



Contemporary Review

A Review of Telemedicine Applications in Otorhinolaryngology: Considerations During the Coronavirus Disease of 2019 Pandemic

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Objective/Hypothesis: Review the published literature of telemedicine's use within otorhinolaryngology (ORL), highlight its successful implementation, and document areas with need of future research.

Study Design: State of the Art Review.

Methods: Three independent, comprehensive searches for articles published on the subject of telemedicine in ORL were conducted of literature available from January 2000 to April 2020. Search terms were designed to identify studies which examined telemedicine use within ORL. Consensus among authors was used to include all relevant articles.

Results: While several, small reports document clinical outcomes, patient satisfaction, and the cost of telemedicine, much of the literature on telemedicine in ORL is comprised of preliminary, proof-of-concept reports. Further research will be necessary to establish its strengths and limitations.

Conclusions: Particularly during the coronavirus disease of 2019 pandemic, telemedicine can, and should, be used within ORL practice. This review can assist in guiding providers in implementing telemedicine that has been demonstrated to be successful, and direct future research.

Key Words: coronavirus disease of 2019, telehealth, telemedicine, review, otorhinolaryngology.

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INTRODUCTION

Telemedicine has enabled providers to care for patients in increasingly efficient, effective, and cost-saving manners.^{1,2} Many specialties have taken advantage of these technologies, primarily in triaging new patients and for follow-up of postoperative patients.^{3–10} While the utilization of telemedicine has gradually increased over the past decades in the United States,¹¹ the 2019 novel coronavirus (coronavirus disease of 2019 [COVID-19]) pandemic has thrust both its necessity and implementation into the forefront of medical practice. Similar to other medical fields, otorhinolaryngology (ORL) is experiencing challenges in attempting to maximize continued quality patient care, while minimizing risk to patients and providers.^{12,13}

ORL presents unique barriers to telemedicine implementation due to pervasive necessity of in-person examination techniques and procedures.¹⁴ The objective of this review is to document the manners in which telemedicine

has already been implemented across the various subspecialties of ORL as a guide for current practitioners, highlight limitations of telemedicine, and elucidate areas in need of further study.

MATERIALS AND METHODS

Three independent searches of Scopus, PubMed, Google Scholar, and Google for articles published on the subject of telemedicine in ORL were conducted from January 2000 to April 2020 (Fig. 1). Search terms were designed to identify studies which examined telemedicine use within ORL (Appendix S1). A total of 219 unique articles were found. Articles were sorted according to the following categories: head and neck oncology, otology/neurotology, laryngology, rhinology, facial plastic and reconstructive surgery, and pediatrics, and selected based on relevance. Case reports, and articles with a focus outside ORL were excluded. A qualitative literature review was summarized (Table I). Implications for practice and potential opportunities for additional investigation were discussed and established among all authors.

RESULTS

Head and Neck Oncology

Findings. Compared to the other ORL subspecialties, head and neck surgical oncology has demonstrated relatively wide adoption of telemedicine (Table II). A study conducted by Dorrian et al. concluded that initial assessment by telemedicine lowered

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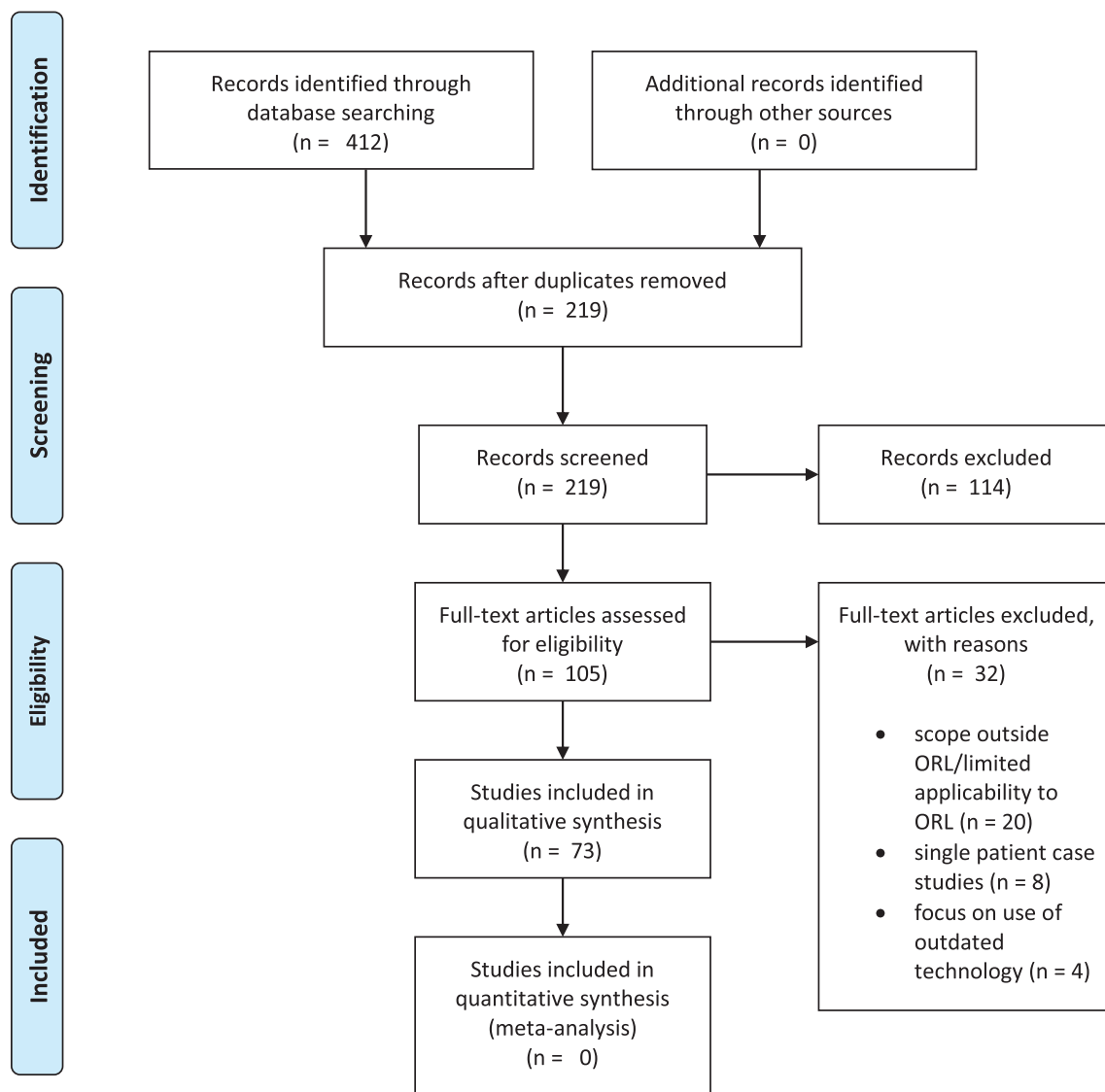


Fig 1. Inclusion and exclusion criteria flow diagram [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

equipment costs for providers, travel costs for patients, and unnecessary transfers to specialist centers, without compromising diagnostic accuracy or patient satisfaction.¹⁷ Within the Veterans Affairs (VA) system, Beswick et al. demonstrated the safe use of a telemedicine protocol for preoperative visits in patients with high-grade head and neck malignancies.¹⁸ Kohlert et al. found that head and neck surgical oncology cases accounted for 48.6% of all ORL consults to a regional electronic consulting service.¹⁹

Head and neck cancer care plans are often developed in a multi-disciplinary tumor board that includes otolaryngologists, pathologists, radiologists, medical and radiation oncologists. Several studies note that a combination of real-time videoconferencing, and safely shared laboratory, imaging, and pathology data facilitate tumor board workflow, streamlining cooperation between colleagues.^{20–22}

Lastly, telemedicine has proven effective in easing provider demands in the postoperative setting. Rimmer et al. reported that, in appropriately selected patients, telemedicine postoperative visits were safe, time-saving, and satisfactory to patients.²¹ Recent studies on remote free flap monitoring provide clear examples of how telemedicine can not only expedite care, but also improve patient outcomes.²³ Similarly, Hwang and Mun found that sharing of digital photographs of flaps between providers facilitated better communication within the care team, earlier detection of flap compromise, and ultimately increased overall flap survival.²⁴

Recommendations for practice. We strongly recommend that telemedicine be utilized to expedite workup of new tumors, especially when there is concern for high-grade/aggressive pathology. This can be accomplished through streamlining referral systems, obtaining imaging based on electronic consultation, and hosting multi-

disciplinary discussions on audio/visual platforms. Furthermore, we recommend that telemedicine be strongly considered in postoperative head and neck surgery visits when feasible. Successful use of remote free flap monitoring suggests there is also a role for inpatient head and neck telemedicine implementation (Table I). There is a further need for controlled studies comparing telemedicine to in-person assessment of head and neck cancer patients in terms of cost, safety, surveillance adherence, and oncologic outcomes.

Otology and Neurotology

Findings. The field of otology/neurotology demonstrated early adaptation of telemedicine, driven by a high patient volume and lack of specialist centers, particularly in rural settings. Advances in recorded otoscopy have bolstered promise in remote evaluation, but given the degree of specialized training and equipment required, concerns exist regarding the accuracy and safety of these technologies (Table III).

In a landmark study, Kokesh et al. described a “store-and-forward model (SAF),” wherein audiologists and advanced practice providers obtain patient histories and otologic examinations and forward these to otolaryngologists.^{25–27} Compared to in-person visits, SAF evaluations demonstrated decreased wait times and reduced patient travel costs.

Recent technological advances have allowed for the recording and storage of otoscopic examinations, allowing for SAF neurotology consults, with high level of accordance with in-person diagnoses.^{16,28–33} With a focus on otitis media, Biagio et al. used video-otoscopy recordings in children recorded by facilitators with limited training.¹⁶ The quality of the video-otoscopy recordings was noted to be acceptable or better in 87% of cases. In a study by Erkkola-Antinen et al., parents of pediatric patients were trained to use otoscopes attached to smartphones for diagnosis of acute otitis media, though videos of sufficient technical quality were only obtained in 67% of cases.³⁴ The primary concerns regarding video-otoscopy are poor image quality and examination reliability. Subtle findings such as mild retraction pocket, atelectasis, pinhole perforation, or small cholesteatoma may not be apparent on low-quality images.³⁴ Other limitations include access to at-home equipment, such as otoscopes, specula, and image-capturing devices, as well as high-speed internet needed to transmit high-resolution images.^{34–36}

Telehealth has been applied to tinnitus rehabilitation, cochlear implant fitting, programming, and maintenance, as well as hearing aid assessment and programming.^{37,38} A VA study of tinnitus management utilizing a skills education program delivered via telephone showed far greater improvement in symptom management than the wait-list group.³⁹ Luryi et al. examined the role of telemedicine in cochlear implant programming of VA patients, and concluded that cochlear implant threshold, comfort, and impedance levels were readily obtained via telehealth and did not differ significantly to in-person sessions.¹⁵ When assessing the feasibility of remote evaluation of cochlear implant candidacy, Fletcher

et al. reported comparable testing results across remote and in-person conditions in a within-subject control study.⁴⁰

Despite the demonstrated applicability of telemedicine to neurotology, there is documented needs for improvement. Several studies note that a reliable standardized grading scale or diagnostic guide could be of significance in remote evaluation of otitis media to ensure more uniform, standardized assessments.^{31,41}

Recommendations for practice. We recommend that telemedicine be used for the diagnosis, workup, and management of otologic pathologies in select circumstances (Table I). The feasibility of remote evaluation and programming of both hearing aids and cochlear implants have been demonstrated and may be particularly useful in rural areas with limited access to care. Auditory rehabilitation following cochlear implantation is another promising application for remote health, yet does not come without risks (Table I). Further research assessing the use of telemedicine in diagnosing and triaging inner ear pathologies, otologic/neurotologic tumors, and other common pathologies is warranted.

Laryngology

Findings. To assess the feasibility of remote vocal rehabilitation, Mashima et al. compared treatment outcomes between patients seen in person or by video teleconference.⁴² The authors reported no differences in outcomes between the groups, supporting noninferior use of telemedicine in vocal rehabilitation. Doarn et al. developed an online portal to provide home practice support for children between weekly voice therapy sessions.⁴³ In addition to facilitating increased communication with clinicians, the study documented an increase in patient adherence to therapy recommendations.

While telemedicine has been successfully applied to vocal rehabilitation, it faces challenges in diagnosis of laryngeal pathologies the examination of which requires technical skill and experience (Table IV). Given the significant challenges of transmission risk and limited PPE in the COVID-19 pandemic, alteration of typical methods of voice and swallowing triage, evaluation, and management must be considered. To address this, Ku et al. published clinical practice guidelines for the management of dysphagia in the COVID-19 pandemic, suggesting use of telemedicine for triage and remote evaluation.⁴⁴

For remote voice and swallowing disorder diagnosis, one strategy is the use of non-image-based tools like voice recordings, as described by Wormald et al.⁴⁵ Using an automated speech analysis system, the authors demonstrated 92% sensitivity and 75% specificity for detecting vocal fold paralysis. With regards to other laryngeal pathology, computed tomography (CT) scans and ultrasonography have the benefit of being noninvasive and amenable to store-and-forward telemedicine although such may miss early, small glottic cancers and subtle laryngeal lesions.^{46–50}

Bryson et al. detailed recommendations for remote laryngoscopy evaluation, including use of stroboscopy, archiving capability, and internet connection. However, a

Table I.
Summary of Telemedicine Best Practices by Sub-Specialty.

Discipline	Scope of telemedicine use	Benefits	Limitations	Recommendations for practice	Areas for future research
H&N Oncology	<ul style="list-style-type: none"> Majority for postsurgical follow-up, also preoperative planning Assessment for potential malignancy: video evaluation of oral/mucosal lesions and thyroid nodules or goiters Remote free flap assessment 	<ul style="list-style-type: none"> Cost effective Reduced travel and wait times for pre/postoperative visits yields high patient satisfaction For free flap assessments, reduced travel time and time spent on assessment increases provider satisfaction For inpatient care, can improve communication between members of the care team 	<ul style="list-style-type: none"> Proper evaluation of potential malignancy may require an in-person examination; medicolegal implications Evaluations of free flap requires an in-person assistant; Doppler ultrasound 	<ul style="list-style-type: none"> For clinical visits, use telemedicine for postoperative follow-up and to expedite workup of patients with high grade and/or stage malignancies Telemedicine should facilitate collaboration between staff members, and be used in conjunction with nursing for free flap assessments. Secure sharing of digital photographs between members of the care team 	<ul style="list-style-type: none"> Development of standardized clinical practice guidelines in evaluation of malignancy Controlled studies examining the outcomes of H&N patients evaluated with telemedical methods compared to conventional in-person examination, in terms of cost, safety, surveillance adherence, and oncologic outcomes
Otology/ Neurotology	<ul style="list-style-type: none"> Video-otoscopy for diagnosis or evaluation of general ear complaints, otitis media, posttympanostomy tube placement Smartphone otoscopy; used by primary care providers and parents of pediatric patients Auditory rehabilitation: cochlear implant fitting, programming, and maintenance, as well as hearing aid programming and remote gain assessments 	<ul style="list-style-type: none"> Improved access to care in underserved or rural areas Store-and-forward telemedicine is as effective as in-person evaluation for planning elective ear surgeries such as tympanoplasty and mastoidectomy 	<ul style="list-style-type: none"> Successful implementation of video-otoscopy requires equipment and training: common problems include failure to image the tympanic membrane, and inadequate removal of cerumen Concerns about patient safety in remote cochlear implant programming 	<ul style="list-style-type: none"> Every effort should be made to maximize image quality in video-otoscopy Use of reliable standardized grading scales for diagnosis based on remotely acquired images Remote users of video-otoscopes must be trained to select the correct size speculum, remove cerumen, and identify the tympanic membrane Remote cochlear implant programming must allow for allow termination of stimulation and reversal of any changes in the case of disruption of the internet connection, and an audio-video link between provider and patient must be maintained¹⁵ 	<ul style="list-style-type: none"> Smartphone tele-otoscopy Reimbursement and cost-effectiveness Development of formal diagnostic and management algorithms and guidelines, Development of training guidelines for remote otoscopy, which may include patient positioning, visual inspection of the external ear, appropriate hand position, manipulation of direction of speculum, focus adjustment, recording capture, video-otoscope software use, and equipment cleaning¹⁶
Laryngology	<ul style="list-style-type: none"> Remote laryngoscopy and stroboscopy; examination of lesions Detection of vocal fold paralysis with remote automated analysis Vocal rehabilitation Videoconference Online portal for supported home practice 	<ul style="list-style-type: none"> May facilitate serial imaging of laryngeal carcinoma Vocal rehabilitation: increased communication with clinician and increased compliance with therapy recommendations Avoiding endoscopic examination may reduce disease transmission in the time of COVID-19 	<ul style="list-style-type: none"> Devices required to obtain high-quality imaging are expensive and difficult to obtain; must be operated by trained personnel Examining dynamic functioning of larynx requires videoconferencing with high bandwidth 	<ul style="list-style-type: none"> Use of reliable standardized grading scales for diagnosis based on remotely acquired images Maximizing bandwidth and reliability of internet connection for videoconferencing Maintain regular follow-up with patients for remote vocal rehabilitation 	<ul style="list-style-type: none"> Use of telemedicine for swallowing disorders Reimbursement and cost-effectiveness Use of machine learning to automate detection of vocal pathologies Effectiveness of CT scans as a substitute to nasal endoscopy to facilitate telehealth consultations Development of formal diagnostic and management algorithms and guidelines
Rhinology	<ul style="list-style-type: none"> Remote intranasal imaging or CT sinus imaging History taking; triage of patients who require nasal endoscopy Epistaxis patients 	<ul style="list-style-type: none"> Avoiding intranasal endoscopic examination may reduce disease transmission in the time of COVID-19 	<ul style="list-style-type: none"> Devices required to obtain high-quality intra-nasal imaging are expensive and difficult to obtain Not all cases of epistaxis can be 	<ul style="list-style-type: none"> Forgoing nasal endoscopy for other imaging procedures more medicolegal to telemedicine such as CT has medicolegal implications. 	<ul style="list-style-type: none"> Effectiveness of CT scans as a substitute to nasal endoscopy to facilitate telehealth consultations Development of formal diagnostic and management

(Continues)

Table I.
Continued

Discipline	Scope of telemedicine use	Benefits	Limitations	Recommendations for practice	Areas for future research
Facial Plastics and Reconstructive Surgery	<ul style="list-style-type: none"> Image-based triaging and evaluation of facial trauma, lesions, or deformities Telemedical consultation for facial trauma 	<ul style="list-style-type: none"> Image-based diagnosis is amenable to store-and forward technology Video or image based communication between patient and provider facilitates closer postoperative follow-up and wound care, leading to higher patient satisfaction 	<ul style="list-style-type: none"> Standardized facial images may be difficult to obtain 	<ul style="list-style-type: none"> Clinical guidelines should carefully consider patient history and risk factors for complications. Frequent communication with patients in the postoperative period. Review of images prior to virtual visits may improve patient satisfaction 	<ul style="list-style-type: none"> Development of standardized clinical practice guidelines in evaluation of facial trauma Controlled studies examining the outcomes of facial trauma patients evaluated with telemedical methods, compared to conventional in-person examination
Pediatric ORL	<ul style="list-style-type: none"> Triaging and evaluation of common pediatric ORL problems (e.g. otitis media) Postoperative follow-up of common pediatric ORL procedures, such as tonsillectomies and adenoidectomies 	<ul style="list-style-type: none"> Improved access to care in underserved or rural areas Improved communication with parents Telemedicine specialty consults in the emergency setting may improve outcomes 	<ul style="list-style-type: none"> Limited validation and outcomes research 	<ul style="list-style-type: none"> Frequent communication with patients and parents in the pre- and postoperative periods 	<ul style="list-style-type: none"> Prospective outcomes studies are required to validate concordance of diagnosis and patient safety. Limited research on reimbursement and cost-effectiveness

proxy practitioner capable of performing the procedure would be necessary, such as a speech and language pathologist or primary care provider. As in otology, any remote diagnostic modalities must prioritize high-quality imaging to meet standards of care.⁵¹

Recommendations for practice. We strongly recommend that telemedicine be applied to voice therapy, as it has been shown to meet standards of care with increased provider and patient satisfaction. Machine learning-driven detection of vocal pathologies has also shown to be effective, and further studies examining this diagnostic modality are warranted. There has been early investigation into fiberoptic laryngoscopy with remote analysis by otolaryngologists, but this practice has not been well-established and faces barriers to implementation. Imaging is an option to supplement and, at times, replace in-person laryngoscopy, but further research is needed to demonstrate its reliability.

Rhinology

Findings. Similar to laryngoscopy, nasal endoscopy is considered high risk for exposure to COVID-19.⁵² Furthermore, anesthetic sprays have aerosolizing potential, which increases risk of transmission not just to the direct provider but to adjacent personnel. Due to the clinical needs and risks of nasal endoscopy, investigating alternatives to this procedure is of significant interest (Table V). CT sinus imaging can be used as an alternative to endoscopy.⁵³ A number of studies have revealed high diagnostic concordance between nasal endoscopy and CT in the

evaluation of sinus disorders.^{53,54} An obvious benefit is that any diagnostic imaging is especially amenable to remote evaluation. Another alternative is remote intranasal imaging, with setups similar to those described for video-otoscopy or laryngoscopy. A small number of studies have described systems for remotely performed nasal endoscopy with digital recording and SAF transmission, including use of smartphone-compatible systems, though this has similar limitations to neurotology and laryngology with regards to implementing remote procedures.^{55,56}

Epistaxis is another common rhinologic referral and may be amenable to remote evaluation.^{52,57} Telemedicine can help identify triggers, risk factors, and manage mild bleeding in low-acuity patients. Red flags in the patient history or failure to control bleeding with conservative measures should prompt in-person evaluation.⁵²

Specifically regarding follow-up care in rhinology, Khanwalkar et al. used mobile technology to track postoperative outcomes following septoplasty and functional endoscopic sinus surgery.⁵⁸ Mobile technology has also been successfully used in the management of allergic rhinitis.⁵⁹

Recommendations for practice. Telemedicine has demonstrated applicability in rhinology, and we recommend that it be used for follow-up in the management of allergic rhinitis (AR). Further study is needed in remote management of nonallergic rhinosinusitis. While there is a need to limit intranasal endoscopy in the time of COVID-19, sole use of CT imaging for diagnosis is a deviation from standards of care and may have medicolegal implications. Further research is needed to establish the

Table II.
Summary of Articles in Qualitative Review for Head and Neck Oncology.

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Alemi (2017)	Head and Neck Oncology	3	United States	Observational two-site study with retrospective review	60	Total time spent performing flap assessment, travel time, ratings of perceived quality of flap assessment by house staff	House staff unanimously reported that the remote methodology reduced the total time spent on the assessments as well as travel time, without compromising the perceived quality of the flap assessment	Communication between clinicians; Equivalency of diagnosis or outcomes
Beswick (2016)	Head and Neck Oncology	3	United States	Retrospective chart review and feasibility study	15	Time from referral to initial consultation and surgery, travel costs and time, carbon dioxide emissions	Reduced time to surgery for patients with high grade malignancies; reduced patient travel times and costs	Patient satisfaction
Dorrian (2009)	Head and Neck Oncology	4	United Kingdom	Case series, and feasibility study with cost analysis	42	Travel costs and time, carbon dioxide emissions	Preliminary cost analysis showed tele-ENT became cheaper than travel at a threshold of 35 patients/year	Feasibility; Decreased costs
Hwang (2012)	Head and Neck Oncology	3	South Korea	Retrospective chart review with matched controls	123	Patient demographics, operative details, flap complications, overall survival	Sharing of digital photographs of flaps between providers facilitated better communication within the care team with earlier detection of flap compromise and ultimately increased overall flap survival	Communication between clinicians; Improved patient outcomes
Kohlert (2017)	Head and Neck Oncology	2	United States	Prospective regional observational study	109	Response time, time of consult, number of referrals, perceived value of service by PCPs	Head and neck oncology cases accounted for 48.6% of all ORL consults to a regional electronic consulting service, with the most frequent pathologies assessed being oral/mucosal lesions and thyroid nodules or goiters	Applicability of telemedicine
Lopez (2009)	Head and Neck Oncology	4	United States	Prospective single-institution quality assurance study	154	Diagnostic concurrence, physician satisfaction ratings	Virtual slide telepathology resulted in complete concurrence with the primary diagnosis in 139 (90.3%) of cases	Applicability of telemedicine; Equivalency of diagnosis or outcomes
Rimmer (2018)	Head and Neck Oncology	3	United States	Retrospective chart review	250	Patient demographics, visit type, wait time, travel distance, travel time, patient survey responses	The majority of visits were postoperative encounters. 95% of patients reported they were satisfied with their visit. Commute times decreased by an estimated 78 minutes	Improved access to care; Patient satisfaction

(Continues)

Table II.
Continued

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Weinstein (2007)	Head and Neck Oncology	4	United States	Retrospective case series and feasibility study	171	Physician satisfaction ratings, patient satisfaction ratings	Use of telepathology and teleradiology has facilitated virtual tumor boards	Applicability of telemedicine; Communication between clinicians; Patient satisfaction

efficacy of CT as a substitute to nasal endoscopy. Development of guidelines for triage and remote evaluation of potentially emergent conditions such as epistaxis and invasive processes is also needed.

Facial Plastic and Reconstructive Surgery

Findings. Telemedicine is readily applicable to many aspects of facial plastic and reconstructive surgery (Table VI). Evaluation of facial soft tissue relationships and defects is already heavily based on digital photographic documentation and analysis.^{60,61} As such, assessment of facial trauma may be particularly amenable to remote assessment. Fonseca et al. reported high concordance between in-person evaluations of facial trauma patients and evaluations carried out through smartphone videoconferencing with review of CT imaging.⁶² A remote approach for triage can avoid unnecessary transfers for patients that do not require urgent intervention, and possibly reduce length of hospitalization.

Frequent video or image-based communication between patient and provider may improve patient satisfaction by facilitating closer postoperative follow-up and wound care. After telemedicine was utilized by a VA Plastic Surgery Department for assessment of nonurgent pathologies like skin lesions and wound care, 83% of patients reported that they would prefer telemedicine over traditional evaluation for similar future visits.⁶³ High levels of patient satisfaction were also achieved with smartphone-based follow-up of facial cosmetic surgery and reviewing images remotely.^{64,65} These reports of improved patient experience likely stem from improved perception of communication.

Limitations for telemedicine implementation in facial plastic surgery include the ability to obtain and transmit appropriately oriented, high-quality images for facial analysis, as well as the barriers to patient–surgeon relationship which, while affected in all sub-specialties, are particularly important in this arena.⁶¹

Recommendations for practice. We recommend that telemedicine be used in certain niches within facial plastic and reconstructive surgery such as facial trauma and wound management. While facial analysis can be achieved remotely, questions remain on how to

readily obtain high-resolution photos with properly lighting and orientation. Areas of needed study include viability of remote facial soft tissue image capture and feasibility of remote surgical planning for cosmetic surgery.

Pediatric ORL

Findings. Many disorders in pediatric ORL overlap with adults, and the application of telemedicine to pediatric ORL complaints, such as otitis media, has been described in the previous sections. Telemedicine has a wide applicability in pediatric ORL for obtaining patient history and assessing need for common surgeries such as obstructive sleep apnea, recurrent tonsillitis, and recurrent otitis media (Table VII).^{66,67} Telemedicine has also been used for postoperative follow-up of common pediatric ORL procedures, such as tonsillectomy and adenoidectomy.⁶⁸ For general pediatric care in the outpatient setting, telemedicine may improve communication with parents.⁶⁹

Telemedicine has also been used to evaluate and manage pediatric acute tympanostomy tube otorrhea. Shaffer and Dohar reported that 83% of patients were diagnosed and treated without emergency room or office assessment, with no adverse outcomes recorded.⁷⁰

Recommendations for practice. We recommend that telemedicine be used when feasible to enhance communication and access between parents and providers in pediatric ORL, and to streamline referrals and work-up prior to in-patient consultation. Further study is required to identify and describe most impactful applications. Common pediatric emergencies like aerodigestive foreign bodies and postoperative complications like post-tonsillectomy hemorrhage, however, will continue to require urgent in-person evaluation.

DISCUSSION

In the era of COVID-19, minimizing virus transmission has become a critical part of patient care, propelling telemedicine into the forefront of the healthcare conversation. To help meet the urgent need for telehealth implementation, federal agencies have increased coverage and suspended barriers to telehealth utilization.^{71–73} A general limitation of telemedicine is that patients in rural or

Table III.
Summary of Articles in Qualitative Review for Otology/Neurotology.

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/ sample size	Outcome measured	Key findings	Common themes
Arriaga (2010)	Otology/ Neurotology	4	United States	Retrospective case series and feasibility study	450	Breakdown of procedures and diagnoses performed, patient satisfaction ratings	A telemedicine-assisted neurotology clinic was successfully implemented in post-Hurricane Katrina Louisiana. Patient satisfaction was equivalent between on-site and telemedicine evaluations	Improved access to care; Feasibility; Patient satisfaction
Biagio (2014)	Otology/ Neurotology	4	South Africa	Prospective case series	140	Patient demographics, independent ratings of video-otoscopy quality, patient outcomes	Substantial agreement between diagnoses made from video-otoscopy recordings and those from onsite evaluations. Quality of the video-otoscopy recordings rated as acceptable or better in 87% of cases.	Improved access to care; Equivalency of diagnosis or outcomes; Importance of image or video quality
Bush (2016)	Otology/ Neurotology	2	United States	Systematic review	12	Type of service offered, assessment of electrode-specific measures and speech recognition, remote gain assessments, patient satisfaction ratings	Auditory rehabilitation services with hearing aids and cochlear implants may be offered via telemedicine. A significant concern is internet bandwidth limitations of remote clinics	Applicability of telemedicine
Erkkola-Anttinen (2018)	Otology/ Neurotology	1	Finland	Prospective, randomized control trial	699	Diagnostic quality of tympanic membrane measured with a structured video analysis independently by three physicians, parent's experience questionnaire, comparing teaching schedules for smartphone otoscopy performed by parents	After instruction, parents were able to perform smartphone otoscopy, however videos of sufficient technical quality for diagnosis were only obtained in 67% of cases	Equivalency or diagnosis or outcomes; Importance of image or video quality
Fletcher (2019)	Otology/ Neurotology	2	United States	Prospective comparative within-subject control study.	13	Routine audiometry, word recognition testing, AzBio and CNC testing	Cochlear implant evaluation testing results were comparable across remote and in-person conditions	Equivalency of diagnosis or outcomes
Gupta (2017)	Otology/ Neurotology	4	India	Case series, feasibility study	3000	Practice patterns, type of service offered, practice costs	Remote screening of otologic pathologies by trained technicians with a telemedicine device is feasible and cost-effective in a rural area	Feasibility
Henry (2017)	Otology/ Neurotology	1	United States	Prospective randomized control trial	300	Tinnitus Functional Index scores, to measure effectiveness of coping skills education provided with progressive	The group which underwent a telephone-based skills education program showed far greater improvement in	Patient satisfaction; Applicability of telemedicine

(Continues)

Table III.
Continued

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/ sample size	Outcome measured	Key findings	Common themes
Hofstetter (2010)	Otology/ Neurotology	3	United States	16-year retrospective analysis	3000	tinnitus management Time in months to obtain in-person appointment after initial consultation, before and after implementation of telemedicine	symptoms management than the in-person wait-list group Average wait time for an in-person appointment dropped dramatically after store-and-forward telemedicine was incorporated into practice	Patient satisfaction
Kokesh (2008)	Otology/ Neurotology	4	United States	Case series, prospective study	70	Intraprovider comparative concordance ratings, interprovider diagnostic concordance	Video-otoscopy images of the tympanic membrane are comparable to an in-person examination for assessment and treatment of patients following tympanostomy tubes.	Equivalency of diagnosis or outcomes
Kokesh (2009)	Otology/ Neurotology	3	United States	Retrospective chart review	1458	Number and type of encounters, referrals patterns, travel costs	Travel costs and burdens to the patient were significantly reduced in a store-and-forward model where an audiologist communicates with an otolaryngologist	Feasibility; Decreased costs
Kokesh (2010)	Otology/ Neurotology	3	United States	Case series with retrospective chart review	90	Recommended surgery from telemedicine and in-person evaluation, estimated operative time	SAF telemedicine is as effective as in-person evaluation for planning elective ear surgery	Equivalency of diagnosis or outcomes
Kokesh (2011)	Otology/ Neurotology	2	United States	Retrospective observational study	9559	Technical requirements, clinical outcomes, patient costs and travel times	Similar clinical outcomes, and improved patient wait times and travel costs compared to in-person specialty visits, for store-and-forward electronic consultations made to the Alaska Federal Health Care Access Network (AFHCAN)	Equivalency of diagnosis or outcomes; Patient satisfaction; Improved access to care.
Krumm (2011)	Otology/ Neurotology	5	United States	Expert opinion and literature review	NA	Applications of teleaudiology as demonstrated in the literature	In otology, telehealth has historically been applied to tinnitus rehabilitation, and treatments involving cochlear implants and hearing aids	Applicability of telemedicine; Feasibility
Lundberg (2014)	Otology/ Neurotology	2	South Africa, Sweden	Prospective observational study with matched controls	180	Concordance between onsite otomicroscopy and asynchronous assessments of video-otoscopy recordings, calculated with intra- and inter-rater agreements	The OMGRADE scale (image-based grading scale for otitis media) accurately assesses for otitis media using video-otoscopy recordings	Feasibility; Equivalency of diagnosis or outcomes

(Continues)

Table III.
Continued

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Luryi (2019)	Otology/ Neurotology	3	United States	Retrospective single-site study	20	AzBio scores, impedances, comfort and threshold levels, survey responses.	Threshold, comfort, and impedance levels not significantly different between telehealth and live sessions; high degree of patient satisfaction	Communication between clinicians; Equivalency of diagnosis or outcomes; Importance of image or video quality; Patient satisfaction
Mandavia (2018)	Otology/ Neurotology	4	Nepal, United Kingdom	Cross-sectional study; feasibility study	56	Concordance in primary diagnosis and decision to refer, determine through inter-rater agreements	Development of a mobile video-otoscopy device shows promise for use by trained nonmedical workers to screen for ear disease in remote settings	Improved access to care; Feasibility; Communication between providers
McCool (2018)	Otology/ Neurotology	3	United States	Retrospective chart review	1385	telemedicine eligibility based on prespecified criteria, travel time	62% of otolaryngology encounters in a VA hospital would likely be eligible for telemedicine. Patients with inner and middle ear problems were more likely eligible for telemedicine	Applicability of telemedicine; Patient satisfaction
Moberly (2017)	Otology/ Neurotology	4	United States	Case series, prospective study	210	Diagnosis of digital otoscope eardrum images by 12 neurotologists, percentage correct compared to gold standard of diagnosis, level of confidence in diagnosis reported by reviewers	Digital otoscope images provided sufficient information for neurotologists to make correct diagnoses for some pathologies while others were more difficult to diagnose based on a still image	Equivalency of diagnosis or outcomes; Importance of image or video quality
Moshtaghi (2017)	Otology/ Neurotology	4	United States	Prospective blinded observational study	57	Diagnostic concordance with classification of TM by blinded neurotologist, patient satisfaction ratings	Diagnosis made using smartphone otoscopy resulted in a concordant diagnosis 96% of the time; high degree of patient satisfaction	Equivalency of diagnosis or outcomes; Importance of image or video quality
Shah (2018)	Otology/ Neurotology	4	United States	Case series, prospective study	80	Interrater reliability between video diagnosis and original diagnosis on pneumatic otoscopy	iPhone otoscopy provides reliable images when used by otolaryngologists but images obtained by parents are not suitable for use in diagnosis	Equivalency of diagnosis or outcomes; Importance of image or video quality

medically underserved regions lack access to requisite technology. In 2018, 26.3% of Medicare beneficiaries lacked digital access at home.⁷⁴ In the Coronavirus Preparedness and Response Supplemental Appropriations Act, the Centers for Medicare and Medicaid Services are now allowing nonrural Medicare patients to utilize telehealth services from home.⁷¹ The Office of Civil Rights of the Department of Health and Human Services (HHS) has suspended certain Health

Insurance Portability and Accountability Act requirements broadening the technological applications that may be used to implement telehealth communications with patients during the COVID-19 pandemic.⁷² Furthermore, the Office of Inspector General of the HHS has waived telehealth co-payments for Medicare patients.⁷³

While many states have temporarily relaxed licensure requirements to allow physicians to provide

Table IV.
Summary of Articles in Qualitative Review for Laryngology.

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Bloom (1998)	Laryngology	3	Canada	Retrospective chart review	77	CT findings, pathologic analysis, and endoscopic data	CT is valuable in the assessment of laryngeal cancer, but performs more poorly in staging advanced laryngeal cancer and predicting clinical outcomes following radiotherapy	Potential alternative to invasive procedure
Bryson (2018)	Laryngology	5	United States	Case report and expert opinion	2	Speed of audiovisual transmission, time delay	Two patients were successfully evaluated remotely with real-time interaction	Feasibility; Communication between clinicians
Doarn (2019)	Laryngology	4	United States	Case series	10	Utilization of the web portal by participants, time spent practicing exercises, responses to parental questionnaire	Successfully designed and implemented an online portal to provide supported home practice for children between weekly voice therapy sessions, found an increase in patient adherence to therapy recommendations	Applicability of telemedicine; Communication between patient and physician; Patient satisfaction
Ferri (1999)	Laryngology	3	Italy	Retrospective chart review	187	CT findings, pathologic analysis, and endoscopic data, staging accuracy	Both laryngoscopy and CT have a role in diagnosis and staging of laryngeal cancer	Potential alternative to invasive procedure
Ku (2020)	Laryngology	5	United States	Expert opinion and literature review	NA	Practical workflow for managing dysphagia during the COVID-19 pandemic	Provides clinical practice guidelines to balance risks of SARS-CoV-2 exposure with the risks associated with dysphagia	Applicability of telemedicine
Mashima (2003)	Laryngology	2	United States	Prospective observational study	72	Perceptual judgments of voice quality, acoustic analyses of voice, patient satisfaction ratings, and fiber-optic laryngoscopy	No differences in outcome measures between the conventional group and the remote video teleconference group	Equivalency of diagnosis or outcomes; importance of image or video quality
Nasr (2013)	Laryngology	2	Egypt	Comparative cross-sectional study	68	Detection rate of vocal cord nodules, polyps, and cysts from laryngeal ultrasound compared to CT scan	Laryngeal ultrasound performed comparably to CT scan for detection of all pathologies studied	Equivalency of diagnosis or outcomes; Potential alternative to invasive procedure
Tsui (2012)	Laryngology	5	China	Current review	NA	Reviews recent clinical applications of ultrasound imaging in laryngeal examinations	Combining functional ultrasound imaging with Doppler imaging may be used to evaluate laryngeal tissues	Potential alternative to invasive procedure
Wormald (2008)	Laryngology	4	Ireland	Prospective blinded single-site study	78	Presence or absence of a vocal fold paralysis as determined by an automated classifier	The automated speech analysis system demonstrated 92% sensitivity and 75% specificity for detecting vocal fold paralysis	Equivalency of diagnosis or outcomes; Potential alternative to invasive procedure
Xia (2013)	Laryngology	4	China	Case series	72	Detection rate of ultrasonography compared to CT and laryngoscopy	Ultrasonography may be used as a valuable supplementary imaging method to CT and laryngoscopy in the assessment of laryngeal carcinoma	Potential alternative to invasive procedure

Table V.
Summary of Articles in Qualitative Review for Rhinology.

Author (year)	Level of Discipline evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Bousquet (2019)	Rhinology 5	France	Expert opinion and proposal of guidelines	NA	Use of mobile technology in patients with allergic rhinitis and asthma multimorbidity	Development of a mobile app which allowed patients to keep an allergy diary improved adherence to treatment plan and communication with their physician	Communication between patient and physician; Patient satisfaction
Deosthale (2017)	Rhinology 2	India	Prospective observational study, within-subject design	54	Sensitivity and specificity of diagnosis by nasal endoscopy or CT scan	CT scan may be an alternative to nasal endoscopy in certain patients with chronic rhinosinusitis	Potential alternative to invasive procedure
Khanwalkar (2019)	Rhinology 2	United States	Prospective cohort study	249	Patient reported outcome measures, including pain	A mobile platform may effectively track postoperative outcomes of septoplasty and functional endoscopic sinus surgery, and improve patient engagement	Communication between patient and physician; Patient satisfaction
Lohya (2016)	Rhinology 2	India	Prospective cohort study	100	Scored endoscopic findings and CT scans, clinical diagnosis based on established guidelines	No significant difference was found in diagnostic accuracy between CT and nasal endoscopy for patients with chronic rhinosinusitis	Potential alternative to invasive procedure
Mistry (2017)	Rhinology 5	United Kingdom	Expert opinion	NA	Detailed overview of mobile endoscopic imaging system use and applications	The endoscope-I is a compact, portable, endoscopic viewing system which allows real-time feedback to the patient and physician	Applications of telemedicine; Feasibility; Communication between clinicians
VanLue (2007)	Rhinology 5	United States	Expert opinion	NA	Describes development of a microportable imaging system for nasal endoscopy	Digital recording and SAF transmission used in conjunction with the microportable imaging system may be useful in telemedicine	Applications of telemedicine; Feasibility; Communication between clinicians
Seim (2018)	Rhinology 2	United States	Prospective observational study	21	Physician diagnostic agreement, patient satisfaction scores	Through synchronous telemedicine, conditions including epistaxis may be evaluated remotely	Communication between clinicians; Equivalency of diagnosis or outcomes; Patient satisfaction
Setzen (2020)	Rhinology 5	United States	Current review	NA	Evaluation of elective vs. urgent cases, procedural alternatives, billing	CT sinus imaging may be an alternative to nasal endoscopy. Remote evaluation of epistaxis is feasible but must identify high-risk patients	Alternatives to procedure

telemedicine across state and Medicare began reimbursing audio-only visits at the same rate as video and in-person visits reimbursement reform may be necessary to ensure that a full range of telehealth services is covered by insuring providers.^{75,76} Furthermore, remotely assisting personnel must seek payment directly from the billing physician, requiring a contractual arrangement with the physician.⁷⁷

Fortunately, telemedicine is not new to ORL, and has precedents in each of the main subspecialties (Table I). Applications of telemedicine within ORL, as

in other fields, fall into three distinct categories: synchronous care with and without assistant providers, as well as asynchronous care or SAF. Synchronous care without assistance includes interactions between the otolaryngologist and the patient without an assistant. These evaluations have been proven useful for head and neck oncology triaging and postoperative visits, vocal rehabilitation, endoscopic sinus surgery postoperative evaluation, allergic rhinitis management, facial trauma evaluation, and facial plastic postoperative evaluation.^{17-19,25,45,58,60,62,64}

Table VI.
Summary of Articles in Qualitative Review for Facial Plastic and Reconstructive Surgery.

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Appold (2017)	Facial Plastic and Reconstructive Surgery	5	United States	Expert opinion	NA	NA	Telemedicine appointments after facial plastic survey allow for closer follow-up of postoperative sites, evaluation of wound healing, and response to patient concerns	Communication between patient and physician; Patient satisfaction
Chen (2018)	Facial Plastic and Reconstructive Surgery	4	United States	Prospective observational study, no cohort design	36,836	Patient satisfaction survey scores and results	Patient trust and confidence in provider, and ability to communicate with the provider, is more important than perceived office environment to maintaining satisfaction	Communication between patient and physician; Patient satisfaction
Fonsesca (2020)	Facial Plastic and Reconstructive Surgery	1	Brazil	Prospective randomized control trial	50	Patient demographics, physical examination and CT scan findings, selected treatment option.	Substantial concordance of physical examination findings, CT scan interpretation, and treatment plan selection between in-person evaluations and smartphone videoconferencing	Communication between clinicians; equivalency of diagnosis or outcomes
Douglas (2018)	Facial Plastic and Reconstructive Surgery	4	United States	Prospective single-site study	41	Ratings of overall satisfaction, quality of interaction, and ability to communicate	83% of patients reported they would prefer telemedicine services for future nonurgent plastic surgery consultations in a VA health system	Patient satisfaction
Pozza (2017)	Facial Plastic and Reconstructive Surgery	4	United States	Case series	57	Patient satisfaction survey, postoperative complication rate	Postoperative telephone follow-ups after cosmetic surgery enhance the patient's postoperative experience and alert the surgeon to early postoperative problems	Communication between patient and physician; Patient satisfaction

Table VII.
Summary of Articles in Qualitative Review for Pediatric Otolaryngology.

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Burke (2015)	Pediatrics	5	United States	Expert opinion, literature review	NA	Uses of telemedicine in pediatric patient and parent education, access to care, barriers to implementation	For general pediatric care in the outpatient setting, telemedicine may even improve communication with parents	Communication between patient and physician
Shaffer (2020)	Pediatrics	4	United States	Retrospective case series	82	Patient symptoms recorded on a standardized form by nurses, treatment, referrals, and clinical outcomes	A clinical pathway for managing tympanostomy tube otorrhea beginning with phone triage was developed, obviating clinic visits in 82.9% of patients with a 75.6% cure rate	Applications of telemedicine; Feasibility

(Continues)

Table VII.
Continued

Author (year)	Discipline	Level of evidence	Country of origin	Study design and methods	Number of participants/sample size	Outcome measured	Key findings	Common themes
Smith (2005)	Pediatrics	4	United States	Case series, feasibility study	64	Referral patterns, clinical outcomes	Videoconferencing may be used effectively for pre-screening potential surgical admissions to a tertiary hospital	Applicability of telemedicine; Feasibility
Smith (2008)	Pediatrics	4	Australia	Retrospective chart review	68	Concordance between videoconference and in-person consultation findings	The diagnosis was concurrent in 99% of cases. Surgical management decisions were concurrent in 93% of cases	Communication between clinicians; communication between patient and physician; Equivalency of diagnosis or outcomes
Yang (2016)	Pediatrics	1	South Korea	Randomized control trial	61	Ratings of parents' knowledge of postoperative care and ratings of children's anxiety	Postoperative tonsillectomy care education using smartphone text messaging increases parents' knowledge and reduces children's anxiety	Communication between clinicians; Patient satisfaction

The second category involves synchronous care with the presence of an assistant. Such assistants may be able to perform or facilitate remote diagnostic procedures such as inpatient flap checks, otoscopic evaluation, voice rehabilitation, and swallowing evaluation, as well as pre- and postoperative evaluation of pediatric patients.^{23,35,36,44,45,66–68,70} Personnel must have adequate experience and training, without which the patient may be significantly at risk of pain, injury, or misdiagnosis.^{15,52} Robust telehealth networks must be created, wherein otolaryngologists can easily work with a patient's primary care provider to offer remote services and consultation.⁶⁰

The third category is asynchronous care or SAF telemedicine, in which primary data are collected, transmitted to the consultant, and evaluated at a later time point. Pathologies appropriate for asynchronous care are inherently nonurgent. Utilization of SAF techniques have already proven useful in head and neck oncology consultations, remote otologic and audiology evaluation, cochlear implant and hearing aid management, laryngeal ultrasonography, nasolaryngoscopy, as well as CT sinus review.^{16,19,26–29,31,32,34,35,38,39,41,49–57}

CONCLUSION

Telemedicine has been successfully utilized to varying degrees in the past. Further studies must include rigorous design controls, and standardization of populations and outcome measures to reduce heterogeneity and improve applicability.⁷⁸ The COVID-19 pandemic has propelled its necessity and utilization into the mainstays of current ORL practice. Now is the time to establish standards of practice that are safe, effective, and affordable for providers and patients.

Author contributions

AKS and DAK conceptualized and designed the study, performed literature reviews, drafted and critically revised the manuscript. RJ, JS, ELS, and ML critically reviewed, performed and interpreted data/literature reviews, and revised the manuscript. NK conceptualized and designed the study, critically reviewed the manuscript draft and revisions.

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