TELE-AUDIOLOGY

An opportunity for expansion of hearing healthcare services in Australia

EAR SCIENCE Institute Australia

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Ear Science Institute Australia was established in 2001 as an independent not-for-profit research institute dedicated to improving the lives of people with ear and hearing disorders, through patient focused research, education and treatment.

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1. Executive Summary

The development of guidelines and standards for tele-audiology is a vital process to ensure effective and safe delivery of quality healthcare.

Tele-audiology will continue to grow as an important and viable method for delivering hearing healthcare services across Australia. Tele-audiology will be adopted by more hearing healthcare practitioners and clients in a wide variety of forms, and practice guidelines will be a key factor in fostering this growth.

This report

- Collates information from the literature on current research and practice evidence for tele-audiology, integrated with stakeholder views collected via surveys and interviews;
- Highlights key considerations for the development of tele-audiology practice standards;
- Provides evidence-based recommendations for safe and effective tele-practice within the hearing sector; and
- Advises the Hearing Services Program-Department of Health and Hearing Health Sector Alliance on matters relevant to future development of clinical practice standards for tele-audiology practices.

The key findings are:

1. There is evidence that almost all the primary tasks defined in the scope of practice for audiologists and audiometrists can be conducted by telehealth, be they clinician-led, facilitator-assisted and/or self-led. The tasks for which there is evidence supporting the use of tele-audiology approaches for the delivery of clinical services relate to Otoscopy, Tympanometry and Acoustic Immittance Testing, Otoacoustic Emission Testing, Diagnostic Pure Tone Audiometry, Hearing Screening, Speech Testing, Hearing Aid Fitting/ Initial Programming, Hearing Aid Fine-tuning and Aftercare, Hearing Rehabilitation Support Services and Tinnitus Management/Counselling. At present there is no evidence to support the remote safe and effective delivery of clinical services relating to: Wax Management or Ear Impressions.
2. The impact of COVID-19 on the provision of audiology services in 2020 has seen an increase in

interest by audiologists and audiometrists in providing services by telehealth. Before COVID-19 there was a large proportion of the sector that did not recognise the importance of telehealth, this reduced to almost no one during COVID-19. Clinicians placed priority on providing ongoing maintenance and support, and were most concerned about older adult clients. Their concerns were centred on the capacity of their clients to manage a telehealth consultation, and their own training.

3. Whilst clients generally have a positive attitude towards telehealth, the majority have not used telehealth for medical or audiology services. To date most tele-audiology services have been delivered by telephone, and clients express concerns about communicating effectively in telehealth consultations; most would prefer face-to-face services.
4. The COVID-19 pandemic has encouraged the hearing device manufacturers to increase availability and utility of their tele-audiology solutions.

Key recommendations:

1. **To ensure that tele-audiology services are delivered in a safe and effective manner:** Develop clinical and practice guidelines.
2. **To ensure that service providers are financially able to provide tele-audiology services:** Provide funding for tele-audiology services.
3. **To increase provider use of tele-audiology services:** Provide a funding mechanism to ensure profitability in services delivered by tele-audiology.
4. **To increase the skills and capacity of service providers:** Provide training, education and infrastructure for providers.
5. **To increase uptake of tele-audiology services:** Conduct professional and public awareness campaigns to promote the benefits of tele-audiology services.
6. **To ensure that tele-audiology services do not result in delivery of low-value and no-value care:** Ensure that funding reflects the cost to set up, maintain and deliver tele-audiology services, including store-and-forward modalities.
7. **To provide audiology services to vulnerable adults unable to effectively access current services:** Clinician- and client-driven innovation could reduce health system fragmentation and inefficiency.
8. **To strengthen the evidence-base for tele-audiology services:** Ensure funding for research that targets gaps in evidence, including the cost-utility of tele-audiology services.


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Contents

3. Background

Hearing loss ranks in the top three most prevalent and most burdensome global health conditions. [1]

It affects approximately one in seven people in Australia, estimated to be 3.95 million people in 2019-20, or 15.3% of the population. The prevalence of hearing loss is expected to rise to 7.78 million people by 2066 – 18.2% of the total population [2]. Hearing loss is strongly associated with ageing, disabling at least 75% of people ≥65 years, and 90% of those ≥80 years of age. An ageing population will thus place a significant burden on hearing health services as the number of people with age-related hearing loss increases. Australians living in rural and remote areas also face significant barriers to access ear and hearing health care, as few audiologists are based outside of the capital cities [3].

Hearing loss compromises a person's ability to communicate, causing social and emotional distress. Up to 50% of older adults with hearing loss report feelings of isolation, loneliness, or symptoms of anxiety or depression [4-6]. Furthermore, for all age groups, hearing loss and the associated psychosocial consequences negatively impact on access to education, employment, and financial independence [7-9]. Consequently, the financial costs of hearing loss in Australia (2019-20) were estimated as $20.0 billion, including health system costs of $1.0 billion, employment and productivity losses of $16.2 billion [2]. In addition to financial costs, the value of the lost wellbeing was estimated to be $21.2 billion in 2019-20, which represents 52% of total costs attributed to hearing loss [2].

Despite the benefits of audiological rehabilitation, increasingly sophisticated hearing technologies and an Australian Government program regarded as world-class, a group of Australians remain vulnerable to social and economic disadvantage owing to their hearing loss and the lack of comprehensive programs to address it.

3.1 Hearing Services Program

The Australian Government supports hearing services for eligible persons through the Hearing Services Program (HSP). The HSP is designed to reduce the impact of hearing loss by providing access to hearing services, including assessments, hearing devices, fittings, maintenance and rehabilitation services. A key focus of the program is to improve accessibility of hearing services for the most vulnerable people in society. However, people living in rural and remote communities, work or carer commitments, and health issues can all prevent people from accessing face-to-face hearing healthcare services.

The majority of health services provided in Australia are delivered as face-to-face services in clinical environments. For Australians living in rural and remote areas, specialist medical practitioners visit infrequently, resulting in long waiting times or foregoing services if people are to be seen in their local environment *[10, 11]*. Alternatively, clients must travel long distances to be seen in a large metropolitan centre *[12, 13]*. As a result of these and related factors Australians located in rural and remote areas have reduced health outcomes compared to those living in metropolitan Australia *[11]*.

3.2 Tele-audiology services in Australia

Australian researchers and clinicians have been actively researching, implementing and using tele-audiology for decades *[14-18]*. However, despite apparent enthusiasm, tele-audiology remains underutilised and is not part of routine care. Innovations that broaden the application of tele-audiology strategies are evolving, but policy and funding constraints limit their implementation in Australia *[16, 19-21]*. Targeted policy changes are required to combat barriers to wide-scale implementation and uptake.

The rise of tele-audiology practices in Australia. *Research in Australia over the past decade shows the delivery of tele-audiology services to be effective, safe, and cost-effective.* *[16, 19-23]*

Audiology service delivery has undergone major changes as a result of the COVID-19 pandemic. Some audiology clinics closed in response to government mandated lock-downs, and others experienced an increased demand for services. One of the most significant changes was the inclusion of tele-audiology practices under the Australian Government's Hearing Services Program (HSP) and Medicare service funding schemes. These government schemes have enabled providers to continue to see vulnerable clients by encouraging the use of tele-audiology services wherever clinically appropriate and safe *[12, 13]*.

3.3 Have the much-anticipated changes in policy and funding resulted in changes to practice?

In partnership with the International Society of Audiology, an international study was conducted on how the COVID-19 pandemic has affected audiology services globally. Audiologists practicing around the world, including Australia were interviewed between June and August 2020. The responses from Australian audiologists (n=74) showed that:

57% used some form of tele-audiology before COVID-19.

This increased to 75% during the time of the survey.

83% indicated that they will use tele-audiology post-COVID-19.

This demonstrates a growing willingness of Australian hearing professionals to utilise tele-audiology to deliver services, regardless of whether their clients live in metropolitan, rural or remote areas. Audiologists most commonly used the telephone or video-conferencing for communicating with their adult clients, and focused on hearing aid adjustments.

3.4 Definitions

Telehealth, also referred to as tele-practice, remote care, or eHealth, is the delivery of healthcare from a distance. Tele-audiology describes the use of telehealth to provide audiological services. Tele-audiology may also be described as the use of telecommunications and/or digital technology to provide access to audiological services for clients who are not in the same physical location as the clinician. The prefix "tele" usually refers to, or abbreviates telecommunication, "e" denotes electronic, and "m" denotes mobile. However, the terminology continues to evolve and variations may refer to particular implementations or applications, e.g. tele-education, tele-diagnostics, tele-rehabilitation, tele-consultation, tele-practice, tele-fitting and eAudiology. Audiology Australia define tele-audiology as the use of telecommunications and digital technology to provide access to audiological services for clients who are not in the same location as the clinician *[24]*. The American Speech-Language-Hearing Association *[25]* identifies tele-audiology as an alternative method of service delivery for Audiologists that encompasses diagnostics and intervention services, as well as counselling and education for clients and their family/carers.

There are some challenges to note about the definition of tele-audiology and telehealth in general. Traditionally, telehealth is understood as a real-time consultation that takes place between a clinician and a client (synchronous telehealth) replicating, as much as possible, a face-to-face consultation. Although not always considered telehealth, providing clinical advice or support over the phone, from the clinician to a client, also constitutes telehealth. Therefore, telehealth is not a new concept, with most clinicians and clinics already practicing telehealth.

Consultations can also take place when the clinician and client are not in contact in real time (known as asynchronous telehealth). This usually takes place when collection of information takes some time, often conducted by an assistant, and where the specialist's time is devoted to interpretation of the information; for example, radiology, vestibular/balance assessments etc. Limitations in communication technology, e.g. in remote areas, may also require information to be collected 'off-line' and then transmitted to the clinician later, e.g. otoscopic images *[26, 27]*. Data collected by telemetry from devices e.g. pacemakers, blood pressure monitors, hearing aids, and transmitted regularly or at critical times intervals also constitutes telehealth, as well as completion of surveys by clients in their own homes.

Whilst the above describes telehealth from a clinical point of view, a client-centred view should also be considered. Self-led management refers to how the client uses their knowledge and skills to manage the effects of their chronic condition on all aspects of daily life. Self-led management may also embrace telehealth. This can include not only the ongoing use and management of, for example, hearing devices, but also knowledge of and access to alternative interventions; maintaining physical and emotional wellbeing; monitoring for and responding to changes in hearing condition severity; and taking an active role in clinical decision-making *[28]*. The client's ability to self-manage a chronic condition greatly influences their experience of the condition, as well as their rehabilitation outcomes *[29, 30]*. Self-led management is thus a vital component of audiology rehabilitation and should be supported through both in-clinic and tele-audiology service structures. This includes rehabilitation programmes that are initiated by a clinician, delivered by an electronic device, carried out in a client's own environment, and which report progress to the clinician.

Finally, telehealth should not be considered as involving only two people – a clinician and a client. For example, a client may be joined by a family member; a facilitator may be present to collect information using specialised equipment e.g. audiometry; a clinician in another discipline by be a party to the consultation; or a clinician may deliver a rehabilitation programme to a group of clients across various locations.

Therefore, in the broad sense telehealth, including tele-audiology, can be considered as a fundamental part of the delivery of health services, regardless of the mode and timing of the exchange of information.

Tele-audiology is a tool to provide better care, better access, and potentially a lower cost of care for those with hearing concerns. It can be effectively used as an alternative, or supplementary method for diagnostics and intervention services, as well as for counselling and education for clients and their family/carers.

3.5 Tools used to deliver tele-audiology

The telephone, and before that the wireless *[31]*, is the most long-standing medium for telehealth. However, with the rapid increase in internet-based technologies and systems the modes of communication now includes:

- Text messages and emails
- Generic video-conferencing systems e.g. Apple Facetime, Zoom, Microsoft Teams, Skype, Cisco Webex, GoToMeeting
- Specific telehealth video-conferencing platforms e.g. coviu.com or vcita.com
- Smartphone Apps, such as those developed by hearing device manufacturers to facilitate remote and self-guided clinical care
- Automated audiometry e.g. Geoaxon's KUDUWave
- Websites with multi-media resources.

The digital landscape has become central to the lives of most Australians. The Australian Communications and Media Authority in 2020 *[32]* reported that nearly all Australians (99%) had accessed the internet in the previous 6 months in 2020 (up from 90% in 2019). Australian internet users, on average, used 4.4 types of devices to access the internet (increase from 4.0 types in 2019).

Engagement in online activities including emailing, general web browsing, watching videos and banking/paying bills, increased significantly in 2020, likely driven by COVID-19 restrictions.

The use of communications apps (applications) also increased; from 67% in 2019 to 77% in 2020. The most popular were Facebook Messenger (66%), followed by Zoom (43%).

Whilst older Australians (aged 55 years and above) participated less across nearly all internet activities than those aged 18–54 years, they were more active in telehealth, legal, financial or other professional consultations.

Four in five Australian adults started or increased their participation for both telehealth consultations and video conferencing/calling since COVID-19 restrictions were introduced in March 2020.

4. Methodology/ Approach

This report was commissioned and funded by the Australian Department of Health.

The prime task was to identify current research and practice evidence for tele-audiology, as well as identifying the resource and skills required for safe and effective tele-practice. The results were intended to guide and advise clinical practice standards for tele-audiology services in the hearing sector and within the Hearing Services Program.

Specific tasks were:

- Collate information from the literature on current research and practice evidence for tele-audiology
- Consult with stakeholders via surveys, focus groups, and discussion papers as required
- Highlighting key considerations for the development of tele-audiology practice standards
- Develop evidence-based recommendations for safe and effective tele-practice within the hearing sector
- Advise the Department of Health and Hearing Health Sector Alliance on any matters relevant to future development of clinical practice standards for tele-audiology practices.

The Working Group consisted of:

- **Ms Sandra Bellekom**, CEO, Ear Science Institute Australia
- **Ms Lize Coetzee**, Chief Operating Officer, Ear Science Institute Australia
- **Ms Elissa Campbell**, Advocacy and Policy Manager, Audiology Australia
- **Prof Robert Eikelboom**, Research Manager, Ear Science Institute Australia
- **Dr Rebecca Bennett**, Raine/Cockell Postdoctoral Research Fellow, Ear Science Institute Australia
- **Ms Maddison Brennan**, Clinical Audiologist, Ear Science Institute Australia

The scope of audiology services covered was informed by the audiology Scope of Practice for Audiologists and Audiometrists[1] in Australia *[33]*, but restricted to those services that are funded by the Australian Government's Hearing Services Program (HSP). Historically, HSP specified the required clinical activities to claim for particular service items; however, the revised service items offer greater flexibility and enlist the clinicians to make their own clinical judgements in individualising care, in line with the practice guidelines of their professional bodies and the required rehabilitation outcomes of the Program. Consequently, the evidence in this report has been categorised into specific clinical activities commonly delivered under HSP, with the corresponding claim numbers indicated where relevant.

The literature (peer-reviewed publications, grey literature, white papers, and manufacturer's information and websites) were used to inform this report. The authors did not judge the level of evidence or quality of the studies; however, it has been reported recently that the quality of evidence of many studies in tele-audiology involving hearing aids is low *[19]*. Findings related to telehealth from a number of surveys of audiologists and audiology clients conducted during 2020 were included in the report. These convey the voice of audiologists and their clients as to the current and future application of telehealth to audiology. A number of world experts on telehealth in audiology provided feedback on the report.

1 Audiology services in Australia are delivered by both audiologists and audiometrists, and, if eligible, are funded by the Hearing Services Program. In this report 'hearing health clinicians' or 'clinicians' is used to encompass both.

5. The Evidence on Tele-Audiology Practices

Research to date clearly demonstrates that technology-enabled health care is not only feasible but, in some cases, can be equal to or better than in-person care.[34, 35]

Nearly every area of health has been found to benefit from telehealth to some degree, whether it be cost savings, time to treatment as a function of better access to services, or clinical outcomes.

The purpose of this review is to provide readily accessible and reliable data to guide the development of clinical practice guidelines. This section provides a thorough review of the evidence-base describing tele-audiology practices as they relate to audiological services delivered through the HSP program; the sub-sections align with core services delivered within HSP funded audiological services. Data within each subsection has been further categorised into the three core modes of telehealth services: clinician-led, facilitator-supported, and self-led services. A summary statement describing whether the evidence supports delivery of each service type using each of these three modes is provided in a box at the start of each sub-section. The end of each sub-section provides a list of core recommendations for clinical implementation of telehealth relating to the sub-section service activity.

Modalities

Tele-audiology services can be synchronous (real-time), asynchronous (store-and-forward or offline), or be a combination of these two modes. Tele-audiology services can be separated into services (Table 1) *[36]* that are:

i. Delivered directly by the audiologist. These consultations can be in real-time or offline.

ii. Delivered by a facilitator. The facilitator will usually be a nurse, family member, or trained assistant. They act as a conduit between the client and the audiologist. In synchronous telehealth consultations they can act as the eyes (e.g. inspection of ear canal), ears (e.g. clarify information if client does not understand a question), and hands (e.g. adjust the physical fit of a hearing aid) of the audiologist in charge of the consultation. In an offline consultation the facilitator may be engaged in collecting or collating information e.g. otoscopy images, assessment data, which are stored and relayed to the audiologist

iii. Self-led, where the client is actively involved in tasks, as directed by an audiologist, that immediately or consequently effect their health.

This framework of delivery options has been utilised in this report to present to evidence for different tele-services.

Table 1.
Examples of synchronous and asynchronous tele-audiology services delivered by the audiologist, assisted by a facilitator, or completed by the client (self-management).

	SYNCHRONOUS (LIVE) TELE-PRACTICE	ASYNCHRONOUS (STORE-AND-FORWARD) TELE-PRACTICE
Delivered by the audiologist	The audiologist provides real-time (live) clinical services to the client, but remotely. For example, providing clinical support over the telephone, using video-conferencing software to conduct an appointment, or use of remote fitting and fine-tuning apps.	Where the audiologist provides clinical services to the client not in real-time (delayed) and remotely. For example, providing the client with clinical support via email, or through an app. This also includes remote monitoring, such as where the client might complete surveys to assist with relaying their experiences back to their audiologist.
Delivered by a facilitator (non-audiologist e.g. nurse, family member) acting as a conduit between the client and the audiologist	Where the audiologist and facilitator work together to provide remote services. For example, the audiologist might be in their clinic and the facilitator may be in another clinic, in the client's home or in the next room (as has occurred during COVID). The facilitator performs some of the tasks on behalf of the audiologist e.g. otoscopy.	Client information is captured by the facilitator and forwarded to the audiologist for review at a later date. For example, a healthcare worker may perform otoscopy, tympanometry or audiometry in a remote community and store the data, and then forward these to an audiologist to synthesise and provide clinical advice.
Self-management: where the client is actively involved in tasks that immediately or consequently affect their health	When the person with hearing loss makes real time adjustments to their management of their hearing loss. For example, making adjustments to their hearing aid through an app, or completing a self-directed online program (such as CBT programs for tinnitus management).	Asynchronous self-help would include reading modules and/or completing exercises in a workbook or an internet-based platform (such as regarding hearing device management) and then altering behaviours in regards to the self-management of the hearing condition (such as better device use and/or maintenance). Use of tools for self-monitoring, including use of clinical diaries or surveys (such as Ecological Momentary Assessment) that results in changes to the clients health behaviours (e.g. device use).

The summary of findings shows that there is some evidence for all audiology services being delivered by telehealth (Table 2) through one or more of the three modalities. The findings are summarised in the sections that follow.

Table 2.
Summary of clinical processes, with indications as to whether the literature supports their safe and effective delivery via tele-audiology practices.

CLINICAL SERVICE	CLINICIAN-LED	FACILITATOR-ASSISTED	SELF-LED
Otoscopy	✗	✓	✗
Wax Management	✗	✗	✓
Tympanometry & Acoustic Immittance Testing	✗	✓	✗
Otoacoustic Emission Testing	✗	✓	✗
Acoustic Reflex Testing	✗	✗	✗
Diagnostic Pure Tone Audiometry	✓	✓	✗
Hearing Screening	✓	✓	✓
Speech Testing	✓	✓	✓
Ear Impressions	✗	✗	✗
Hearing Aid Fitting/Initial Programming	✗	✓	✓
Hearing Aid Fine-tuning and Aftercare	✓	✓	✓
Hearing Rehabilitation Support Services	✓	✗	✗
Tinnitus Management/Counselling	✓	✗	✓

5.1 Otoscopy

Otoscopy is a clinical procedure used to examine structures of the ear, particularly the external auditory canal, tympanic membrane (eardrum), and middle ear. Traditional otoscopy requires the clinician to use a handheld or video-otoscope to inspect the eardrum and surrounding structures, either synchronously (live) or asynchronously (via still images and video recordings). Otoscopy is used to assist with diagnosis of ear pathologies and to identify the need for referral for medical intervention (such as otitis media). Otoscopy is routinely completed in almost every audiological appointment, with HSP requiring results to be clearly documented for assessments (600, 800) and fittings (e.g. 630, 640, 820, 830).

Summary of Evidence for Otoscopy

Clinician-led

There was no supporting literature found exploring clinician-led otoscopy via tele-audiology without the support of a trained facilitator.

Facilitator-assisted

There is evidence to support the safe and effective completion of otoscopy in a tele-audiology model with the assistance of a trained facilitator.

Self-led

Although there is emerging evidence demonstrating the potential for self-led otoscopy via tele-audiology, further evidence is required to support its safe and effective use in clinical practice.

Clinician-led

There was no supporting literature found exploring clinician-led otoscopy via tele-audiology without the support of a trained facilitator such as a nurse or physician.

Facilitator-assisted

The following information has been drawn from the literature and should be considered for facilitator-led tele-audiology service.

Equipment

Video-otoscopes are used both in the clinic and for tele-audiology purposes. Evidence shows that the quality of the images produced by video-otoscope is equal, or even superior, to visual inspection when both are performed by qualified clinicians, thus inferring that video-otoscopy is a suitable tool for tele-audiology services [37, 38].

Recent advances in technology have seen the evolution of smartphone-enabled otoscopes. Smartphone-enabled otoscopes are smaller and more affordable than traditional video-otoscopes, and appear to be easier to use than standard otoscopes and can serve as efficacious learning tools for medical students and residents [39]. They are thus more accessible to a wider range of health settings around the world. Research suggests that the quality of the images produced by smartphone-enabled otoscopes is comparable to that produced by traditional video-otoscopes, and when observed via the naked eye [40]. A cross-sectional study (N=56 adults and children) was conducted to evaluate the validity of a smartphone-enabled otoscope as a tool for diagnosing ear disease and in determining whether referral to an ENT centre was warranted [41]. Recordings from four (7.1%) of the participants were of insufficient quality to make a diagnosis. Of the remaining 52 participants, the same diagnosis was reached for 99 of 104 ears when comparing the device (conducted by an ENT trainee and a GP trainee – images store-and-forwarded to a qualified ENT) to standard assessment (hand held otoscope used by a qualified ENT) (95% concordance), with Cohen's kappa coefficient of 0.89. The decision as to whether a client should be referred to an ENT centre for further assessment was the same for all 52 participants when comparing the device to standard assessment.

Facilitator Training/Skill

Variations in the effectiveness of remotely performed otoscopy when compared to traditional otoscopy appear to be related more to the skill of the facilitator than the quality of the equipment. Several studies have demonstrated the equal effectiveness of remotely performed otoscopy when compared to traditional otoscopy, via the use of a facilitator when the facilitator is a fully qualified hospital physician [42], a trained assistant [43, 44], and a trained telehealth clinic facilitator [45]. However, studies have shown that when the facilitator is less experienced, then the quality of the images obtained and the ability to make safe and reliable clinical interpretations and recommendations also deteriorates; including when the facilitator is a parent of the child client [46] or a local health care workers [47]. It is reported that remote video-otoscopy image quality tended to be higher later in the study as a sign of improved skills of examiners [48].

Age of the client

A significant correlation between image quality and age of the subject has been reported [26, 44], suggesting that remote otoscopy should be used with caution for younger children. These findings are possibly explained by the fact that younger children usually have narrower ear canals, and as a consequence have more build-up of wax, and may also may be less cooperative to the imaging procedure. Therefore, it would be advisable to consider how similar issues may impact the completion of otoscopy in the adult population. This should include known challenges like ear canal collapse resulting from degenerative changes to the ear canal, thinning skin which may be more susceptible to tearing, and spontaneous involuntary movements due to other conditions.

Quality of the image

Although studies suggest that overall image quality appears adequate for remote otoscopy facilitated by a trained health professional (e.g. 82.3% of acceptable or excellent quality [48]), image quality can vary between clients, and this can have significant ramifications on an individual basis. The position and thickness of the eardrum are the most important elements in images to be able to assess inflammatory disease [48]. To address the issue of poor image quality, some researchers [48] suggest taking multiple video-otoscopic images or video-clips of each ear, rather than relying on a single image [26, 44]. Others have demonstrated that the lack of depth perception afforded by video-otoscopic images could be addressed via the use of video-pneumatic otoscopy to assist with identification of retracted tympanic membranes and be appropriate for use within a hearing telehealth clinic [49, 50]. Access to tympanometry results reduces dependence on otoscopic image quality for accurate diagnosis during telehealth assessment [51].

Self-led

Although there is emerging evidence demonstrating the potential for self-led otoscopy via tele-audiology, further evidence is required to support its safe and effective use in clinical practice.

Preliminary evidence for a newly developed image-analysis classification system demonstrates promise for self-led tele-otoscopy practices. The system is able to diagnose with high accuracy:

i. A normal tympanic membrane,

ii. Obstructing wax or foreign bodies in the external ear canal,

iii. Acute otitis media,

iv. Otitis media with effusion and

v. Chronic suppurative otitis media [52]. Furthermore, the system appears to classify otitis media with an accuracy comparable to that of general practitioners and paediatricians [53].

Key Considerations for Remote Otoscopy

- Facilitator skill and experience level can impact successful outcomes.
- The use of video-otoscopy is recommended over still images, enabling the audiologist to see more of the eardrum and surrounding tissue when reviewing the image/videos later.
- Success of remote otoscopy may be dependent on the age of the client.
- The quality of images impacts upon the quality of the care provided.
- A set of protocols for video-otoscopy will ensure optimal image/video quality and ensure safety during otoscopy [45] .

5.2 Wax Management

Ear wax accumulation is a normal function of the ear and does not require intervention unless it is symptomatic *[54]*. Impacted or excessive earwax can obscure visualisation of the tympanic membrane and lead to other symptoms, including reduced hearing, ear pain, balance disturbance, and tinnitus *[55, 56]*. Although wax removal is not funded through the HSP, it is routinely completed in audiological settings to allow full view of the auditory canal, accurate hearing evaluation, fitting of hearing aids, and can be required to address amplification issues, like device feedback. Methods for wax removal are dependent on training and may include manual extraction, irrigation, suction, or topical agents *[57]*.

Summary of Evidence for Wax Management

Clinician-led

There is no supporting literature found for clinician-led wax removal via tele-audiology as it is not currently possible for a clinician to perform wax removal without being face-to-face to the client.

Facilitator-assisted

There is no supporting literature demonstrating successful wax removal by a trained facilitator in a telehealth model.

Self-led

The literature indicates that there are options available for individuals to self-manage wax accumulation.

Clinician-led

There is no supporting literature found for clinician-led wax removal via tele-audiology as it is not currently possible for a clinician to perform wax removal without being face-to-face to the client.

In current practice, if a clinician cannot safely or successfully complete wax removal, they must then recommend alternative solutions for wax management, such as referral to a GP or nurse practitioner. Although not explored in the literature, if a clinician detected occluding wax was problematic for a client during a remote consultation, they could provide recommendations for wax management or referral to a GP for wax management.

Facilitator-assisted

There is no supporting literature demonstrating successful wax removal by a trained facilitator in a telehealth model.

In current practice, if a clinician cannot safely or successfully complete wax removal, they must then recommend alternative solutions for wax management, such as referral to a GP or nurse practitioner. Although not explored in the literature, if a clinician during a remote session detected occluding wax was problematic for a client with the support of a facilitator, they could provide recommendations for wax management or referral to a GP for wax management.

Wax removal requires considerable skill and the general consensus is that it should be performed by a qualified professional; however, there are no set requirements for what qualifications or training are necessary to provide this service. Therefore, it could be argued that there is future scope for a facilitator to perform wax removal on behalf of a clinician, provided they have received adequate training, are appropriately supervised, and obtain the necessary skills for this service.

However, consideration should be given to the potential significant adverse effects caused by wax removal. These may in include mild symptoms, like pain or nausea, but can extend to significant trauma of the auditory system, resulting in tympanic membrane perforation, permanent hearing loss, facial paralysis, and/or loss of balance *[58, 59]*. To ensure client safety these risks should be thoroughly considered and specific training requirements should be met. There are also liability issues for an allied health professional to provide this service without adequate training and the appropriate administrative and insurance cover *[60]*.

Self-led

The literature indicates that there are options available for individuals to self-manage wax accumulation. However, if attempted without seeking advice from a trained professional, an individual may attempt wax removal when there is another underlying ear pathology present which could potentially cause significant problems.

Cerumenolytics (earwax softening solutions) can be purchased over the counter in pharmacies, but should not be used in the case of ear perforation or ear infection. Thus, we recommend that trained health professionals play an important role in first diagnosing the ear condition, and providing appropriate clinical advice for its subsequent management *[61]*.

In current audiological practice, self-administered softening agents are commonly recommended by the audiologist to aid the normal wax process once diagnosis has been made and related conditions taken into account. Softening agents can be used independent of other interventions, however, research suggests they perform best when followed by irrigation *[54, 62]*.

Self-irrigation devices are available, which allow an individual to flush their own ears. These have been shown to be effective for the initial treatment for wax accumulation with minimal risk of harm *[63]*.

Evidence suggests that the use of cotton buds or ear candles pose significant health risks and should not be used for the management of earwax *[64, 65]*.

Key Considerations for Wax Removal

- Otoscopic examination of auditory canal prior to wax removal is recommended to ensure appropriate management solutions.
- In rural and remote Australia there is opportunity for audiologists to refer to local GPs and/or health nurse clinics for wax removal, or to train local facilitators, such as health nurses.
- Audiologists should be aware of the dangers of self-led wax management practices.

5.3 Tympanometry & Acoustic Immittance Testing

Tympanometry is a measurement of middle ear function, measuring the acoustic immittance in the ear canal as a function of varying ear canal pressure *[66]*. It requires a probe tip to be placed at the entrance of the ear canal. An air tight seal is required to allow air pressure changes to be transferred to the eardrum *[66]*.

Tympanometry is routinely completed to assess middle ear function during diagnostic hearing assessments and is used to review middle ear health as clinically indicated. Tympanometry can be completed as a portion of an HSP hearing assessment (600/800 claim) and also be carried out as part of an annual review appointment (930/940 claim).

Summary of Evidence for Tympanometry & Acoustic Immittance Testing

Clinician-led

There was no supporting literature found for clinician-led tympanometry testing via tele-audiology without the support of a facilitator.

Facilitator-assisted

The literature supports that tympanometry can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator.

Self-led

There was no supporting literature found for self-managed tympanometry testing via tele-audiology.

Clinician-led

There was no supporting literature found for clinician-led tympanometry testing via tele-audiology without the support of a trained facilitator.

Facilitator-assisted

The literature supports that tympanometry can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator. The evidence shows a high agreement (76-100%) between traditional face-to-face methods and tympanometry results obtained by a trained facilitator via tele-practice *[43, 51, 67]*.

Several studies *[50, 51]* have demonstrated successful completion of tympanometry by a trained facilitator asynchronously, where the results were sent to a qualified clinician for interpretation. One study *[50]* has shown a full agreement between tympanometry results obtained onsite by an audiologist and asynchronously by a trained assistant, whilst another *[51]* showed a 76% agreement between the two test conditions.

Synchronous completion of tympanometry, with the clinician controlling equipment from a remote location, was shown to be successful *[68]*. However, of the 82 ears included at the start of the study only 40 ears were subsequently tested via telehealth due to logistical barriers such as internet connectivity and scheduling issues. Of the 42 ears then tested via telehealth, tympanometry was unsuccessful for 10 ears as a sufficient seal could not be obtained by the facilitator.

One study *[51]* has reported that access to tympanometry results reduces dependence on otoscopic image quality for accurate diagnosis during telehealth assessment.

Additionally, case study reports have described successful implementation of synchronous tympanometry by trained facilitators in adults *[69]* and children *[70]*, with these reports stating that no technical or environmental issues interfered with testing or prevented satisfactory completion of assessment.

The following information has been drawn from the literature and should be considered in any future facilitator-led tele-audiology service.

Testing methods

Clinicians can provide live feedback and assess the accuracy of the tympanometry seal *[68]*. Even with live feedback available, there were still approximately 25% of ears where an adequate seal was not obtained.

It could be argued that this number would have been higher without the input and assistance of the clinician in real time. However, in the study the number of different probe tip sizes available to the facilitator was limited to improve ease of testing, which may have restricted the facilitator's ability to adapt testing for individual clients and restricted success in obtaining an adequate seal. Regardless, even within a standard clinical setting the success rate for clinicians to obtain a clinically useful tympanogram tracing is between 74-94% *[71]*.

Self-led

There was no supporting literature found for self-managed tympanometry testing via tele-audiology.

Key considerations for Tympanometry

- Current evidence supports completion of tympanometry with a trained facilitator
- Facilitators needs adequate training and skill.
- Synchronous is preferred over asynchronous testing as it allows the clinician to give real-time feedback to facilitator on their technique.

5.4 Otoacoustic Emission Testing

Otoacoustic emissions (OAEs) are sounds that originate in the inner ear, which can be measured to determine the presence of pathology *[66]*. Assessment of OAEs are not a requirement for claiming through the HSP, however, they are often used by clinicians to objectively confirm the presence of a hearing loss. Objective evaluations can be particularly useful when working with young children, people with cognitive impairment, or when needing to confirm the reliability of results in instances of possible malingering.

Summary of Evidence for Otoacoustic Emission Testing

Clinician-led

There was no supporting literature found for clinician-led OAE testing via tele-audiology without the support of a facilitator.

Facilitator-assisted

There is literature to support the safe and effective completion of OAE testing in a tele-audiology model with the support of a trained facilitator.

Self-led

There was no supporting literature found for self-managed OAE testing via tele-audiology.

Clinician-led

There was no supporting literature found for clinician-led OAE testing via tele-audiology without the support of a facilitator.

Facilitator-assisted

There is literature to support the safe and effective completion of OAE testing in a tele-audiology model with the support of a trained facilitator. Three studies demonstrated that results obtained synchronously by an offsite clinician, with the support of a facilitator, produced equivalent results to traditional methods *[72-74]*. Additionally, others have demonstrated that there was no significant timing difference between the different methods *[68, 72]*.

The Children's Hospital Colorado also report to have successfully implemented OAE testing within a pilot program for tele-audiology in the western Pacific region. Eight infants were assessed in this program and no technical or environmental issues interfered with testing or prevented satisfactory completion of assessment *[70]*.

The following information has been drawn from the literature and should be considered in any future facilitator-led tele-audiology service.

Environment

OAE testing is highly susceptible to interference from environmental and internal noise, like fans, talking or restlessness *[66]*. A quiet testing room is required to effectively test OAEs to ensure a minimal noise floor for testing *[73]*. It is therefore pivotal to ensure the testing environment is calm and quiet to minimise interference.

Testing methods

The learnings in tympanometry *[68]* can be applied to OAE testing as both tests require a tight seal for accurate results.

Self-led

There was no supporting literature found for self-managed OAE testing via tele-audiology.

Key considerations for OAEs

- Current evidence supports completion of otoacoustic emissions testing with a trained facilitator.
- Facilitators require adequate training and skill.
- A quiet and calm room is required to ensure a minimal noise floor for testing.

5.5 Acoustic Reflex Testing

Muscles in the middle ear reflexively contract in response to sound, which is known as the acoustic reflex *[66]*. The acoustic reflex can be measured following presentation of sound stimuli to the ear and is often recorded with tympanometry instrumentation. Although acoustic reflex testing is not a requirement for claiming through HSP, testing can provide additional information to help establish clinical diagnoses during hearing assessments.

Summary of Evidence for Acoustic Reflex Testing

Clinician-led

There was no supporting literature found for acoustic reflex testing via tele-audiology.

Facilitator-assisted

There was no supporting literature found for facilitator-assisted acoustic reflex testing via tele-audiology.

Self-led

There was no supporting literature found for self-managed acoustic reflex testing via tele-audiology.

There was no evidence found in the literature search assessing the feasibility or efficacy of acoustic reflex testing via telehealth in any modality. However, the testing procedure for acoustic reflexes is similar to tympanometry and OAE testing, whereby a probe tip, with a tight seal, is inserted into the ear canal for a measurement to be taken. Given the similarities, it should be possible to extrapolate the findings from these tests and apply the principles to acoustic reflex testing.

The following is relevant if it can be assumed that findings from the tympanometry and OAE literature search are adequate to make inferences for acoustic reflex testing.

Clinician-led

There was no supporting literature found for clinician-led tympanometry or OAE testing via tele-audiology. Therefore, there is no evidence to infer that acoustic reflex testing can currently be successfully completed in a clinician-led telehealth service delivery model.

Facilitator-assisted

There is literature to support the safe and effective completion of tympanometry and OAE testing synchronously in a tele-audiology model with the support of a trained facilitator. These findings suggest it should be feasible to complete acoustic reflex testing with a facilitator supported telehealth model.

Self-led

There was no supporting literature found for self-managed tympanometry or OAE testing via tele-audiology. Therefore, it can be inferred that acoustic reflex testing cannot be successfully completed in a self-managed service model.

Key considerations for Acoustic Reflexes

- Facilitator requires adequate training and skill.
- Synchronous testing may be preferred over asynchronous as it allows the clinician to give real-time feedback to the facilitator on their technique and the results being produced.
- A quiet and calm room is required to ensure a minimal noise floor for testing.

5.6 Diagnostic Pure Tone Audiometry

Diagnostic pure tone audiometry (PTA) allows a clinician to establish the degree of hearing loss and quantify frequency-specific information regarding function of the auditory system *[66]*. Diagnostic PTA involves testing of both air conduction (AC) and bone conduction (BC) thresholds at varying intervals between 125 to 8000Hz. AC testing assesses the entire auditory pathway, whilst BC testing provides cochlea-specific threshold information. Following assessment, AC and BC thresholds can be compared to establish the status of different components of the ear *[66]*. According to the HSP, PTA is a required task for a first assessment (600) and reassessment (800).

Summary of Evidence for Diagnostic Pure Tone Audiometry

Audiologist

There is some evidence to support the completion of diagnostic AC testing via telehealth with a clinician independently running the appointment; however, there was no evidence found for BC testing in this model.

Facilitator-assisted

The research supports that pure tone audiometry testing can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician.

Self-led

There was no supporting literature found for self-led diagnostic PTA via tele-audiology.

Clinician-led

There is some evidence to support the completion of diagnostic AC testing via telehealth with a clinician independently running the appointment; however, there was no evidence found for BC testing in this model.

There are no significant differences between AC thresholds obtained in-clinic compared to those obtained in a synchronous assessment *[75]*. It was noted that although the differences were not significant, there were more errors with testing at the remote site. Additionally, the "remote site" used for the study was a sound proof booth, so it is likely the errors would have been higher if tested in a more realistic tele-environment where ambient noise can be higher, such as in the client's home. A valuable aspect of this study was that an automatic calibration was utilised in the system to allow for differing technology with the end user (client), ensuring that the sound pressure level generated during testing was controlled.

Current hearing aid technology also allows for synchronous assessment of hearing, whereby the clinician remotely connects to a client's device to perform audiometry. For example, the tested threshold in Phonak's Audiogram Direct showed results of standard and in-situ AC audiometry through the hearing aid were highly correlated and suggested a high level of agreement *[76]*. The authors report that the mean difference between pure tone averages was <1dB HL, which is negligible from a clinical viewpoint This finding is supported with results using Widex technology *[77]*, showing the test-retest reliability of their audiometry software was within 1dB and equivalent to that of currently accepted audiometric procedures.

Testing through the hearing aid is considered advantageous given signals are presented through the same speaker system that will be used for amplification *[78]*; however, these methods only test AC and do not allow for BC assessment. Furthermore, testing via this method may be impacted by poor condition of the hearing aid (e.g. blocked filter or tubing), the physical fit of device and potential for sound leakage through venting *[79]*, or condition of the ear (e.g. wax block, ear infection). Additionally, software needs to control for varying sound pressure levels in the ear canal given different acoustic properties of devices and ambient noise needs to be minimised during testing *[80]*.

Smart device applications also allow the opportunity for remote assessment of AC thresholds. One study *[81]* found that automated AC evaluation completed in the home environment using a tablet-based application produced statistically equivalent threshold information when compared to traditional test methods from 500 to 8000Hz. However, thresholds at 250Hz were elevated when tested in the home environment, which was attributed to the likely impact of increased ambient noise in this setting. Accurate representation of low frequency thresholds is important for pathologies like Meniere's disease, where low frequency hearing fluctuations are observed during episodes of the disease. These individual variations are also common in general clinical practice.

Facilitator-assisted

Pure tone audiometry (PTA) testing can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician.

Six studies were found assessing the feasibility of PTA synchronously tested through a remotely controlled audiometer via the internet. Thresholds obtained remotely varied by no more than 1.3dB for AC and 1.2dB for BC when compared to conventional methods *[82]*; which is within the accepted limits of test-retest reliability. This is consistent with findings from others *[83]* who found remotely assessed AC and BC thresholds with a computer-based audiometer were within typical test-retest limits.

Additional research has found no clinically significant difference for AC thresholds between conventional face-to-face testing and testing via a remotely controlled audiometry system. *[68, 84-87]*. An Australian case study has also described successful implementation of synchronous audiometry by trained facilitators *[69]*.

The following information has been drawn from the literature and should be considered in any future facilitator-led tele-audiology service.

Environment

The majority of these studies were completed in a typical sound treated environment, however, a study of audiometry in a natural environment (non-sound treated office setting) found thresholds were equivalent to results obtained in a sound proof booth *[86]*. This study, and one other study *[88]* utilised insert headphones coupled with headphones that cover the ears to minimise the impact of background noise, whilst also incorporating noise level monitoring in the test set-up.

Facilitator Role

In these studies, for the audiologist to be able to remotely access the audiometer at the client site a facilitator was required to establish the connection. In addition to technical set-up, the use of a trained facilitator ensured correct headphone placement during testing *[84]*.

Automated audiometry

A number of devices are available that automated the process of audiometry. The evidence from numerous studies have shown them to accurately and reliably measure pure tone air and bone conduction thresholds *[26, 83, 88-92]*. For example, the KUDUWave (Geoaxon, South Africa) uses inset earphones and headphones that cover the ears to provide the same level of ambient sound attenuation as sound booths *[93]*. Mobile technologies have also been

Key considerations for Pure Tone Audiometry

- A quiet room is required to minimise impact of ambient noise on low frequency thresholds.
- Insert headphones coupled with circumaural headphones are recommended to further reduce the negative effects of background noise.
- Trained facilitators are required to ensure correct positioning of headphones.
- Bluetooth and tele-compatible hearing aid technology is beneficial for remote assessment, however, may be impacted by poor condition of the device.
- Adequate internet connection and speed required given the time-locked nature of audiometry.
- Remote assessment of hearing via the hearing aid appears promising; however, current test methods only allow for AC and not BC assessment. The quality of results are heavily affected by the condition (cleanliness and functioning) of the hearing aid at time of assessment.
- All results are impacted by the condition of the test subject’s ear.
- Automated audiometry should be considered for facilitator-led audiometry.

5.7 Hearing Screening

As noted in the previous section (6.6 Diagnostic Pure Tone Audiometry), diagnostic pure tone audiometry (PTA) is a comprehensive assessment of hearing thresholds, which provides information on the degree and nature of hearing loss. PTA involves testing of both air conduction (AC) and bone conduction (BC) thresholds at varying intervals between 125 and 8000Hz.

Prior to PTA testing, hearing screenings act as a valuable tool in the initial identification of a hearing problem. Screenings are usually a modified or shortened PTA assessment, which follow a pass/fail method, and can serve as a prompt for further diagnostic evaluation. Although screening practices are not funded through the HSP, they are often utilised by service providers as an initial engagement service.

In addition to hearing loss identification, hearing screening can be used at regular intervals following a full diagnostic hearing assessment to determine if there have been any changes to hearing thresholds. Screenings carried out for this purpose can compose part of a "client review" appointment type within the HSP (claims 930/940), with an assessment of middle ear status (tympanometry or check of bone conduction) also required in conjunction to a screening test.

Summary of Evidence for Hearing Screening

Clinician-led

The research supports that hearing screening can be safely and effectively completed in a tele-audiology model.

Facilitator-assisted

The research supports that hearing screening can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician.

Self-led

The research supports safe and effective hearing screening via self-led tele-audiology approaches.

Clinician-led

Evidence for pure tone audiometry (section 6.6) can be further applied to support audiologist-led screening procedures.

No significant difference was found for synchronous assessment of AC thresholds obtained remotely via computer and tablet-based interfaces when compared to traditional methods *[75, 81]*. In-situ AC assessment completed through hearing devices has also demonstrated a high level of agreement with traditional audiometry *[77]*.

Facilitator-assisted

There is evidence to support facilitator-assisted hearing screenings within a tele-audiology service model.

It has been shown *[98]* that a gamified tablet application was equally as sensitive for screening adult hearing as traditional methods. Testing was completed outside a sound-proof booth, in a controlled quiet environment.

Synchronous hearing screening by an audiologist in a school environment was shown to be consistent with in-person test results *[99]*. The facilitator was able to complete a listening check in the test location to ensure suitability for testing and a video connection was utilised so the audiologist could ensure correct headphone placement and observe each child's responses during testing. No significant timing differences were noted between the two methods.

Evidence for pure tone audiometry (section 6.6) can be further applied to support audiologist-led screening procedures. As highlighted, research supports that PTA can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician *[68, 82, 85-87, 100]*.

Patient Suitability

Studies have shown poorer accuracy and increased client fatigue for tele-screening in paediatric populations *[43, 101, 102]*. Therefore, prior consideration before introduction into other population groups, including adults with additional impairments, would be beneficial to determine suitability of these methods.

Connectivity

As hearing assessment requires a time locked response, the viability of remote assessment is dependent on good internet connection, with bandwidths greater than 15Kbps recommended *[85, 99]*.

Environment

A quiet testing environment is required to minimise the impact of noise on testing *[99]*.

Self-led

Telephone, smart device and web-based screening tools are available to help individuals identify when further testing or intervention is required.

There is evidence that these screening tools are comparable to traditional methods *[103-106]*. However, it is noted that these studies were conducted in controlled listening environments with low ambient noise levels. Additionally, as the results were obtained under experimental conditions researchers were able to complete otoscopy to control for ear health. These factors are not consistent with real world telehealth services delivered in-the-home.

Screening and assessment programmes that utilise spoken digits (digit triplet test) have been developed and implemented, showing good sensitivity and specificity in identify hearing difficulties *[107-110]*.

Key considerations for Hearing Screening

- A quiet room is required to minimise impact of ambient noise on low frequency thresholds.
- Bluetooth and tele-compatible hearing aid technology is beneficial for remote assessment; however, this may be impacted by poor condition of the device.
- Adequate internet connection and speed required given the time-locked nature of audiometry.
- Results may be negatively impacted by the condition of the client's ear and/or hearing device/s.
- Although technical aspects of hearing screening can be safely and effectively delivered via self-led approaches, clinician involvement is still required to provide explanation of the test results and consultation regarding treatment/ management options following hearing screening.

5.8 Speech Testing

The applications for speech testing within audiology are diverse. Speech testing can serve as a screening or diagnostic tool to help determine pathology, an instrument to quantify degree of communication difficulty, or to allow insight into the rehabilitative needs of the client. In clinical practice, varied speech materials and presentation methods are utilised.

Under the HSP program, a full hearing evaluation (600/800 claim) usually includes completion of speech discrimination testing. Speech tests are also used within the HSP program to validate outcomes with amplification, which includes documentation of aided benefit for claimable hearing aid fittings (e.g. 630, 640, 650, 820, 830).

Summary of Evidence for Speech Testing

Clinician-led

There is limited evidence supporting clinician-led speech testing via telehealth without the support of a facilitator.

Facilitator-assisted

The research supports speech testing via telehealth with the support of a trained facilitator.

Self-led

The research supports speech testing via telehealth with the support of a trained facilitator.

Clinician-led

One article was found in the literature search supporting clinician-led speech testing via telehealth without the support of a facilitator. Speech in noise recognition scores obtained through an automated tablet application was equivalent between the remote and sound proof booth test conditions *[81]*. It was reported that tests completed at home with the tablet were statistically equivalent to suprathreshold tests of speech recognition in noise.

The HSP fitting process requires that aided speech testing is completed to demonstrate benefit with amplification *[111]*. Although no evidence was found in the literature, it would be possible to complete aided speech testing via tele-audiology with the clinician presenting speech material with monitored live voice and video link. Video would allow the option to test with visual cues if necessary. It would be required to ensure controlled test conditions. Further research into the suitability and reliability of this method is recommended.

Facilitator-assisted

There is research to support that speech testing can be completed in a telehealth model with the support of a trained facilitator.

In participants with normal hearing, good reliability (Kappa Coefficient 0.96-0.98) between measures of speech intelligibility in noise obtained via standard methods and remotely over the internet has been demonstrated *[112]*. Testing was completed synchronously using video and microphone capabilities with the participant in a sound proof booth.

Others have demonstrated successful assessment of aided speech testing synchronously with the support of a facilitator *[113]*. The HINT test was administered to assess performance in quiet and in noise. No significant difference was documented for either test condition between the control and tele group. However, it was noted that of the 25 participants in the telehealth group, three individuals failed to complete the evaluation of speech which may have impacted results.

Speech presented remotely via direct-audio-input to an individual's device was comparable to in-person testing in a sound proof booth for cochlear implant users *[114]*. The direct link to the hearing device circumvents the effect of ambient noise, which allowed comparable results to testing in the booth. Therefore, there may be future scope for this technology to be incorporated into hearing aids to allow the remote testing of speech without a booth. The limitation of this method is that if there is an issue with the device (e.g. debris in microphone) it may not be known and result in poorer performance *[114]*.

Simpler speech testing, e.g. the Ling-test, has been used to assess cochlear implant performance *[115]*.

The following information has been drawn from the literature and should be considered in any future facilitator-led tele-audiology service.

Scoring

One study found that the voice signal heard by the testing clinician became degraded with high internet traffic *[112]*. To overcome this issue the facilitator connected with the clinician via telephone so an adequate audio signal could still be heard. However, this study is over 15 years old, and internet capacity has increased for most users since then. Another study demonstrated success with an automatic speech scoring algorithm, which was shown to perform better than the human operator, and there may be further scope to implement this in testing to further reduce the impact of poor audio signal for scoring *[116]*.

Test Environment

Studies have shown that remote test conditions in an office without a sound proof booth can result in poorer speech scores for cochlear implant users *[117, 118]*. If fluctuating background noise can be controlled, like air-conditioning or electronics, better scores are obtained but it is likely not enough to provide an adequately controlled environment *[119]*. However, the appropriateness of speech testing in a booth has been questioned *[119]*, given it often results in inflated performance compared to subject reports of real-life abilities.

Self-led

Self-led speech-based tools are available to help individuals identify when they may need to consult their hearing professional or to illustrate particular difficulties.

A self-led online speech testing tool was developed by Blamey & Saunders Hearing Pty Ltd which was demonstrated to show a high correlation with conventional audiograms in the better ear *[120]*. The authors report the test can be utilised to assess hearing and prescribe amplification without the need for specialised audiological equipment. However, it was documented that the test is not as sensitive to mild hearing losses, where speech perception is not impacted, or hearing losses of greater severity, where speech is no longer audible. Additionally, poorer results were obtained for non-native English speakers and for people with non-Australian accents.

The National Acoustic Laboratories (Sydney, Australia), in partnership with Cochlear Ltd (Sydney, Australia), have developed "The Hearing Aid Check", which is a language-independent measure of an individual's ability to discriminate between similar speech sounds. The test is utilised to determine a client's aided ability and identify if they are likely to benefit from cochlear implantation. Whilst the test is not intended to serve as a diagnostic tool or replace audiological advice, it can help navigate clients towards required services.

Key considerations for Speech Testing

- A quiet room is required to minimise impact of ambient noise on low frequency thresholds.
- Trained facilitators are required to ensure correct positioning of headphones.
- Adequate internet connection and speed is required given the time-locked nature of audiometry.
- For verification of aided performance, it may be difficult to discern whether a hearing device is functioning sufficiently well when conducting speech tests remotely; poor performing devices can negatively affect the accuracy of speech test results.

5.9 Ear Impressions

For custom-made amplification accessories or devices, an impression of the ear is required. To make an impression of the ear, a foam block is inserted into the ear canal and then the ear is filled with soft material that then sets to create a 3D impression of the ear. Best clinical practice and HSP guidelines indicate it is a requirement for the clinician to protect the safety and comfort of the client when making impressions of the ear *[121]*.

Summary of Evidence for Ear Impressions

Clinician-led

There was no supporting literature found for clinician-led ear impressions via tele-audiology.

Facilitator-assisted

There was no supporting literature investigating the viability of a trained facilitator obtaining ear impressions in a telehealth model.

Self-led

The literature does not support self-made ear impression procedures.

Clinician-led

There was no supporting literature found for clinician-led ear impressions via tele-audiology.

Facilitator-assisted

There was no supporting literature investigating the viability of a trained facilitator obtaining ear impressions in a telehealth model.

Consideration should be given to the potential for adverse effects caused by ear impressions. There are no set guidelines for what qualifications or training are required to provide this service. Therefore, it could be argued that there is future scope for a facilitator to obtain ear impressions on behalf of a clinician, provided they have received adequate training, are appropriately supervised, and obtain the necessary skills for this service.

There is also future potential for high resolution scanning of the ear canal to be completed by facilitators to obtain an impression of the ear. 3D ear scanning solutions are commercially available (e.g. Natus Medical's Otoscan®); however, their effectiveness, particularly when operated by a non-clinician, needs to be determined prior to implementation in a tele-setting. Additionally, the cost effectiveness of such technology is worthy of exploration.

Self-led

The literature does not support self-made ear impression procedures.

In an investigation of the ability of untrained consumers to obtain adequate ear impressions using an "at home" impression kit, participants worked in familiar pairs to take an impression of each other's ear *[122]*. The quality of these impressions was then rated and compared to impressions taken by trained audiology students in a blind study. Unsurprisingly, the quality of impressions by audiology students were significantly (p=0.001) higher rated than the untrained consumer. The study also highlights that participants felt uncomfortable inserting the foam block deep in the ear.

Concerns were also raised regarding safety of do-it-yourself impression kits, highlighting the potential for ear trauma during the process or debris remaining in the canal following the procedure *[122]*. Another concern is the impact that ill-fitting devices will have on sound quality and output. In a study of hearing protection devices created from self-made impressions, Pack *[123]* found that amateur made impressions resulted in poorer sound attention and were considered inadequate.

Key considerations for Ear Impressions

- There was no supporting literature demonstrating ear impressions successfully obtained via remote methods.

5.10 Hearing Aid Fitting/ Initial Programming

Hearing loss rehabilitation within HSP is primarily focused on the provision of amplification devices to address communication difficulties and improve hearing. For new device users or return clients who are proceeding with new devices, a fitting appointment is required for the clinician to complete the initial programming of the device (e.g. claims 630, 640, 820, 830).

It is a requirement for devices fitted through the HSP program are verified against a prescriptive target using Real-Ear-Measures (REMs), which require complex fitting programs and computer systems to carry out *[111]*. REMs are the only objective measure of sound between the hearing aid and tympanic membrane and are considered to be the "gold standard" for verifying hearing aid output *[124]*.

There is an argument that devices should be programmed to manufacturer "first fit" prescription settings, as the research and development of the devices has been completed with these settings. However, independent research has shown better perceived benefit with devices verified against a prescriptive target *[125]*. Additionally, a study has found that individual's experiencing unsuccessful hearing aid outcomes were programmed with significantly lower gain than when compared to their prescriptive target *[126]*.

Furthermore, at the fitting appointment the subjective response to sound is determined and adjusted for, the physical fit of devices is assessed, the management of devices is explained and practised with the client, and expectations and communication strategies are discussed.

Individuals who are satisfied with the service from their hearing provider also reported greater satisfaction with their amplification devices *[127]*. Therefore, in any future tele-service model it is important to ensure the quality of care is not compromised to guarantee optimal hearing outcomes and best practice routine hearing aid use.

Summary of Evidence for Hearing Aid Fitting/Initial Programming

Clinician-led

There was no supporting literature found for clinician-led hearing aid fitting using REMs via tele-audiology.

Facilitator-assisted

Research evidence suggests that the fitting of amplification can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician.

Self-led

There is evidence to support the feasibility of self-fitting hearing aids as a rehabilitation option, however, the service delivery model involving self-fitting hearing aids is not currently supported by the HSP program

Clinician-led

There was no supporting literature found for clinician-led hearing aid fitting using REMs via tele-audiology.

Although verification via REMs is not viable in a clinician-led tele-model, it would be feasible to pre-program and verify device performance using coupler measures, with the device then sent out to the client. Once the client receives their devices, the clinician would then be able to conduct a tele-consultation to complete adjustments as required based on subjective aid performance and review device use and management with the client. This model was adopted by the HSP in response to the COVID-19 pandemic and the requirement for restricted interpersonal contact; however, it has not been permanently implemented within the program.

The drawback of 2cc-coupler measurements is that they use an approximate volume of the adult ear canal, which can impact amplification settings for individuals with canals that differ significantly from average (e.g. perforations, exostoses). Additionally, 2cc-coupler measurements provide poor approximation of sound at frequencies above 3KHz and are not as accurate for invisible-in-the-ear and completely-in-the-canal hearing devices *[128]*.

For this model to be viable, clients would be required to have Bluetooth compatible devices capable of remote adjustments, which is a feature not universally offered by manufacturers on the HSP full-subsidised schedule of devices.

Facilitator-assisted

Research evidence suggests that the fitting of amplification can be safely and effectively completed in a tele-audiology model with the support of a trained facilitator working synchronously with a clinician.

Five studies were found in the literature search supporting the completion of synchronous tele-fittings. Synchronous tele-fitting allows the clinician to ensure amplification settings have been adjusted appropriately and an accurate match to target has been obtained.

Conventional face-to-face REMs have been compared with measurements obtained remotely by an untrained facilitator working synchronously with a clinician *[129]*. Measurements were recorded at seven discrete frequencies between 250Hz and 6KHz. There was a significant correlation between the two methods and any differences that were documented fell within intra-tester retest variability. Similar findings were documented by another study *[113]*, which demonstrated that the magnitude of difference between REM targets for the control and tele-fittings were clinically negligible and fell within REIG test-retest variability.

Self-report measures of tele-fitting outcomes have also been presented in the literature and support the implementation of this service. No significant difference was found between client's reported experience during the tele process and a face-to-face consultation, including whether they felt understood by the clinician during the session *[130]*. Global outcomes measures have been used to demonstrate the effectiveness of hearing aid treatments, showing no significant difference between tele-audiology and face-to-face delivery of services *[113]*. Another study reported significant improvements following tele-fitting for outcome measures of aided hearing aid handicap, communication ability, and psychosocial function *[131]*.

The United States Department of Veterans Affairs (VA) has implemented synchronous tele-audiology practises for hearing aid fitting *[132]*. It demonstrated no clinically significant differences between hearing aid effectiveness for those fitted via tele-audiology versus conventional in-person methods.

Case study reports also support the implementation of tele-fitting, with these studies demonstrating successful completion of synchronous hearing aid fittings with adult clients *[69, 133]*.

The following information has been drawn from the literature and should be considered in any future facilitator-led tele-audiology service.

Timing

No significant difference for consultation time for tele-fittings conducted by trained facilitators (audiology students or audiologists with minimal amplification experience) *[113]*. This study utilised software with video capabilities, which enabled synchronous interaction between the clinician and client. The researchers found that although overall consultation time was the same in both conditions, for the tele group more time was spent fitting the hearing aid, however, less time was spent on informational counselling and the client orientating themselves with the device. They researchers considered that the video link prompted clients to be more actively involved in the process and to strive to demonstrate to the clinician over the video rather than just passively observe or listen to instructions. However, it could be argued that less time was spent on device management as the clinician was unable to notice subtle cues from the client indicating difficulties. However, upon review one month after fitting there was no significant difference regarding management difficulties experienced within each group. To minimise the chance of these subtle cues being missed, it would be essential for facilitators to be trained to recognise potential difficulties to alert the clinician when indicated. Another study *[130]* has found that tele-fitting consultations were 4.23 minutes longer in total time compared to face-to-face due to increased time spent instructing the facilitator, however, this was more than offset by the reduced travel time for the client to attend the appointment.

Environment

These studies were limited to tele-services offered in a clinical/office environment, therefore, the accuracy of tele-fitting in a home environment cannot be commented on. However, home-based visits are already accepted within HSP *[134]* and routinely completed for eligible clients who experience a medical condition that prevents them from travelling to the clinic.

Patient Suitability

Many of these studies did not include individuals with additional impairments and consequently the findings cannot necessarily be translated to other population groups. Additionally, the studies did not assess the feasibility of tele-fitting for complex hearing losses and the impact of atypical ear canal resonances on the ability of the facilitator to complete testing in this situation.

Technical Difficulties

Technical difficulties were reported in four of the studies, which included internet connectivity issues and technology malfunction (e.g. no video connection) *[113, 130, 131, 133]*. A 29 month-study found technical problems occurred primarily in the first year and were only minimal thereafter *[131]*. This suggests that technical issues may be minimised with training and experience. Research has demonstrated that, for cochlear implant users aligned with a facilitator, when the quality of audio-visual connection was not assessed as "good" these participants also rated contact with the audiologist poorer and reported lower satisfaction with feelings of security *[135]*. The exchange of written messages (e.g. text or chat function) is recommended so if there are issues with the video or audio connection, the clinician can still communicate with the facilitator *[133]*.

Equipment

A video otoscope can be used by a clinician to confirm correct probe placement by a facilitator when completing REMs *[131]*.

Self-led

There is evidence to support the feasibility of self-fitting hearing aids as a rehabilitation option, however, this model of service delivery is currently not supported by the HSP program.

A self-fitting hearing aid is a stand-alone instrument, capable of performing assessment, programming, optimisation and fine-tuning within the device. It is a hearing aid that can be fitted and managed entirely by the user, without assistance from a hearing health care professional. An Australian study found that, overall, there was a positive opinion of the concept of a self-fitting hearing aid *[136]*. Australian research has demonstrated that older adults with hearing loss are able to successfully self-fit hearing aids *[137]*. Greater fitting success was reported for people who have good cognitive function and have had previous experience with hearing aids and smartphones. Additionally, of those self-fitted successfully most required a trained support person available to answer questions about the procedure and help troubleshoot any problems they encounter. When self-fitting hearing aids were compared with conventional hearing aids that have been fitted by an audiologist, they found that people can understand speech equally well with both types of hearing aid. This is consistent with findings from another study which demonstrated no differences between traditional or self-fit methods in terms of hearing aid benefit or speech perception in noise *[138]*.

It should be considered that there is a risk of an audiologically inappropriate hearing aid fitting if advice is not sought from a health professional prior to purchasing the device *[139]*. Therefore, the input of an audiologist, or a health professional of some kind, is still recommended to identify any contraindications to hearing aid fitting. The risk of undetected medical issues means that the provision of self-fitting devices should be regulated to ensure there are safeguards against this happening.

Key considerations for Hearing Aid Fittings

- Procedures need to allow verification against a prescriptive target for best amplification outcomes.
- Bluetooth and tele-compatible hearing aid technology is beneficial for remote fittings.
- The facilitator needs adequate training and skill to be sensitive to the subtle cues of clients when they are experiencing difficulties.
- Synchronous testing is beneficial as it allows the clinician to give real-time feedback and build rapport with the client. Use of a video-otoscope can also be beneficial to ensure correct placement of probe tube.
- Technical difficulties can impact a client's satisfaction with the experience and their feelings of security; however, these difficulties are minimised with training and experience.
- A quiet and calm room is needed to ensure minimal noise floor for verification.
- Self-fitting hearing aids appear to be more successful for people who have good cognitive function and have had previous experience with hearing aids and smartphones.

5.11 Hearing Aid Fine-Tuning and Aftercare

Following the initial programming of a hearing device and at various intervals following this, individuals may require fine-tuning or re-programming of their device settings. These adjustments address issues regarding the subjective listening experience of the client in their everyday environments or other issues, like feedback.

Patients may also require aftercare, which covers further training and support regarding the management of their devices. This may include reviewing removal and insertion of the device, battery management, or device cleaning procedures. Additionally, there may be issues with device fit or comfort and physical modifications may be required to address this.

For initial and subsequent fittings, it is a requirement under HSP that a timely follow-up appointment is completed after an individual is fitted with a device (included under the device fitting claim items). Additionally, if it has been more than 12 months since the fitting and a client is experiencing suboptimal benefit or is not satisfied with their device, HSP will fund a review appointment (claim 930/940) to address hearing concerns. A review service can include adjustment to amplification settings and a review of device management and expectations *[140]*. However, throughout the rehabilitation journey, clients may require adjustments or aftercare outside of the HSP time frame and audiologists will often see clients at no cost for this support to ensure optimal client care.

Summary of Evidence for Hearing Aid Fine-Tuning and Aftercare

Clinician-led

There is research to support that fine-tuning and aftercare following fitting can be completed via telehealth with a clinician independently running the appointment.

Facilitator-assisted

There is research to support that fine-tuning and aftercare following amplification fitting can be completed via telehealth with the support of a facilitator working synchronously with a clinician.

Self-led

With advances in technology it is now feasible for clients to be able to fine-tune their devices independent of a clinician. However, the clinician needs to enable these features, train the client in how to make appropriate adjustments, and review changes to ensure that settings remain optimal for the client's hearing needs.

Clinician-led

There is research to support that fine-tuning and aftercare following fitting can be completed via telehealth with a clinician independently running the appointment.

Synchronous follow-up appointments are a feasible option for remote fine-tuning and management review (e.g. device cleaning, battery management), with an overall positive reaction from participants receiving care in this manner *[141]*. In this study a video interface was used for communication during the appointment and telephone communication was used as a back-up in instances of poor connection. 77% of appointments were successfully completed using video and these participants reported video-based communication was preferred over use of the telephone. Additionally, overall satisfaction was higher when video was used.

The operating system, age of computer, and internet connections varied for participants as to be representative of differing technology amongst clients. 23% of participants were unable to successfully establish a video connection, which was attributed to the age of the participant's computer or operating system, poor weather, or poor internet connection, rather than user error or familiarity.

A paediatric case study found tele-appointments following device fittings helped address issues impacting device usage *[142]*. Clinicians were able to access data-logging information more frequently to alert them to the potential need for troubleshooting. The advantages documented included readily available appointments to facilitate learning and increased consistency of device use; flexible appointments to help fit within family life; and opportunity for multiple family members to be involved, a valuable benefit given the importance of family-centred care. One respondent noted "if my child is ill, I could still hold our visit". Given the ever-changing landscape of interpersonal contact amidst the COVID-19 pandemic, the ability to remotely access care is of significant value.

Although not always considered under the umbrella of telehealth, telephone communication does allow a clinician to provide remote support to clients to help address and troubleshoot difficulties experienced with their devices. Telephone support has long been utilised by clinicians in this manner to provide care to their clients, although, there is limited research exploring outcomes related to telephone-delivered support. People with severe hearing loss often experience difficulty communicating over the phone *[143]*, and as such the broad applications of telephone-based services are questionable.

With advances in hearing aid and mobile phone technology, device manufacturers have developed smart device applications which allow remote sound adjustments and provide infrastructure for tele-appointments. Different manufacturers offer different tele-solutions, with some offering asynchronous support, others synchronous, some text chat features, and others video communication. Historically, these features were only available for partially subsidised devices under HSP, however, with advancing technology and in response to the COVID-19 pandemic there has been a shift towards some manufacturers offering these features in fully subsidised devices.

Manufacturer market research has shown these smart device applications provide a benefit in terms of convenience and improved accessibility to hearing healthcare *[144]*, the option of in-situational support, improved engagement with family members *[145]*, and a correlation with tele-services and hearing aid acceptance rate *[146]*.

A study has shown that manufacturer applications were rated as highly usable by participants *[147]*. The application took the client through a series of questions to identify their problem, which were then used by the clinician to make asynchronous adjustments to the sound settings which could then be downloaded through the application to client's hearing aids. There was no significant difference in fitting outcomes for these clients compared to those who attended the clinic face-to-face. Participants did report that the questions used to identify the problem were limited and did not always cover their individual needs. Additionally, it was noted that almost half of the requests received through the application required advice from the clinician or physical modification of the device. This limitation is consistent with findings of a systematic review that further exploration into the troubleshooting of physical and acoustic aspects of hearing aids and earmolds (e.g., grinding, drilling, re-tubing) given the challenges to complete this via telehealth *[19]*.

For clinician-led follow-up appointments, instruction guides should be provided, which include only the necessary steps in brief and exact language *[141]*. "Screenshots" or visual hints in the guide were also found to be helpful for the client to independently establish a connection from their end. A back-up communication method should also be in place should there be issues with connection.

These studies have only assessed the short-term satisfaction and outcomes of participants. However, the novelty of these methods may have impacted results and further study into long term outcomes may be beneficial *[141]*.

Facilitator-assisted

There is research to support that fine-tuning and aftercare following amplification fitting can be completed via telehealth with the support of a facilitator working synchronously with a clinician.

It has been demonstrated that remote fine-tuning and aftercare can be successfully completed with a trained facilitator, with no statistically significant difference noted between remote and face-to-face appointments *[22]*. Additionally, there was no statistically different outcome for new or experienced users. A median time difference of two minutes was observed for the remote condition; however, this was reported to not be clinically significant. 82% of participants reported that remote appointments similarly met their needs, however, no participants indicated a preference for tele appointments. Five participants (8.9%) experienced technical difficulties at the remote site. Additionally, there were instances where the facilitator had to repeat or rephrase information for the client as the clinician was from a culturally and linguistic diverse background. In the remote condition, adjustment procedures like finding the right dome size and modifying the fit of the ear mould with a grinder could not be adequately completed as the facilitator lacked confidence/skills with these tasks which thus prevented resolution of the client's difficulties.

These findings are further supported by case study reports which have demonstrated successful completion of synchronous hearing aid adjustments and management review with adult clients *[69, 148]*. In one instance, a client had returned for a follow-up appointment experiencing difficulties with management of the battery and insertion of the hearing aid *[69]*. An immediate correction of the problem was noted following re-instruction and demonstration over video link.

It was reported that without a tele-appointment this client would have waited a further two months to have the problem rectified. Another participant in this study reported problems with sound quality and the facilitator was able to successfully connect the hearing aids to allow remote adjustments. Furthermore, through the video link the clinician was able to provide information on listening tactics relevant to the client's specific situation.

Studies in cochlear implant users have also demonstrated that remote programming can be reliably completed with the support of a facilitator, further supporting implementation of tele-adjustments in a hearing aid mode *[115, 149-153]*.

Telephone calls have been used as a back-up communication method in instances where internet connectivity was poor *[22]*. Additionally, a portable Bluetooth speaker can be used at the remote site to provide better sound quality compared to the computer sound card and facilitate understanding *[22]*.

Self-led

With advances in technology it is now feasible for clients to be able to fine-tune their devices independent of a clinician. Additionally, clients now have access to a myriad of self-led management and counselling tools, including instructional videos and interactive device applications.

Bluetooth compatible hearing devices allow clients to self-adjust amplification settings and create personalised listening programs through smart device applications. Other manufacturers, like Blamey Saunders, provide clients with Bluetooth-enabled programming interfaces to allow clients to modify the gain/frequency response, compression parameters and the noise reduction algorithm of the device. Whilst these self-led adjustments may not be typically be considered telehealth, as they are independent of a clinician, there is usually a requirement for the clinician to set-up, demonstrate and instruct clients on these features at an initial fitting appointment.

In addition to sound adjustments, some smart device applications have the capacity for clients to perform diagnostic checks of their device. For example, applications from Starkey and Widex have in-built diagnostic checks for clients to identify issues with the system microphone or speaker, and detect internal noise issues *[154]*. Furthermore, these applications can allow for timely notifications to change batteries, check wax guards, or reminders to clean, as seen with the Unitron coach feature *[155]*.

Key considerations for Hearing Aid Fine-Tuning & Aftercare

- A video interface for demonstration of device handling skills and observation of ability, with back-up audio communication if technical issues present is desirable.
- Bluetooth and tele-compatible hearing aid technology is beneficial for remote support.
- The facilitator needs adequate training and skill to ensure physical modifications of the device can be accurately completed.
- Visual instruction guides are a useful additional tool.

5.12 Hearing Rehabilitation Support Services

Hearing loss not only affects a person's ability to hear, but also to communicate. Communication breakdowns negatively impact upon personal relationships, social engagement and emotional well-being. Rehabilitation support services are offered through the HSP to clients who are likely to benefit from further support and training regarding communication (claims 670, 680, 681). These service-based programs aim to improve a variety of skills for the person with hearing loss (and sometimes their communication partners). They tend to focus on communication skills and strategies, hearing device management skills, and emotional impacts of hearing loss (such as embarrassment, frustration or worry) *[156]*. The Active Communication Education (ACE) program *[157]* is widely used in Australia as a framework to assist audiologists with the provision of communication training, and includes education and skill development regarding communicating in challenging environments, such as listening skills, turn taking, responding with purpose, assertiveness, and managing the background noise.

Although less utilised, auditory training programs have been developed as formal listening activities wherein one learns to make distinctions between sounds presented systematically, with the goal to optimise (bottom-up) sensory refinement of sounds (often speech perception) *[158]*. Available programs include the Listening and Communication Enhancement program (LACE) *[159]* and the Earobics program *[160]*. These programs are predominantly developed as self-directed activities. However, clinicians are still required to monitor client's progress and engagement with the activity.

Summary of Evidence for Hearing Rehabilitation Support Services

Clinician-led

There is research to support that hearing rehabilitation support services can be delivered safely and effectively via telehealth with a clinician independently running the appointment.

Facilitator-assisted

There is limited research exploring the provision of hearing rehabilitation support services via telehealth with the support of a facilitator working synchronously with a clinician.

Self-led

With advances in technology it is now feasible for clients to access information and training on topics relating to hearing rehabilitation support services; however, clinician input is still required for optimal outcomes.

Clinician-led

Several research groups have worked towards development of online platforms to facilitate remote delivery of Hearing Rehabilitation Support Services. An Australia-based research group developed the Hear–Communicate–Remember intervention, designed for family caregivers of people with both dementia and hearing impairment *[161]*. It used a psychoeducational approach, comprising four modules: (i) helping with hearing aids; (ii) memory strategies for hearing aid use; (iii) communication strategies and (iv) putting it together. The modules were designed to be delivered within participants' homes weekly, across four weeks, by a speech–language pathologist, audiologist or psychologist via telehealth. Educational components were delivered via goals and planning (e.g., goal setting), feedback and monitoring (e.g., feedback on behaviour), shaping knowledge (e.g., instruction on how to perform a behaviour), comparison of behaviour (e.g., modelling of the behaviour) and repetition and substantiation (e.g., behavioural practice/ rehearsal). Feasibility of the training programme was explored via a combination of semi-structured interviews, self-report questionnaires and field notes, involving six groups of two people, consisting of adults with dementia and hearing impairment, and their family caregivers. Results from the satisfaction survey indicated that caregiver participants were mostly satisfied with all aspects of the intervention except the use of some technological components. Implementation via telehealth was challenging as a result of lack of familiarity with technology, issues associated with poor connectivity (such as videos freezing and low volumes). Some participants also expressed concern that telehealth delivery might result in a loss of 'human contact'.

A Swedish group have developed a range for various online support adaptations. In 2011 and 2014 *[162, 163]*, they developed a five-week online intervention program, which included self-studies, training and professional coaching in hearing physiology, hearing aids, and communication strategies, as well as online contact with peers. The program was developed based on four elements; (i) Reading, (ii) Home training, (iii) Interaction with an audiologist, and (iv) Interaction with peers in an online discussion forum. The findings showed significant reductions in hearing-handicap, psychosocial wellbeing and hearing aid outcomes in the intervention group after the intervention. The effects were maintained and improved at the follow-up. This study provides further evidence that the internet can be used to deliver intervention of rehabilitation to hearing-aid users. In 2015 and 2017 the researchers further developed the online program and conducted a randomised controlled trial within the clinical setting, comparing hearing aid fitting supplemented with combined telephone and internet-based hearing rehabilitation support services, compared with hearing aid fitting supplemented with reading materials only *[164]*. The intervention group received weekly home training assignments related to topic-based reading instructions. The assignments were submitted via Internet by the participants and were discussed with the audiologist by telephone at the end of each treatment week. The trial implementation demonstrated successful remote delivery of hearing rehabilitation support services within the clinical setting *[164]*. Participants in the intervention group showed improved self-reported communication skills compared with a control group *[165]*. Barriers to clinician participation included lack of staff, training, and rewards and a lack of interest in the research program *[164]*.

In 2016 the same Swedish research group adapted for audiology purposes a pre-existing internet-based support system developed for psychologists and their clients *[166]*. Twenty-three clients managed by four audiologists used and evaluated the support system. Both clients and audiologists reported positive experiences with the system in terms of content, navigation and clinical benefit. However, audiologists reported that the support system did not address the needs of all clients.

Facilitator-assisted

One of the aforementioned studies [161] described the use of speech-language pathologists and psychologists as being trained to provide the online intervention program in place of the audiologist. However, there do not appear to be any studies exploring remote delivery of hearing rehabilitation support services by non-professionally qualified facilitators.

Self-led

Research groups have developed digital tools to help clients to self-manage a range of topics delivered during traditional face-to-face Hearing rehabilitation support services, including hearing aid management skills, and auditory training.

A UK based group have developed a series of self-guided multimedia educational programs for first-time hearing aid users (C2Hear) [167]. These interactive programs are accessible online, and provide education on the practical and psychosocial components of hearing aid ownership, displayed in a visual format using videos, images, self-assessment and client testimonials, underpinned by pedagogical learning principles. A small scale (N=47) two-arm randomised controlled trial showed significantly greater improvement in self-efficacy and knowledge of hearing aids than the control group [168].

Another group explored whether remotely delivered auditory training programs improve speech-in-noise understanding [169]. Findings suggested that online delivery of the auditory training program was successful, despite no measureable improvement in speech-in-noise understanding following intervention with the ReadmyQuips (RMQ; www.sensesynergy.com/readmyquips) self-directed online auditory training program.

Key considerations for Hearing Rehabilitation Support Services

- Successful delivery of Hearing Rehabilitation Support Services will need to overcome issues relating to client's & clinician's lack of familiarity with technology, limited availability of software platforms to support required activities, and poor connectivity.
- Clinicians should be cognisant of client' concerns relating to the perceived loss of 'human contact' when services are delivered via tele-audiology as opposed to face-to-face.
- Staff will need to be adequately trained in the use of the technology, but also the delivery of content via tele-audiology mediums.
- Clients may need some convincing as to the benefits of these services, as research suggests that they have low interest currently.
- Digital platforms facilitating remote delivery of Hearing Rehabilitation Support Services do not currently address all aspects of hearing loss impact, nor are they designed in a way that they are user friendly to all client demographics.

5.13 Tinnitus Management/ Counselling

Tinnitus is described as the perception of sound in the absence of any external sound stimulus. There are a wide range of associated symptoms for those experiencing tinnitus, which can include sleep disturbance, concentration difficulties, irritation, anxiety, and depression *[170]*. Furthermore, it is reported that for those experiencing distressing tinnitus, there is a significant economic impact due to reduced productivity, higher rates of sick leave, and increased health care costs *[171]*.

Tinnitus treatment options can focus on reducing the audibility of tinnitus or can address the patient's subjective reaction to the tinnitus through counselling. Cognitive behavioural therapy (CBT) is the most well-supported intervention to address tinnitus-related distress and its associated symptoms *[172]*.

Tinnitus management and counselling services are not funded through HSP, however, they are a routine component of adult audiological rehabilitation for clients receiving services under HSP, as hearing loss is one of the leading causes for tinnitus *[173]*. Tinnitus is relevant within the scope of HSP given its inclusion under criteria 1.B in the minimum hearing loss threshold exemption guidelines, yet currently no funding is provided to cover the costs of tinnitus assessment or management.

Summary of Evidence for Tinnitus Management/ Counselling

Clinician-led

Internet-based therapies are considered to be a viable intervention for clients with tinnitus, with positive effects on tinnitus distress and improved secondary symptoms post-intervention.

Facilitator-assisted

There was no evidence found exploring the delivery of tinnitus services in an audiological setting with the support of a facilitator.

Self-led

There is evidence to support self-led tinnitus interventions.

Clinician-led

For clients experiencing distressing tinnitus, internet-based cognitive behavioural therapy (CBT) has been shown to be a viable alternative for face-to-face individual and group CBT, with positive effects on tinnitus distress reported post-intervention *[174-178]*. Internet-based acceptance and commitment therapy (a cognitive therapy derived from CBT) has also been shown to positively impact tinnitus distress *[179]*. Furthermore, these interventions have been shown to reduce secondary tinnitus-related symptoms, including anxiety, depression, and sleep difficulties *[175-179]*. Client outcomes following tinnitus intervention are maintained long-term, with improvements in tinnitus distress lasting up to one year following treatment *[174, 176, 179]*.

The following information has been drawn from the literature and should be considered for any future internet-based tinnitus interventions.

Clinical Training

Typically, CBT interventions are carried out by trained psychologists; however, internet-based CBT interventions supported by audiologists have shown similar outcomes to those offered by psychologists *[177, 178]*. Audiologists delivering intervention within these studies were appropriately trained, and had prior experience supporting clients with tinnitus.

Perception of Treatment

The credibility of internet-based interventions appears to be rated lower by clients when compared to face-to-face methods *[174]*. However, ratings of credibility did not impact treatment outcomes, so it is suggested that the importance of this result may be minimal.

Time

Internet-based CBT has been demonstrated to require less therapist time than group treatment, with this time saving reportedly making it 1.7 times more cost-effective *[174]*.

Client Suitability

Given the significant distress and psychological impacts associated with tinnitus *[180]*, it is essential to determine client suitability for tinnitus interventions. Self-report measures may be a valuable tool to assess severity of psychiatric conditions or suicidality to identify clients who may require more directed assistance. These tools were implemented in the literature to select study participants, ruling out anyone in significant psychological distress *[174, 176, 177]*.

Facilitator-assisted

There was no evidence found exploring the delivery of tinnitus services in an audiological setting with the support of a facilitator.

Self-led

There is evidence to support self-led tinnitus interventions. Self-led internet-based CBT, without active monitoring or contact with a clinician, has been demonstrated to significantly improve tinnitus distress *[175, 181, 182]*. Furthermore, improvements in secondary outcomes (e.g. anxiety, depression, sleep) have also been shown post-intervention *[182]*. These improvements remained stable at the six-month follow-up. It was proposed that this intervention could be utilised for clients experiencing lower levels of tinnitus distress when intensive CBT is not clinically indicated *[175]*.

There is some evidence to suggest that non-professional support can be helpful in the management of tinnitus *[183]*, however, better outcomes have been demonstrated with guided support for internet therapeutic interventions *[184]*.

Time

In one study, there was an optional opportunity for the client to communicate with the clinician once a week via online messaging if required *[182]*. An average time of 13.76 minutes was spent per week communicating with each participant. It was reported that the usual upper limit of therapist time for internet-based CBT programs is 10 minutes, therefore, with over 13 minutes of clinician time spent on the self-guided intervention, there was no advantage regarding time-saving using this tele-solution *[182]*.

Key considerations for Tinnitus

- Clinicians should have adequate experience and understanding of intervention principles for tinnitus clients.
- Internet-based tinnitus interventions are perceived as less credible by clients.
- In a clinician-led model internet interventions are more time efficient; however, in a self-guided model more therapist time was used when compared to face-to-face methods.
- Self-report measures are likely to be a valuable tool in determining client suitability for interventions.

5.14 Summary

Common practice recommendations that can be drawn across different clinical areas include:

- Protocols for safe and effective delivery of services will ensure optimal quality and safety during healthcare delivery.
- Facilitators require adequate training and skill.
- Visual instruction guides are useful tools to aid the provision of tele-audiology services.
- Synchronous is preferred over asynchronous methods as it allows the clinician to give real-time feedback to the client/facilitator.
- Video-conferencing is preferred over telephone consultations to optimise communication for those with hearing impairment.
- The use of video for otoscopy is recommended over still images for diagnostic purposes.
- The quality of test results (such as otoscopy images) may impact upon the quality of the care provided.
- While some clinical activities can be safe and effectively delivered via self-led approaches, clinician involvement is still required to provide explanation of the test results and consultation regarding treatment/management options.
- Clinicians should be cognisant of client' concerns relating to the perceived loss of 'human contact' and potential communication difficulties when services are delivered via tele-audiology as opposed to face-to-face.
- Successful delivery of Hearing Rehabilitation Support Services will need to overcome issues relating to client's and clinician's lack of familiarity with technology, limited availability of software platforms to support required activities, and poor connectivity.
- Self-led internet-based interventions may be perceived as less credible by clients.
- A quiet and calm room is required to ensure a minimal noise floor for testing.
- Success of remote assessments may be dependent on the age of the client.
- Results may be affected by the condition of the client's ear (e.g. wax occlusion) and/or hearing device/s.
- Technical difficulties can impact a client's satisfaction with the experience and their feelings of security; however, these difficulties are minimised with training and experience.
- Adequate internet connection and speed are required at both ends of the service delivery arrangement.

6. Principles for safe practices in telehealth

The review of the clinical literature highlighted general considerations for delivering a tele-audiology service.

These general considerations included the importance of reliable internet and adequate connectivity; the need for alternative procedures and interface options to overcome technical difficulties; the benefits of video communication and visual information for those with hearing loss; and the importance of training in a facilitator-assisted model.

Beyond the clinical literature, there have been no studies investigating the non-clinical considerations for safe and effective tele-audiology practice, and clinical studies have not elucidated any unsafe practices. However, there is a plethora of tele-medicine related research describing non-clinical considerations for safe and effective telehealth practice. We draw your attention to the information, policies and resources provided by the American Telemedicine Association (ATA; ww.americantelemed.org/). A review of the literature relating to the risks and harms of general health tele-services *[185-189]* has identified four domains as key to guiding safe practice (Figure 2; Table 3).

Figure 2.
Principles of safe and effective telehealth

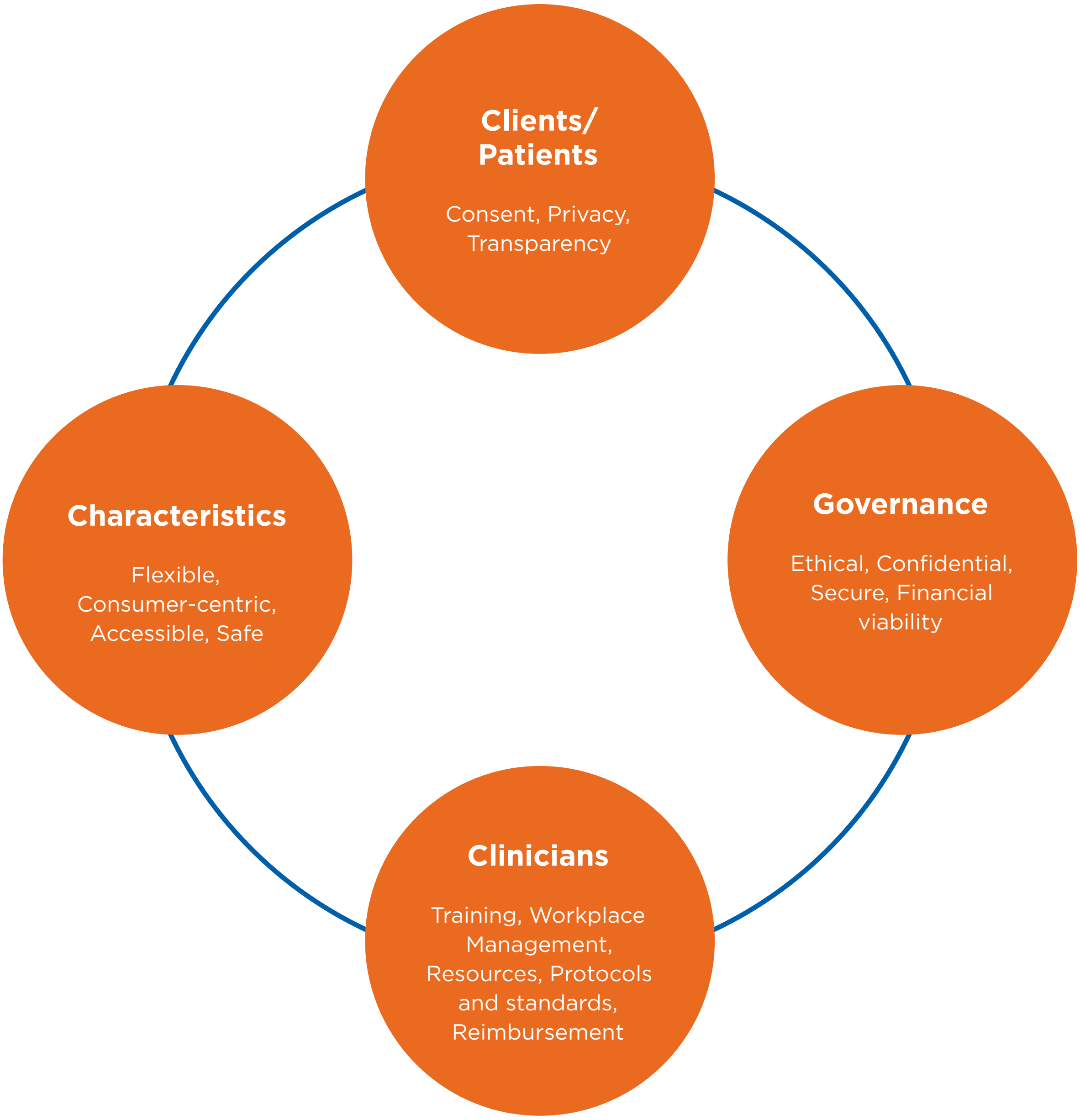


Table 3.
Principles of safe and effective telehealth

1	**Flexibility**	Manage rapid change and evolution of technology.
2	**Consumer-centric**	Respect consumer choice, improve health literacy, co-design healthcare, to produce meaningful outcomes. Manage potential loss of inter-personal relationships, increased risk of miscommunication, equipment failure or inadequacies, loss of respect for timelines (e.g. calls for help on a 24/7 basis).
3	**Transparency in coverage and reimbursement**	Limitations to telehealth to be understood and communicated to clients, with alternative methods of providing care offered. Additional costs due to telehealth service to be communicated.
4	**Accessibility**	Increased access to disadvantaged populations and communities
5	**Training**	Orientation and ongoing training in use of equipment, and tele-audiology protocols.
6	**Workforce management**	Managing the potential reduction in amount of physical contact with clients and colleagues, and potential increase in feelings of not belonging and isolation.
6	**Privacy**	Facilities required for verification of identity, privacy during the consultation, confidentiality of data.
7	**Consent**	The client has easy access to plain language information about telehealth, plus the other relevant options for providing care. The client gives informed consent to the use of telehealth (verbally or in writing), including involvement of other staff, use of recordings, the structure and timing of services, record keeping, scheduling, privacy and security, potential risks, confidentiality, mandatory reporting, billing, and any information specific to the nature of videoconferencing. Organisations and professionals shall have a mechanism in place to ensure that clients are aware of their rights and responsibilities with respect to accessing tele-audiology services and/or their personal health records including the process for communicating complaints and grievances.
8	**Documented policies and procedures (or administrative requirements)**	Organisations shall be aware of and comply with all professional state board regulations and any guiding scope of practice policies. Professionals shall be aware of and comply with laws and regulations and shall integrate guidelines, and standards set forth by nationally recognised professional associations (e.g., American Speech- Language Hearing Association, American Physical Therapy Association, and American Occupational Therapy Association) and other credentialing, privileging, accrediting, and regulatory requirements for licensing, certification, professional liability, and ongoing professional development or training for use of ICT for delivering provisional services and products.

9	**Patient safety - clinical/health**	Professionals assume responsibility for ensuring the client's safety during telerehabilitation service encounters. If during the virtual encounter, the professional observes the client might be experiencing any medical symptoms, complications, or emergency, the virtual encounter shall be terminated and the client referred to an appropriate local healthcare provider or emergency services according to established policy and procedure.
10	**ITC security**	The information and communications technology used for telehealth must be fit for the clinical purpose. Use communication modes and applications that have appropriate verification, confidentiality, and security parameters necessary to be utilised properly. Audio, video, and all other data transmission shall be secure through the use of encryption (at least on the side of the healthcare professional) and password protection that meets recognised standards. Protected health information and other confidential data shall only be backed up to or stored on secure data storage locations.
11	**Resources - clinical tools**	Equipment and clinical tools are safe and sufficient to support diagnostic and/or treatment needs, and function properly at the time of clinical encounters. This includes having available additional types of technologies or peripheral devices (e.g. measurement tools, sound meters, sensor technologies etc) that may be necessary to provide evaluations and interventions.
12	**Management of physical environment**	Adequate room set up (at both ends), including adequate physical space and conditions to conduct consultations (e.g. good lighting, little or no background noise, distance for best use of camera), and ensures privacy and comfort (physical and emotional) of the client.
13	**Risks & harms**	A risk analysis is performed to determine the likelihood and magnitude of foreseeable problems, supplemented by a mitigation plan.
14	**Ethical considerations**	Organisations and professionals shall be aware of and comply with ethical principles and standards set forth by nationally recognised professional associations and other regulatory bodies, and have in place internal policies and a formal process for resolving ethical issues associated with the provision of tele-audiology services.
15	**Maintain high quality clinical standards**	Avoid Care provision with less than ideal information or misinformation.
16	**Technical difficulties**	Have procedures and 'work-arounds' in place to manage technological dysfunctions.

7. Professional practices in Australia

During 2020, Australian audiologists were surveyed regarding telehealth and tele-audiology.

A snapshot of some of the results are provided, with permission of the authors.[2]

An international survey of audiologists was conducted with the International Society of Audiology from 23 June to 13 August 2020. A total of 76 Australian hearing professionals participated. Their mean age was 46.5 years and they had an average of 16.8 years of experience in audiology. They were employed in the public and private sector, as single operators, and in small and large organisations. Collectively they covered the full range of audiology services.

Past, current and future use of telehealth

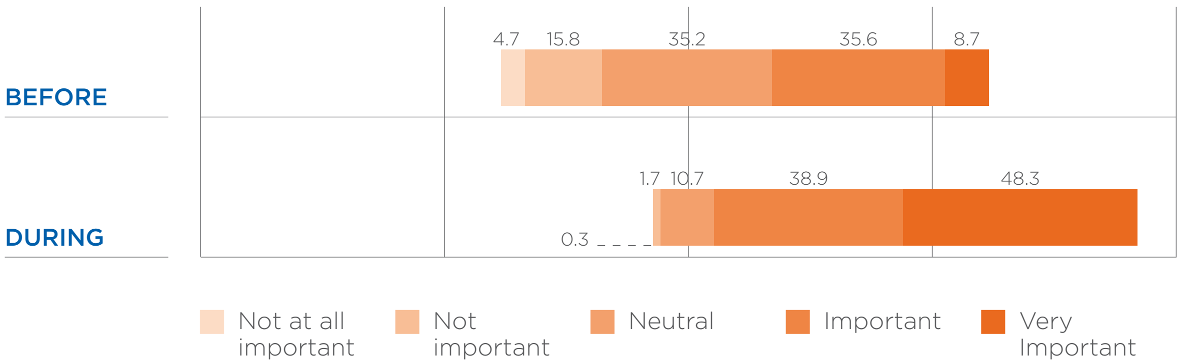
Tele-audiology was used by 57% before COVID-19, which increased to 75% at the time that the COVID-19 pandemic was affecting many aspects of daily life. Furthermore, 83% reported that they envisaged using tele-audiology post-COVID-19.

Importance of telehealth

Approximately 16% reported that they did not find telehealth important before COVID-19, and approximately 30% were neutral on this. At the time of the survey, the number who did not recognise the importance dropped to 1.3% and approximately 8% were still neutral on the importance. The number who felt telehealth was ***Important*** or ***Very Important*** rose from 54% to almost 91% (Figure 3).

2 International survey of audiologists, conducted with the International Society of Audiology) by De Wet Swanepoel, University of Pretoria, South Africa; Rob Eikelboom and Bec Bennett, Ear Science Institute Australia; and Vinaya Mancahiah, Lemay University, USA.

Figure 3.
Importance of telehealth before COVID-19 and during COVID-19.



What audiology services can be delivered adequately by telehealth?

Respondents to the survey reported that telehealth would be suitable for the delivery for most audiology services (Table 4). Between 70 and 81.2% indicated that tasks that included maintenance and counselling could be adequately conducted by telehealth. Tasks that required the use of specialised audiology equipment (especially hearing assessment) and physical contact with the client (i.e. device fitting) were favoured by less than half of the respondents, and by only 11% for hearing assessments.

Table 4.
Tasks that the respondents (n=64) considered could be adequately conducted by telehealth.

TASK	PERCENTAGE
Device fitting follow-up or fine-tuning	81.3
Discussion on hearing loss intervention options	79.7
Review appointments	78.1
Communication training	75.0
Psychosocial support	71.9
Hearing screening	40.6
Device fitting	37.5
Hearing assessments	10.9

Priorities during lockdowns

Respondents were asked to prioritise audiology services during lockdown, and indicated that support, maintenance and device adjustment were the highest priorities (Table 5).

Provision of new devices, hearing implant services and tinnitus services were considered the lowest priorities. However, these responses likely reflect the clinical services provided by the individual participants, and not their perceptions of overall importance.

Table 5.
Relative ranking of priority of audiology services during periods of lock-down; mean ranking from 1 (lowest priority) to 10 (highest priority).

AUDIOLOGY SERVICE	MEAN PRIORITY RATING
Audiological support (device use/cleaning/maintenance, communication training, education on acclimatisation)	6.6
Cleaning & maintenance of current hearing devices	6.6
Device adjustment post-fitting	5.9
Hearing assessments	5.0
Psychosocial support (education and advice regarding loneliness and social engagement)	4.6
Emotional support (education and advice regarding the emotional impacts of hearing loss and how to manage their mental health)	4.2
Paediatric-specific services	4.1
New devices	3.4
Hearing implant specific services	2.7
Tinnitus specific services	1.7

8. Consumer opinion in Australia

The views of consumers are important in the planning and provision of telehealth services.

Reports of research studies on tele-audiology services have shown that a large segment, although often not a majority, of the population is willing to utilise telehealth services. This has been shown in general *[190-192]* and audiology populations *[22, 115, 193]*. These reports often indicate that the majority of clients retain a preference for face-to-face services.

8.1 Survey of audiology clients – Ear Science Institute Australia

Over 400 clients of an audiology clinic in Western Australia participated in a telehealth survey in August 2020.[3]

21% of respondents lived in regional, rural or remote areas; 79% lived within metropolitan areas. Approximately one quarter of respondents (27.4%) reported that they had used telehealth for health services. 68% had used telehealth for GP consultations, 28% for other specialists, and 15% for audiologists. The telephone was the primary mode of communication (75%), and 28% had used video-conferencing.

37.8% of the respondents indicated that they would use telehealth in the future (Table 6). A third (34.7%) of those who had not utilised telehealth in the past indicated that they would be interested in the future. However, of those who had utilised telehealth in the past, over half (54%) indicated that they would not be interested in the future. This indicates a challenge to providers of services by telehealth; that there is a willingness amongst those who had no experience

3 Data used by permission; Dr Cathy Sucher, Ear Science Institute Australia.

with telehealth to use telehealth, and yet some experience with telehealth has resulted in a decrease in interest in further telehealth consultations. Note: this is not necessarily amongst those who accessed audiology services – of the 14 people who had access audiology services, 8 indicated that they would do so in the future. It is important to recognise and overcome, if possible, barriers to telehealth, and also that some clients will not be willing to available themselves of telehealth. On the other hand, a significant sector of the population is willing and motivated to use telehealth and therefore this form of service delivery cannot be ignored.

Table 6.
Percentage of those who have or have not used telehealth in the past, and of those who would be interested in using it in the future.

		Would you be interested in having telehealth appointments for your hearing in the future?		
		NO	**YES**	**TOTAL**
Have you used telehealth services?	**NO**	47.4	25.2	**72.6**
	YES	14.8	12.6	**27.4**
	TOTAL	**62.2**	**37.8**	

Survey participants were asked for suggestions on what they would like to see available in an audiology telehealth service. Some of the specific suggestions demonstrate that a portion of the community is open to using telehealth for a wide range of audiology-related services:

- "More focus on the impact of hearing loss on relationships, particularly regarding advice for both parties in a close relationship, on how to manage living with hearing loss. I have observed this is a massively under estimated and under reported problem."
- "In early stages of the program it is extremely relevant to have access to mental health support. Sudden and profound hearing loss impacts your life so dramatically that it is imperative that you have a support network to lean on."
- "Personal stories: what people do and how they overcome their hearing loss and challenges."
- "Music perception training/exercises. For any information packs, provide a variety of levels of information from plain language summaries of topics to more advanced resources or reading list of higher level

documents/resources. Patients with hearing loss rarely get access to higher level information that can help to explain how their brain perceives sound coming via a CI differently from a person with normal hearing."

- "Access to appropriate software to be able to try various adjustments to the device - cochlear speech processor or hearing aid as it can be quite difficult to explain to the Audiologist just what the sounds are that you are hearing, i.e. low or high frequency issues."
- "My biggest problem is when my hearing aid has a fault and I am travelling interstate. Not sure how telehealth could help but it would be nice to have someone to talk to about it."

However, some respondents indicated a preference for face-to-face services over telehealth, not particularly focussed on audiology services:

- "Your question assumes that audiological telehealth is a positive step.... I can see nothing less appealing to me as a deaf person than having a conference or appointment over the devices that cause me the most frustration i.e. electronically amplified devices such as phones and TV's both of which must have subtitles."
- "I prefer an in person at the clinic service than online."
- "I feel Telehealth is less than desirable."
- "I think audiological telehealth service would be good for routine consults but face-to-face would be better for more complex issues."
- "Because my hearing loss is extreme so communicating electronically is very difficult my preferred option is face-to-face counselling."

8.2 Survey of audiology patients – National Acoustic Laboratory

A 2020 study of audiology services provided by telehealth was conducted by the National Acoustic Laboratory of 102 Australia-based adults with hearing loss *[23]*.

In one phase of the study, 56% of clients (57 of 102) received remote support in addition to face-to-face services; most of these (74%) were by a telephone call only. No difference was found across a range of outcome measures of hearing aid benefit.

A sub-set of these participants (N=11) were interviewed regarding their experiences. They reflected the findings of others that whilst there was some appreciation of the offer for telehealth services, face-to-face services are preferred, although this preference was less for those who had experienced telehealth services. Supporting statements included a preference for 'seeing' someone when speaking with them; this finding may reflect the fact that most of these telehealth consultations took place over the phone. Non-use of the internet was also cited as barrier to telehealth services. COVID-19 was not considered a barrier to face-to-face consultations for some of the participants.

8.3 Case study

Audiologist from a practice in Melbourne

During the COVID-19 restrictions I have had the good fortune to be able to use tele-audiology services to support and maintain care for many of my clients in a safe and effective manner. The benefits of tele-audiology have been that I have been able to fit clients with new hearing aids, undertake follow-up, hearing aid adjustment and communication training appointments for clients to maintain and improve their social engagement and communication during a period of restricted social interaction without unduly exposing them to the risk of COVID-19. Being able to provide these appointments was highly valuable as social isolation and negative impacts upon mental health were high during these months and being able to optimise my clients' ease of communication was imperative.

Unfortunately, tele-audiology is not without its limitations, effective otoscopy and audiological assessments and some hearing aid adjustments are not possible using these services. At times technical difficulties can also impede effective adjustment or communication between a client and the audiologist. As such the combination of tele-audiology coupled with effective in office appointments could improve many client's access to effective audiological care moving forward.

One example of where I used tele-audiology for a client was for a client with a longstanding asymmetrical hearing loss whom I met just prior to the first COVID-19 restrictions. She had been unsatisfactorily aided for many years possibly because she experiences significant distortion on her poorer ear. She was still eager to pursue a traditional style binaural fit using newer technology aids but we also discussed the potential benefit of a bi-cros aid system for her. When the restrictions were instigated we adjusted her fitting appointment to a tele-audiology appointment. I initially checked her hearing aids in the clinic and explained over the phone how to download the appropriate app on her mobile and sent the aids out to her. Her aids had been sent from the manufacturer set to the 2cc coupler requirements for her loss, we undertook the initial fitting session and two follow up sessions using tele-audiology without incidence. However, as she still had reservations about the aids I organised a bi-cros aid trial for her during the short period of eased restrictions, these were unable to be fitted by tele-audiology and we had to organise an in office appointment for her where we fitted the aids and then undertook further follow up appointments during the increased restrictions again by tele-audiology and she has been very happy with the fitting subsequently.

Tele-audiology has allowed me to continue to provide care for many of my clients some of whom are frail and elderly, others who are immunocompromised and many who would be at risk of significant isolation if they were not able to have their hearing optimised during this period. Whilst it is not an effective means of providing all audiological services it certainly is a highly valuable and effective means of providing good audiological care in the appropriate circumstances.

Case Study – Client at same practice

In April of 2020 I visited [practice name] and met the audiologist. She assured me that with the number of different hearing aids available to her that she would be able to help me. After testing my hearing she suggested a particular aid which she sent by mail to my home. She explained to me how to set up remote contact with her so that she could adjust the settings on the aids without me putting myself at risk from the coronavirus to visit her clinic again. The remote consultation worked very well. She kept in touch with me by phone and email over the next few weeks to see if I was having any problems and if I was not happy with these aids I could try a different type. She suggested bi-cross aids which could help with the problem of my right ear. I needed to visit her rooms for that consultation so that she could set them up for me. I wear them happily.

I have made an investment in my own health and wellbeing and I know that with the ongoing help and advice that I receive from [audiologist's name], my quality of life will be much improved.

She has made this experience stress free and informative.

9. Manufacturers' support of telehealth

Technological innovation by manufacturers within the hearing device industry has long been driven by consumer needs.

It is therefore unsurprising that manufacturers have recognised the transformative role of connectivity and smart technology in healthcare, with efforts in research and product development focused on enhancing service provision through digital solutions. Technology is at the forefront of tele-audiology and solutions developed by manufacturers are pivotal in establishing a comprehensive and effective tele-audiology service model.

With current technology, hearing devices can be paired with smart phone applications to allow for asynchronous and/or synchronous remote support via video, audio, and/or text functions. Using this feature, clinicians are able to conduct remote telehealth appointments or provide prompt feedback and advice to clients. These applications also provide infrastructure for clinicians to synchronously and/or asynchronously remotely fine tune amplification settings and complete *in situ* hearing tests through their devices. These features enable clients to virtually consult with a clinician, have their hearing assessed and their devices adjusted via tele-audiology, without needing to present in person at a clinic for support.

Current technology also provides the end-user greater personal control of their hearing via sound adjustments through a smart phone application. Although volume control and program options have been available in hearing aids for many years, these recent applications allow a greater degree of adjustments for other acoustic properties like frequency and noise reduction. These controls can be used real-time in challenging situations to immediately address amplification issues. Additionally, hearing device manufacturers have also developed a variety of readily accessible, asynchronous, web-based supports, including instructional guides and videos for understanding hearing loss, device management, family support, and communication training.

These device features have been available for some time but until recently they were considered a bonus to standard amplification, with limited emphasis given to them in a clinical setting. However, 2020 saw a large industry shift towards tele-audiology solutions in response to the COVID-19 pandemic, where effective communication was critical for the safety and health of individuals. For example, in their US market, manufacturer Phonak reported an almost 500% increase in remote support usage from February to March 2020 *[194]*, as the demand for tele-audiology grew with increasing social restrictions.

In response to the pandemic, manufacturers have prioritised keeping clients connected with their health professionals. Manufacturers like Phonak, Oticon, and Starkey have fast tracked updates within their remote care delivery systems to optimise clients' access to tele-audiology support. Historically, these features have been unique to higher end devices and were not available fully subsidised under the HSP. However, in response to consumer needs manufacturers like Signia, Widex and ReSound have increased their offerings at the fully subsidised level to ensure wider access to tele-audiology and hearing services.

Manufacturers play a critical role in the effective implementation and success of tele-audiology through research and development of appropriate digital solutions.

10. Recommendations

Data generated within this report demonstrates the important role that tele-audiology plays in the delivery of services to Australians requiring services outside traditional face-to-face consultations.

Although clinician-led models of tele-audiology service delivery appear advantageous over facilitator-led models due to the clinical expertise that the clinician brings, not all clinical procedures can be delivered remotely by the clinician, and thus currently require a facilitator-led model of service delivery for safe and effective practice. We urge funding bodies and service providers to consider this when future planning. Although self-led models of tele-audiology service delivery appear promising, much development and research is required before self-led models are able to deliver clinical services at the high standards currently delivered via face-to-face, clinician-led, or facilitator-assisted models of care.

The COVID-19 pandemic and associated lockdowns affected audiology service delivery across Australia. Many audiology clinics and clinicians were unprepared for the consequences, as few audiology professionals and service providers had the skills and equipment necessary to offer audiology services remotely using telehealth solutions *[195, 196]*. Interviews with audiology professionals and service providers suggest that audiology professionals and practices did their best to provide services where possible, mostly over the phone. It appears that tele-audiology service provision during this time was less than optimal and that audiology professionals and service providers were not generally utilising best-practice approaches.

For safe and effective tele-audiology practices to become more widely integrated to routine care, core barriers need to be overcome:

CORE BARRIERS	POTENTIAL DRIVERS
Hearing healthcare clinicians lack knowledge and skills for provision of safe and effective tele-audiology practice	• Clinical guidelines • Clinician training (to be incorporated into university programs to ensure future audiologists have adequate skills, but also to be incorporated into existing continued professional development requirements for practicing clinicians) • Practice guidelines to help clinic owners/managers manage factors relating to governance, ethics and security
Poor uptake of tele-audiology services appear driven by the low profitability of telehealth models	• Continued funding for tele-services
Concern that rapid increase in tele-audiology service delivery may result in delivery of low-value and no-value care	• Ensure funding reimbursement structures reflect the time requirements for all components of telehealthcare, including video-consultations as well as financial support for remote monitoring and store-and-forward modalities • Clear practise guidelines should be set by the governing bodies to ensure the quality of care via tele-services is not compromised and is equal to that of traditional face-to-face methods, with clinicians understanding their responsibility in effectively providing these services
Poor uptake of tele-audiology services appear driven by the low awareness of the high quality outcomes achieved using tele-audiology practices	• Public awareness campaign promoting the benefits of tele-audiology services (targeting both clinicians and clients)
To provide audiology services to vulnerable adults unable to effectively access current services	• Clinician- and client-driven innovation could reduce health system fragmentation and inefficiency
Limited evidence supporting some clinical tasks required for comprehensive tele-audiology services	• Funding for research that targets gaps in evidence, including the cost-utility of tele-audiology services.

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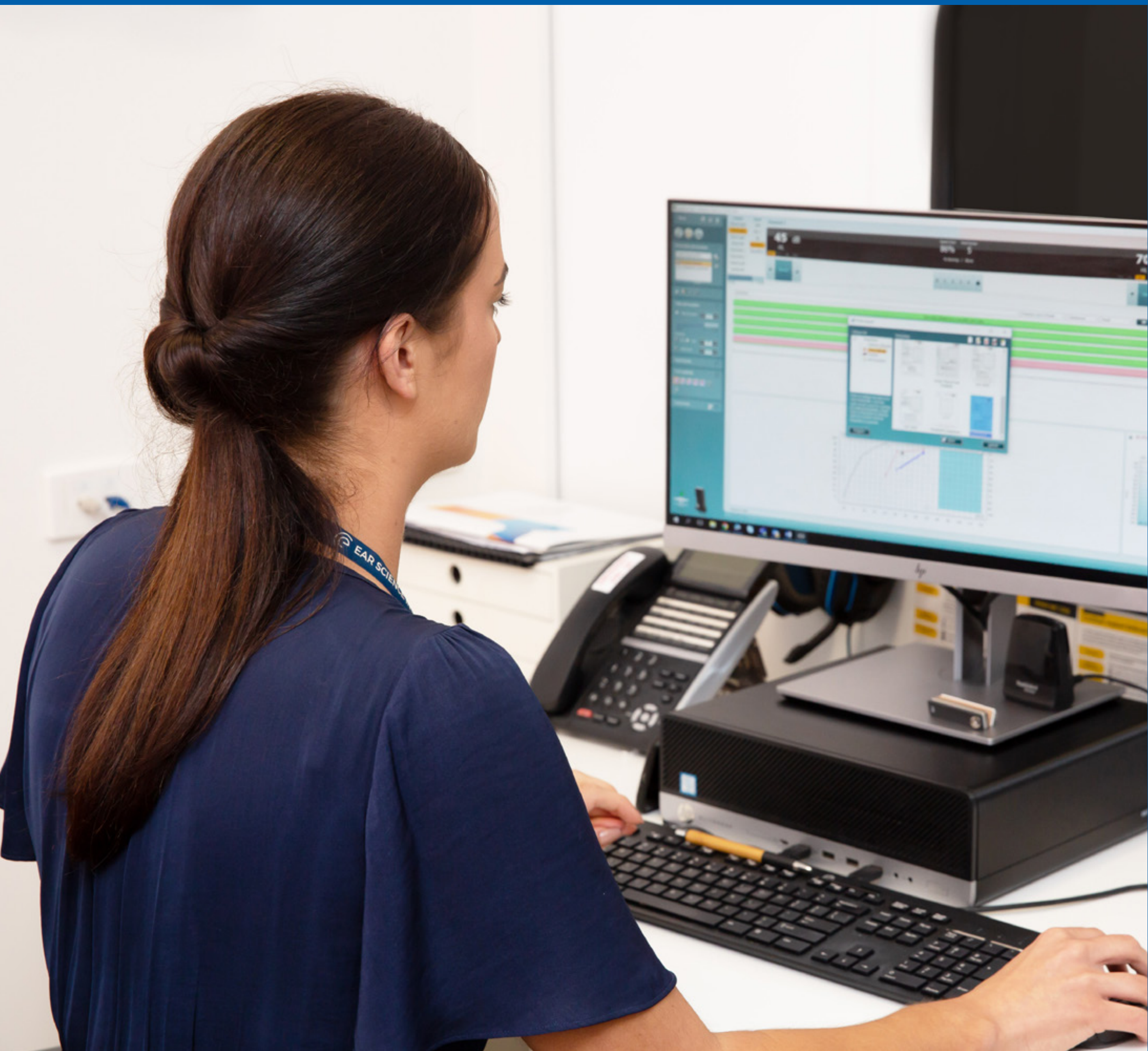

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