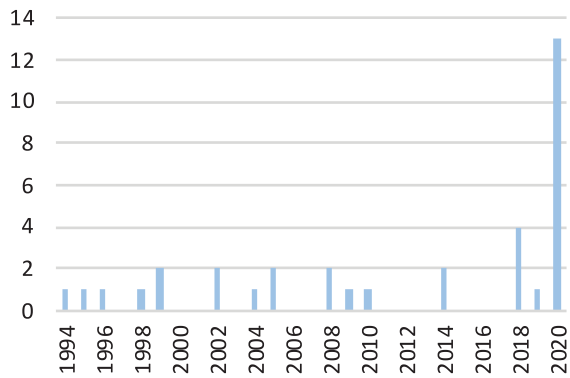
who had an antibiotic and corticosteroid prescribed during the tele-visit.⁶⁷

A few studies focused on remote cochlear implant (CI) management, and feasibility was supported,^{18-20,97} as patients with CIs or hearing aids can use tele-visits to undergo pure tone audiometry (PTA), tympanometry, and speech tests. Remote programming of CI is also possible, and when compared with CI programmed in-person, there was no significant difference in patients' performance at 3 months according a group of researchers.¹⁵¹ Patient satisfaction for the telemedicine experience was high.^{21-23,73,151} However, as expected, performance of audiology or speech tests was suggested to be better in a sound-treated booth.^{28,96} For PTA conducted in a non-sound-treated booth, results were promising,^{110,111} and others reported the test and retest thresholds between remote and in-person testing to be similar.^{112,113} With regard to concordance rates, results were contradicting. Threshold differences of PTA conducted in remote sound booths were clinically acceptable and equivalent to in-person testing,¹⁰²⁻¹⁰⁸ although 1 study found more errors generated when the personal computer-based audiometer was used in a telemedicine setup as compared with in-person appointment settings.¹⁰⁹

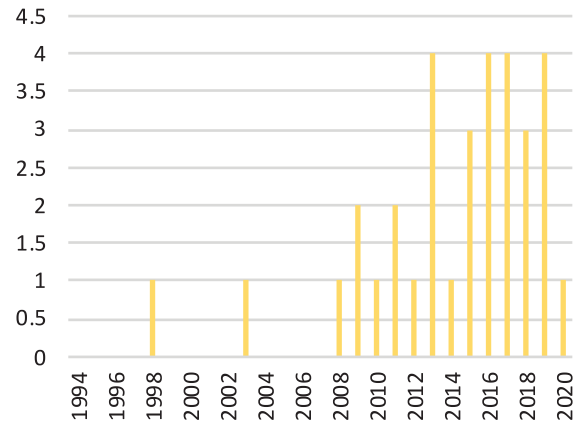
Overall trend in publications



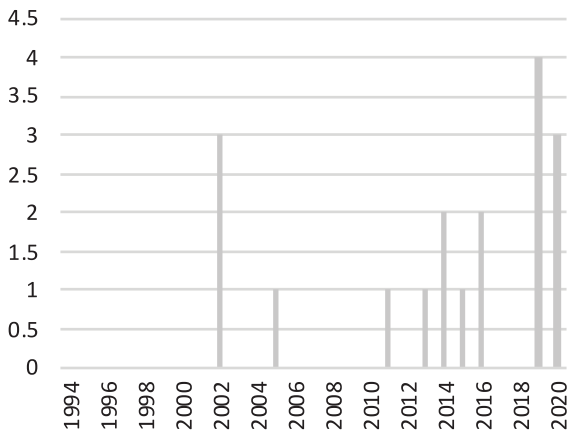
Trends in comprehensive OHNS



Trends in Laryngology



Trends in Rhinology



Trends in Otology

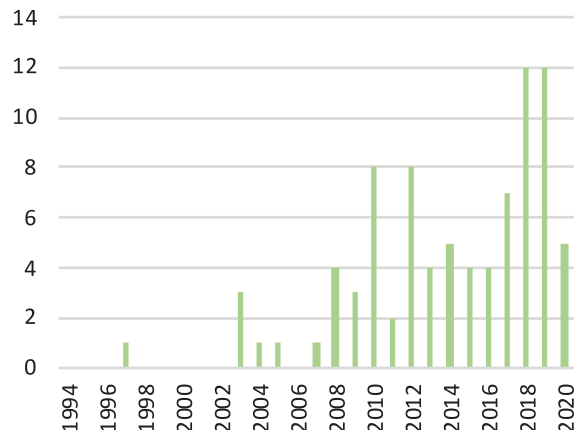


Figure 2. Trend in number of publications. OHNS, otolaryngology–head and neck surgery.

Most studies showed acceptable to high agreement between diagnosis made via telemedicine and that made through FTF encounters,^{76-79,82,86-92,122} yet 2 noted discordance.^{80,81} Common concerns for this discrepancy were with regard to image/recording quality of the physical examination.^{6,8,29,156} A higher percentage of video otoscopy recording taken by nonphysicians was lower quality and unusable than that taken by physicians.^{17,89,121,124} In a pediatric study, this was shown to improve upon appropriate training of parents on how to use an otoscope.²⁶ In contrast, usefulness of endoscopic videos taken by health care personnel can be limited.^{25,118,148,149}

Nonetheless, when VEs were utilized for CI management, studies demonstrated no significant differences in performance of CIs, session duration, neural responses, electrode-specific measure, and threshold and comfort levels^{18,93-101,123} as compared with those managed in person. When VE was used for dysphagia evaluations, results suggested that remote evaluation yielded substantial levels of agreement for treatment recommendations and subjective severity ratings as compared with traditional FTF evaluations,¹¹⁴⁻¹¹⁷ with comparable efficacy. According to cost-efficiency analysis, tele-visits are more cost-efficient than in-person appointments.⁸⁶ At an institution level, the cost reduction was achieved after the number of tele-visits surpassed the threshold to pay off the fixed costs from the initial technology installment; for example, in 1 study this was reported at a threshold of 35 patients per year.^{11,152,153}

During COVID-19, there has been a surge in literature describing the implementation and efficacy of the tele-clinic,¹⁵⁵⁻¹⁶⁸ especially when compared with a similar period prior to the pandemic.^{157,162} Some studies reported no-shows to be more frequent when the tele-visit was utilized,¹⁵⁸ while others noted attendance to increase.^{160,168} Some reported reasons for no-shows included technical issues^{158,159} or patients declining it due to no direct physical examination.¹⁶⁵ While there are numerous studies investigating the efficacy of otoscopes for “at home” use, during the pandemic, only 1 case series reported the use of a commercially available otoscope by patients for telemedicine purposes.¹⁶⁷ Nonetheless, patient satisfaction with telehealth encounters was high or improved as compared with standard care after implementation of the tele-clinics.^{161,164,166} Furthermore, studies showed that patients preferred continued use of tele-visits in addition to,^{160,163} and in some studies even instead of,¹⁶¹ FTF office appointments.

Patient Engagement Tools. Various mobile- and internet-based platforms have been developed to facilitate patient engagement. Almost all articles except for 2 were published in the field of rhinology, which included management of allergy-related symptoms,^{30,31,69,125,126} patient-reported outcome measures tracking after sinonasal surgery,³² and remote nasal airflow evaluation.^{33,34} Studies noted that mobile patient engagement tools aided with physician-patient communication efficacy,¹²⁵ helped diagnose allergies,³⁰ held advantages in improving adherence rate and average daily

use of prescribed medications for patients with allergies,^{31,69,126} allowed for remote nasal airflow evaluation,^{33,34} and yielded high patient response rates when tracking patient-reported outcome measures.³² For nonrhinology articles, one group showed the feasibility of using an online consultation service to connect potential patients interested in maxillofacial surgery to physicians who answered inquiries.²⁷ Another study investigated the utility of a mobile instant messenger in the postoperative management of pediatric tonsillectomy and found this to improve compliance with at-home care instructions.⁶⁶

Physician-Physician Interaction. Twelve studies focused on tele-consultations, during which physicians remotely consulted another physician for better case management. Remote consultations among physicians were shown to be feasible and able to prevent unnecessary encounters for general otolaryngology outpatient clinics,^{35,36} as well as more specialized audiologic management of CI cases.^{37,38} ICT also allowed for remote observation and consultation for laryngeal intubation^{39,40} and extubation.⁴¹

Results indicated that physician-physician tele-consultations had good interrater agreement for diagnostic indicators^{127,128} and management recommendations¹²⁹ for patients with dysphagia. Virtual consultations among physicians also accurately predicted otologic surgery as compared with those from in-person appointments.¹³⁰ Two studies evaluated diagnostic accuracy for patients whose imaging was sent via ICT. The study population consisted of emergency ENT patients and pediatric patients with lateral neck x-rays. Results for both studies showed high accuracy.^{4,131}

Tele-screening. In tele-screening (ie, telemedicine for the purpose of screening), the 18 eligible articles mostly focused on the field of otology. Almost exclusively, technology was used for hearing screening. These were described in articles from America,^{42,132} Australia,⁴³⁻⁴⁷ Brazil,¹³³ Canada,⁴⁸ Germany,⁷¹ India,^{74,134} Kenya,⁷² South Africa,^{49-51,75} and Tajikistan.⁵² In general, results suggest feasibility. Tele-screening resulted in increased screening coverage, shortened referral waiting time, decreased outpatient and failure-to-attend appointments at tertiary centers from a remote community, and reduced costs.^{43-48,50,51,71} Testing and identification during tele-screening were also suggested to be reliable and comparable to in-person screening.^{42,52,132-134} In a rare study that investigated tele-screening in the adult population, it was found that an online screening test was feasible, but only a small portion of participants provided their contact information to proceed with a hearing evaluation and hearing aid trial.⁴⁹

Tele-rehabilitation. In tele-rehabilitation, the 27 articles were mainly in the field of otology, audiology, laryngology, or head and neck cancer. The feasibility and effectiveness of various online-delivered or software-based therapies were investigated (eg, acceptance and commitment, auditory-verbal, cognitive-behavioral, voice, speech, and swallow) to manage tinnitus, chronic vestibular syndromes, hearing loss,

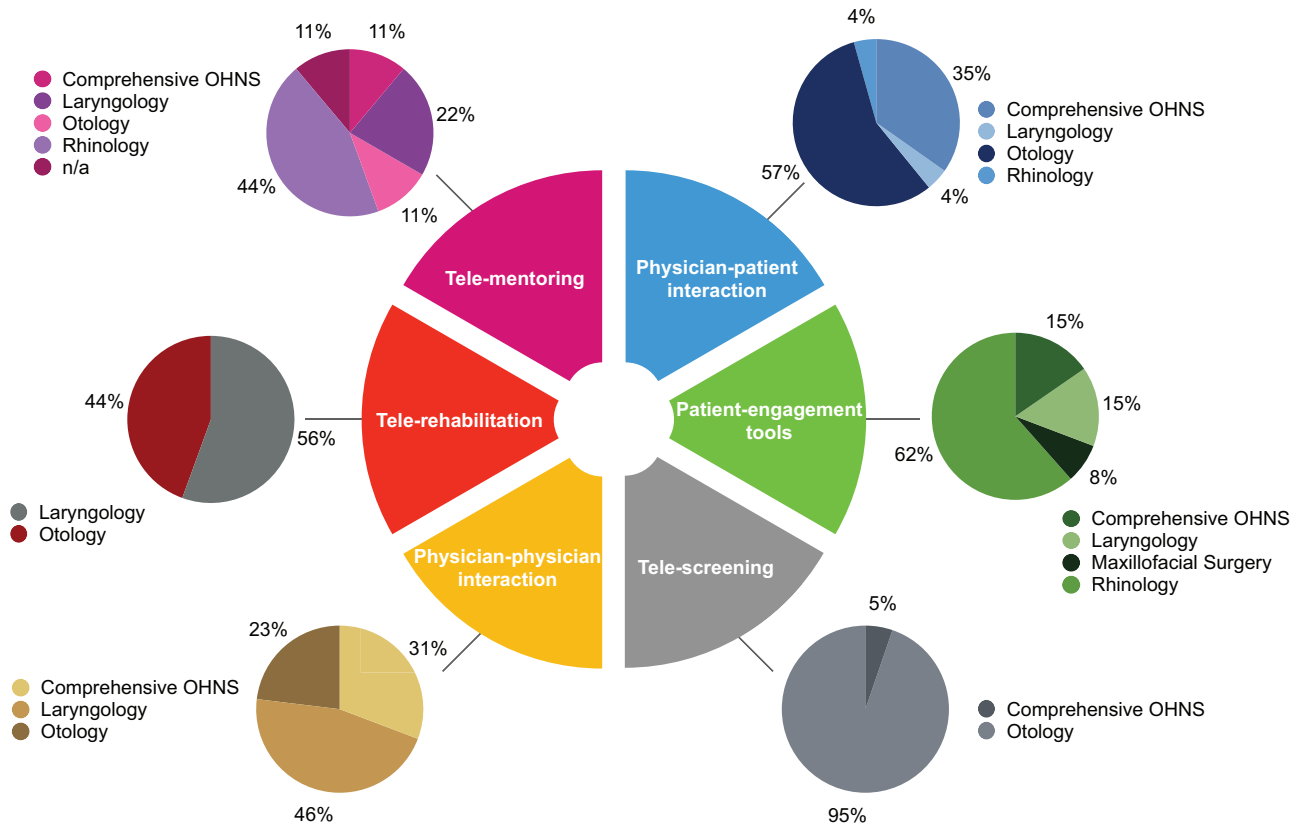


Figure 3. Subdomains of telemedicine applied in each subspecialty. OHNS, otolaryngology–head and neck surgery.

deafness,^{53-57,135-140} speech/voice pathology, and dysphagia.^{58-64,141-147,154} In articles focused in otology and audiology, tele-rehabilitation groups showed improvement in tinnitus severity,^{53-57,136} vertigo severity,¹³⁷ and hearing aid problems,¹³⁸ with no significant difference in improvements from in-person therapy.^{139,140} In articles concerned with the field of laryngology, tele-rehabilitation suggested cost-effectiveness¹⁵⁴ and improvements in vocal fold function, acoustic and physiologic parameters, nodule sizes, patient perceptions of voice-related quality of life,⁶¹ vocal self-evaluation skill,⁵⁸ and vocal pattern.⁵⁹ Comparable levels of agreement were achieved between online and FTF environments.^{60,141-143,145-147} Moreover, a higher adherence rate than that of patient-directed therapy⁶⁴ was found. Overall, patient and therapist satisfaction rates on tele-rehabilitation were also high.^{59,61-63,65,144}

Telementoring

Nine studies evaluated the concept of telementoring (ie, mentoring by means of telecommunication or computer networks). Detailed results are illustrated in Supplemental Tables S6a and S6b (available online). Overall, results are encouraging and certainly show the feasibility of this approach.¹⁶⁹ When in-person surgical guidance and telementoring endoscopic sinus surgery were compared, no significant differences in clinical outcomes were observed.^{170,171} Yet, the authors recommend that only surgeons of a certain

training level and experience be telementored intraoperatively when acting as the primary surgeon.^{172,173} Telementoring procedures have also been described,^{174,175} including intubation, laryngoscopy, otoscopy, and nasopharyngoscopy, and 1 study identified a \$25,450 reduction in travel expenses after implementing a tele-clinic,¹⁷⁶ demonstrating the potential of significant financial savings. However, Melo et al found that only the in-person group showed a statistically significant difference in pre- and posttraining performances for the overall score and individual topic scores when compared with remotely trained community health workers for nonprocedural tasks.¹⁷⁷

Discussion

This scoping review of the literature provides an up-to-date summary of the current applications of telemedicine in otolaryngology and rhinology in particular, including the latest studies on the widespread use of telemedicine during the COVID-19 pandemic.¹⁵⁵⁻¹⁶⁸ We aim to discuss our results related to the various subdomains that we have identified to appreciate the extensive work that has been done in this field. Interestingly, subspecialties focused on different subdomains of telemedicine, as summarized in **Figure 3**.

VE is one of the oldest and most common applications of telemedicine in otolaryngology, and coincidentally, most articles in telemedicine focused on this and related strategies. When VE was compared with in-person appointments, results

were promising,^{18,76-79,82,86-108,112-117,122,123,151} with only a few studies reporting discrepancies.^{81,109,118} Most studies demonstrated moderate ($\kappa = 0.41-0.60$) to substantial ($\kappa = 0.61-0.80$) diagnostic agreement between VE and FTF evaluations.^{25,82,84,87,88,91,92,114-117,121,124,148-150,160} A major issue is the quality of the physical examination being conducted remotely, which obviously has a lot of limitations.^{6,8,17,25,28,29,89,96,121,124,156} However, VE has been found to expand health coverage, prevent unnecessary visits, and save travel costs.^{7,8,11,13-15,17,19,23,38,68,70,86,152-155} With the development of adaptors for mobile-based endoscopes, mobile/internet-based patient engagement platforms, and internet-based examination and analysis software, the applications of VE will be advanced.

The use of patient engagement tools was most widespread in rhinology, possibly because the subspecialty deals with the management of many common chronic conditions. Regardless of subspecialty, studies have shown that these tools can enhance diagnostic accuracy, management, and follow-up efficacy, as well as facilitate more efficient communication and improve adherence to medications.^{27,30-34,66,69,125,126} Tele-rehabilitation has been applied in most subspecialties. One study investigated the feasibility of providing therapy via a mobile app,⁵⁸ pointing toward the likely future applications of many tele-rehabilitation services. With the development of interactive smart tools and artificial intelligence, tele-rehabilitation in times ahead may not even require a therapist but deal with many common tasks via programmed branching logics and permutations.

Tele-screening has been applied for screening of otologic conditions, in particular the remote screening of hearing disorders, mainly in the pediatric population.^{42-48,50-52,71,72,132-134} It is another subset of telemedicine that has been increasingly incorporating automated algorithms to aid with its purposes. Results show great potential for tele-screening in rural communities with regard to the demonstrated testing reliability of remote hearing tests, cost-effectiveness, increase in the local screening rate, and efficient referral workflow. While tele-screening is still limited on the global level, this concept and the related technologies have a huge potential for more widespread use.

Tele-consultation has been utilized among providers within^{36-40,130} and beyond^{35,127-129} the confines of the country. It is also useful in connecting ENT providers with those from different specialties in emergency situations or when a complex case is encountered requiring multidisciplinary care,^{4,41,131} underscoring its potential in the field of otorhinolaryngology.

Telementoring is another subdomain of telemedicine that we identified, and studies show that this can be an invaluable tool for the training. Surgical telementoring was mainly utilized and tested within the field of rhinology.¹⁶⁹⁻¹⁷³ While studies show a positive experience, many identify the balance between high-quality video/audio transmission and reduction of lag time as a key challenge, but technological advances should easily overcome this in the years to come. It is intriguing to imagine that commercially available technologies,

such as augmented or virtual reality, will be implemented in the use of surgical telementoring in ENT. Other technologies, such as Google glasses, allow for visualization of the entire operating room, which provides the mentor with the important aspect of situational awareness. Furthermore, with holistic projection of augmented or virtual reality via the glasses or on the screen, this may enhance the mentoring experience. While only a few articles reported the feasibility of tele-education in the field of otolaryngology so far,¹⁷⁴⁻¹⁷⁷ this area of research shows great potential. One limitation is that surgical specialties, including ENT, require a high level of hands-on experience and FTF teaching for the initial period of surgical training. However, for training and mentoring the advanced surgical trainee, this concept represents an extremely useful adjunct in the education of the next generation of surgeons and physicians.

Taking all this into account, different subdomains of telemedicine have been assessed for different measurable outcomes. The most commonly investigated outcomes that we encountered during our analysis were feasibility, cost-efficiency, patient and/or physician satisfaction, waiting time, concordance between remote and local physicians, validity, reliability, and diagnostic accuracy of telemedicine. Interestingly, we observed a wide range of mean ages of adult patients surveyed, from 20 to 66 years,^{12,21,23,61-63,70,73,76,79,156,166} and some studies also examined satisfaction among older patients. Moreover, various studies on the pediatric population reported parent satisfaction.^{26,42,48,65,95} On the whole, the majority of patients have been pleased with their telemedicine experience, especially with the reduced traveling costs. The introduction of new telemedicine platforms and familiarization with these technologies for other purposes in daily life will facilitate the encounters and certainly improve patient satisfaction.

While this review aims to provide a detailed overview of the current applications of telemedicine in otorhinolaryngology, there are limitations. Due to the broad nature of the question and the fact that the quality of published data is limited and heterogeneous, a systematic review could not be performed; hence, a more limited review (ie, scoping review) was conducted.

While it appears that telemedicine has more advantages than disadvantages, this approach must continue to be critically appraised, and more rigorous research needs to be conducted and demonstrate patient benefit at high levels of evidence to allow for its widespread adoption. While telemedicine does reduce traveling costs for patients and provide outreach care for those in rural areas, the patient must be aware of and consent to many limitations. Moreover, patients may prefer FTF appointments as they can facilitate the encounter by building a better rapport between the patient and the physician. Certain aspects of the clinical evaluation, such as endoscopies, will yield more information if performed by an experienced health care provider FTF, rather than by patients themselves. Details lost in the transmission of audio and video data is also a problem, as the physician's perception and understanding of the patient can be limited by the

technical quality of the VE. Moreover, some patients may not have access to such technology. All examinations, as far as the VE allows, should be standardized for all examination and analysis devices that can be self-administered by patients at home. The active engagement of patients in familiarizing themselves with the newly devised systems is crucial to allow providers to make accurate diagnoses.

The telemedicine market has shown exponential growth in recent years, but at the same time it is important to ensure security and privacy for the patient by the use of HIPAA-compliant systems (Health Insurance Portability and Accountability Act) that are integrated in the existing patient management software. This will allow for possible recording of parts of the examination and/or photodocumentation and will facilitate billing and coding. While telemedicine allows for easy access to care, licensing requirements need to be taken into account, in particular for patients who live in other states and who have never presented FTF in the state for which the physician's license has been granted.

Implications for Practice

COVID-19 has brought telemedicine center stage, but many studies had already demonstrated the huge potential of this concept. From VE to tele-education, telementoring, and platform development to allow for self-examination and rehabilitation at home, telemedicine is here to stay and will be further developed in years to come.

Acknowledgments

We thank Christopher Stave, Lane Medical Library, Stanford University, for his invaluable help and guidance during the literature search and scoping review.

Author Contributions

Angela Yang, design, data acquisition, data analysis and interpretation, drafting, revision; **Dayoung Kim**, design, data acquisition, data analysis and interpretation, drafting, revision; **Peter H. Hwang**, conception, design, data interpretation, revision, final approval; **Matt Lechner**, conception, design, data interpretation, revision, final approval

Disclosures

Competing interests: None.

Sponsorships: None.

Funding source: None.

Supplemental Material

Additional supporting information is available at <http://journals.sagepub.com/doi/suppl/10.1177/2473974X211072791>

References

- Gagnon M-P, Desmartis M, Labrecque M, et al. Systematic review of factors influencing the adoption of information and communication technologies by healthcare professionals. *J Med Syst*. 2012;36(1):241-277. doi:10.1007/s10916-010-9473-4
- World Health Organization, ed. *Telemedicine: Opportunities and Developments in Member States—Report on the Second Global Survey on Ehealth*. World Health Organization; 2010.
- Mick P, Murphy R. Aerosol-generating otolaryngology procedures and the need for enhanced PPE during the COVID-19 pandemic: a literature review. *J Otolaryngol Head Neck Surg*. 2020; 49(1):29. doi:10.1186/s40463-020-00424-7
- Yamamoto LG, Inaba AS, DiMauro R. Personal computer tele-radiology interhospital image transmission to facilitate tertiary pediatric telephone consultation and patient transfer: soft-tissue lateral neck and elbow radiographs. *Pediatr Emerg Care*. 1994; 10(5):273-277. doi:10.1097/00006565-199410000-00007
- Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467-473. doi:10.7326/M18-0850
- Crump WJ, Driscoll B. An application of telemedicine technology for otorhinolaryngology diagnosis. *Laryngoscope*. 1996; 106(5, pt 1):595-598. doi:10.1097/00005537-199605000-00014
- Hofstetter PJ, Kokesh J, Ferguson AS, Hood LJ. The impact of telehealth on wait time for ENT specialty care. *Telemed J E Health*. 2010;16(5):551-556. doi:10.1089/tmj.2009.0142
- Haegen TW, Cupp CC, Hunsaker DH. Teleotolaryngology: a retrospective review at a military tertiary treatment facility. *Otolaryngol Head Neck Surg*. 2004;130(5):511-518. doi:10.1016/j.otohns.2004.01.010
- Smith AC, Williams J, Agnew J, Sinclair S, Youngberry K, Wootton R. Realtime telemedicine for paediatric otolaryngology pre-admission screening. *J Telemed Telecare*. 2005;11(suppl 2): S86-S89. doi:10.1258/135763305775124821
- Blakeslee DB, Grist WJ, Stachura ME, Blakeslee BS. Practice of otolaryngology via telemedicine. *Laryngoscope*. 1998;108(1, pt 1):1-7. doi:10.1097/00005537-199801000-00001
- Dorrian C, Ferguson J, Ah-See K, et al. Head and neck cancer assessment by flexible endoscopy and telemedicine. *J Telemed Telecare*. 2009;15(3):118-121. doi:10.1258/jtt.2009.003004
- Rimmer RA, Christopher V, Falck A, et al. Telemedicine in otolaryngology outpatient setting—single center head and neck surgery experience. *Laryngoscope*. 2018;128(9):2072-2075. doi:10.1002/lary.27123
- Walijee H, Sood S, Markey A, Krishnan M, Lee A, De S. Is nurse-led telephone follow-up for post-operative obstructive sleep apnoea patients effective? A prospective observational study at a paediatric tertiary centre. *Int J Pediatr Otorhinolaryngol*. 2020;129:109766. doi:10.1016/j.ijporl.2019.109766
- Penza KS, Murray MA, Myers JF, Furst JW, Pecina JL. Management of acute sinusitis via e-visit. *Telemed J E Health*. 2021;27(5):532-536. doi:10.1089/tmj.2020.0047
- Arriaga MA, Nuss D, Scrantz K, et al. Telemedicine-assisted neurotology in post-Katrina Southeast Louisiana. *Otol Neurotol*. 2010;31(3):524-527. doi:10.1097/MAO.0b013e3181cdd69d
- Viiirre E, Warner D, Balch D, Nelson JR. Remote medical consultation for vestibular disorders: technological solutions and case report. *Telemed J*. 1997;3(1):53-58. doi:10.1089/tmj.1.1997.3.53

17. Ramkumar V, Rajendran A, Nagarajan R, Balasubramaniyan S, Suresh DK. Identification and management of middle ear disorders in a rural cleft care program: a telemedicine approach. *Am J Audiol*. 2018;27(3S):455-461. doi:10.1044/2018_AJA-IMIA3-18-0015
18. Slager HK, Jensen J, Kozlowski K, et al. Remote programming of cochlear implants. *Otol Neurotol*. 2019;40(3):e260-e266. doi:10.1097/MAO.0000000000002119
19. Shapiro WH, Huang T, Shaw T, Roland JTT, Lalwani AK. Remote intraoperative monitoring during cochlear implant surgery is feasible and efficient. *Otol Neurotol*. 2008;29(4):495-498. doi:10.1097/MAO.0b013e3181692838
20. Steuerwald W, Windmill I, Scott M, Evans T, Kramer K. Stories from the webcams: Cincinnati Children's Hospital Medical Center audiology telehealth and pediatric auditory device services. *Am J Audiol*. 2018;27(3S):391-402. doi:10.1044/2018_AJA-IMIA3-18-0010
21. Kuzovkov V, Yanov Y, Levin S, et al. Remote programming of MED-EL cochlear implants: users' and professionals' evaluation of the remote programming experience. *Acta Otolaryngol*. 2014;134(7):709-716. doi:10.3109/00016489.2014.892212
22. Cullington H, Kitterick P, Weal M, Margol-Gromada M. Feasibility of personalised remote long-term follow-up of people with cochlear implants: a randomised controlled trial. *BMJ Open*. 2018;8(4):e019640. doi:10.1136/bmjopen-2017-019640
23. Burns CL, Ward EC, Hill AJ, Kularatna S, Byrnes J, Kenny LM. Randomized controlled trial of a multisite speech pathology telepractice service providing swallowing and communication intervention to patients with head and neck cancer: evaluation of service outcomes. *Head Neck*. 2017;39(5):932-939. doi:10.1002/hed.24706
24. Maurrasse SE, Schwanke TW, Tabae A. Smartphone capture of flexible laryngoscopy: optics, subsite visualization, and patient satisfaction. *Laryngoscope*. 2019;129(9):2147-2152. doi:10.1002/lary.27803
25. Demant MN, Jensen RG, Bhutta MF, Laier GH, Lous J, Homøe P. Smartphone otoscopy by non-specialist health workers in rural Greenland: a cross-sectional study. *Int J Pediatr Otorhinolaryngol*. 2019;126:109628. doi:10.1016/j.ijporl.2019.109628
26. Erkkola-Anttinen N, Irjala H, Laine MK, Tähtinen PA, Löyttyniemi E, Ruohola A. Smartphone otoscopy performed by parents. *Telemed J E Health*. 2019;25(6):477-484. doi:10.1089/tmj.2018.0062
27. Brockes C, Schenkel JS, Buehler RN, Grätz K, Schmidt-Weitmann S. Medical online consultation service regarding maxillofacial surgery. *J Craniomaxillofac Surg*. 2012;40(7):626-630. doi:10.1016/j.jcms.2012.03.018
28. Goehring JL, Hughes ML, Baudhuin JL, et al. The effect of technology and testing environment on speech perception using telehealth with cochlear implant recipients. *J Speech Lang Hear Res*. 2012;55(5):1373-1386. doi:10.1044/1092-4388(2012/11-0358)
29. Lundberg T, Westman G, Hellstrom S, Sandstrom H. Digital imaging and telemedicine as a tool for studying inflammatory conditions in the middle ear—evaluation of image quality and agreement between examiners. *Int J Pediatr Otorhinolaryngol*. 2008;72(1):73-79. doi:10.1016/j.ijporl.2007.09.015
30. Bianchi A, Tsilochristou O, Gabrielli F, Tripodi S, Matricardi PM. The smartphone: a novel diagnostic tool in pollen allergy? *J Investig Allergol Clin Immunol*. 2016;26(3):204-207. doi:10.18176/jiaci.0060
31. Costa C, Menesatti P, Brighetti MA, et al. Pilot study on the short-term prediction of symptoms in children with hay fever monitored with e-health technology. *Eur Ann Allergy Clin Immunol*. 2014;46(6):216-225.
32. Khanwalkar AR, Shen J, Kern RC, et al. Utilization of a novel interactive mobile health platform to evaluate functional outcomes and pain following septoplasty and functional endoscopic sinus surgery. *Int Forum Allergy Rhinol*. 2019;9(4):345-351. doi:10.1002/alr.22273
33. Seren E. Web-based analysis of nasal sound spectra. *Telemed J E Health*. 2005;11(5):578-582. doi:10.1089/tmj.2005.11.578
34. Choi H, Park I-H, Yoon HG, Lee H-M. Wireless patient monitoring system for patients with nasal obstruction. *Telemed J E Health*. 2011;17(1):46-49. doi:10.1089/tmj.2010.0105
35. Kohlert S, Murphy P, Tse D, Liddy C, Afkham A, Keely E. Improving access to otolaryngology—head and neck surgery expert advice through eConsultations. *Laryngoscope*. 2018;128(2):350-355. doi:10.1002/lary.26677
36. Gilani S, Bommakanti K, Friedman L. Electronic consults in otolaryngology: a pilot study to evaluate the use, content, and outcomes in an academic health system. *Ann Otol Rhinol Laryngol*. 2020;129(2):170-174. doi:10.1177/0003489419882726
37. McRackan TR, Noble JH, Wilkinson EP, et al. Implementation of image-guided cochlear implant programming at a distant site. *Otolaryngol Head Neck Surg*. 2017;156(5):933-937. doi:10.1177/0194599817698435
38. Kokesh J, Ferguson AS, Patricoski C, LeMaster B. Traveling an audiologist to provide otolaryngology care using store-and-forward telemedicine. *Telemed J E Health*. 2009;15(8):758-763. doi:10.1089/tmj.2009.0046
39. Sibert K, Ricci MA, Caputo M, et al. The feasibility of using ultrasound and video laryngoscopy in a mobile telemedicine consult. *Telemed J E Health*. 2008;14(3):266-272. doi:10.1089/tmj.2007.0050
40. Mosier J, Joseph B, Sakles JC. Telebation: next-generation telemedicine in remote airway management using current wireless technologies. *Telemed J E Health*. 2013;19(2):95-98. doi:10.1089/tmj.2012.0093
41. Newmark JL, Ahn YK, Adams MC, Bittner EA, Wilcox SR. Use of video laryngoscopy and camera phones to communicate progression of laryngeal edema in assessing for extubation: a case series. *J Intensive Care Med*. 2013;28(1):67-71. doi:10.1177/0885066612437528
42. Ciccia AH, Whitford B, Krumm M, McNeal K. Improving the access of young urban children to speech, language and hearing screening via telehealth. *J Telemed Telecare*. 2011;17(5):240-244. doi:10.1258/jtt.2011.100810
43. Smith AC, Armfield NR, Wu W-I, Brown CA, Mickan B, Perry C. Changes in paediatric hospital ENT service utilisation following the implementation of a mobile, indigenous health screening

- service. *J Telemed Telecare*. 2013;19(7):397-400. doi:10.1177/1357633X13506526
44. Smith AC, Brown C, Bradford N, Caffery LJ, Perry C, Armfield NR. Monitoring ear health through a telemedicine-supported health screening service in Queensland. *J Telemed Telecare*. 2015;21(8):427-430. doi:10.1177/1357633X15605407
 45. Smith AC, Armfield NR, Wu W-I, Brown CA, Perry C. A mobile telemedicine-enabled ear screening service for Indigenous children in Queensland: activity and outcomes in the first three years. *J Telemed Telecare*. 2012;18(8):485-489. doi:10.1258/jtt.2012.gth114
 46. Reeve C, Thomas A, Mossenson A, Reeve D, Davis S. Evaluation of an ear health pathway in remote communities: improvements in ear health access. *Aust J Rural Health*. 2014;22(3):127-132. doi:10.1111/ajr.12098
 47. Elliott G, Smith AC, Bensink ME, et al. The feasibility of a community-based mobile telehealth screening service for Aboriginal and Torres Strait Islander children in Australia. *Telemed J E Health*. 2010;16(9):950-956. doi:10.1089/tmj.2010.0045
 48. Hatton JL, Rowlandson J, Beers A, Small S. Telehealth-enabled auditory brainstem response testing for infants living in rural communities: the British Columbia Early Hearing Program experience. *Int J Audiol*. 2019;58(7):381-392. doi:10.1080/14992027.2019.1584681
 49. Ratanjee-Vanmali H, Swanepoel DW, Laplante-Lévesque A. Characteristics, behaviours and readiness of persons seeking hearing healthcare online. *Int J Audiol*. 2019;58(2):107-115. doi:10.1080/14992027.2018.1516895
 50. Yousuf Hussein S, Swanepoel DW, Mahomed F, Biagio de Jager L. Community-based hearing screening for young children using an mHealth service-delivery model. *Glob Health Action*. 2018;11(1):1467077. doi:10.1080/16549716.2018.1467077
 51. Govender SM, Mars M. Assessing the efficacy of asynchronous telehealth-based hearing screening and diagnostic services using automated audiometry in a rural South African school. *S Afr J Commun Disord*. 2018;65(1):e1-e9. doi:10.4102/sajcd.v65i1.582
 52. Skarzyński PH, Świerniak W, Piłka A, et al. A hearing screening program for children in primary schools in Tajikistan: a telemedicine model. *Med Sci Monit*. 2016;22:2424-2430. doi:10.12659/msm.895967
 53. Beukes EW, Baguley DM, Allen PM, Manchaiah V, Andersson G. Audiologist-guided internet-based cognitive behavior therapy for adults with tinnitus in the United Kingdom: a randomized controlled trial. *Ear Hear*. 2018;39(3):423-433. doi:10.1097/AUD.0000000000000505
 54. Beukes EW, Allen PM, Manchaiah V, Baguley DM, Andersson G. Internet-based intervention for tinnitus: outcome of a single-group open trial. *J Am Acad Audiol*. 2017;28(4):340-351. doi:10.3766/jaaa.16055
 55. Weise C, Kleinstäuber M, Andersson G. Internet-delivered cognitive-behavior therapy for tinnitus: a randomized controlled trial. *Psychosom Med*. 2016;78(4):501-510. doi:10.1097/PSY.0000000000000310
 56. Hesser H, Gustafsson T, Lundén C, et al. A randomized controlled trial of Internet-delivered cognitive behavior therapy and acceptance and commitment therapy in the treatment of tinnitus. *J Consult Clin Psychol*. 2012;80(4):649-661. doi:10.1037/a0027021
 57. Henry JA, Zaugg TL, Myers PJ, et al. Pilot study to develop telehealth tinnitus management for persons with and without traumatic brain injury. *J Rehabil Res Dev*. 2012;49(7):1025-1042. doi:10.1682/jrrd.2010.07.0125
 58. van Leer E, Porcaro N. Feasibility of the fake phone call: an iOS app for covert, public practice of voice technique for generalization training. *J Voice*. 2019;33(5):659-668. doi:10.1016/j.jvoice.2018.02.014
 59. Dias AE, Limongi JCP, Barbosa ER, Hsing WT. Voice telerehabilitation in Parkinson's disease. *Codas*. 2016;28(2):176-181. doi:10.1590/2317-1782/20162015161
 60. Howell S, Tripoliti E, Pring T. Delivering the Lee Silverman Voice Treatment (LSVT) by web camera: a feasibility study. *Int J Lang Commun Disord*. 2009;44(3):287-300. doi:10.1080/13682820802033968
 61. Fu S, Theodoros DG, Ward EC. Delivery of intensive voice therapy for vocal fold nodules via telepractice: a pilot feasibility and efficacy study. *J Voice*. 2015;29(6):696-706. doi:10.1016/j.jvoice.2014.12.003
 62. Wall LR, Ward EC, Cartmill B, Hill AJ, Porceddu SV. Examining user perceptions of SwallowIT: a pilot study of a new telepractice application for delivering intensive swallowing therapy to head and neck cancer patients. *J Telemed Telecare*. 2017;23(1):53-59. doi:10.1177/1357633X15617887
 63. Sharma S, Ward EC, Burns C, Theodoros D, Russell T. Assessing dysphagia via telerehabilitation: patient perceptions and satisfaction. *Int J Speech Lang Pathol*. 2013;15(2):176-183. doi:10.3109/17549507.2012.689333
 64. Wall LR, Ward EC, Cartmill B, Hill AJ, Porceddu SV. Adherence to a prophylactic swallowing therapy program during (chemo) radiotherapy: impact of service-delivery model and patient factors. *Dysphagia*. 2017;32(2):279-292. doi:10.1007/s00455-016-9757-z
 65. Constantinescu G. Satisfaction with telemedicine for teaching listening and spoken language to children with hearing loss. *J Telemed Telecare*. 2012;18(5):267-272. doi:10.1258/jtt.2012.111208
 66. Yu KE, Kim JS. Effects of a posttonsillectomy management program using a mobile instant messenger on parents' knowledge and anxiety, and their children's compliance, bleeding, and pain. *J Spec Pediatr Nurs*. 2019;24(4):e12270. doi:10.1111/jspn.12270
 67. Dvorin EL, Rothberg MB, Rood MN, Martinez KA. Corticosteroid use for acute respiratory tract infections in direct-to-consumer telemedicine. *Am J Med*. 2020;133(8):e399-e405. doi:10.1016/j.amjmed.2020.02.014
 68. Shaffer AD, Dohar JE. Evidence-based telehealth clinical pathway for pediatric tympanostomy tube otorrhea. *Int J Pediatr Otorhinolaryngol*. 2020;134:110027. doi:10.1016/j.ijporl.2020.110027
 69. Fraia MD, Tripodi S, Arasi S, et al. Adherence to prescribed e-diary recording by patients with seasonal allergic rhinitis: observational study. *J Med Internet Res*. 2020;22(3):e16642. doi:10.2196/16642

70. Pedersen S, Holand U. Tele-endoscopic otorhinolaryngological examination: preliminary study of patient satisfaction. *Telemed J*. 1995;1(1):47-52. doi:10.1089/tmj.1.1995.1.47
71. Delb W, Merkel D, Pilorget K, Schmitt J, Plinkert PK. Effectiveness of a TEOAE-based screening program: can a patient-tracking system effectively be organized using modern information technology and central data management? *Eur Arch Otorhinolaryngol*. 2004;261(4):191-196. doi:10.1007/s00405-003-0662-3
72. Yancey KL, Cheromei LJ, Muhando J, Reppart J, Netterville JL, Jayawardena ADL. Pediatric hearing screening in low-resource settings: incorporation of video-otoscopy and an electronic medical record. *Int J Pediatr Otorhinolaryngol*. 2019;126:109633. doi:10.1016/j.ijporl.2019.109633
73. Cullington HE, Agyemang-Prempeh A. Person-centred cochlear implant care: assessing the need for clinic intervention in adults with cochlear implants using a dual approach of an online speech recognition test and a questionnaire. *Cochlear Implants Int*. 2017;18(2):76-88. doi:10.1080/14670100.2017.1279728
74. Gupta N, Chawla N, Gupta D, Dhawan N, Janaki VR. Community triage of otology patients using a store-and-forward telemedicine device: a feasibility study. *Ear Nose Throat J*. 2017;96(7):246-249.
75. van Wyk T, Mahomed-Asmail F, Swanepoel DW. Supporting hearing health in vulnerable populations through community care workers using mHealth technologies. *Int J Audiol*. 2019;58(11):790-797. doi:10.1080/14992027.2019.1649478
76. Seim NB, Philips RHW, Matrka LA, et al. Developing a synchronous otolaryngology telemedicine clinic: prospective study to assess fidelity and diagnostic concordance. *Laryngoscope*. 2018;128(5):1068-1074. doi:10.1002/lary.26929
77. Heneghan C, Sclafani AP, Stern J, Ginsburg J. Telemedicine applications in otolaryngology. *IEEE Eng Med Biol Mag*. 1999;18(4):53-62. doi:10.1109/51.775489
78. Sclafani AP, Heneghan C, Ginsburg J, Sabini P, Stern J, Dolitsky JN. Teleconsultation in otolaryngology: live versus store and forward consultations. *Otolaryngol Head Neck Surg*. 1999;120(1):62-72. doi:10.1016/S0194-5998(99)70371-2
79. Yulzari R, Bretler S, Avraham Y, Sharabi-Nov A, Even-Tov E, Gilbey P. Mobile technology-based real-time teleotolaryngology care facilitated by a nonotolaryngologist physician in an adult population. *Ann Otol Rhinol Laryngol*. 2018;127(1):46-50. doi:10.1177/0003489417745089
80. Ullah R, Gilliland D, Adams D. Otolaryngology consultations by real-time telemedicine. *Ulster Med J*. 2002;71(1):26-29.
81. Melcer T, Hunsaker D, Crann B, Caola L, Deniston W. A prospective evaluation of ENT telemedicine in remote military populations seeking specialty care. *Telemed J E Health*. 2002;8(3):301-311. doi:10.1089/15305620260353199
82. Smith AC, Dowthwaite S, Agnew J, Wootton R. Concordance between real-time telemedicine assessments and face-to-face consultations in paediatric otolaryngology. *Med J Aust*. 2008;188(8):457-460.
83. Mehrotra A, Paone S, Martich GD, Albert SM, Shevchik GJ. A comparison of care at e-visits and physician office visits for sinusitis and urinary tract infection. *JAMA Intern Med*. 2013;173(1):72-74. doi:10.1001/2013.jamainternmed.305
84. Johnson KM, Dumkow LE, Burns KW, Yee MA, Egwuatu NE. Comparison of diagnosis and prescribing practices between virtual visits and office visits for adults diagnosed with sinusitis within a primary care network. *Open Forum Infect Dis*. 2019;6(9):ofz393. doi:10.1093/ofid/ofz393
85. Davis CB, Marzec LN, Blea Z, et al. Antibiotic prescribing patterns for sinusitis within a direct-to-consumer virtual urgent care. *Telemed J E Health*. 2019;25(6):519-522. doi:10.1089/tmj.2018.0100
86. Jacups SP, Newman D, Dean D, Richards A, McConnon KM. An innovative approach to improve ear, nose and throat surgical access for remote living Cape York Indigenous children. *Int J Pediatr Otorhinolaryngol*. 2017;100:225-231. doi:10.1016/j.ijporl.2017.07.011
87. Lundberg T, Biagio L, Laurent C, Sandström H, Swanepoel DW. Remote evaluation of video-otoscopy recordings in an unselected pediatric population with an otitis media scale. *Int J Pediatr Otorhinolaryngol*. 2014;78(9):1489-1495. doi:10.1016/j.ijporl.2014.06.018
88. Kokesh J, Ferguson AS, Patricoski C, et al. Digital images for postsurgical follow-up of tympanostomy tubes in remote Alaska. *Otolaryngol Head Neck Surg*. 2008;139(1):87-93. doi:10.1016/j.otohns.2008.04.008
89. Patricoski C, Kokesh J, Ferguson AS, et al. A comparison of in-person examination and video otoscope imaging for tympanostomy tube follow-up. *Telemed J E Health*. 2003;9(4):331-344. doi:10.1089/153056203772744653
90. Biagio L, Swanepoel DW, Laurent C, Lundberg T. Video-otoscopy recordings for diagnosis of childhood ear disease using telehealth at primary health care level. *J Telemed Telecare*. 2014;20(6):300-306. doi:10.1177/1357633X14541038
91. Eikelboom RH, Mbaio MN, Coates HL, Atlas MD, Gallop MA. Validation of tele-otology to diagnose ear disease in children. *Int J Pediatr Otorhinolaryngol*. 2005;69(6):739-744. doi:10.1016/j.ijporl.2004.12.008
92. Lundberg T, Biagio de Jager L, Swanepoel DW, Laurent C. Diagnostic accuracy of a general practitioner with video-otoscopy collected by a health care facilitator compared to traditional otoscopy. *Int J Pediatr Otorhinolaryngol*. 2017;99:49-53. doi:10.1016/j.ijporl.2017.04.045
93. Hughes ML, Sevier JD, Choi S. Techniques for remotely programming children with cochlear implants using pediatric audiological methods via telepractice. *Am J Audiol*. 2018;27(3S):385-390. doi:10.1044/2018_AJA-IMIA3-18-0002
94. Wesarg T, Wasowski A, Skarzynski H, et al. Remote fitting in Nucleus cochlear implant recipients. *Acta Otolaryngol*. 2010;130(12):1379-1388. doi:10.3109/00016489.2010.492480
95. Hughes ML, Goehring JL, Sevier JD, Choi S. Measuring sound-processor thresholds for pediatric cochlear implant recipients using visual reinforcement audiometry via telepractice. *J Speech Lang Hear Res*. 2018;61(8):2115-2125. doi:10.1044/2018_JSLHR-H-17-0458
96. Hughes ML, Goehring JL, Baudhuin JL, et al. Use of telehealth for research and clinical measures in cochlear implant recipients:

- a validation study. *J Speech Lang Hear Res.* 2012;55(4):1112-1127. doi:10.1044/1092-4388(2011/11-0237)
97. Lohmann AR, Carlson ML, Sladen DP. Intraoperative cochlear implant device testing utilizing an automated remote system: a prospective pilot study. *Otol Neurotol.* 2018;39(3):313-317. doi:10.1097/MAO.0000000000001719
 98. Campos PD, Ferrari DV. Teleaudiology: evaluation of teleconsultation efficacy for hearing aid fitting. *J Soc Bras Fonoaudiol.* 2012;24(4):301-308. doi:10.1590/s2179-64912012000400003
 99. Goehring JL, Hughes ML. Measuring sound-processor threshold levels for pediatric cochlear implant recipients using conditioned play audiometry via telepractice. *J Speech Lang Hear Res.* 2017;60(3):732-740. doi:10.1044/2016_JSLHR-H-16-0184
 100. Sevier JD, Choi S, Hughes ML. Use of direct-connect for remote speech-perception testing in cochlear implants. *Ear Hear.* 2019;40(5):1162-1173. doi:10.1097/AUD.0000000000000693
 101. Fletcher KT, Dicken FW, Adkins MM, et al. Audiology telemedicine evaluations: potential expanded applications. *Otolaryngol Head Neck Surg.* 2019;161(1):63-66. doi:10.1177/0194599819835541
 102. Crowell ES, Givens GD, Jones GL, Brechtelsbauer PB, Yao J. Audiology telepractice in a clinical environment: a communication perspective. *Ann Otol Rhinol Laryngol.* 2011;120(7):441-447. doi:10.1177/000348941112000704
 103. Yao J, Givens GD, Wan Y. A Web services-based distributed system with browser-client architecture to promote teleaudiology assessment. *Telemed J E Health.* 2009;15(8):777-782. doi:10.1089/tmj.2009.0031
 104. Givens GD, Elangovan S. Internet application to tele-audiology—"nothin' but net." *Am J Audiol.* 2003;12(2):59-65. doi:10.1044/1059-0889(2003/011)
 105. Yao J, Wan Y, Givens GD. Using web services to realize remote hearing assessment. *J Clin Monit Comput.* 2010;24(1):41-50. doi:10.1007/s10877-009-9208-6
 106. Givens GD, Blarovich A, Murphy T, Simmons S, Blach D, Elangovan S. Internet-based tele-audiometry system for the assessment of hearing: a pilot study. *Telemed J E Health.* 2003;9(4):375-378. doi:10.1089/153056203772744707
 107. Yao JJ, Yao D, Givens G. A browser-server-based teleaudiology system that supports multiple hearing test modalities. *Telemed J E Health.* 2015;21(9):697-704. doi:10.1089/tmj.2014.0171
 108. Swanepoel DW, Koekemoer D, Clark J. Intercontinental hearing assessment—a study in tele-audiology. *J Telemed Telecare.* 2010;16(5):248-252. doi:10.1258/jtt.2010.090906
 109. Choi JM, Lee HB, Park CS, Oh SH, Park KS. PC-based teleaudiometry. *Telemed J E Health.* 2007;13(5):501-508. doi:10.1089/tmj.2007.0085
 110. Jacobs PG, Silaski G, Wilmington D, et al. Development and evaluation of a portable audiometer for high-frequency screening of hearing loss from ototoxicity in homes/clinics. *IEEE Trans Biomed Eng.* 2012;59(11):3097-3103. doi:10.1109/TBME.2012.2204881
 111. Whitton JP, Hancock KE, Shannon JM, Polley DB. Validation of a self-administered audiometry application: an equivalence study. *Laryngoscope.* 2016;126(10):2382-2388. doi:10.1002/lary.25988
 112. Margolis RH, Bratt G, Feeney MP, Killion MC, Saly GL. Home hearing test: within-subjects threshold variability. *Ear Hear.* 2018;39(5):906-909. doi:10.1097/AUD.0000000000000551
 113. Masalski M, Kręcicki T. Self-test web-based pure-tone audiometry: validity evaluation and measurement error analysis. *J Med Internet Res.* 2013;15(4):e71. doi:10.2196/jmir.2222
 114. Malandraki GA, McCullough G, He X, McWeeny E, Perlman AL. Teledynamic evaluation of oropharyngeal swallowing. *J Speech Lang Hear Res.* 2011;54(6):1497-1505. doi:10.1044/1092-4388(2011/10-0284)
 115. Morrell K, Hyers M, Stuchiner T, et al. Telehealth stroke dysphagia evaluation is safe and effective. *Cerebrovasc Dis.* 2017;44(3-4):225-231. doi:10.1159/000478107
 116. Kantarcigil C, Sheppard JJ, Gordon AM, Friel KM, Malandraki GA. A telehealth approach to conducting clinical swallowing evaluations in children with cerebral palsy. *Res Dev Disabil.* 2016;55:207-217. doi:10.1016/j.ridd.2016.04.008
 117. Burns CL, Ward EC, Hill AJ, Phillips N, Porter L. Conducting real-time videofluoroscopic swallow study via telepractice: a preliminary feasibility and reliability study. *Dysphagia.* 2016;31(3):473-483. doi:10.1007/s00455-016-9701-2
 118. Akhtar M, Van Heukelom PG, Ahmed A, et al. Telemedicine physical examination utilizing a consumer device demonstrates poor concordance with in-person physical examination in emergency department patients with sore throat: a prospective blinded study. *Telemed J E Health.* 2018;24(10):790-796. doi:10.1089/tmj.2017.0240
 119. Lozada KN, Morton K, Stepan K, Capo J, Chai RL. The clinical impact of bedside fiberoptic laryngoscopic recording on a tertiary consult service. *Laryngoscope.* 2018;128(4):818-822. doi:10.1002/lary.26821
 120. Wu C-J, Wu S-Y, Chen P-C, Lin Y-S. An innovative smartphone-based otorhinoscope and its application in mobile health and teleotolaryngology. *J Med Internet Res.* 2014;16(3):e71. doi:10.2196/jmir.2959
 121. Shah MU, Sohal M, Valdez TA, Grindle CR. iPhone otoscopes: currently available, but reliable for tele-otoscopy in the hands of parents? *Int J Pediatr Otorhinolaryngol.* 2018;106:59-63. doi:10.1016/j.ijporl.2018.01.003
 122. Shah MU, Lotterman S, Roberts D, Eisen M. Smartphone telemedical emergency department consults for screening of nonacute dizziness. *Laryngoscope.* 2019;129(2):466-469. doi:10.1002/lary.27424
 123. Rodríguez C, Ramos A, Falcon JC, Martínez-Beneyto P, Gault A, Boyle P. Use of telemedicine in the remote programming of cochlear implants. *Cochlear Implants Int.* 2010;11(suppl 1):461-464. doi:10.1179/146701010X12671177204624
 124. Biagio L, Swanepoel DW, Adeyemo A, Hall JW 3rd, Vinck B. Asynchronous video-otoscopy with a telehealth facilitator. *Telemed J E Health.* 2013;19(4):252-258. doi:10.1089/tmj.2012.0161

125. Cingi C, Yorgancioglu A, Cingi CC, et al. The “physician on call patient engagement trial” (POPET): measuring the impact of a mobile patient engagement application on health outcomes and quality of life in allergic rhinitis and asthma patients. *Int Forum Allergy Rhinol.* 2015;5(6):487-497. doi:10.1002/alr.21468
126. Pizzulli A, Perna S, Florack J, et al. The impact of telemonitoring on adherence to nasal corticosteroid treatment in children with seasonal allergic rhinoconjunctivitis. *Clin Exp Allergy.* 2014;44(10):1246-1254. doi:10.1111/cea.12386
127. Malandraki GA, Markaki V, Georgopoulos VC, Bauer JL, Kalogeropoulos I, Nanas S. An international pilot study of asynchronous teleconsultation for oropharyngeal dysphagia. *J Telemed Telecare.* 2013;19(2):75-79. doi:10.1177/1357633x12474963
128. Furukawa M, Furukawa MK, Mizojiri G, Matsuda H. Telemedicine in laryngology. *Telemed J.* 1998;4(4):329-333. doi:10.1089/tmj.1.1998.4.329
129. Mayadevi M, Thankappan K, Limbachiya SV, et al. Interdisciplinary telemedicine in the management of dysphagia in head and neck. *Dysphagia.* 2018;33(4):474-480. doi:10.1007/s00455-018-9876-9
130. Kokesh J, Ferguson AS, Patricoski C. Preoperative planning for ear surgery using store-and-forward telemedicine. *Otolaryngol Head Neck Surg.* 2010;143(2):253-257. doi:10.1016/j.otohns.2010.04.265
131. Eze N, Lo S, Bray D, Toma AG. The use of camera mobile phone to assess emergency ENT radiological investigations. *Clin Otolaryngol.* 2005;30(3):230-233. doi:10.1111/j.1365-2273.2005.00982.x
132. Lancaster P, Krumm M, Ribera J, Klich R. Remote hearing screenings via telehealth in a rural elementary school. *Am J Audiol.* 2008;17(2):114-122. doi:10.1044/1059-0889(2008)07-0008)
133. Botasso M, Sanches SGG, Bento RF, Samelli AG. Teleaudiometry as a screening method in school children. *Clinics (Sao Paulo).* 2015;70(4):283-288. doi:10.6061/clinics/2015(04)11
134. Ramkumar V, Hall JW, Nagarajan R, Shankarnarayan VC, Kumaravelu S. Tele-ABR using a satellite connection in a mobile van for newborn hearing testing. *J Telemed Telecare.* 2013;19(5):233-237. doi:10.1177/1357633X13494691
135. Kleinstäuber M, Weise C, Andersson G, Probst T. Personality traits predict and moderate the outcome of Internet-based cognitive behavioural therapy for chronic tinnitus. *Int J Audiol.* 2018;57(7):538-544. doi:10.1080/14992027.2018.1432902
136. Henry JA, Thielman EJ, Zaugg TL, et al. Telephone-based progressive tinnitus management for persons with and without traumatic brain injury: a randomized controlled trial. *Ear Hear.* 2019;40(2):227-242. doi:10.1097/AUD.0000000000000609
137. van Vugt VA, van der Wouden JC, Essery R, et al. Internet based vestibular rehabilitation with and without physiotherapy support for adults aged 50 and older with a chronic vestibular syndrome in general practice: three armed randomised controlled trial. *BMJ.* 2019;367:15922. doi:10.1136/bmj.15922
138. Thorén ES, Öberg M, Andersson G, Lunner T. Internet interventions for hearing loss. *Am J Audiol.* 2015;24(3):316-319. doi:10.1044/2015_AJA-15-0009
139. Havenga E, Swanepoel DW, le Roux T, Schmid B. Tele-intervention for children with hearing loss: a comparative pilot study. *J Telemed Telecare.* 2017;23(1):116-125. doi:10.1177/1357633X15617886
140. Constantinescu G, Waite M, Dornan D, et al. A pilot study of telepractice delivery for teaching listening and spoken language to children with hearing loss. *J Telemed Telecare.* 2014;20(3):135-140. doi:10.1177/1357633X14528443
141. Rangarathnam B, McCullough GH, Pickett H, Zraick RI, Tulunay-Ugur O, McCullough KC. Telepractice versus in-person delivery of voice therapy for primary muscle tension dysphonia. *Am J Speech Lang Pathol.* 2015;24(3):386-399. doi:10.1044/2015_AJSLP-14-0017
142. Mashima PA, Birkmire-Peters DP, Syms MJ, Holtel MR, Burgess LPA, Peters LJ. Telehealth: voice therapy using telecommunications technology. *Am J Speech Lang Pathol.* 2003;12(4):432-439. doi:10.1044/1058-0360(2003)089)
143. Theodoros DG, Hill AJ, Russell TG. Clinical and quality of life outcomes of speech treatment for Parkinson’s disease delivered to the home via telerehabilitation: a noninferiority randomized controlled trial. *Am J Speech Lang Pathol.* 2016;25(2):214-232. doi:10.1044/2015_AJSLP-15-0005
144. Constantinescu G, Theodoros D, Russell T, Ward E, Wilson S, Wootton R. Treating disordered speech and voice in Parkinson’s disease online: a randomized controlled non-inferiority trial. *Int J Lang Commun Disord.* 2011;46(1):1-16. doi:10.3109/13682822.2010.484848
145. Constantinescu G, Theodoros D, Russell T, Ward E, Wilson S, Wootton R. Assessing disordered speech and voice in Parkinson’s disease: a telerehabilitation application. *Int J Lang Commun Disord.* 2010;45(6):630-644. doi:10.3109/13682820903470569
146. Ward EC, Burns CL, Theodoros DG, Russell TG. Impact of dysphagia severity on clinical decision making via telerehabilitation. *Telemed J E Health.* 2014;20(4):296-303. doi:10.1089/tmj.2013.0198
147. Ward EC, Sharma S, Burns C, Theodoros D, Russell T. Validity of conducting clinical dysphagia assessments for patients with normal to mild cognitive impairment via telerehabilitation. *Dysphagia.* 2012;27(4):460-472. doi:10.1007/s00455-011-9390-9
148. Cha D, Shin SH, Kim J, et al. Feasibility of asynchronous and automated telemedicine in otolaryngology: prospective cross-sectional study. *JMIR Med Inform.* 2020;8(10):e23680. doi:10.2196/23680
149. Binol H, Niazi MKK, Essig G, et al. Digital otoscopy videos versus composite images: a reader study to compare the accuracy of ENT physicians. *Laryngoscope.* 2021;131(5):E1668-E1676. doi:10.1002/lary.29253
150. Halpren-Ruder D, Chang AM, Hollander JE, Shah A. Quality assurance in telehealth: adherence to evidence-based indicators. *Telemed J E Health.* 2019;25(7):599-603. doi:10.1089/tmj.2018.0149

151. Ramos A, Rodriguez C, Martinez-Beneyto P, et al. Use of telemedicine in the remote programming of cochlear implants. *Acta Otolaryngol.* 2009;129(5):533-540. doi:10.1080/00016480802294369
152. Xu CQ, Smith AC, Scuffham PA, Wootton R. A cost minimisation analysis of a telepaediatric otolaryngology service. *BMC Health Serv Res.* 2008;8:30. doi:10.1186/1472-6963-8-30
153. Philips R, Seim N, Matrka L, et al. Cost savings associated with an outpatient otolaryngology telemedicine clinic. *Laryngoscope Investig Otolaryngol.* 2019;4(2):234-240. doi:10.1002/lio2.244
154. Wall LR, Kularatna S, Ward EC, et al. Economic analysis of a three-arm RCT exploring the delivery of intensive, prophylactic swallowing therapy to patients with head and neck cancer during (chemo)radiotherapy. *Dysphagia.* 2019;34(5):627-639. doi:10.1007/s00455-018-9960-1
155. Qualliotine JR, Orosco RK. Self-removing passive drain to facilitate postoperative care via telehealth during the COVID-19 pandemic. *Head Neck.* 2020;42(6):1305-1307. doi:10.1002/hed.26203
156. Fieux M, Duret S, Bawazeer N, Denoix L, Zaouche S, Tringali S. Telemedicine for ENT: effect on quality of care during COVID-19 pandemic. *Eur Ann Otorhinolaryngol Head Neck Dis.* 2020;137(4):257-261. doi:10.1016/j.anorl.2020.06.014
157. Jiang W, Magit AE, Carvalho D. Equal access to telemedicine during COVID-19 pandemic: a pediatric otolaryngology perspective. *Laryngoscope.* 2021;131(5):1175-1179. doi:10.1002/lary.29164
158. Kolb CM, Born K, Banker K, Barth PC, Aaronson NL. Improving attendance and patient experiences during the expansion of a telehealth-based pediatric otolaryngology practice. *Otolaryngol Head Neck Surg.* 2021;164(5):952-958. doi:10.1177/0194599820965917
159. Govil N, Raol N, Tey CS, Goudy SL, Alfonso KP. Rapid telemedicine implementation in the context of the COVID-19 pandemic in an academic pediatric otolaryngology practice. *Int J Pediatr Otorhinolaryngol.* 2020;139:110447. doi:10.1016/j.ijporl.2020.110447
160. Darr A, Senior A, Argyriou K, et al. The impact of the coronavirus (COVID-19) pandemic on elective paediatric otolaryngology outpatient services—an analysis of virtual outpatient clinics in a tertiary referral centre using the modified paediatric otolaryngology telemedicine satisfaction survey (POTSS). *Int J Pediatr Otorhinolaryngol.* 2020;138:110383. doi:10.1016/j.ijporl.2020.110383
161. Zammit M, Siau R, Williams C, Hussein A. Patient satisfaction from ENT telephone consultations during the coronavirus disease 2019 pandemic. *J Laryngol Otol.* Published online November 17, 2020. doi:10.1017/S0022215120002480
162. Belcher RH, Phillips J, Virgin F, et al. Pediatric otolaryngology telehealth in response to COVID-19 pandemic: lessons learned and impact on the future management of pediatric patients. *Ann Otol Rhinol Laryngol.* 2021;130(7):788-795. doi:10.1177/0003489420976163
163. Vijayasundaram S, Karthikeyan P, Mehta SD. Proficiency of virtual follow-up amongst tinnitus patients who underwent intratympanic steroid therapy amidst COVID 19 pandemic. *Am J Otolaryngol.* 2020;41(6):102680. doi:10.1016/j.amjoto.2020.102680
164. Svider PF, Setzen M, Ow R, Folbe AJ, Eloy JA, Johnson AP. Incorporation of telemedicine by rhinologists: the COVID-19 pandemic and beyond. *Am J Otolaryngol.* 2020;41(6):102567. doi:10.1016/j.amjoto.2020.102567
165. Ohlstein JF, Garner J, Takashima M. Telemedicine in otolaryngology in the COVID-19 era: initial lessons learned. *Laryngoscope.* 2020;130(11):2568-2573. doi:10.1002/lary.29030
166. Layfield E, Triantafillou V, Prasad A, et al. Telemedicine for head and neck ambulatory visits during COVID-19: evaluating usability and patient satisfaction. *Head Neck.* 2020;42(7):1681-1689. doi:10.1002/hed.26285
167. Jayawardena ADL, Mankarious LA, Keamy DG, Cohen MS. Pediatric, family-centered, “at-home” otologic physical examination in the COVID-19 era. *Otolaryngol Head Neck Surg.* 2020;163(5):1061-1063. doi:10.1177/0194599820934776
168. Kasle DA, Torabi SJ, Savoca EL, Judson BL, Manes RP. Outpatient otolaryngology in the era of COVID-19: a data-driven analysis of practice patterns. *Otolaryngol Head Neck Surg.* 2020;163(1):138-144. doi:10.1177/0194599820928987
169. Snyderman CH, Gardner PA, Lanisnik B, Ravnik J. Surgical telementoring: a new model for surgical training. *Laryngoscope.* 2016;126(6):1334-1338. doi:10.1002/lary.25753
170. Burgess LP, Holtel MR, Syms MJ, Birkmire-Peters DP, Peters LJ, Mashima PA. Overview of telemedicine applications for otolaryngology. *Laryngoscope.* 1999;109(9):1433-1437. doi:10.1097/00005537-199909000-00014
171. Burgess LPA, Syms MJ, Holtel MR, Birkmire-Peters DP, Johnson RE, Ramsey MJ. Telemedicine: teleproctored endoscopic sinus surgery. *Laryngoscope.* 2002;112(2):216-219. doi:10.1097/00005537-200202000-00003
172. Klapan I, Simić L, Risavi R, et al. Tele-3-dimensional computer-assisted functional endoscopic sinus surgery: new dimension in the surgery of the nose and paranasal sinuses. *Otolaryngol Head Neck Surg.* 2002;127(6):549-557. doi:10.1067/mhn.2002.129732
173. Klapan I, Simić L, Pasarić K, et al. Realtime transfer of live video images in parallel with three-dimensional modelling of the surgical field in computer-assisted telesurgery. *J Telemed Telecare.* 2002;8(3):125-130. doi:10.1177/1357633X0200800301
174. Berg BW, Beamis EK, Murray WB, Boedeker BH. Remote videolaryngoscopy skills training for pre-hospital personnel. *Stud Health Technol Inform.* 2009;142:31-33.
175. Prescher H, Grover E, Mosier J, et al. Telepresent intubation supervision is as effective as in-person supervision of procedurally naive operators. *Telemed J E Health.* 2015;21(3):170-175. doi:10.1089/tmj.2014.0090
176. Faulkner J, Taylor E, Nessen S, Boedeker D, Boedeker B. Development of a tele ENT program to support distant military treatment facilities for the European regional medical command. *Stud Health Technol Inform.* 2014;196:101-106.
177. Melo TM de, Alvarenga K de F, Blasca WQ, Taga MF de L. Community health agents training on hearing health: effectiveness of videoconference. *Pro Fono.* 2010;22(2):139-145. doi:10.1590/s0104-56872010000200012