Tele-Audiology Services for Rehabilitation with Hearing Aids in Adults – A Systematic Review

Karina FM Tao,[a,b,c] Christopher G Brennan-Jones,[a,b,d] Dirce M Capobianco,[e] Dona MP Jayakody,[a,b] Peter L Friedland,[a,b,g,h] De Wet Swanepoel,[a,b,f] Robert H Eikelboom[a,b,f]

Affiliations

[a] Ear Sciences Centre, The University of Western Australia, Nedlands, WA, Australia.

[b] Ear Science Institute Australia, Nedlands, WA, Australia.

[c] CAPES Foundation, Ministry of Education of Brazil, Brasilia, DF, Brazil.

[d] Telethon Kids Institute, The University of Western Australia, Crawley, WA, Australia

[e] Department of Emergency Medicine and Evidence Based Medicine, Paulista School of Medicine, Universidade Federal de São Paulo [Federal University of Sao Paulo], Brazil.

[f] Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa.

[g] Department of Otolaryngology Head & Neck Skull Base Surgery, Sir Charles Gairdner Hospital, Nedlands, Australia

[h] School of Medicine, The University of Notre Dame, Fremantle, Australia

Correspondence

Karina F.M. Tao, Ear Science Institute Australia, 1 Salvado Road, Subiaco WA 6008, Perth, Australia. E-mail: karina.tao@earscience.org.au

Abstract

Purpose: This review examined (i) the current evidence from studies on tele-audiology applications for rehabilitation of hearing impaired adults with hearing aids and (ii) whether it is sufficient to support the translation into routine clinical practice.

Methods: A search strategy and eligibility criteria were utilised to include papers specifically related to hearing aid fitting and follow-up procedures that are involved in consultations for the rehabilitation of adults, where the service was provided by the clinician by tele-audiology. A search using keywords and MeSH terms was conducted on the main electronic databases that index health-related studies. The included studies were assessed using validated evaluation tools for methodological quality, level of evidence, and grade recommendations for application into practice.

Results: Fourteen studies were identified as being within the scope of this review. The evaluation tools showed that none of these studies demonstrated either a strong methodological quality or high level of evidence. Analysis of evidence identified nineteen activities, which were classified into service outcomes categories of feasibility, barriers, efficiency, quality and effectiveness. Recommendations could be made regarding the (i) feasibility, (ii) barriers and (iii) efficiency of tele-audiology for the rehabilitation of hearing loss with hearing aids.

Conclusion: This review provides up-to-date evidence for tele-audiology hearing aid services in new and experienced hearing aid users in different practice settings. Findings direct future research priorities to strengthen evidence-based practice. There is a need for further studies of many aspects of tele-audiology services for rehabilitation with hearing aids to support their implementation into clinical practice.

Keywords: Systematic review, Audiology, Telepractice, Auditory rehabilitation, Aural rehabilitation, Intervention, Amplification or Hearing aids.

Introduction

The high prevalence of hearing loss is a major global public health challenge. Over 5.3% of the world's population has disabling hearing loss and a further 10% have a non-disabling hearing impairment such as mild hearing loss, normal hearing with sloping high frequency loss or unilateral hearing loss (WHO, 2013a; WHO, 2013b). The ageing of the world's population is adding to this public health challenge (Kulik, Ryan, Harper & George, 2014; Salomon et al., 2012). Hearing loss affects communication and quality of life (Dalton et al., 2003; Ciorba, Bianchini, Pelucchi & Pastore, 2012), and is linked with cognitive decline (Lin et al., 2013; Lin et al., 2011). Providing timely services to those with hearing loss is therefore of critical importance.

Hearing loss is most commonly managed and treated with hearing aids provided by an audiologist. However, the worldwide scarcity of audiologists is a barrier to those in need of hearing health services (WHO, 2013b; Goulios & Patuzzi, 2008; Windmill & Freeman, 2013). The WHO reported that availability of these professionals varies with income levels with less than one audiologist available per million people in low income countries (e.g. Sub-Saharan Africa regions, India, Indonesia, Argentina, Mexico) compared to 2.76-124.77 audiologists available per million people in middle and high income countries (e.g. Canada, Australia, Brazil) (WHO, 2013b). The shortage of ear health professional places burdens on existing services to deliver timely and equitable care, with those in need of services at best facing long distance travel to access health care, or at worst doing without. Not only is this an issue for developing countries, but also developed countries such as Australia with scattered populations across large areas. Similarly, it is an issue for countries with large populations such as India, Brazil and Indonesia who have low or poor financial and/or professional resources (Goulios & Patuzzi, 2008; Nemes, 2010; Swanepoel et al, 2010). Less than 10% of

global need for hearing aids has been met, with an estimated 72 million people in developing countries in need of hearing aids (WHO, 2013a).

Tele-audiology has been proposed as a potential solution to address the global burden of hearing loss (WHO, 2013b; Stevens et al., 2013; Swanepoel et al., 2010). As a subset of telehealth (also known as ehealth, telecare or telemedicine), tele-audiology refers to the delivery of audiology services where the clinician uses information and communication technologies for the patient care in another location (Swanepoel et al, 2010; Krumm & Syms, 2011). These services can be delivered synchronously (i.e. in real-time, for example by videoconferencing) or asynchronously (also known as store-and-forward, for example by emailing results of an assessment to a health care professional) (Krumm & Syms, 2011; Scott & Mars, 2015). The improvement of technologies over time has often been the driver for telehealth services, especially for those in under-serviced communities (Swanepoel et al, 2010; Scott & Mars, 2015). Furthermore, utilising an evidence-based approach to implement tele-audiology into clinical practice is recommended (Atkins, Fink & Slutsky, 2005).

Three previous systematic reviews of the literature on tele-audiology have been published and examined the following: (i) the use of telehealth in audiology (Swanepoel & Hall 2010), (ii) telehealth studies in hearing sciences and speech-language (Molini-Avejonas, Rondon-Melo, Amato & Samelli, 2015), and (iii) the feasibility and effectiveness of synchronous telehealth in hearing rehabilitative services (Bush, Thompson, Irungu, & Ayugi, 2016). These reviews concluded that (a) there is a lack of protocols and models of service delivery for specific populations, (b) there are resource constraints e.g. internet speed, (c) very little is known about the patient and clinician's perceptions of tele-audiology services, and (d) there is a lack of research on the cost-effectiveness of tele-audiology services. However, there are no published systematic reviews specifically on intervention studies in rehabilitation with hearing aids by telehealth.

This systematic review aimed to identify all types of evidence currently available in the published literature on tele-audiology services for the rehabilitation of hearing impaired adults with hearing aids and to determine whether there is sufficient evidence for translation of these services into practice. Thus, the main research question of this review is: Is there sufficient current evidence to support the provision of tele-audiology services for the rehabilitation of hearing impaired adults with hearing aids? To do this, the published evidence from quantitative and qualitative studies was examined through the use of validated tools and was classified as assessing specific service outcomes such as feasibility, barriers, efficiency, quality and effectiveness. In this review rehabilitation services were defined as clinical interventions involved in hearing aid fitting and follow-up consultations that are part of conventional practices for the rehabilitation of hearing loss with hearing aids.

Methods

This systematic review is reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff & Altman, 2009) and with the Institute of Medicine's recommended standards for systematic reviews (Eden, Levit, Berg & Morton, 2011). It was registered in the Prospero International prospective register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO/; registration number CRD42016036136).

Eligibility criteria

All the relevant papers related to tele-audiology service delivery of hearing-aid rehabilitation published and available on searched databases before 20 May 2017 were considered.

Table 1. Eligibility criteria

Eligibility criteria	**Include**	**Exclude**
Types of studies	Any type of research design of qualitative or quantitative intervention studies (e.g. comparative studies, case-studies, case-report, proof of concept studies).	Reviews, letters, editorials, miscellaneous reports and non-empirical studies.
	Studies written in English, Portuguese, Spanish or Dutch. No restriction on publication date.	Reports in any other language rather than the ones in the inclusion list. ---
Types of participants	Hearing impaired people ≥ 18 years of age.	Any study on disability associated with hearing loss (identifiable major impairment that compromises hearing aid rehabilitation (i.e. blind, known psychological or cognitive disorders).
	Any type of hearing loss with any degree, configuration, laterality and symmetry.	---
	Hearing-aid new and experienced users.	Studies on non-hearing aid users.
Types of intervention	Hearing-aids	Cochlear implant, amplified listening devices (e.g. remote microphone, FM systems) or Hearing-aid algorithms (e.g. noise reduction, mic directionality) or remote control applicative mobile (e.g. for patients self-managing volume and programs or streaming audio direct to the hearing-aid).
	Telehealth component (synchronous or asynchronous clinician involvement) to deliver hearing aids rehabilitation procedures.	Telehealth intervention tools (e.g. online platforms, website, software, app) that do not have synchronous or asynchronous clinician involvement and enhance face-to-face intervention
	Rehabilitation procedures realised in conventional hearing aid fitting and follow-up consultations (physical and sensory management, instructions, counselling and validation).	Auditory training for central auditory processing (e.g. speech processing) or cognition (e.g. memory). Remote application of speech tests performed only in unaided condition or using headphones. Remote application of validated and reliable speech tests performed in aided condition but not deliberately part of a remote consultation (e.g. use of sound booth or audiometer for test application). Remote application of questionnaires to evaluate results from a face-to-face consultation.
Types of outcome measures	Any outcome measured by any type of measurement at any time (short or long term).	---

The eligibility criteria (Table 1) was designed to include clinical procedures involved in conventional hearing aid fitting and follow-up consultations, as found in guidelines of professional audiology bodies (e.g. American Academy of Audiology, 2006; Audiology Society of Australia, 2013; British Society of Audiology, 2012). These procedures were categorized by this review as: (i) physical management (i.e. fitting and comfort with ear moulds, domes, tubes and device), (ii) sensory management (fitting, programming, fine-adjustments and verification of the device with real ear measurements), (iii) instructions (training and demonstration of device use, device management and troubleshooting), (iv) counselling (informational and emotional in which include communication strategies) and (v) validation (validated and reliable speech tests and questionnaires applied in aided condition).

Training programs (i.e. auditory, hearing, listening or speech-communication training and cognitive training) and assistive listening devices were not included as they are used only to enhance the intervention with amplification (Table 1).

Information sources

The search was conducted on PubMed, CINAHL Plus (EBSCOhost), Scopus, MEDLINE (Ovid), EMBASE (Ovid) electronic databases, which are the most likely to index reports of studies in rehabilitative audiology, and includes all audiology and telemedicine related journals (Hickson, Laplante-Lévesque & Wong, 2013; Cox, 2003 and 2005).

Additionally, a hand-search of references of the included articles and citations of the included articles was carried out by using Google Scholar. Authors of methodology-only papers were contacted for unpublished recent work. Grey literature was searched using Google Scholar and two electronic databases: Open Grey, ClinicalTrials.gov and International Clinical Trials Registry Platform (ICTRP); the inclusion of unpublished studies e.g. conference proceedings, scientific meetings or theses, help to avoid publication bias.

Search strategy

The sensitivity of the search strategy was maximised utilising MeSH terms in exploded mode (MEDLINE and EMBASE), text searches or keywords (PubMed, CINAHL Plus and Scopus), with truncations, synonyms and different spellings. Even though Pubmed accesses the MEDLINE database, using MeSH terms was considered warranted to utilise MEDLINE's standardised indexing system; utilising both searches is recommended by librarians. The search terms were in four domains: (i) Telehealth, (ii) Hearing aids, (iii) Audiology and (iv) Hearing aid rehabilitation (Table 2). Searches of each combination of search terms were conducted in the title, abstract and full text fields.

Table 2. Keywords and MeSH terms (explode) applied per domain respectively on PubMed, Scopus and CINHAL Plus, and on MEDLINE (Ovid) and EMBASE (Ovid) databases.

Domain	**Key words**	**MeSH Terms**
Telehealth	telemedicine OR ehealth OR "e_health" OR "e-health" OR telehealth OR "tele-health" OR teleaudiology OR "tele-audiology" OR teleconsultation OR "tele-consultation" OR telefitting OR "tele-fitting" OR remote OR telerehabilitation OR "tele-rehabilitation" OR telepractice OR "tele-practice" OR "telehearing" OR "tele-hearing" OR teleintervention OR tele-intervention OR mhealth Or "m-health" OR "m_health" OR "mobile health"	telemedicine OR computer communication networks OR remote consultation
Hearing aids	"hearing aid" OR "hearing-aid" OR "hearing aids" OR "hearing-aids"	hearing aids
Hearing aids rehabilitation	rehabilitation OR fitting OR "follow-up" or "follow up" OR "outcome(s) assessment(s)" OR consultation(s) OR "face-to-face" OR intervention OR counselling or counseling OR "fine-tune" OR "fine-tuning" OR tuning OR adjustment(s) OR programming	correction of hearing impairment OR continuity of patient care OR treatment outcome OR patient outcome assessment OR quality of health care OR delivery of health care
Audiology	audiolog*	audiology

The same search strategy was used for keywords and MeSH terms in the four domains as follows: telehealth AND [(Hearing aids AND Audiology) OR (Hearing aids AND Hearing-aid rehabilitation)] (supplemental material S1). See supplemental material S2 for an example.

The search strategy was reviewed by an independent librarian as recommended (Crowther, Lim & Crowther, 2010). A dual independent review was applied to the search strategy as well as to the processes of identification and assessment of studies to reduce random errors and bias (Eden, Wheatley, MacNeil & Sox, 2008).

Study selection

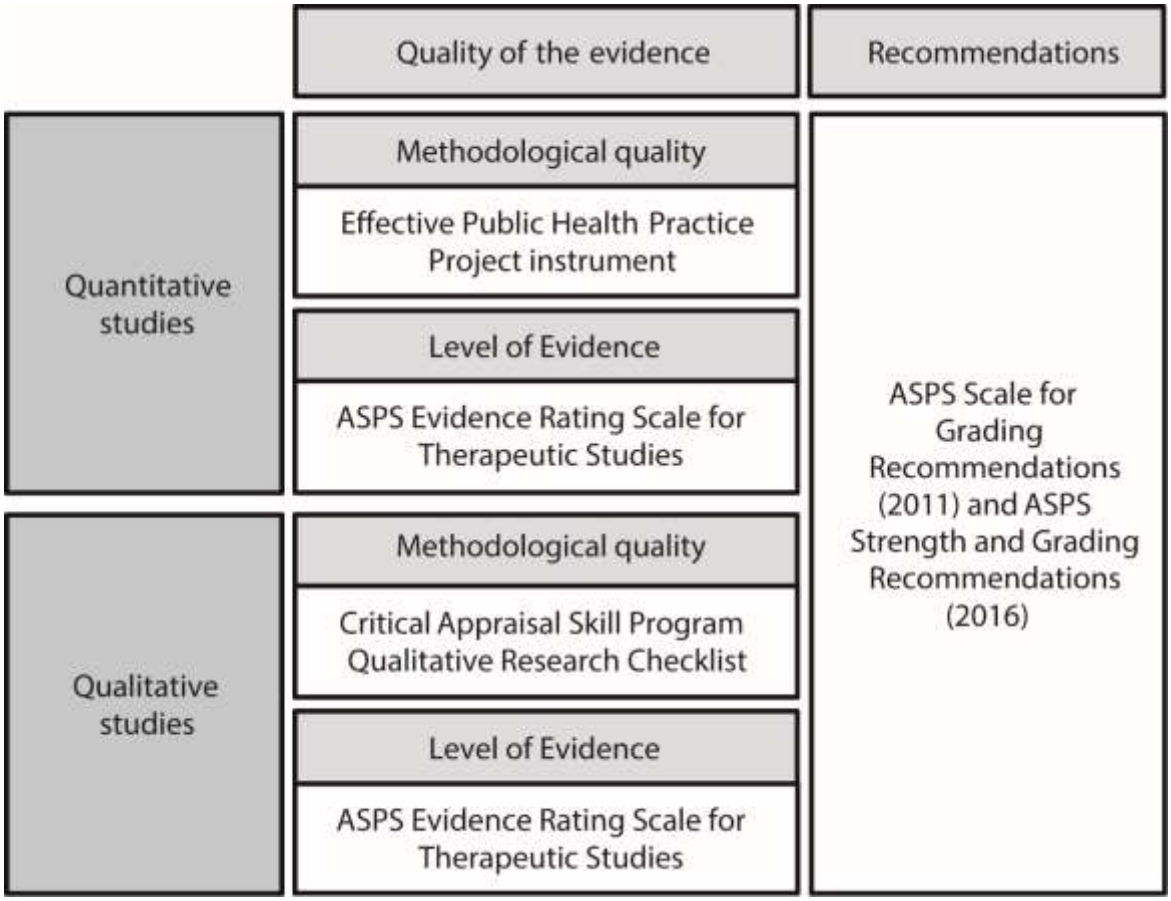
After duplicates were removed, titles and abstracts were analysed against the eligibility criteria. Items that did not provide an abstract or in which the abstract did not provide enough information were kept for full-text analysis.

The search strategy and screening of papers were replicated independently by two authors assisted by Covidence (Veritas Health Innovation, Melbourne, 2015) a systematic review organisational tool (www.covidence.org). Papers kept for full-text analysis were also screened by a third researcher. Conflicts were solved by consensus and those eligible were included for qualitative synthesis.

Assessment of study quality and analysis of evidence

The authors (i) separated the included studies into quantitative and qualitative studies, (ii) assessed their methodological quality and (iii) analysed the level of evidence for the provision of overall quality of the evidence, and (iv) graded recommendations (Figure 1). Conflicts were solved by consensus.

Figure 1. Assessment of study quality and analysis of evidence



Two tools recommended by the Cochrane Collaboration Group were used to assess the methodological quality of quantitative and qualitative studies (Higgins & Green, 2011).

The *methodological quality of quantitative studies* was evaluated using the Effective Public Health Practice Project (EPHPP) instrument (EPHPP, 1998; Thomas, Ciliska, Dobbins & Micucci, 2004; Thomas, 2003; Deeks et al., 2003). This validated instrument includes eight core components consisting of 21 items, with a standardized guide and a dictionary ensuring a systematic approach to determining the rate for each component and global methodological quality as weak, moderate or strong.

The *methodological quality of qualitative studies* was evaluated using the Critical Appraisal Skill Program Qualitative Research Checklist (CASP, 2014). This validated checklist comprises nine questions with a series of prompts to generate a Yes/No/Can’t tell

answer. In the absence of a scoring system, the following was used to score the methodological quality of the studies: strong (all 9 questions were answered "Yes"), moderate (7 or 8 "Yes" answers) or weak (6 or less "Yes" answers).

The *level of evidence* of each study was assessed using the American Society of Plastic Surgeons' ASPS Evidence Rating Scale for Therapeutic Studies (ASPS, 2011) (Appendix A) by examining the study design. With this scale lesser-quality randomized trials have the same level of evidence as cohort or comparative studies (Appendix A).

Therefore, the *quality of the evidence* was determined by assessing the results of *methodological quality* and *level of evidence* of each study; the findings of each study may contribute evidence for a specific activity that is shared with other studies. The quality of the evidence was classified as high, moderate, low or very low. However, in order to avoid bias due to the absence of a clear descriptor for systematically grading the *quality of the evidence* with respect to the number of studies, strength of methodological quality and level of evidence of the studies sharing a specific activity, this review considered the criteria below, also based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Guyatt et al., 2008) that is used by ASPS, when judging the overall quality of evidence and strength of recommendations (Appendix C).

High quality of evidence may be arrived at by (a) the findings from two or more studies with strong methodological quality and high level of evidence (Level I), or (b) consistent findings from multiple studies with strong methodological quality and lower levels of evidence (Level II, III or IV). *Moderate* quality of evidence may be arrived at by (a) single study with strong or moderate methodological quality and high level of evidence (Level I), or (b) consistent findings from two or more studies with moderate methodological quality and lower levels of evidence (Level, II, III or IV). *Low* quality of evidence may be arrived at by (a) a single study with moderate methodological quality and lower levels of evidence (Level

II, III, IV) or with strong methodological quality and very low level of evidence (Level V), or (b) consistent or inconsistent findings from one or more studies with weak methodological quality and lower levels of evidence (Level II, III, IV) or with moderate methodological quality and very low level of evidence (Level V). Finally, *Very low* quality of evidence is defined by (a) a single study with moderate methodological quality and very low level of evidence (Level V), or (b) one or more studies with weak methodological quality and very low level of evidence (Level V). It was established that a minimum number of ten consistent studies at the same strength of methodological quality was required to upgrade one level the strength of the quality of the evidence. If the quality of the evidence is moderate, low or very low, this is considered insufficient to support a *strong recommendation* for translation into clinical practice.

Recommendations for application into clinical practice were determined by the ASPS Scale for Grading Recommendations (ASPS, 2011) (Appendix B), and the *strength of the recommendations* were determined by the ASPS Strength and Grading Recommendations (ASPS, 2016) (Appendix C), both based on the *quality of the evidence* described above. This scale takes into account consistent but lower levels of evidence from multiple studies; these contribute to making a confident recommendation (Burns, Rohrich, & Chung, 2011). Lower levels of evidence studies (e.g. case series and case-reports) can be important for generation of hypotheses and improving controlled studies (Burns, Rohrich & Chung, 2011). This way, Grade A (strong recommendation) indicates evidence that comes from studies with a strong methodological quality classified as Level I, II, III or IV (Appendix B). Additionally, consistent evidence from multiple studies which have weaker study designs (lower levels of evidence, Level, II, III or IV) but moderate or weak methodological quality can also provide a recommendation although not a strong recommendation (Appendix C). The strength of a recommendation can be rated as weak, moderate or strong, and also as an “option” when

clinician should opt whether or not to apply the activity as the quality of the evidence is very low. These weaker recommendations (Grade B, C or D) generally inform that the evidence was insufficient to confidently support a specific activity and that clinicians should consider patient preferences. They should also be attentive to new information as further evidence may confirm or change the estimate effect (Oxman & GRADE working group, 2004).

These three ASPS scales, developed for medical specialties and based on other scales from the Center for Evidence-Based Medicine (Center for Evidence Based Medicine, 2001) and GRADE (Guyatt et al., 2008), were considered appropriate in the case of audiology intervention studies in which it is difficult to control the clinician expertise as an important variable and where high-quality randomized controlled trials may be rare.

Data extraction

The following information was extracted from the studies: (i) authors, year of publication and journal, (ii) geographical location of the study, (iii) research type (qualitative or quantitative) and design, (iv) demographics of subjects examined (e.g. n, age, gender, hearing loss characteristics), (v) aims/purpose of the study (vi) clinical methods applied, (vii) outcomes measured, (viii) major findings (results/conclusions), (ix) limitations or difficulties. The collated information was tabulated and analysed qualitatively, noting patterns, agreement and/or disagreement between studies, and gaps in knowledge.

Data synthesis

The results from applying the appraisal tools were tabulated showing the rating for the overall methodological quality, the level of evidence and the main findings of each study. These findings were analysed by specific patient group (new or experienced hearing aid uses) and clinical practice activity (type, mode and method of service-delivery, time for effect and

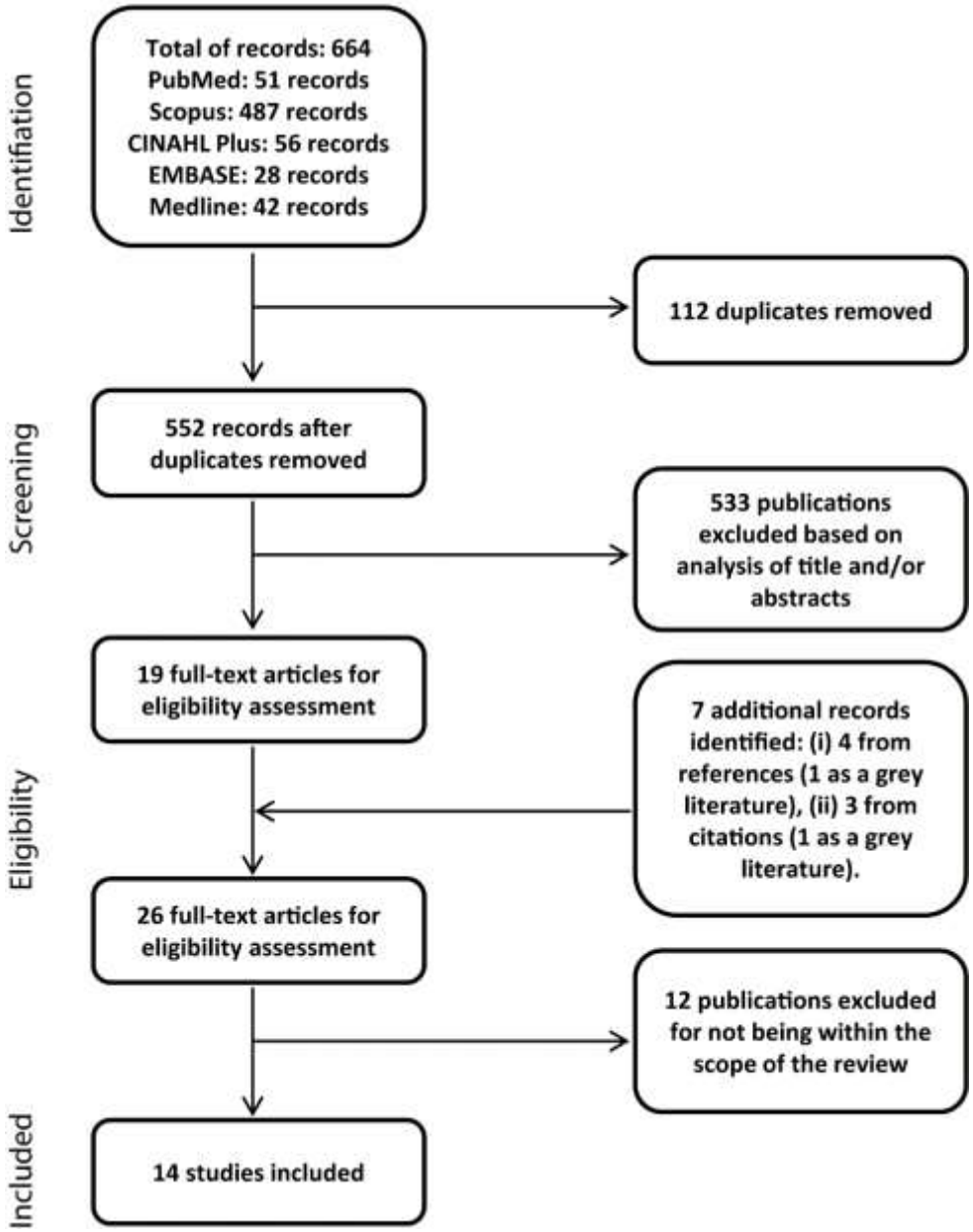
type of outcome measured) to synthetise the evidence. This developed an understanding on how the included papers assessed specific service outcomes: feasibility, barriers, efficiency, quality and effectiveness. Note, that these were not necessarily aligned to the aims of the included studies, but to the objectives of this review. Contributing to each of the five service outcomes were various activities, each activity highlighting evidence as to whether there was sufficient evidence for a recommendation for translation into clinical practice (Oxman & GRADE working group, 2004). This review adopted the term "remote" to refer to consultations or procedures performed at distance, by tele-audiology.

Results

Search strategy

The initial search retrieved 552 reports excluding duplicates (Figure 2). Analysis of titles and abstracts against the eligibility criteria excluded 533 studies as they fell outside the scope of this review for not meeting the eligibility criteria. This high number of exclusions was a result of the need to have a broad search strategy (in the audiology and hearing aid domains) (searches C and D, see supplemental material S1) because papers often did not clearly state in their keywords or MeSH terms whether they were an intervention study. Most of the excluded papers did not report an intervention study. The remaining 19 studies were analysed in full. A review of their reference lists and citations revealed seven more eligible studies that were not captured by our search strategy as they did not use a telehealth-related keyword or MeSH term.

Figure 2. PRISMA study flow diagram



Twelve publications of these 26 studies were excluded in the full-text analysis, as they did not meet the eligibility criteria. Four studies were excluded as they did not present a synchronous or asynchronous clinician involvement, two were not empirical studies, one was a child's case-report, one was about hearing assessment by tele-audiology, one was on speech testing in unaided conditions, one was on the use of a hearing-aid (HA) accessory, one was a

tele-monitoring system for non-HA users or HA users dissatisfied with their hearing-aids (HAs), and one was an online support platform designed to enhance a face-to-face intervention.

A total of 14 studies (Table 3; Supplemental Material S3) were identified as being within the scope of this review including one from the grey literature (conference paper) (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006).

Methodological quality assessment

None of the 14 included studies met all of the core components of assessment (Table 4) mostly due to under-reporting or lack of clarity. Of the eleven studies analysed using the quantitative tool (EPHPP instrument), four were rated as 'moderate' and seven as 'weak' (Table 3). Of the three studies (Pearce, Ching & Dillon, 2009; Penteado, Ramos, Battistella, Marone & Bento, 2012; Laplante-Lévesque, Pichora-Fuller & Gane, 2006) analysed using the qualitative tool (CASP checklist), one was rated as 'moderate' and two as 'weak' (Table 3). The risk of bias was evident in all included studies for at least one of the components analysed (e.g. description of randomization method, control of confounders).

Level of evidence

Eight studies were classified using ASPS scale (2011) as level II (lesser-quality, randomized controlled trial or prospective cohort or comparative study), one as level III (retrospective cohort or comparative study; case-control study), two as level IV (case series with pre-/post-test or only post-test) and three as level V (case report or clinical example) (Table 3). Although some studies were reported as being an RCT (level I of evidence), none were judged to be so in the context of the objectives of this review.

Table 3. Summary of evidence and the grade of recommendation

Service Outcome	Activity and evidence	References	Level of evidence	Methodological quality*	Grade of recommendation	Quality of the evidence	Strength of recommendation
Feasibility	i- Remote HA fitting consultation** and specific procedures of programming, verification, fine-adjustments, instructions and counselling through a synchronous telehealth mode is feasible for new and experienced users.	Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006	II	Weak	B	Low	Weak
		Ferrari & Bernardez-Braga, 2009	IV	Weak			
		Campos & Ferrari, 2012	II	Moderate			
		Reginato & Ferrari, 2014	II	Weak			
		Pearce, Ching & Dillon, H, 2009	V	Weak			
		Penteado, Ramos, Battistella, Marone & Bento, 2012	V	Weak			
		Penteado, Bento, Battistella, Silva & Sooful, 2014	IV	Weak			
	ii- Remote HA counselling programme through asynchronous telehealth mode through daily e-mail exchange with an audiologist may not be feasible in a conventional clinical practice.	Laplante-Lévesque, Pichora-Fuller & Gane, 2006	V	Moderate	D	Very low	Option
	iii- Remote HA instructions and counselling 5-week programme with weekly telephone calls initiated by an audiologist, reading material and weekly tasks based on COSI goals may be feasible in a conventional clinical practice.	Lundberg, Andersson & Lunner, 2011	II	Moderate	D	Low	Weak
Barriers	iv- Facilitator's lack of training in appropriately positioning the probe microphones may or may not affect verification results from REM.	Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006	II	Weak	C	Low	Weak
		Ferrari & Bernardez-Braga, 2009	IV	Weak			
	v- Facilitator's lack of training in appropriately performing real ear measurements with probe microphones is a barrier for the time spent on remote verification procedures compared to face-to-face.	Campos & Ferrari, 2012	II	Moderate	B	Low	Weak
		Reginato & Ferrari, 2014	II	Weak			
Efficiency	vi- The time-efficiency of remote HA fitting consultation** is clinically equivalent to face-to-face consultations.	Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006	II	Weak	B	Low	Weak
		Campos & Ferrari, 2012	II	Moderate			
		Reginato & Ferrari, 2014	II	Weak			
	vii- Remote specific procedures of programming, verification and counselling may be as efficient as face-to-face procedures.	Campos & Ferrari, 2012	II	Moderate	D	Low	Weak
		Reginato & Ferrari, 2014	II	Weak			

* Methodology analysed considering the evaluation of remote consultations and procedures of intervention for rehabilitation with hearing aids (Thomas, Ciliska, Dobbins & Micucci, 2004; Thomas, 2003; CASP, 2014).

** Remote HA fitting consultation: consisting of fitting, verification with REM, programming, instructions and counselling procedures.

Table 3. Summary of evidence and the grade of recommendation (*continued)*

Service Outcome	Activity and evidence	References	Level of evidence	Methodological quality*	Grade of recommendation	Quality of the evidence	Strength of recommendation
Quality	viii- Remote HA fitting consultation** for new HA users may be quality-equivalent to face-to-face consultation immediately after the consultation.	Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006 Reginato & Ferrari, 2014	II II	Weak Weak	D	Low	Weak
Effectiveness	ix- Remote HA fitting consultation** for new HA users may be as effective as face-a-face consultation for HA outcomes measured by IOI-HA about one to two months after consultation.	Campos & Ferrari, 2012 Pross, Bourne & Cheung, 2016	II III	Moderate Weak	D	Low	Weak
	x- A blended service consistent of face-a-face consultations for HA fitting and remote follow-up for fine-adjustments and counselling may be comparable to a purely face-a-face service for HA satisfaction measured by SADL questionnaire.	Penteado, Bento, Battistella, Silva & Sooful, 2014	IV	Weak	D	Low	Weak
	xi- Remote instructions and counselling for new and experienced HA users delivered by telephone clinician-initiative during the first three months (at 6, 9 and 12 weeks) post-HA fitting consultation may not be effective to reduce the number of unresolved complaints at 4 months and 1 year post-HA fitting.	Cherry & Rubinstein, 1994 Cherry & Rubinstein, 1995	II II	Weak Weak	D	Low	Weak
	xii- Remote instructions and counselling for new and experienced HA users delivered by telephone clinician-initiative during the first three months (at 6, 9 and 12 weeks) post-HA fitting consultation may be effective in early identifying complaints but may not be to improve use, satisfaction and aided hearing disability measured by the HHIE questionnaire at 4 months post-HA fitting.	Cherry & Rubinstein, 1994 Cherry & Rubinstein, 1995	II II	Weak Weak	D	Low	Weak
	xiii- Remote counselling programme for new HA users in the form of daily emails may be effective to change perceptions and behaviours related to HA fitting whilst participating in the programme. This type of programme may not present long-term effective results.	Laplante-Lévesque, Pichora-Fuller & Gagne, 2006	V	Moderate	D	Very low	Option
	xiv- Remote counselling 5-week programme consisting of interaction with an audiologist through weekly telephone calls, reading material and weekly tasks based on COSI goals may be effective to improve hearing disability, residual participation restrictions, depression and anxiety in experienced HA users in a short-term (5 weeks), immediately after the program finished, but may have no effect on overall HA outcomes.	Lundberg, Andersson & Lunner, 2011	II	Moderate	D	Low	Weak

Table 3. Summary of evidence and the grade of recommendation (*continued)*

Service Outcome	Activity and evidence	References	Level of evidence	Methodological quality*	Grade of recommendation	Quality of the evidence	Strength of recommendation
Effectiveness	xv- Remote counselling 5-week programme consisting of online reading material, home training tasks, interaction with an audiologist by e-mail exchange and a 5-week discussion forum with peers may be effective on reducing perceived aided hearing disability (HHIE questionnaire) at a short-term (5 weeks), immediately after finishing the programme, and at a longer-term (6 months) in experienced HA users with significant communication difficulties.	Thorén et al., 2011	II	Moderate	D	Low	Weak
	xvi- Remote counselling 5-week programme consisting of online reading material, home training tasks, interaction with an audiologist by e-mails exchange may be more effective to reduce perceived aided hearing disability (HHIE questionnaire) than a 5-week discussion forum with peers at a short-term (5 weeks), immediately after finishing the programme, and may be less effective at a longer term (6 months) in experienced HA users with significant communication difficulties.	Thorén et al., 2011	II	Moderate	D	Low	Weak
	xvii- Remote counselling 5-week programme consisting of online reading material, home training tasks, interaction with an audiologist through e-mails exchange may be more effective than a 5-week discussion forum with peers to improve overall anxiety and depression (HADS questionnaire) at a longer-term (6 months) in experienced HA users with significant communication difficulties, but may not have difference at a short-term.	Thorén et al., 2011	II	Moderate	D	Low	Weak
	xviii- Remote counselling 5-week programme consisting of online reading material, home training tasks, interaction with an audiologist through e-mails exchange and a 5-week discussion forum with peers may not be effective to change HA outcomes (IOI-HA questionnaire) and HA satisfaction (SADL questionnaire) in experienced HA users with significant communication difficulties.	Thorén et al., 2011	II	Moderate	D	Low	Weak
	xix- A combination of a rehabilitative online education programme that includes interaction with an audiologist and with peers in a discussion forum may be effective to significantly improve: (i) the perceived hearing disability at a short-term (5weeks) and maintain results in up to 3 months, (ii) to improve residual participation restrictions and impact on others in a short-term (5 weeks), (iii) to improve anxiety and depression in a longer-term (3 months) when compared to a non-treatment group.	Thorén, Oberg, Wanstrom, Andersson & Lunner, 2014	II	Moderate	D	Low	Weak

Table 4. Qualitative assessment results for quantitative and qualitative studies

Quantitative studies (n=11)		
Core item	**Tool question (EPHPP, 1998 & Thomas et al. 2004)**	**Number of studies with positive assessment**
Selection bias	Are the individuals selected to participate in the study likely to be representative of the target population?	10
	What percentage of selected individuals agreed to participate?	8 (80-100%)
Study design	Was the study described as randomized? If NO, go to CONFOUNDERS	9
	If Yes, was the method of randomization described? (See dictionary)	4
	If Yes, was the method appropriate? (See dictionary)	4
Confounders	Were there important differences between groups prior to the intervention?	6
	If Yes, indicate the percentage of relevant confounders that were controlled either in the design (e.g. stratification, matching) or analysis)?	0
Blinding	Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?	1
	Were the study participants aware of the research question?	0
Data collection methods	Were data collection tools shown to be valid?	7
	Were data collection tools shown to be reliable?	7
Withdraws and dropout	Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?	7
	Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).	7
Intervention Integrity	What percentage of participants received the allocated intervention or exposure of interest?	9 (80-100%) 1 (60-79%)
	Was the consistency of the intervention measured?	1
	Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?	5
Analysis	Indicate the unit of allocation	Individual (10)
	Indicate the unit or analysis	Individual (10)
	Are the statistical methods appropriate for the study design?	7
	Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?	7 (NO)
Qualitative studies (n=3)		
Core item	**Tool question (CASP, 2014)**	**Number of studies with positive assessment**
Aim	Was there a clear statement of the aims of the research?	3
Methodology	Is a qualitative methodology appropriate?	2
Study design	Was the research design appropriate to address the aims of the research?	1
Recruitment strategy	Was the recruitment strategy appropriate to the aims of the research?	1
Data collection	Was the data collected in a way that addressed the research issue?	1
Researcher effects	Has the relationship between researcher and participants been adequately considered?	0
Ethical aspects	Have ethical issues been taken into consideration?	2
Data analysis	Was the data analysis sufficiently rigorous?	1
Findings aspects	Is there a clear statement of findings?	1

Evidence

The included studies contributed evidence to at least one of the five service outcomes, generating 19 different activities related to the service outcomes. These were then graded with a recommendation for translation into clinical practice. Quality of the evidence was low for 16 and very low for two of these activities (Table 3).

Grade of recommendations

Three activities, in the service categories of feasibility, barriers and efficiency, were graded B because of generally consistent findings (Table 3; Appendix B). One activity was graded C due inconsistent findings, with the remaining activities graded D due to lack of systematic findings. The strength of these recommendations was mostly weak. Besides those graded B and C, two activities that were graded D were judged to be an option for the clinician as the evidence was insufficient to support a weak recommendation.

Feasibility:

Nine studies evaluated the feasibility of tele-audiology HA consultations, procedures or intervention programmes with new (n = 6) and experienced HA users (n = 3). The majority of these were delivered in a synchronous mode focused on remote HA fitting consultation (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Campos & Ferrari, 2012; Reginato & Ferrari, 2014), and on one or more specific procedures that are part of conventional HA fitting or follow-up consultations, covering (i) physical and (ii) sensory management procedures such as fitting, programming (Penteado, Ramos, Battistella, Marone & Bento, 2012) and verification with real ear measurements (Ferrari & Bernardez-Braga, 2009), and a combination of programming and verification, fine-adjustments, (iii) instructions and (iv) counselling procedures (Pearce, Ching & Dillon, 2009; Penteado, Bento, Battistella, Silva &

Sooful, 2014). In each case, the evaluation conducted in this review concluded that the feasibility was demonstrated as the evidence for the activity of remote HA programming, verification, fine-adjustments, instructions and counselling provided a Grade B of recommendation. However, the recommendation for translation into practice is weak, and therefore clinicians implementing these procedures into practice should do so cautiously, being alert to new information and consider patient preferences (ASPS, 2011).

Two studies examined the feasibility of intervention programmes, one investigating counselling by emails exchange (Laplante-Lévesque, Pichora-Fuller & Gane, 2006), and the other counselling and instructions in a mixed tele-audiology mode (synchronous and asynchronous) using telephone calls, book reading and training tasks (Lundberg, Andersson & Lunner, 2011). The former postulated that their mode of service delivery may not be feasible in a conventional clinical practice. The other study concluded that their approach may be feasible. As both studies did not provide strong evidence or consistent findings, there is insufficient evidence to conclude whether providing remote counselling and instruction programmes, as described in these two studies, are feasible (Grade D).

Barriers:

Four studies provided evidence on the barriers of the delivery of remote HA fitting consultations or procedures, all of which focused on using REM (Real Ear Measurements) to verify the HA fitting. Two test-retest studies (Ferrari & Bernardez-Braga, 2009; Ferrari et al., 2006) utilised an untrained facilitator to conduct REM, concluding that the facilitator may be the source of variability. However, as supporting data was not available this factor could not be explored by this review and thus inconsistent findings precluded a confident recommendation for this activity (Grade C). The other two studies measured time spent on specific procedures of the HA fitting consultation (fitting, programming, verification,

instructions and counselling) (Campos & Ferrari, 2012; Reginato & Ferrari, 2014), concluding that extra time was spent on verification procedures and that these were due to the lack of facilitator's training. However, the quality of the evidence is low and thus, provided a weak recommendation (Grade B).

Efficiency:

Three studies reported time spent on face-to-face and remote HA fitting consultations and procedures. The overall amount of time on HA fitting consultations was not significantly different in two of the studies (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Campos & Ferrari, 2012). Although the third study (Reginato & Ferrari, 2014) reported a significant difference, the mean time difference of four minutes could be considered as clinically insignificant in some practices. The findings of these three were generally consistent (Grade B) and the evidence is that the time does not appear to negatively affect the time efficiency of a remote HA fitting consultation service. However, there was insufficient evidence regarding the efficiency of specific remote procedures such as HA programming, verification and counselling investigated by two studies (Campos & Ferrari, 2012; Reginato & Ferrari, 2014). As there were scarce consistent findings regarding these specific HA procedures and evidence is weak, a confident recommendation could not be made (Grade D).

Quality:

Two studies with new HA users evaluated the quality of the remote HA fitting consultations immediately after consultations by measuring the outcomes of the service delivered.

One study measured confidence, interaction, counselling, communication quality and satisfaction (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006), reporting no significant differences between face-to-face and remote groups.

Another study (Reginato & Ferrari, 2014) measured patient's perceptions during the consultation finding no significant difference. They also observed clinician-patient behaviours finding significantly different outcomes, where remote consultations were more centred on discussing procedures whereas the others were more on health and treatment discussions.

However, because the quality of the evidence provided by these two studies was low and consistent findings were scarce, there is insufficient evidence that remote HA fitting consultation may deliver an equivalent quality of service as face-to-face consultations.

Effectiveness:

Eight studies evaluated the effectiveness of varied remote HA rehabilitation services.

(i) HA fitting consultations for new users was reported by three studies. Two of these (Campos & Ferrari, 2012; Pross, Bourne, & Cheung, 2016) used the International Outcome Inventory for Hearing Aids (IOI-HA), reporting no difference between remote and face-to-face consultations. However, it is unclear whether or not participants received follow-up consultations or other assistance during the interval between the HA fitting consultation and questionnaire response. A speech-perception test was also conducted in one of these studies (Campos & Ferrari, 2012), with no differences observed, but details on the HA fitting conditions (aided or unaided) were not reported. In the other study, the satisfaction with hearing aids amplification was measured after a remote follow-up consultation and was assessed with the Satisfaction with Amplification in Daily Life (SADL) survey (Penteado, Bento, Battistella, Silva & Sooful, 2014). A limitation was that given the nature of the SADL

questions, there was no period of adjustment to outcomes of the remote consultation before the patient was assessed. This differs it from the other two studies described above in that it provided a blended service model; face-to-face and tele-audiology. Furthermore, population characteristics of the study did not allow for a proper comparison to published normative data (Cox and Alexander, 1999) to support the finding of enhanced outcomes for a remote consultation.

These studies contributed insufficient evidence for two different activities for new HA users (Table 3), one for remote HA fitting consultation and another for a blended service. Recommendations could not be made (Grade D).

(ii) Two studies evaluated a telephone-based counselling and instruction programme (Cherry & Rubinstein, 1994; Cherry & Rubinstein, 1995) for new and experienced HA users. Although the difference in outcomes between the intervention and control groups was not significant, the number of clinic visits and amount of contact with clinicians did not appear to be controlled, although it was reported that it was recorded. Therefore, the effectiveness of a telephone intervention is still unclear. Together, these two studies contributed weak evidence for two different activities and hence recommendations could not be made (Grade D).

(iii) Four studies reported the effectiveness of counselling programmes for new and experienced HA users, utilising emails or weekly phone calls alongside home-based exercises and a discussion forum with peers. Regular email exchanges with an audiologist after HA fitting for new users may be effective in influencing perceptions and changing their behaviour during the first month post-hearing aid fitting period whilst participating in the counselling programme (Laplante-Lévesque, Pichora-Fuller & Gagne, 2006). Face-to-face consultations were allowed during the programme period, a confounding factor that may have affected results. The study's results suggest that this type of programme may not be effective in a long-term. A short-term remote counselling programme by telephone calls with an

audiologist and home-based exercises versus only home-based exercises (same for experimental group) (Lundberg, Andersson & Lunner, 2011) may be effective in improving hearing disability, residual participation restrictions, overall depression and anxiety in experienced HA users at the end of the programme, but may have no effect on overall HA outcomes. There was no control or under-reporting of the clinical visits by participants in the control group which weakened this study's evidence. A similar study with experienced HA users but interacting with an audiologist by email versus a discussion forum with peers without audiologist interaction as control (Thorén et al., 2011), showed a significant reduction of perceived hearing disability, depression and anxiety. However, there was no improvement in satisfaction with HAs or in HA fitting outcomes in both groups (experimental and control), suggesting that these aspects may not be improved with these programmes. The effectiveness of this experimental programme is unclear due to three uncontrolled variables: time allowed for access to home based exercises material for each group, the different topics discussed in both groups and the audiologist's intervention (e.g. possible clinic visits during outcome measures intervals), generating a weak recommendation for translation into practice.

A subsequent study evaluated the effectiveness of a similar counselling programme by email exchanges with an audiologist but with a discussion forum with peers for experienced HA users and a control group of people on a waiting list for participation in the programme (Thorén, Oberg, Wanstrom, Andersson & Lunner, 2014). The experimental group showed a significant improvement in various outcome measures such as aided hearing disability, some HA outcomes, anxiety and depression. Although presented an RCT with a control group, this study was classified as a randomised non-comparative and not controlled study as it did not directly compare a remote intervention with a gold-standard treatment.

Although these four studies each examined the role of the telephone or emails for the audiologist to support the HA user, the variations in approaches and outcome measures made the weight of evidence low and it was not possible to provide a stronger recommendation for adoption into clinical practice (Grade D).

Discussion

Tele-audiology is a relatively new field of study, and the studies included in this review are led by pioneers in this field where it was utilised in hearing-aid rehabilitative services. These studies make important contributions that can inform further research and translation into clinical practice. It is recognized that there are challenges to develop studies on this field where, for example, controlling variables and bias may be difficult. This review was intended to make a constructive analysis in order to summarise current knowledge in tele-audiology rehabilitation to direct future research and promote the translation of evidence into practice.

All studies discussed below involved synchronous tele-audiology consultations, unless stated otherwise.

Feasibility

Although the feasibility of conducting a number of hearing aid procedures was demonstrated (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Ferrari & Bernardez-Braga, 2009; Campos & Ferrari, 2012; Reginato & Ferrari, 2014; Pearce, Ching & Dillon, H, 2009; Penteado, Ramos, Battistella, Marone & Bento, 2012; Penteado, Bento, Battistella, Silva & Sooful, 2014), the evidence was such that translation in practice should be done with caution. A number of key procedures remain unexplored: (i) ear impressions in remote consultations, although in some countries (e.g. Brazil) there are professional-legal implications if this is not performed by a hearing professional (Pearce, Ching & Dillon, 2009), (ii) trouble-shooting the

physical and acoustic aspects of ear moulds e.g. grinding, drilling, retubing, (iii) HA fitting issues e.g. technical problems, changing the microphone cover, inspecting the ear canal, choosing the size of the dome, verifying appropriate fitting and position of domes in the ears. The experience of participants with HAs may influence the feasibility of remote HA procedures. However, none of the nine studies commented on this matter.

Barriers

It is important to identify barriers to the implementation of a health service. Although these are negatively associated with feasibility, they normally relate to non-clinical matters such as capacity and acceptance of support staff (Jarvis-Selinger, Chan, Payne, Plohman, & Ho, 2008; Wade, Eliott, & Hiller, 2014), specialised equipment e.g. video-otoscope (Biagio, Swanepoel, Adeyemo, Hall, & Vinck, 2013), infrastructure, e.g. quality of service of a telecommunication network (Li & Wilson, 2013) and reimbursement (Weinstein et al., 2014). The four studies that documented potential barriers examined for remote HA fitting consultations and procedures were performed with the assistance of untrained facilitators (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Ferrari & Bernardez-Braga, 2009; Campos & Ferrari, 2012; Reginato & Ferrari, 2014). However, inconsistent findings related to untrained facilitators being the source of variability in REM results precluded this review from making a confident recommendation regarding this activity that requires further investigation. Although there is some evidence that extra time is required when using unskilled facilitators for performing REMs, this matter deserves further investigation as this evidence is not strong. Facilitators are likely to be key resources in most telehealth implementations (Biagio, Swanepoel, Adeyemo, Hall, & Vinck, 2013). Therefore, further studies comparing the inter- and intra-tester variability in real ear measurements performed by a non-trained facilitator, a well-trained facilitator and an experienced audiologist would be valuable to add to the existing evidence.

Efficiency

Efficiency factors in telehealth include time spent on conducting a consultation, and additional costs e.g. equipment, work practices (Jang-Jaccard, Nepal, Alem, & Li, 2014). Non-clinical factors such as travel time of patients also relate to efficiency (Wade, Karnon, Elshaug, & Hiller, 2010).

Although, the evidence of the three included studies (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Campos & Ferrari, 2012; Reginato & Ferrari, 2014) is that tele-audiology consultations do not differ significantly in length of time compared to the face-to-face HA fitting consultations, it could not be made for specific procedures for which evidence was insufficient.

The range of time reported in these studies for completion of the remote HA fitting consultations varied from 25 minutes to 93 minutes, almost four times as long. This was probably related to additional procedures included in the consultations. As standardisation of procedures across clinics is unlikely, and documenting the times for individual tasks may be difficult to accomplish, a better approach may be to design studies that represent the conventional clinical practice.

However, as the evidence is not strong, this and other associated matters related to efficiency deserve future investigation. For example, all three studies above were with new HA users. As participant's experience with HAs may influence the time required for a service, there is also scope for comparative studies on time spent for providing services to new and experienced HA users. Furthermore, there is considerable scope for studies of many other aspects of efficiency, particularly patient- and community-level economic benefits that will be needed to guide public policy on funding tele-audiology services (Weinstein, Lopez, & Krupinski, 2014) and workforce utilisation (Jang-Jaccard et al., 2014).

Quality

Quality of a service is generally measured by taking opinion of users regarding factor(s) relevant to service quality that are antecedents to (i.e. reliability, personal attention, comfort and features) and a consequence of this (i.e. user satisfaction) that reflects on behavioural intentions (Dabholkar, Shepherd, & Thorpe, 2000). These measurements can determine whether the service satisfies stated or implied needs. It is important to consider patient perceptions and expectations regarding before and after service provision (Dabholkar, Shepherd, & Thorpe, 2000), aspects that were not specifically addressed in any of the included studies. Furthermore, there is a lack of consistent and strong evidence regarding the quality of HA fitting and follow-up consultations. Only two studies evaluated the quality of the remote HA fitting consultations for new HA users and demonstrated no difference between remote and face-to-face consultations (Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006; Reginato & Ferrari, 2014). However, these studies provided weak evidence meaning that a strong recommendation cannot be made. Before remote HA services are implemented into practice, more research is required to determine overall service quality equivalency to face-to-face service, and to clarify benefit versus harm. This important evidence is essential to confirm that remote HA services do not compromise service quality and patients are satisfied with remote treatment.

Effectiveness

The effectiveness of a tele-audiology service is an important element to be evaluated to determine whether patients' clinical outcomes are affected.

Each study of effectiveness included in this review investigated different activities related to remote HA fitting consultations and online counselling and instructions programmes by telephone and/or email (Campos & Ferrari, 2012; Pross, Bourne & Cheung,

2016; Penteado, Bento, Battistella, Silva & Sooful, 2014; Cherry & Rubinstein, 1994; Cherry & Rubinstein, 1995; Laplante-Lévesque, Pichora-Fuller & Gagne, 2006; Lundberg, Andersson & Lunner, 2011; Thorén et al., 2011; Thorén, Oberg, Wanstrom, Andersson & Lunner, 2014). More comparative studies to gold standard consultations or procedures in new and experienced HA users are required to test effectiveness in these activities, and also in others such as remote follow-up consultations, remote HA handling skills and the facilitator's role in improving or assisting the patient in these skills, and remote assessment of speech perception. Speech perception testing may be a challenge as sound controlled environments may not be available in remote sites. Its validity and reliability thus, need to be evaluated for remote application.

When designing studies, care must be taken to avoid confounding factors by controlling variables, as for example the amount of contact with audiologists in the experimental and control groups, the experience of the HA user (new, experienced and inexperienced), and the skills and experience of a facilitator that may be involved. In addition, care must be taken (when possible) to measure outcomes from variables such as local of practice (e.g. private/public), target population (e.g. rural/urban), and participant's expectations which may affect perceived benefit and satisfaction and be influenced by involvement of financial resources (e.g. private/publically funded clients) and family involvement. Furthermore, clinical protocols for face-to-face and remote consultations should be matched as closely as possible. A summary of the areas explored within the tele-audiology use for rehabilitation with hearing aids in adults to date (Table 5) also highlights the areas requiring further research.

Table 5. Summary of the procedures studied with the number of studies and population (new or experienced HA users)

Procedure category	Procedure subcategories	Population studied	Number of studies	Reference
Remote HA fitting consultation	Fitting, Verification with REM, Programming, Instruction and Counselling	New HA users	3	Ferrari, Rasmussen, Paulsen, Andersen & Larsen, 2006 Ferrari & Bernardez-Braga, 2009 Reginato & Ferrari, 2014
		Not reported	1	Pross, Bourne & Cheung, 2016
Remote HA follow-up consultation	- Programming and verification (1 case) - Fine adjustments and counselling (1 case) - Instructions (1 case)	New HA users	1	Pearce, Ching & Dillon, 2009
	Instructions and counselling	New and experienced HA users	2	Cherry & Rubinstein, 1994 Cherry & Rubinstein, 1995
Blended service (face-to-face HA fitting and remote follow-up)	Fine-adjustments and counselling	New HA users	1	Penteado, Bento, Battistella, Silva & Sooful, 2014
Specific procedures	Verification with REM	Experienced HA users	1	Ferrari & Bernardez-Braga, 2009
	Programming	Experienced HA users	1	Penteado, Ramos, Battistella, Marone & Bento, 2012
	Counselling	New HA users	1	Laplante-Lévesque, Pichora-Fuller & Gane, 2006
	Counselling	Experienced HA users	3	Lundberg, Andersson & Lunner, 2011 Thorén et al., 2011 Thorén, Oberg, Wanstrom, Andersson & Lunner, 2014

Methodology

This review found few recommendations for translating research findings into clinical practice. In general, the methodology quality was assessed as low. The primary factors were under reporting and lack of clarity to satisfy the core items of methodological quality assessment (Table 4). The strength of the recommendations was also affected by the low number of studies and quality of the evidence. Although RCTs may be difficult, more studies on the same procedures or aspects will be important contribution to building the evidence base. For future systematic reviews it is also important for studies to use standard National Library of Medicine (NLM) vocabulary to search indexed citations (i.e. MeSH terms); this differentiates a MEDLINE search from the one that only uses Pubmed keywords (NIH, 2016). It is recommended that all future studies that involve remote management of patients, be it in intervention or diagnostic procedures, use relevant indexed keywords or MeSH terms to telehealth or tele-audiology to allow future systematic reviews on this field to easily retrieve the study.

Conclusion

There appears to be an increasing role for tele-audiology services to manage the growing number of people with hearing loss requiring services. However, this review has shown that (i) there are only a few studies that have investigated tele-audiology as a mode of providing hearing aid services, focussing on a limited number of aspects or procedures, and (ii) that the overall quality of evidence is lower than optimal. Hence, these factors provide insufficient evidence to support the adoption of remote intervention services for hearing rehabilitation with hearing aids into clinical practice.

The review revealed only three consistent findings. Firstly, remote real ear measurements performed by an untrained facilitator added extra time to this procedure. Secondly and

importantly, this additional time did not practically influence to the time for the overall hearing aid fitting consultation. Thirdly, remote hearing aid fitting and follow-up procedures are feasible. However, there is limited recommendation for translation into clinical practice due to current lack of strong or even moderate quality of evidence.

This systematic literature review highlights the required areas for further evidence based studies for the implementation of tele-audiology and hearing aid services.

Declaration of Interest

The authors report no declarations of interest.

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Appendix A. ASPS Evidence Rating Scale for Therapeutic Studies, 2011

Level of Evidence	**Qualifying Studies**
I	High-quality, multi-centered or single-centered, randomized controlled trial with adequate power; or systematic review of these studies
II	Lesser-quality, randomized controlled trial; prospective cohort or comparative study; or systematic review of these studies
III	Retrospective cohort or comparative study; case-control study; or systematic review of these studies
IV	Case series with pre-/post-test; or only post-test
V	Expert opinion developed via consensus process; case report or clinical example; or evidence based on physiology, bench research or "first principles"

 Source: http://www.plasticsurgery.org / http://edmgr.ovid.com/prs/accounts/ifauth.htm / https://www.plasticsurgery.org/documents/medical-professionals/health-policy/evidence-practice/ASPS-Rating-Scale-March-2011.pdf

Appendix B. ASPS Scale for Grading Recommendations, 2011

Grade	Descriptor	Qualifying Evidence	Implications for Practice
A	Strong Recommendation	Level I evidence or consistent findings from multiple studies of levels II, III, or IV	Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
B	Recommendation	Levels II, III, or IV evidence and findings are generally consistent	Generally, clinicians should follow a recommendation but should remain alert to new information and sensitive to patient preferences
C	Option	Levels II, III, or IV evidence, but findings are inconsistent	Clinicians should be flexible in their decision making regarding appropriate practice, although they may set bounds on alternatives; patient preference should have a substantial influencing role.
D	Option	Level V: Little or no systematic empirical evidence	Clinicians should consider all options in their decision-making and be alert to new published evidence that clarifies the balance of benefit versus harm; patient preference should have a substantial influencing role.

Appendix C. ASPS Strength and Grading Recommendations, 2016

Strength	**Overall Strength of Evidence**	**Description**
Strong	Strong	Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Benefit or harm predominates. The vast majority of well-informed patients (> 90%) would most likely use or not use this patient-care strategy, compared to alternative patientcare strategies or no treatment.
Moderate	Moderate	Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Benefit or harm predominates. The majority of well-informed patients would most likely use or not use this patient-care strategy, compared to alternative patient-care strategies or no treatment.
Weak	Low Strength Evidence or Inconsistent Evidence	Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention. Benefit or harm predominates or is unclear. The majority of well-informed patients would most likely use or not use this patient-care strategy, compared to alternative patient-care strategies or no treatment.
Option	Very Low Strength Evidence or Inconsistent Evidence	Evidence from one or more "Very Low" quality studies with consistent findings or evidence from a single "Weak" quality study recommending for or against the intervention. Potential benefits are harms are balanced. The majority of well-informed patients would most likely use or not use this patient-care strategy, compared to alternative patient-care strategies or no treatment.

 Source: https://www.plasticsurgery.org/documents/medical-professionals/quality-resources/ASPS-Evidence%E2%80%90Based-Clinical-Practice-Guideline-Methodology.pdf