The University of Cape Town

Department of Health and Rehabilitation Sciences

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Beyond hearing aid fitting:

Investigating the feasibility of providing tele-rehabilitation for adult hearing aid users in a South African public health context

Thesis submission for the degree

MSc. Audiology

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ABSTRACT

Introduction: Disabling hearing loss is one of the most common sensory deficits; affecting approximately 466 million people worldwide. In the South African context, public health facilities have an uneven ratio between audiologists and patients in need and thus audiological services are often minimal. Successful application of tele-health may increase the scope of audiological services for hearing aid (HA) users. Research is needed to investigate feasibility of tele-health for audiological rehabilitation programmes such as auditory training (AT).

Aim and Objectives: This study aimed to investigate the feasibility of implementing a tele-rehabilitation programme in a South African public health context. Objectives included: 1) determining online AT compliance; 2) determining the effect of online AT on speech perception in noise; 3) assessing experience and benefit of tele-rehabilitation through questionnaires and interviewing; and 4) cost estimation around tele-rehabilitation implementation.

Research Design: A convergent mixed methods design with a feasibility approach was utilized. Data collection was through questionnaires, in-booth speech assessments, online AT and face-to-face interviewing. Participants undertook online AT over four weeks. Pre-/post- online AT: the APHAB, QuickSIN, Entrance/Exit Questionnaires, Interviews and System Usability Scale were administered. Descriptive statistics were used to analyse the quantitative data collected, and descriptive thematic analysis was used for the qualitative data.

Study sample: Purposive sampling was used and three female adult (35 - 55 years) HA users from a public health facility participated.

Results: 1) High compliance rate (84.82%) with 3 hours 25 minutes total clinician contact time, 2) clinical benefit with improvement in listening skills and perceived HA benefit, 3) positive participant feedback, and 4) estimated cost at R1350.00 per person.

Conclusions: Findings from this feasibility study can be seen as positive indicators towards the use of tele-health as a delivery modality for audiological rehabilitation, also a tele-health hybrid model is recommended. However, larger-scaled research is needed.

Key words: tele-audiology; tele-rehabilitation; public health; auditory training; South Africa

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ABBREVIATIONS

ABR:	Auditory Brainstem Response
APHAB:	Abbreviated Profile of Hearing Aid Benefit
AT:	auditory training
CI:	cochlear implant
dB:	decibels
DPOAE:	Distortion Product Otoacoustic Emissions
GB:	Gigabytes
HA:	hearing aid
LACE:	Listening And Communication Enhancement
SNR:	Signal-To-Noise Ratio
SUS:	System Usability Scale

GLOSSARY

Audiometry:	standard hearing testing procedure conducted by audiologists or other suitably qualified hearing healthcare practitioners
Audiometer:	a device whereby standard audiology testing is conducted
Auditory Training:	systematic listening practice with the aim of improving speech perception (usually for people with hearing loss)
Bilateral:	a hearing loss in both ears
Binaural:	fitted with two hearing devices (e.g. hearing aids/cochlear implants)
Cloud-based/internet-based:	storage of information in an online drive which can be retrieved or sometimes altered online
Audiological rehabilitation:	an umbrella term which encompasses hearing technology fitting, perceptual training, communication strategies, and other methods that provide the patient with hearing impairment with the tools to communicate optimally

Monaural: fitted with one hearing device (e.g. hearing aid/cochlear implant)

Sensorineural hearing loss: a permanent hearing loss which can either be congenital; age-related; caused by excessive noise exposure; or as a result of certain medications and infections

Signal-To-Noise Ratio: the ratio between the desired signal (e.g. speech) and noise (e.g. environmental or background sounds)

Tele-rehabilitation: rehabilitation provided at a distance through communication technology, such as online based programmes or videoconferencing

Tympanometry: audiological assessment of middle ear function (including eardrum compliance; ear canal volume; and middle ear pressure)

Unilateral: a hearing loss in one ear

VU (volume unit) meter: a display function on audiometers whereby the level of signal can be monitored against a range, determining the risk of distortion and over/under amplification.

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CHAPTER 1: INTRODUCTION

Introduction: This chapter will provide background information on the global and South African disabling hearing loss prevalence statistics as well as the impact of disabling hearing loss. The connection between audiological management and hearing healthcare in the South African context will be discussed. This chapter will also cover tele-health applications within audiology and auditory training will be introduced. Finally, the problem statement and research question for the study will be stated.

1.1 Background

Global Burden of Hearing Loss

In adults, disabling hearing loss refers to a hearing impairment of more than 40 decibels (dB) in the better hearing ear (WHO, 2019). It is estimated that 466 million people worldwide live with a disabling hearing loss, making it one of the most common sensory impairments (WHO, 2019). The global prevalence of hearing loss predominantly occurs in the low-resourced countries of Africa and Asia (Emmett & West, 2015; Lukama, Kalinda, & Aldous, 2019). A recent prevalence study found that hearing loss affects approximately 27.7 million people in the United States of America (USA), which translates to an estimated prevalence rate of 8.5% (Hoffman, Dobie, Losonczy, Themann, & Flamme, 2017). Comparatively in Sub-Saharan Africa; disabling hearing loss has a substantially higher estimated prevalence rate ranging between 11.4% and 20.3% (Stevens et al., 2013; WHO, 2018a).

Impact of Disabling Hearing Loss

The consequences of permanent disabling hearing loss not only includes communication difficulties, but also various psychosocial and quality of life handicaps (Brodie, Smith, & Ray, 2018). The impact that permanent disabling hearing loss has on communication can include: a decrease in speech sound discrimination abilities; a decrease in speech comprehension; and a decrease in hearing in background noise abilities (Hlayisi, Petersen, & Ramma, 2019). An untreated disabling hearing loss not only affects communication but also leads to severe socio-economic issues, such as employment problems and societal isolation (Emmett & West, 2015; Peer & Fagan, 2015; Shan et al., 2020). In the

USA, the estimated economic burden of hearing loss can reach up to $194 billion and global estimated costs up to $750 billion (Davis & Hoffman, 2019; Huddle et al., 2017).

Disabling Hearing Loss in South Africa

The causes of hearing loss in South Africa can be partially attributed to the high burden of communicable disease prevalence and ototoxic treatment options for these diseases, including HIV/AIDS and TB (Peer & Fagan, 2015). However, recent research has also shown that the rising rate of non-communicable diseases (such as cancer and diabetes) in developing countries, have also contributed to the burden of disabling hearing loss (Hlayisi et al., 2019; Hong et al., 2019; Peer & Fagan, 2015). A community survey of the prevalence of hearing impairment, conducted in Cape Town found that 12.35% of the population surveyed had some degree of hearing impairment, and 4.57% had a disabling hearing loss (Ramma & Sebothoma, 2016). The survey by Ramma and Sebothoma (2016), also found that family history, hypertension, age and head or neck trauma to be the greatest factors associated with hearing loss in Cape Town. A similar study done in rural areas of South Africa showed a disabling hearing loss prevalence of 8.9%, with the participant age group of >65 years old presenting with the highest prevalence (74.65%) (Pullen, 2015). A recent prevalence study in Tshwane, revealed a hearing loss prevalence rate of 17.5% at a primary healthcare level (Louw, Swanepoel, Eikelboom, & Hugo, 2018), which is consistent with the estimated prevalence rate range of 11.4 – 20.3% in Sub-Saharan Africa (Stevens et al., 2013).

Audiological Management of Disabling Hearing Loss

When it comes to disabling hearing loss intervention, hearing technology (e.g. hearing aids [HAs] and cochlear implants [CIs]) is the leading strategy in providing sensory compensation (Lesica, 2018). However, recent research has shown that the majority (83%) of people with hearing impairment globally do not have access to HAs (Orji et al., 2020). In line with the disabling hearing loss prevalence, this means that there are approximately 401.4 million people globally in need of hearing amplification and only 67.9 million are being fitted (Orji et al., 2020). In Africa up to 90% of people with hearing impairment, do not have access to HAs and in South Africa this may be largely attributed to lack of resources (devices) and few qualified audiologists to provide HA services (Orji et al., 2020; Pienaar,

Stearn, & Swanepoel, 2010). Without sensory compensation (through HAs) not only do patients with hearing loss have severe communication deficits but the neurological impact of untreated hearing loss can include early onset dementia and other adverse cognitive function deficits (Jayakody, Friedland, Eikelboom, Martins, & Sohrabi, 2018; Peer, 2014). Therefore, the fitting of hearing technology is a paramount first step in audiological management of disabling hearing loss. However, comprehensive audiological management includes further hearing rehabilitative strategies that are often not included in low-resourced contexts like South Africa; due to circumstantial barriers (e.g. financial, resource-based etc.) (Rutherford & Petersen, 2019).

According to recent local research, the most commonly provided audiological services by South African audiologists are: 1) HA fittings; 2) communication strategies training; and 3) informational counselling (Makhoba & Joseph, 2016). Based on this, it can be inferred that management of disabling hearing loss by most South African audiologists is largely focused on amplification, subsequent communication education and device management. In the South African public health context; rehabilitative strategies should be implemented with the goal to assist HA patients to compensate better with their limited technology as well as provide a cost-effective service.

In South Africa there is a significant need for provision of comprehensive audiological management including more than just hearing amplification in rehabilitation services (Makhoba & Joseph, 2016). Comprehensive audiological rehabilitation services would refer to sensory management (i.e. HAs/CIs), patient counselling, motivation and perceptual training (e.g. auditory training [AT]) (Boothroyd, 2007). Incorporating patient counselling and motivation in hearing rehabilitation has been shown to assist in identifying the specific communication priorities of the patient and encourage successful uptake of HAs (Ferguson, Maidment, Russell, Gregory, & Nicholson, 2016). A key aspect of comprehensive audiological rehabilitation is perceptual training; which is a form of rehabilitation aimed at retraining lost listening skills due to prolonged untreated hearing loss (Boothroyd, 2007). The ultimate goal of comprehensive audiological rehabilitation should be holistic and patient-centred management which includes treatment of the sensory deficit (e.g. HA fitting); counselling (e.g. informational); perceptual training and shared patient-clinician goals (Boothroyd, 2007; Grenness,

Hickson, Laplante-Lévesque, & Davidson, 2014b). The aim of the current study was to investigate the feasibility of implementing an online AT programme within a South African public health context.

Hearing Healthcare in the South African Public Health Context

The majority of South Africans (83.6%) receive their hearing healthcare through the public health sector. Subsequently audiologists in the public sector serve a vast population (Statistics, 2018; Swanepoel, 2006). South African public health facilities have few audiologists catering for a large patient load; with the approximate patient to audiologist ratio being 53 000:1 (HPCSA, 2020; Statistics, 2018). With more South African households dependent on the national government social grants than labour market income, one of the main reasons a large amount of South Africans seek public healthcare, is a result of financial constraints (Statistics, 2020). This limits patient healthcare options and subsequently prevents access to advanced hearing technology interventions, often found in private sector facilities (Rutherford & Petersen, 2019). According to local research, the hearing healthcare services offered, range from diagnostics to basic HA fittings. This range of hearing healthcare services often excludes services such as hearing rehabilitation which includes perceptual training (Makhoba & Joseph, 2016; Pienaar et al., 2010; Swanepoel, 2006). Also, according to local research, the public health sector resource constraints only allows adult patients with bilateral hearing loss to be monaurally fitted, which limits HA benefit (Hlayisi & Ramma, 2019). Therefore, there is a need for comprehensive audiological rehabilitation to assist patients in managing hearing loss difficulties; coupled with minimal hearing amplification given in the public health sector.

In South Africa the factors which impact the provision of HAs and comprehensive audiological rehabilitation are funding, resources, and political factors (Rutherford & Petersen, 2019). The monaurally fitted patients in the South African public health facilities require further rehabilitation beyond HA fitting, because monaurally fitted people face greater communicative struggles than people who are binaurally fitted (Avan, Giraudet, & Büki, 2015; Hlayisi & Ramma, 2019; Pienaar et al., 2010).

The main limitations of a monaural fitting include sub-optimal localisation abilities and significant difficulties with speech perception in background noise (Pienaar et al., 2010). Furthermore,

the low budget available for HAs in South Africa results in the utilization of older technology, which creates further limitations on programmable features on the device (e.g. the strength of any noise-cancelling or speech enhancing features) (Hlayisi & Ramma, 2019). Additional comprehensive audiological rehabilitation beyond amplification, is required to assist public health patients to communicate better despite their monaural fittings (Pienaar et al., 2010).

The lack of resources (i.e. HAs, audiologists, contextually relevant audiological rehabilitation tools) paired with the large patient load, has resulted in a delay of service provision and hindered the successful implementation of comprehensive audiological rehabilitation (Pascoe, Rogers, & Norman, 2013; Pienaar et al., 2010; Rutherford & Petersen, 2019). Strategies such as perceptual training (e.g. AT) after HA fitting is a critical aspect in comprehensive audiological rehabilitation and hearing healthcare services. One delivery method which may allow more hearing healthcare services to be provided to these underserved patients is tele-health (Ravi, Gunjawate, Yerraguntla, & Driscoll, 2018; Scott & Mars, 2015).

Tele-health Applications in Audiology

The term tele-health (or tele-medicine) is defined as incorporating communication technology to provide healthcare at a distance (Ravi et al., 2018; Swanepoel et al., 2010). The successful application of tele-health methods has the potential to increase the dissemination of audiology services, especially in low-resourced countries (Nemes, 2010; Swanepoel et al., 2010). In the scope of audiology this can include: diagnostics; HA fittings; and providing audiological rehabilitation through video-conferencing (Swanepoel et al., 2010). Tele-health includes three main branches of delivery manner: 1) synchronous – referring to real-time service delivery (e.g. remote diagnostic testing or counselling through videoconferencing); 2) asynchronous – meaning store-and-forward methods (e.g. emailing photos or test results to the health professional); and 3) hybrid – which involves aspects of both synchronous and asynchronous methods (Krumm & Syms, 2011; Swanepoel et al., 2010; Swanepoel & Hall, 2010). A recent systematic review on tele-audiology services by Tao et al. (2018) concluded that the positive impact tele-audiology strategies potentially has on the increase in demand for comprehensive

audiological rehabilitation pushes the need for further research to support the clinical implementation of such strategies.

Device Access

Solutions to assist the under-resourced audiology sector in South Africa may include the use of mobile applications (Rutherford & Petersen, 2019). The use of mobile applications to provide aspects of hearing healthcare services is one of the most underutilized resources, particularly in low-income countries such as South Africa (Rutherford & Petersen, 2019). It can be argued that the use of mobile applications in low-income countries, may be restricted because the general population does not have access to a smartphone. However, Rutherford and Petersen (2019) reported data from the World Bank which showed that 70% of people in poorer countries have a smartphone. In addition the penetration of the smartphone market in South Africa is 73% (Rutherford & Petersen, 2019). The above-mentioned statistics have shown the existence of large-scale access to smartphones in third world countries; opening up opportunities for tele-health services to be delivered to a larger population. In terms of audiological service provision; rehabilitative applications, such as AT programmes (which may provide an appealing alternative to the traditional modality of in-clinic AT delivery), are available (Sato, Yabushita, Sakamoto, Katori, & Kawase, 2019).

Auditory Training (AT)

AT can be described as structured listening exercises which aim to optimize speech perception in individuals with hearing impairment through active listening (Brouns, El Refaie, & Pryce, 2011; Henshaw & Ferguson, 2013). Research shows that systematic listening practice or AT, can be used (in conjunction with HAs) to improve speech perception, particularly speech in noise (Saunders et al., 2016; Song, Skoe, Banai, & Kraus, 2012; Sweetow & Henderson-Sabes, 2004; Tye-Murray, Spehar, Barcroft, & Sommers, 2017). Although the benefits of AT on HA users have been established through various studies; it is still under-utilized in audiological rehabilitation, as it has been traditionally deemed as time-consuming (Chisolm et al., 2013; Dubno, 2013; Ferguson & Henshaw, 2015; Sweetow & Palmer, 2005). However, newer updated modalities of AT such as online platforms and mobile applications has allowed easier inclusion of AT in clinical practice (Brouns et al., 2011).

A possible modality for providing AT without further burdening current SA audiologists' patient load, potentially include the use of tele-health methods. The benefits of incorporating online resources (e.g. rehabilitation mobile applications or online AT programmes) with traditional face-to-face audiological rehabilitation, may include: reduced patient expenses; home-based training; and increased scope of patient reach (Henshaw, McCormack, & Ferguson, 2015; Nemes, 2010; Regina Molini-Avejonas, Rondon-Melo, de La Higuera Amato, & Samelli, 2015; Swanepoel, 2016; Sweetow & Henderson-Sabes, 2010).

1.2 Problem Statement

Hearing healthcare provision for public health patients with hearing loss in South Africa is marred with challenges which include: a lack of qualified audiologists; a lack of contextually relevant rehabilitative tools; and limited provision of comprehensive audiological rehabilitation such as AT.

Audiologists globally are using modern technology and non-traditional clinical methods to provide audiology to the larger underserved population (Havenga, Swanepoel, Le Roux, & Schmid, 2017; Ramkumar et al., 2018; Tao et al., 2018). With the notable influence of tele-health on developing countries' hearing healthcare (Ratanjee-Vanmali, Swanepoel, & Laplante-Lévesque, 2019; Scott & Mars, 2015; Swanepoel, 2016), it can be said that there is a need for the investigation of tele-rehabilitation in South Africa to assist in the limited comprehensive audiological rehabilitation provision.

Tele-rehabilitation in South African public health audiology is a topic with limited evidence-based practice protocols and standards. This poses difficulties in the implementation of services, the enforcement and maintenance of quality control measures. The current feasibility study used online AT to investigate tele-rehabilitation implementation, as it is not prioritised in South African public health. Furthermore, AT has proven to benefit HA users (Dubno, 2013; Tye-Murray et al., 2017). The current study was a feasibility study and was, to the knowledge of the researcher, the first to address the research question: *Is the implementation of a tele-rehabilitation programme for adult HA users feasible in a South African public health context?*

Feasibility studies are used to determine the appropriateness and suitability of an intervention in a specific context, with the underlying question: *can it work?* (Orsmond & Cohn, 2015). This is completed before conducting a pilot study, which is a smaller scaled version of the larger intended study. Pilot studies include more rigorous methodological components, unlike the adaptive and flexible methodologies seen in feasibility studies (Orsmond & Cohn, 2015). Feasibility studies address the following factors: participant recruitment; data collection procedures; intervention modality; as well as participant usability and experience of said intervention (Orsmond & Cohn, 2015). These are applicable when studies addressing a specific topic or research aim are few (Bowen et al., 2009). A feasibility study is additionally suitable when interventions or treatments have been researched in a different context other than the intended study context (Bowen et al., 2009).

A feasibility study was deemed to be appropriate for the current study because; firstly, no South African research studies currently exists in the literature, with a similar aim as the current study. Secondly, previous online AT studies have had positive outcomes in developed contexts (Abrams, Bock, & Irey, 2015; Tye-Murray et al., 2012; Tye-Murray et al., 2017), and the appropriateness of this intervention modality was not investigated in a South African public health context. Finally, unlike a pilot study which largely focuses on patient outcomes, the current study investigated tele-rehabilitation feasibility by including: cost evaluations; intervention compliance and patient self-perceived experiences (i.e. benefit and usability of intervention) (Orsmond & Cohn, 2015).

CHAPTER 2: LITERATURE REVIEW

Introduction: This chapter will highlight key studies pertaining to the topic of the current feasibility study. It will describe firstly, the challenges in preventing comprehensive audiological rehabilitation in a South African public health context; the tele-health applications and technology; and lastly tele-audiology strengths and limitations as it applies in a South African context. Benefits and limitations of AT as well as current AT modalities will also be discussed.

2.1 Challenges in Providing Comprehensive Audiological Rehabilitation

2.1.1 Contextually Relevant Resources

One of the main challenges in preventing comprehensive audiological rehabilitation in South Africa is the lack of contextually relevant tests and materials (Pascoe et al., 2013). Contextually relevant refers to rehabilitative materials which can be applied to a specific context. In the case of South Africa this would refer to materials being in a language or vernacular familiar to South Africans. In addition, materials which are affordable and accessible. The importance of contextually relevant materials stems from the concern over the reliability of the patient's response to tests or materials which are not contextually relevant – i.e. is the patient's progress or result a true reflection of their abilities? This is particularly important in a public health context as most appointments have long waiting periods, thus it is crucial that patients are accurately assessed. Most standardised tests and materials available to South African audiologists are based on international data, which at times presents difficulties when applied to the South African context. South African audiologists have translated existing materials, as well as research into developing contextually relevant audiology assessment materials (Pascoe et al., 2013). However, a gap in contextually relevant tools available in other languages besides English, exists. Also, current materials may be an expense not every public health facility can afford. The development of tools and materials in South African languages may only be addressed with the research and development of such resources, however, the use of alternate delivery methods for hearing healthcare such as tele-health may allow rehabilitation to be more accessible and affordable.

2.1.2 Limited Hearing Technology

The limited number of HAs available to fit public health patients should not hinder efforts to offer comprehensive audiological rehabilitation which, for example, would include AT. This is because there is research to show HA benefit at a public health level. Such as the study by Pienaar et al. (2010) which aimed to describe the self-reported outcomes of HA users with regards to satisfaction and benefit. The study made use of a questionnaire, and most participants were fitted monaurally through public health facilities. The findings of the study showed that participants did perceive benefit from the amplification; despite being fitted monaurally and with basic HA technology. Although the perceived benefit of the participants from the study was limited, it was a positive indicator that the technology fitted does provide some means of amplification and listening improvement. The current feasibility study sought to investigate how tele-health methods may be used to offer comprehensive audiological rehabilitation beyond the basic HA fittings; to assist public health patients compensate further with their monaural fittings.

2.2 Tele-health and Tele-audiology

The use of tele-health, specifically with regards to audiology, is an important and emerging topic in current audiology research. A recent systematic review by Ravi et al. (2018), aimed to investigate the existing knowledge and current perception of audiologists with regards to tele-audiology and its applications. The authors included a total of 6 studies in their review, and noted an overall positive trend in the participating healthcare professionals' attitudes towards tele-health methods (Ravi et al., 2018). They further outlined some of the barriers or limitations which exist and prevents a wider inclusion of tele-audiology practices in audiology clinics. Some of the main barriers included: insufficient training, lack of appropriate facilities, reliability of results, and reduced service quality when compared to face-to-face clinic interactions (Ravi et al., 2018). These factors may apply to various contexts where tele-health methods are explored, as they are outlined in previous tele-health studies – both in rural and urban settings (Havenga et al., 2017; Ramkumar et al., 2018; Regina Molini-Avejonas et al., 2015). It can be said that although the different contexts present with similar barriers there may be context-specific limitations. For example, internet speed may differ in rural versus urban settings.

Despite the known barriers with tele-health application, a great potential need for incorporating such methods which arguably outweighs the limitations can be anticipated, thus prompting further research. Therefore, the current study aimed at investigating the feasibility of audiological rehabilitation using tele-health methods in order to add to the growing pool of research.

2.2.1 The Potential of Tele-audiology

It is known that there is a global need for audiologists and provision of hearing healthcare. Furthermore, tele-audiology has quickly become a vital delivery model for many hearing health programmes targeted at providing services to rural and undeserved communities (Nemes, 2010). The healthcare challenges which many developing countries face include: general population education, low number of qualified health professionals, and equipment and financial constraints (Nemes, 2010; Swanepoel, 2006).

A tele-health cost study by Ramkumar et al. (2018) aimed to evaluate the costs and outcome of a paediatric hearing screening programme in India using tele-audiology methods for the follow-up diagnostic assessment. The hearing screening (DPOAE – *Distortion Product Otoacoustic Emissions*) was conducted by trained village healthcare workers in rural India. The follow-up diagnostic assessment (ABR – *Auditory Brainstem Response*) for the children who referred the screening was conducted in real-time by a hospital-based audiologist using remote ABR testing through internet and tele-conferencing (Ramkumar et al., 2018). Their results suggested that similar tele-audiology programmes have the potential to yield long-term cost saving, and in addition incorporating tele-audiology in their programme improved patient follow-up compliance (Ramkumar et al., 2018). The results from a similar study by Dharmar et al. (2016) in rural California, on using tele-audiology for follow-up paediatric diagnostic assessment, also suggested an improvement in follow-up and compliance. According to the evidence there is a potential for tele-audiology methods in developing contexts, to lower costs associated with providing audiology services; and a potential for tele-audiology methods to improve the sustainability of audiology service-delivery protocols (i.e. patient follow-up compliance). This is an important factor to consider for potential South African implementation of tele-rehabilitation, as costs and sustainability affect the feasibility of such methods.

A recent review by Tao et al. (2018), included international tele-audiology studies focusing on adult HA users. Their report included a total of fourteen studies; nine of which evaluated the feasibility of implementing tele-audiology methods for HA consultations, HA fittings and follow-up procedures. Hearing related training programmes (i.e. AT, tinnitus training or cognitive training) were not included in their study as the review was solely investigating the role of tele-audiology for HA related procedures. They acknowledged that there is a significant place for tele-audiology methods to be implemented as a means to address the vast population in need of hearing healthcare (Tao et al., 2018). However, their review conclusion suggests that the few studies that are currently available, lack a strong methodological quality and only address some aspects of potential tele-audiology applications (mainly HA fittings) (Tao et al., 2018). It was noted that one of the consistent findings of their review was that remote HA fittings and subsequent follow-ups were indeed feasible (Tao et al., 2018). However, they argue that the lack of research and current quality of tele-audiology studies available, hinders the transition of these methods into clinical practice (Tao et al., 2018). The Tao et al. (2018) review highlighted the great need for further tele-audiology research, particularly including the delivery of rehabilitative strategies such as AT. The current feasibility study aimed to contribute to the knowledge base on tele-rehabilitation applications involving AT provision for adult HA users.

A USA based study by Abrams et al. (2015) investigated the effects of a web-based AT programme on new HA users' speech-in-noise understanding. They used the Read-My-Quips programme and included a control group which allowed comparison of results. The results showed no statistically significant difference in listening skills between the two groups (Abrams et al., 2015). The researchers concluded that this may have been due to the AT group not allocating enough time for their training (i.e. 4 hours instead of a minimal of 7.5). A strength of the Abrams et al. (2015) study was that they had control over the participants' HA fitting, as each participant was first fitted by the researchers and subsequently included in the study. This allowed for control over the HA verification which would result in assurance over optimal fitting standards met. The findings of the study showed that the online platform presents an intriguing alternative for AT delivery. However, the updated modality of training fails to change some of the traditional factors to consider, when administering AT (e.g. time spent

training) (Abrams et al., 2015). Training time is a critical factor in AT, as sufficient time is needed for possible neural improvements to occur (Weihing, Chermak, & Musiek, 2015). The required individual session training time has been cited to be between 20-45 minutes (depending on the programme), and regular sessions (3-5 times a week) are just as critical if improvements are to be maintained (Abrams et al., 2015; Sweetow & Henderson-Sabes, 2004; Weihing et al., 2015). This is important to consider for the South African public health context, as clinical time is arguably one of the limitations that prevents comprehensive audiological rehabilitation beyond HA fitting. This propels the need to research the feasibility and factors involved in implementing an online AT programme in a South African public health context, which the current study sought to investigate.

The potential of tele-audiology and future development in the field is increasing. However, there are significant challenges which currently hinder the growth of tele-audiology. For example there are audiologists in the USA who have noted challenges such as hesitation, among tele-audiology patients in accepting a diagnosis concluded from tele-health methods (e.g. remote diagnostic testing) (Nemes, 2010). The practicality and potential cost-efficiency of tele-audiology is understandably appealing to many audiologists and other hearing health professionals, however, should be implemented without disregarding duties towards patient trust and overall patient care (Nemes, 2010). The overall efforts of tele-audiology should be supplemented by incorporating face-to-face clinician contact with online contact (hybrid delivery) as appropriate, in so helping to build rapport with patients (Ratanjee-Vanmali et al., 2019). This method prompted the current feasibility study to acknowledge and incorporate the implied face-to-face clinician contact time required to administer tele-rehabilitation.

2.2.2 Tele-health within the South African Context

Online Clinical Application and Patient Readiness

The positive potential applications of tele-audiology are known by audiologists and other hearing healthcare professionals. However, the successful inclusion of tele-audiology in clinical practice also depends on the attitudes, knowledge and beliefs of the intended patient population (Nemes, 2010; Ratanjee-Vanmali et al., 2019). A South African study by Ratanjee-Vanmali et al. (2019), aimed to explore and describe the characteristics and readiness of patients wanting online hearing healthcare.

The researchers created an online hearing healthcare clinic in which participants were able to complete a free self-administered hearing screening test and use their results to determine if they wished to seek further evaluation from a qualified audiologist (Ratanjee-Vanmali et al., 2019). The online clinic received a relatively high number of visitors (n=2 693) within a three month study period, however, the turn-over for participants pursuing further audiological evaluation (by providing their contact details) was low – with 81.18% of participants failing to provide their contact information (Ratanjee-Vanmali et al., 2019). The researchers suggest that the low turn-over rate may be due to uncertainty on the part of participants, of the validity of online hearing services; as face-to-face contact with health professionals throughout diagnosis and treatment has been the traditional clinical expectation (Ratanjee-Vanmali et al., 2019). It was suggested that the combination of both online and face-to-face interaction (hybrid model) between the clinician and patient may prove to be a viable service delivery model (Ratanjee-Vanmali et al., 2019). The incorporation and importance of clinician contact in tele-health was also noted by Nemes (2010). The evidence supports the notion that tele-health methods should not serve as a replacement for clinical contact but rather as complementary means to provide cost-effective healthcare services and patient support.

Health Science Academics' Perception of Tele-health

Another recent South African study aimed to report the perspectives and experiences of health science academics regarding tele-health and its inclusion in university healthcare training (Govender & Mars, 2018). Govender and Mars (2018) included a total of 66 academics from different professions across the health science faculties. Up to 71% of the participants felt tele-health has the potential to positively affect their profession; and 17% acknowledged the positive benefits of tele-health but had a negative outlook on the sustainability of using tele-health (Govender & Mars, 2018). Regarding practical application of tele-health in their respective clinics, 30% of participants indicated that the lack of practice standards or guidelines in tele-health creates a negative attitude towards the field (Govender & Mars, 2018). From the results of this study it can be said that there is positivity among healthcare academics regarding tele-health (Govender & Mars, 2018). However, overall hesitation to include such methods has been noted and can be attributed to: the lack of standard protocols; the lack of education

and training; ethical issues; and sustainability concerns (Govender & Mars, 2018). These issues, with regards to the field of tele-audiology, may be resolved with research on the feasibility and applications of the tele-rehabilitation services involved in comprehensive audiological rehabilitation (e.g. online AT).

2.2.3 South African Tele-audiology Devices and Applications

With the development of pioneering technology, allowing the delivery of tele-audiology services to rural and underserved communities, South Africa is widely recognised for innovative tele-audiology solutions (Kriel, 2018; Swanepoel & Biagio, 2011).

One of the most well-known South African-made mobile testing solutions is the Kuduwave™ (https://www.kuduwave.com/) designed by eMoyo. The Kuduwave™ is a hearing testing device that consists of a pair of soundproof headphones (which connects via USB cable to a laptop) and audiometry programme software. The applications for the Kuduwave™ range from offsite hearing testing and large-scale hearing healthcare projects to private practice use. The Kuduwave™ not only proves to be more affordable than the standard audiometric booth and audiometer, but also more flexible as their software is regularly updated and provides a wide range of testing materials.

The HearX™ Group (https://www.hearxgroup.com/), has also made a significant impact in the tele-audiology sector with their HearX™ mobile testing solutions; namely the HearX™ device and smartphone testing applications. The HearX™ device is a hearing testing system which includes sound-buffered headphones and a smartphone. The sound-buffered headphones allow for some noise protection but is not completely soundproof. However, the HearX™ smartphone applications provide real-time noise monitoring which alert the tester if unacceptable noise limits have been reached (Mahomed-Asmail, Swanepoel, Eikelboom, Myburgh, & Hall, 2016). The test results and patient information recorded on the HearX™ device can be synced to cloud-based storage which allows for offsite use. This function has proven useful in large-scale screening projects and clinician monitoring (Mahomed-Asmail et al., 2016; Swanepoel, 2016).

South African solutions for tele-audiology diagnostic testing are world renowned and local tele-audiology research is predominantly conducted with diagnostic applications in mind. Therefore, the need for research into tele-audiology applications for the provision of comprehensive audiological rehabilitation beyond diagnostics and HA fitting (i.e. tele-rehabilitation) exists.

2.3 Auditory Training

Although continuous advances in HA programmes, size, and power have provided revolutionary means for sensory compensation; limitations, mainly in understanding speech in noise, exist (Dubno, 2013; Gil & Iorio, 2010; Lesica, 2018; McCormack & Fortnum, 2013). In addition, HAs alone are unable to directly address the neurological implications of hearing loss (e.g. auditory memory decline, temporal resolution issues, and central processing deficits) (Gil & Iorio, 2010; Santos, Marangoni, Andrade, Prestes, & Gil, 2014; Sweetow & Henderson-Sabes, 2010). Various studies have linked systematic exposure to acoustic stimulation (AT) to an improvement in auditory skills and central neural functioning (Arlinger et al., 1996; Kraus et al., 1995; Santos et al., 2014; Song et al., 2012). There are various AT strategies which include in-clinic sessions or at-home computer/online training (Brouns et al., 2011). The guiding principles behind AT are: 1) neural plasticity – the ability of neurons to alter their function in response to sensory input; 2) HAs are limited in their capacity to provide sensory compensation; and 3) AT activities allow for real-world generalization (Brouns et al., 2011; Bryck & Fisher, 2012; Kraus et al., 1995; Olson, 2015; Saunders, 2012).

2.3.1 Benefits of Auditory Training

Improvement in Speech Perception

The consequence of permanent hearing loss is a decline in speech perception skills, which increases in the presence of background noise (Humes et al., 2019). Many studies have shown that AT improves auditory skills in people with hearing loss (Humes et al., 2019; Santos et al., 2014; Tye-Murray et al., 2017). Stropahl, Besser, and Launer (2020), presented a review of 16 studies evaluating the effects of AT on communication abilities of adults with hearing loss. Their review consisted only of controlled trials and the majority (10/16) of the studies showed participant improvement in speech perception skills (Stropahl et al., 2020). However, Stropahl et al. (2020) argue that successful AT

outcomes should not be solely interpreted with clinical assessments but also alongside self-perceived measurements which would enable clinicians to comprehensively evaluate the effects of AT. This prompted the current study to incorporate self-perceived measurements. Furthermore, the feasibility of an intervention should take into account the experiences and satisfaction of participants; thus self-perceived measurements were included in the current study (Orsmond & Cohn, 2015).

A recent American randomized control trial by Humes et al. (2019) aimed to investigate the effectiveness of a home-based AT programme on 43 older adult HA users. The study included three groups (intervention group; active control group [placebo intervention] and passive control group [no intervention]) and the data collection period was 5 weeks (Humes et al., 2019). Outcome measures included the Connected Speech Test and self-report HA benefit questionnaires (Humes et al., 2019). The results indicated an overall improvement in task-based skills (i.e. speech perception skills trained in the AT programme); however, no generalisation of skills was apparent (Humes et al., 2019). Humes et al. (2019) state that the clinical benefit of AT with regards to improving speech perception, may be strengthened by including AT with cognitive training tasks. They argue that the training of cognitive skills which underlie successful speech perception and not solely sensory training, may provide more generalizable outcomes and benefits for HA users (Humes et al., 2019). This is similar to Ferguson and Henshaw (2015) who concluded from an analysis of their previous AT studies; that the inclusion of AT programmes with combined auditory and cognitive driven tasks, showed to enable more effective and generalised communication benefits.

Improvement in Cognitive Function

The natural degradation of cognitive functioning (e.g. working memory, attention) in older adults is exacerbated by permanent hearing loss (both treated [amplification] and untreated) (Lawrence et al., 2018). Goh and Park (2009), suggests that memory and attention (which are both needed in speech perception) are overly used by older adults with hearing loss as a way to neurologically compensate for their impairment. This overuse paired with the neural effects of hearing loss, results in the rapid decline in cognitive function (Goh & Park, 2009; Lawrence et al., 2018). According to a recent systematic

review, evidence shows that some AT programmes may have positive effects on cognition in older adults with hearing loss (Lawrence et al., 2018).

The systematic review by Lawrence et al. (2018) examined international studies on the effects of auditory and cognitive training on cognitive function in adults with hearing loss. Of the nine studies included in their review, four used AT and five used cognitive training. Lawrence et al. (2018) determined through their analysis of the AT studies that there is minimal but significant evidence of minor improvements in cognitive functioning as a result of training. They suggested that because the training tasks required certain cognitive functions (e.g. memory); the regular administration of these AT tasks subsequently improved those cognitive functions (Lawrence et al., 2018). This serves as a significant conclusion from their review and shows that evidence exists to support cognitive benefits of AT (Krishnamurti, Tingle, Bannon, & Armstrong, 2015; Lawrence et al., 2018). This evidence-based possible outcome, may allow clinicians to further motivate HA patients to adhere and complete AT programmes, thus allowing for potentially improved HA benefit and satisfaction.

Patient Satisfaction and Lower HA Return Rate

AT may be an influential factor in improving patient HA satisfaction, and in the private sector this could translate to lower HA return rate (Martin, 2007; Stropahl et al., 2020). An observational study by Martin (2007) in four American private practices, investigated the influence of AT on HA satisfaction and HA return rate. The study included 625 participants and evaluated the HA return rate of participants who completed AT and participants who had no intervention (Martin, 2007). The participants were given the choice to complete the AT or not. As a result there were 173 participants who completed the AT and 452 participants who had no intervention (Martin, 2007). The results showed that participants who completed the AT, had a significantly lower HA return rate (3.5%) compared to those who did not complete the AT (13.1%) (Martin, 2007). Little evidence outlining AT effects on HA return rate exists; however, the Martin (2007) study highlighted positive effects AT potentially has on HA satisfaction and benefit. Increased HA satisfaction and benefit may further encourage regular HA use in new HA users (Martin, 2007; Stropahl et al., 2020). Although the Martin (2007) study was conducted in the private sector and mostly has implications for this sector; the result of AT positively

influencing HA satisfaction and HA use are factors to be considered in all audiology clinical settings providing HAs – including the public health sector.

2.3.2 Limitations of Auditory Training

Limited Evidence to Guide Intervention

A systematic review by Henshaw and Ferguson (2013) investigated internationally published evidence on the efficacy of computer-based AT; and their review included the analysis of 13 articles. They found positive indicators in the majority of the articles (11/13) to suggest that AT improved general speech recognition skills, however, Henshaw and Ferguson (2013) noted that the skill improvements reported in the articles were small. At the time of the review, they emphasized that the existing studies and evidence are not robust enough to be reliably used to guide intervention and clinical practice protocols; but rather highlights the significant need for higher quality experimental research (Henshaw & Ferguson, 2013).

A recent large-scale randomised control trial in the USA with 279 participants aimed to evaluate the effectiveness of a supplementary AT programme and regular HA intervention (Saunders et al., 2016). Outcome measures included both behavioural and self-report assessments and were obtained immediately after intervention (AT completion) and 6 months post-intervention (Saunders et al., 2016). The results indicated that there were no statistically significant effects in the use of AT compared to regular HA intervention on any of the outcome measures (Saunders et al., 2016). The conclusion of the Saunders et al. (2016) study is significant as the researchers suggest that the clinical implications of their results, will require audiologists to manage expectations when introducing and implementing AT for HA patients. The scale of the Saunders et al. (2016) study is also significant as previous studies in AT have included small sample sizes (Santos et al., 2014; Sweetow & Henderson-Sabes, 2004). The use of both behavioural and self-report measures in the Saunders et al. (2016) study proved to be a comprehensive means to assess participant outcomes, similar to the Stropahl et al. (2020) study.

Limited AT Applicability

In regards to the South African context, one of the main challenges with providing comprehensive hearing rehabilitation is the limited contextually relevant rehabilitative tools available (Pascoe et al., 2013). The languages of current AT programmes are not diverse (mostly English or European languages), thus are not applicable for the average population of developing countries such as South Africa; where English is a home language to less than 10% of the population (Olson, 2015; Statistics, 2018). The fact that most programmes are only available in English, is in itself a concern. Furthermore, the English used (mostly American) would be from a different cultural context and therefore may not be as easily identifiable to English speaking hearing impaired South Africans. For example, words like *"sidewalk"* (American) and *"pavement"* (South African) are used for the same concept but are linguistically different. This was an important aspect to consider for the current study as the language competency of the participants would influence their performance. This prompted a language inclusion criterion of English speaking participants, which partially addressed the AT language availability concern. However, could not address the fact that current AT programmes are not in a South African English vernacular.

Patient Motivation and Compliance

Henshaw et al. (2015) noted with their AT study that patient motivation is connected to improved AT outcomes and compliance. The more motivated a patient is, the more likely they will adhere to the AT schedule and complete the programme (Henshaw et al., 2015). According to Henshaw et al. (2015) patient motivation is influenced by the degree of their hearing difficulties and inclusion of positive feedback during training. Patient motivation may become an issue when, firstly, patients use an AT programme that is not enjoyable or makes them feel incompetent (i.e. AT programme is overly complicated or too long) (Henshaw et al., 2015). Secondly, too much effort is required to include AT in their personal schedules, as a result of required regular clinic visits for training (Sweetow & Henderson-Sabes, 2004). Lastly, patients perceive minimal or no benefit from the training and thus are unmotivated to continue or complete the programme (Tye-Murray et al., 2012). The issue of motivation was a notable concern for the current study and thus strategies that were suggested in the literature were

included in the current research in order to encourage participants' compliance (i.e. positive feedback, shorter AT sessions) (Henshaw et al., 2015).

Compliance may refer to the individual completion rate of an AT programme or the percentage of patients who complete the programme (Henshaw & Ferguson, 2013; Sweetow & Henderson-Sabes, 2010). It has been found through clinical research that in order for patients to receive optimal benefit from AT; sessions should be done regularly and consistently (Chisolm et al., 2013; Musiek, Chermak, & Weihing, 2014). The importance of compliance to AT programmes stems from the neural implications that AT can have on the brain (i.e. neurophysiological changes) with regular training – which allows for improved speech perception (Musiek et al., 2014; Tremblay, Kraus, & McGee, 1998).

Even though the connection between consistent training and improved outcomes has been established, the issue of compliance is a known limitation in AT (Sweetow, 2009; Sweetow & Henderson-Sabes, 2010). Few studies which address the issue of compliance in AT as noted by the outcome of the systematic review by Henshaw and Ferguson (2013), exist. Henshaw and Ferguson (2013) found only 6 of the 13 articles reported on compliance. Of the studies which had reported on compliance, all noted high compliance rates (>73%); which is inconsistent with the results of a large-scale AT study by Sweetow (2009) which only found a compliance rate of 30% for a sample of 3000 participants. Henshaw and Ferguson (2013) suggested that the studies in their review, which reported high compliance rates, may be attributed to the small scale of the studies in comparison to the Sweetow (2009) study.

Compliance is a known limiting factor in AT implementation. However, the development of more patient-led AT (e.g. online/remotely delivered) and shorter programme lengths may allow for higher compliance rates (Abrams et al., 2015; Sweetow & Henderson-Sabes, 2010). It has also been suggested through clinical studies that AT compliance rates may be improved through the inclusion of written instructions and telephonic follow-ups or regular clinician contact (Chisolm et al., 2013; Karawani, Bitan, Attias, & Banai, 2016; Tye-Murray et al., 2012). In order to encourage compliance in

the current study; efforts were made to include all of these strategies, as they were suggested to be linked to improved compliance in previous AT studies (Chisolm et al., 2013; Tye-Murray et al., 2012).

2.3.3 Auditory Training Mediums

The early traditional delivery of AT involved routine clinic-based face-to-face training sessions with the audiologist. Given the time consuming nature of regular face-to-face training; most audiologists considered this approach as not cost-effective, and difficult to incite patient motivation (Sweetow & Henderson-Sabes, 2004). A way to combat this was created through patient self-administered AT which involved pre-recorded CDs/DVDs with clinically validated AT programmes (Sweetow & Henderson-Sabes, 2004; Sweetow & Sabes, 2007). This medium created an opportunity for patient empowerment by allowing the training to be at their own convenience. With the growing increase of online resources and smartphone capabilities; AT has now moved onto web-based options as well as mobile applications. This is an important rehabilitative resource for both clinicians and patients, which allows AT to be delivered in a flexible manner. However, most mobile-based applications are not clinically validated or lack a remote patient monitoring function.

Considerations with Online AT Results

When implementing AT that is largely controlled by the patient (as it is completed at home) there are factors to consider when analysing the results of the AT. These factors are: 1) patients should be explicitly informed of the setting in which they should complete the AT (i.e. quiet and while wearing their HA); 2) patients should not receive outside assistance (i.e. from friends or family members); and 3) patients should complete sessions regularly. These factors cannot be entirely controlled by the clinician. Therefore, when implementing online AT an effort should be made to do in-booth speech assessments before and after AT implementation; in order to control environmental factors that cannot be controlled when patients complete training at home (Sweetow & Sabes, 2007).

The concept of patient-led or home-based AT allows for many benefits, which arguably over shadow the factors needed to be considered with online AT. Grenness, Hickson, Laplante-Lévesque, and Davidson (2014a), found that the desire for individualised care, was a recurring theme among a

survey of older adults with HAs. A significant benefit of patient-led AT is its positive effect on patient compliance and, patient empowerment; with respect to their individual communication goals (Abrams et al., 2015). Therefore, any means to promote joint analysis of communication goals and shared patient-audiologist decision making will not only allow individualised patient care, but further promote patient empowerment.

The development of patient-led web-based AT programmes and AT mobile applications have presented an appealing option for AT. Auditory training mediums have evolved from face-to-face clinician driven rehabilitation to online programmes; with the goal to continue evolving into shorter and more entertaining programmes, in order to encourage patient compliance (Tye-Murray et al., 2012). The table below lists and describes popular AT programmes that are currently available, all of which were considered for this study. Their advantages and disadvantages are outlined in regard to the South African context and links to factors such as: implied costs; device availability and other restrictive factors (e.g. programme interface).

Table 1:

Comparison of Different AT Programmes

Programme	Platform	Language(s) available	Advantages	Disadvantages
LACE Online (by Neurotone)	Web browser (any device)	American and British English	• Comprehensive listening tasks • Systematic programme progression (i.e. Session 1…Session 2 etc.) • Positive reinforcement and communication tips in-between programme activities • Audiologist able to monitor progress online • Variety of device compatibility • Once-off payment	• Unable to adjust text font size in programme – may be a restrictive factor for use on smaller devices (e.g. smartphone) • May be seen as expensive in comparison to other rehabilitation programmes available
Clear (by Dr. Nancy-Tye Murray)	Web browser (any device)	American English	• Comprehensive listening tasks • Audiologist able to monitor progress online • Variety of device compatibility • Different lesson plans	• Unable to adjust text font size in programme – may be a restrictive factor for use on smaller devices (e.g. smartphone) • May be seen as expensive in comparison to other rehabilitation programmes available • Monthly subscription
Hearoes (by Games4Hearoes)	Android and Apple (iPhone/iPad) devices	Australian English	• Free mobile application • Systematic programme progression (i.e. Module 1…Module 2 etc.) • Fun and interactive application (provides the rehabilitation as various mobile games)	• Basic skills targeted (individual speech sounds or environmental noises) • Some sub-modules can only be unlocked by completing other sub-modules. • Application does not allow text size adjustment
Hear Coach (by Starkey)	Android (v 4.0.3 and up) and Apple (iPhone/iPad) devices	American English	• Free mobile application • Fun and interactive application (provides the rehabilitation as various mobile games)	• Limited device compatibility • Application does not allow text size adjustment • Limited modules/activities available
ABClix (by Advanced Bionics)	iPad (iOS 6.0 and up) only	American English	• Free application • Variety of activities that can be chosen	• Limited device compatibility • Application does not allow text size adjustment
Angel Sound (by TigerSpeech Technology)	Computer/laptop only	American English	• Free programme • Variety of activities that can be chosen (including music training)	• Limited device compatibility • Extensive variety of programme activities may overwhelm some users (especially older adults)
ReadMyQuips (by Sense Synergy)	Computer/laptop only	American English	• Uses video of speaker for listening activities	• Limited device compatibility • Complicated interface of programme may confuse some users

The constrained audiological resources (i.e. health professionals, hearing technology and contextually relevant rehabilitation tools) in South Africa has prevented the successful inclusion of rehabilitation beyond HA fittings. Tele-health methods have become increasingly included in clinical settings around the world, particular for underserved communities, to allow wider access to healthcare. The use of online AT programmes could prove to be a cost-effective and clinical time-saving alternative for providing rehabilitation beyond HA fitting in the underserved South African public health sector.

AT may provide a strategy for neural retraining in HA patients based on the fact that prolonged untreated hearing loss deprives the auditory nerve of normal auditory stimulation; as HA technology is limited (Brouns et al., 2011; Lesica, 2018). However, there are studies that have shown insignificant or no improvement in auditory processing skills despite AT administration (Saunders et al., 2016; Stacey et al., 2010). Despite these limitations, the possible benefits of AT such as improvement in speech perception and cognitive skills are intriguing outcomes; which should motivate clinicians to include AT in hearing healthcare (Lawrence et al., 2018; Stropahl et al., 2020).

CHAPTER 3: METHODOLOGY

Introduction: This chapter will firstly present the aim and objectives of this study. Secondly, a description of the research design, participant recruitment and sampling method will be given. Thirdly, the data collection methods, data collection tools, data collection procedures and data analysis will be described. Finally, the chapter will outline the ethical considerations of this study.

3.1 Aim and Objectives

3.1.1 Aim

The aim of this study was to investigate the feasibility of implementing an online AT programme within a South African public health context.

3.1.2 Objectives

1) Determine participants' compliance to an online AT programme (LACE Online) with respect to the following:
    a) Number of sessions spent on the LACE Online programme per week;
    b) Frequency of interactions and contact time between researcher (clinician) and each participant (orientation and subsequent support as required);
    c) Number of participants who complete the prescribed sessions versus any participants who withdraw.
2) Determine the effect of the online AT programme on participants' speech perception in noise (pre- and post- administration of the online AT programme).
3) Assess participants' experience and benefit of online AT documented through interviewing and self-report questionnaires.
4) Estimate the costs around online AT programme implementation (online access/participant data usage/travel costs).

3.2 Research Design

A feasibility study using a convergent mixed methods design (quantitative and qualitative) was utilized. Convergent mixed methods is a research design for the parallel collection, analysis and interpretation of both quantitative and qualitative data from a single study (Fetters, Curry, & Creswell, 2013). This type of design was more appropriate for this study because it allowed the collection of different types of data simultaneously; which aided in the investigation of each objective outlined under the study aim. In addition, a convergent mixed methods design is best suited for feasibility studies as they allow the investigation and inclusion of data from different aspects of the intervention modality (e.g. patient performance, patient experience, expenses) (Orsmond & Cohn, 2015). Lastly, a convergent mixed methods design was best suited because the objectives outlined in the current study required the collection of both quantitative and qualitative data and therefore required the use of both quantitative and qualitative methods. Further detail on the methods used to collect the quantitative data and the methods used to collect the qualitative data are outlined below.

3.2.1 Quantitative Data

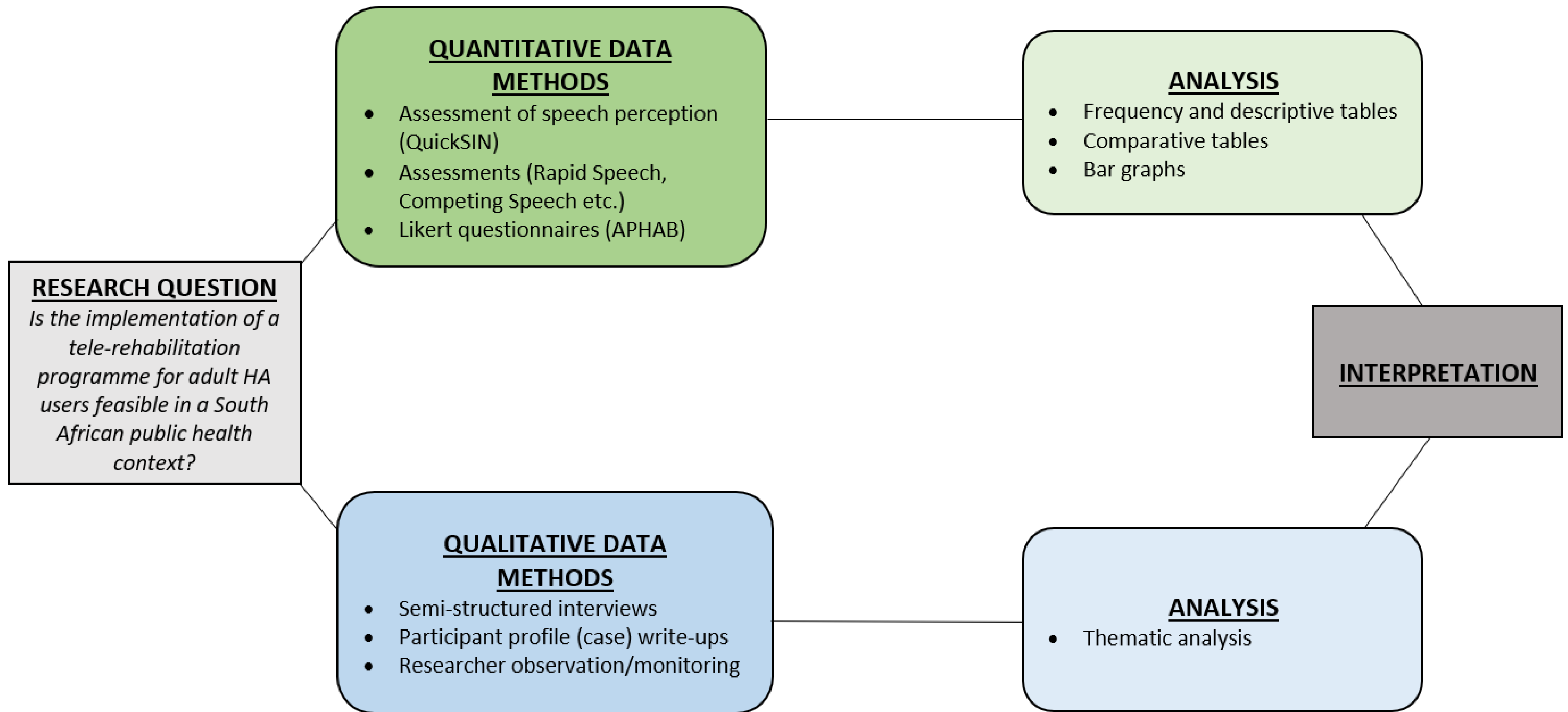
The quantitative methods, which included assessments of auditory skills (speech perception and online AT modules) and Likert questionnaires, were used within a single group pre-test/post-test design, as this design is best used to determine the effects of an intervention on participants (Allen, 2017). The characteristics for this design include firstly, all participants receiving the same intervention and secondly, determining any difference in pre-test/post-test assessment results (Allen, 2017). A concern of this design was the possibility of participants' performance and responses being influenced by the fact that they are aware of their inclusion in a research study (i.e. Hawthorne Effect) which may produce a falsely favourable outcome (Allen, 2017). However, efforts were made to limit this effect (further detail in *Threats to Internal Validity*); as advantages of this design for the current feasibility study are found in its simplicity and suitability for research involving one group of participants (Allen, 2017).

3.2.2 Qualitative Data

The qualitative methods which included semi-structured interviews were used within a generic qualitative research design. The goal of this design is to describe the experiences of individuals at either a surface or deep-set level, depending on the aim of the study (Willis, Sullivan-Bolyai, Knafl, & Cohen, 2016). A limitation of this design is the restricted inferences which could be made from qualitative data (Ochieng, 2009). Data which is individual participant-based may not reflect the experiences of the general population. However, the feasibility intent of the current study required a straightforward analysis of any commonality between the qualitative data collected – with the goal to provide an outline of the experiences and opinions of the individual participants. Thus, a qualitative research design was appropriate for this section of the data. See Figure 1 below for a brief summary of the research design, methods and analysis used in the current study. These will be discussed in further detail in this chapter.

Figure 1:

Current Study - Convergent Mixed Methods Design Outline



3.3 Participants

The participants in this study were adult HA users with a sensorineural hearing loss and at least one month HA experience. Participants were audiology patients at a public health facility. All participants were required to be able to communicate in English and have access to an internet capable device.

3.3.1 Participant Recruitment

In this feasibility study, participants were recruited from Groote Schuur Hospital; one of the largest public health hospitals in Cape Town. The availability of the necessary tools and equipment, to carry out the intended research, was only available at two hospitals (determined through telephonic enquiry). Due to unforeseeable challenges with one of the hospitals, data collection was only administered at Groote Schuur Hospital. Participants for the current study were adult HA users in the public health sector. Participant profiles in the current study referred to individual profiles of each participant. Participant profiles were included in the current study to allow the opportunity to gather more comprehensive information from each participant in line with the feasibility intent of the study. In addition, previous researchers in AT implementation have suggested outlining similarities in AT patients to help determine which type of patients may benefit from AT (Abrams et al., 2015; Dubno, 2013).

Participant recruitment was carried out using multiple methods and included both indirect and direct strategies, to recruit as many participants as possible.

Indirect recruitment: paper-based study adverts/posters were placed in and around the audiology department; and potential participants were able to contact the researcher if they were interested in being included in the study.

Direct recruitment: audiology file review (of existing HA patients at Groote Schuur Hospital to identify those that meet the study criteria) followed by direct phone contact, to invite prospective participants. The audiology department at Groote Schuur Hospital separates their patients according to "Diagnostic Tests" and "Hearing Aid Fittings"; and holds patients' folders in their main database

cabinet for approximately three years before archiving them. The researcher was given access to the HA fitting files to review and directly contact prospective participants. Contact was made using the contact details and language noted in the files. For this study, the entire database of the patients under "Hearing Aid Fitting" in their active database cabinet was perused; and eligible participants were contacted.

3.4 Sampling Method

Non-probability purposive sampling was used. Purposive or judgemental sampling enables researchers to target specific qualities or criteria to allow for deliberate inclusion of participants in a study (Etikan, Musa, & Alkassim, 2016). Purposive sampling is a useful method to utilize when researching whether an intervention or phenomenon is worth further investigation, which makes it an appropriate fit for investigating the aim of the current feasibility study (Sharma, 2017).

The greatest advantage of the purposive sampling method for the current study was the fact that the current research required certain participant criteria, making purposive sampling ideal. In this study this sampling strategy was used to specifically select individuals firstly, with a sensorineural hearing loss (i.e. hearing defect in the cochlear and associated neural structures) because this specific patient is targeted by AT intervention (Brouns et al., 2011; Bryck & Fisher, 2012). Secondly, the method of AT delivery in the current study required participants to have access to an internet capable device, thereby only allowing people with device access to be included. Finally, the language restrictions on the currently available AT programmes excluded people who were unable to communicate in English. The full participant criteria were as follows:

Inclusion Criteria

- HA users
    - Aged 19 – 59 years.
        - In older adults, the possibility of cognitive challenges and possible struggles with technology may hinder their participation in the study (Charness & Boot,

2009; Lehohla, 2014; WHO, 2018b). This was also noted in the Saunders et al. (2016) study; which investigated the different modalities of LACE.

  - With a mild to severe sensorineural hearing loss (unilateral/bilateral)
    - AT is designed for people with sensorineural hearing loss. HA users with a sensorineural loss require further auditory compensation as a result of the neurological changes resulting from the hearing loss.
    - Hearing loss degree was classified according to the classification system outlined in Katz (2015).
  - With access to a smartphone/laptop/computer/tablet
    - LACE Online requires access to a web-browser.
  - Could communicate in English
    - The LACE Online is currently only available in English.
  - Had at least one month experience of HA use (monaural/binaural)
    - A LACE training study by Olson, Preminger, and Shinn (2013); found that new HA users reported greater benefit than experienced users.

Exclusion Criteria

The following individuals were excluded from the study; those who:

- Were already receiving AT
  - Participants who were already receiving AT may influence the results.
- Had a known cognitive impairment
  - The intervention programme required basic understanding and memory to complete the tasks.
- Had a known literacy impairment
  - The intervention programme required basic literacy as all tasks involve reading.
- Had a bilateral flat profound sensorineural hearing loss
  - According to Sweetow and Sabes (2007), the LACE is most suited for individuals with a mild to severe hearing loss.

3.5 Data Collection

3.5.1 Data Collection Methods

In alignment with the convergent mixed methods design, both quantitative and qualitative methods were used. The quantitative measures included AT assessments, speech perception testing and Likert questionnaires. The qualitative measures included semi-structured interviews, participant profile (case) write-ups and researcher observation.

3.5.2 Data Collection Tools (Assessments and AT Intervention)

After the recruitment process, an in-clinic screening was done to determine which potential participants were eligible to continue with the study. Screening was done in relation to factors such as cognitive competency. The screening included a cognitive screening scale [*Mini-Cog* Borson, Scanlan, Brush, Vitaliano, and Dokmak (2000)], and a technology competency screener (*Task Questionnaire*). After the screening there were three sections of assessment: pre-intervention, intervention, and post-intervention. The following will describe the tools used under the sub-headings: "Screening Tools"; "Pre-Intervention"; "Intervention"; and "Post-Intervention". Under the "Intervention" sub-heading, will describe the intervention (LACE Online AT programme); the evidence surrounding its clinical development and application; as well as the intervention programme structure.

SCREENING TOOLS

(i) Mini-Cog (Appendix A)

The Mini-Cog (Borson et al., 2000) is a standardised test used to distinguish between persons with dementia and persons without dementia. The Mini-Cog was used because according to Borson et al. (2000), the Mini-Cog has a higher sensitivity, when compared to the Cognitive Abilities Screening Instrument (CASI) and the Mini-Mental State Exam (MMSE). In addition the Mini-Cog is shorter and has a higher accuracy than the CASI and MMSE; when screening for dementia (Borson et al., 2000).

(ii) Task Questionnaire (Task Ability Checklist) (Appendix B)

This checklist was designed by the researcher; to quickly assess potential participants' ability to perform the basic technological functions, to use the online AT programme. It is a self-report measure

and includes four questions. A similar questionnaire type was also included in the Abrams et al. (2015) AT study. It was important to administer the *Task Questionnaire* for the current study; as the technological knowledge of participants, would influence their ability to complete the at-home online training.

PRE-INTERVENTION

(i) Entrance Questionnaire (Appendix C) & Entrance Interview

Entrance Questionnaire

This questionnaire was a simple Likert scaled questionnaire, designed by the researcher to determine previous exposure to AT; anticipated motivation to complete the AT; preferred internet-capable device; and preferred method of contact. See Table 2 below for details of the questions included.

Table 2:

Entrance Questionnaire – Question Rationales

QUESTIONS	RATIONALE
Have you ever received auditory training before this research study?	Participants were briefed about AT, before answering this. Patients with recent auditory training exposure (<1 year) could not have been included because their previous training could have influenced their performance and results, in the current study's online AT programme.
Do you think you will benefit from auditory training? **Do you think you will be able to make time each week to complete your auditory training sessions?**	These questions were included to determine the initial perceptions of the participants, after being introduced to the online AT programme. In addition, they were told about the expectations of their inclusion in the study. The responses to these questions were reviewed after the participants' responses to the *Exit Questionnaire.*
Which of the following do you think you will use the most when accessing the auditory training programme online? (Smartphone/Laptop/Tablet/Computer)	The availability of an internet capable device was a crucial inclusion criterion. This question was included to determine which devices were available and initially preferred by the participants. The responses to this question were reviewed after the participants' responses to the *Exit Questionnaire.*
Select an option as your preferred method of contact. (Email/WhatsApp/SMS/Call)	Participants' preferred method of contact was noted in order to allow regular clinician (researcher) contact and support using a platform that each participant was able to access (or preferred).

Entrance Interview

The Entrance Interview was conducted to determine the participants' case history, hearing concerns, technological knowledge, and expectations of the online AT. If patients indicated in their Entrance Questionnaire that they have recently received AT, further questions in regard to the nature and duration of that AT was asked in the Entrance Interview.

The inclusion of semi-structured interviews (pre- and post- intervention) in the current feasibility study served to allow comprehensive inclusion of participant experiences and opinions, as well as enable the researcher to build rapport with participants. The way interview questions were asked, and the rapport built was important in limiting the threat of social desirability bias (further detail in *Bias Threats*).

(ii) Abbreviated Profile of Hearing Aid Benefit (APHAB) (*Appendix D*)

The APHAB (Cox & Alexander, 1995) is a Likert scaled questionnaire, which includes questions based on the HA user's experience in specific listening situations. It was adapted and shortened from the 66 item Profile of Hearing Aid Benefit (PHAB), to the 24 item APHAB; which can be separated into 4 sub-scales (EC: Ease of communication; RV: Reverberation; BN: Background Noise; AV: Aversiveness) (Cox & Alexander, 1995). The APHAB uses real-world situations and is a quick measurement for determining the difference between listening with and without HAs. Each item addresses listening, ability while wearing HA(s) and when not wearing their HA(s). The total benefit for each item is calculated by subtracting the aided score from the unaided score. Furthermore, each test item corresponds to one of the aforementioned sub-scales. According to Cox and Alexander (1995), the APHAB produced a test-retest correlation coefficient that was found to be moderate to high. They noted that this result in reliability, was consistent with other studies involving similar scales. The APHAB proved to be an effective pre-/post- intervention measurement in the AT study by Santos et al. (2014); which had some similar objectives to the current study, thus selected to be included.

(iii) QuickSIN

The QuickSIN (Etymōtic Research, 2001) test, is a standardised test used to determine patients' ability of understanding speech in noise. According to the QuickSIN development team, Etymōtic Research (2001), the score obtained in the QuickSIN test is accurate to 2.7 decibels (dB) at a 95% confidence level. Although a QuickSIN assessment was included in the LACE Online training programme; it was also conducted by the researcher in an audiometric booth before and after intervention. In order to minimise the influence of the learning effect, the in-booth QuickSIN was administered with different wordlists for each participant (i.e. the wordlist at the pre-intervention assessment was different to the post-intervention assessment wordlist).

INTERVENTION

(i) LACE Online

One of the most widely used and researched AT programmes is the Listening And Communication Enhancement (LACE) programme (Sweetow & Henderson-Sabes, 2004). In comparison to other AT programmes, the LACE is considered to be the most user-friendly. It further provides real-world generalizable speech activities, as well as communication tips and helpful videos within each session (Karawani et al., 2016). The programme aims to provide comprehensive, cost effective and self-paced training. It is available in various mediums: DVD, CD-ROM and web-based (LACE Online https://www.neurotone.com/lace-interactive-listening-program) (Sweetow & Henderson-Sabes, 2004; Sweetow & Sabes, 2007). The LACE Online includes four different types of activities (e.g. word memory, rapid speech, speech in noise and competing speaker). Three of the speech activities include tasks around difficult listening conditions (e.g. rapid speech, speech in noise and competing speakers); and one of the speech modules include activities around improving auditory memory (word memory) (Saunders et al., 2016).

The initial study for the LACE was conducted at the University of California San Francisco (UCSF), and the AT was based on informal feedback from the university's clinic patients (Sweetow & Henderson-Sabes, 2004). The results post-AT, showed the test group had overall improvement in speech perception compared to the control group (Sweetow & Henderson-Sabes, 2004). The results

suggested that LACE assisted in speech perception improvement (Sweetow & Henderson-Sabes, 2004). A follow-up study by Sweetow and Sabes (2007), included behavioural and self-report measures (post LACE) with a larger sample size (65 participants). The results also showed speech perception improvement for the majority (83%) of the participants (Henderson-Sabes & Sweetow, 2007). Using behavioural and self-report measures, Henderson-Sabes and Sweetow (2007), could review the outcomes from a comprehensive perspective. In addition, unlike their 2004 study, the inclusion of a larger sample size allowed for improved statistical analysis.

The LACE is available in American and British English; which limits its applicability to South Africa. However, future South African AT tele-rehabilitation programmes can use the LACE Online platform design to build a more contextually relevant programme. The LACE Online runs from a cloud-based system which allows clinician monitoring and support and does not restrict user access based on device. It was determined that the LACE Online was the optimal programme for the current research. LACE Online provides a strong evidence-based platform for AT and proves to be the most reliable in relation to software strength and functioning.

The LACE Online includes a clinician monitoring function and a shorter programme moulded from years of research and HA user feedback; to provide similar benefit as the original LACE, however, at a more accessible level (DeFauw & Henderson-Sabes, 2014). This served as further motivation for the use of LACE Online for the current study. Furthermore, it proved to be the most affordable when taking into account the simple web-based application and cloud-based clinician monitoring – features; which were best suited for the purpose of this study. The LACE Online consists of 11 sessions, each approximately 25-45 minutes in length. Each session contains a combination of listening exercises including speech-in-noise tasks, rapid speech tasks, competing speaker tasks and word memory tasks. As patients progress through the 11 sessions, the difficulty of the level changes depending on their scoring – if patients improve in their scores the tasks become more challenging (lower signal-to-noise ratio [SNR]). The inverse being that if patients struggle, then tasks become easier (higher SNR).

POST-INTERVENTION

(The APHAB and QuickSIN were re-administered in the post-intervention session)

(i) Exit Questionnaire (Appendix E) & Exit Interview

Exit Questionnaire

Similar to the Entrance Questionnaire, the Exit Questionnaire was a Likert scaled questionnaire designed by the researcher, to allow participants to provide some feedback on their tele-rehabilitation experience. Questions were framed around: programme accessibility, interface, and participant motivation to complete the programme. See Table 3 below for details on the questions included.

Table 3:

Exit Questionnaire – Question Rationales

QUESTIONS	RATIONALE
Which of the following did you use the most when accessing the auditory training program online? (Smartphone/Laptop/Tablet/Computer)	The responses to this question were cross-checked with the participants' original device indication in the *Entrance Questionnaire*. The participants' choice and reason behind their preferred device was addressed in the *Exit Interview*.
Did you find the auditory training to be beneficial? **Did the programme meet your expectations?**	These questions were included to quickly determine the participants' perception and attitude towards the online AT. The *Exit Interview* allowed the participants to expand on their views and interview questions also addressed their reasoning behind their choices.
Did you find it easy to log-in to the programme?	The initial introductory session during the pre-intervention appointment was included, to address possible participant struggles to navigate the programme. This question was included to determine if participants struggled with starting the online programme. Further questions on navigating the intricacies of the programme interface were asked during the *Exit Interview*.
Did you have problems with internet access?	It was anticipated that internet access could have been an issue, which is why participants were given data during the post-intervention appointment. However, there would have been no way for the researcher to monitor or control the data usage. Therefore this question was included to determine if internet access was available to all participants throughout the duration of the study (i.e. did participants use the data as intended).

Did you find the American accent easy to follow?	One of the challenges in administering AT in South Africa is the lack of contextually relevant tools and materials. People with hearing loss already have known struggles hearing and understanding speech in a familiar accent and this needed to be taken into account in the current study; as an unfamiliar accent and vernacular could have influenced the participants' performance.
Were you able to make time each week to complete your auditory training sessions?	Time management in home-based rehabilitation is an important aspect to consider as this directly influences patient outcomes.
Do you believe auditory training should be included in audiological management?	The participants' initial attitude towards the online AT they completed was screened with this question. During the *Exit Interview* the reasons behind their response were explored before asking further questions on the structure and delivery of the tele-rehabilitation.

Exit Interview

The Exit Interview allowed participants the opportunity to provide responses to questions surrounding the online programme, delivery, accessibility, and clinician contact. They were also asked questions pertaining to what they enjoyed and what they did not enjoy about the online AT. The interviews also allowed the opportunity to expand on their questionnaire responses and participants were also encouraged to provide any other feedback or comments. As with the Entrance Interview, the questions were largely open ended, and all participants were asked the same questions.

(ii) System Usability Scale (SUS) (Appendix F)

The SUS (Brooke, 1996), is a ten item questionnaire used to assess participants' perceived usability of a programme (i.e. LACE Online). According to Brooke (1996), measuring usability should include: 1) the effectiveness of the programme or system – the ability of participants to complete the programme; 2) efficiency – the resources needed and used to complete the programme; and 3) satisfaction – participants' opinion and experience. The SUS was included because, it is a simple standardised scale that has been widely used in research and is considered an intrinsic tool when assessing perceived usability (Lewis, 2018). Although other methods such as participant observation could assess usability; the current study design, employed remote rehabilitation that was largely patient led with clinician support. This made a participant self-report questionnaire ideal. Other health and rehabilitation studies, which assessed usability of tele-health programmes, also used paper-based

methods (e.g. surveys and questionnaires) (Agnisarman et al., 2017; Schutte et al., 2015). Therefore, the SUS was deemed appropriate as it is a simple validated scale which could be administered post-intervention.

3.5.3 Data Collection Procedure

Participant Rehabilitation and Assessment Factors

The LACE Online programme was instructed to be completed while the participants were wearing their HA(s). The QuickSIN was conducted in an audiometric booth, through free field speakers, while the participants were wearing their HA(s). All questionnaires and paper-based assessments (Mini-Cog, Task Questionnaire, APHAB, SUS, Entrance Questionnaire and Exit Questionnaire) were self-administered with the supervision of the researcher.

Screening

1) Potential participants from the hospital's audiology database were contacted and given details on the current study aim; and afforded the opportunity to ask questions or raise concerns about inclusion. Potential participants were then given letters of consent (Appendix G) and once they consented to participate, were booked for in-clinic eligibility screening. Participants were first screened for cognitive impairment using the Mini Cog (Borson et al., 2000); which was administered with the instruction of the researcher, as it is a clinical screening tool. They were also screened with a Task Questionnaire, to ensure they had the basic technology skills necessary to navigate the online AT programme. The questionnaire was self-administered by the participants with the supervision of the researcher.

Pre-Intervention

2) Participants who passed all the screening tests were then seen for the pre-intervention assessments at Groote Schuur Hospital by the researcher. At the beginning of the pre-intervention session, Entrance Interviews were conducted, and questions were asked about participants' case history, hearing concerns and technology knowledge. Participant responses were recorded (via clinical notes) for later review and analysis. In addition an Entrance

Questionnaire asking questions pertaining to AT knowledge and pre-empted availability for weekly AT sessions was completed. This was self-administered by the participants.

3) Pre-intervention assessments included:

    a. The Abbreviated Profile of Hearing Aid Benefit (APHAB) (Cox & Alexander, 1995), which assesses self-perceived HA benefit. This was self-administered by the participants.

    b. The QuickSIN test (Etymōtic Research, 2001), which assesses speech in noise abilities. This was conducted by the researcher in an audiometric booth. The HAs of each participant was given a quick listening check by the researcher before any testing was done.

4) After pre-intervention assessments were completed, a LACE Online introductory and demonstration session was facilitated using a face-to-face demonstration. In addition, participants were given a one-page summary (Appendix H) of log-in instructions to take home.

5) Participants were logged on and registered by the researcher with the LACE Online programme.

    a. All participants were given standard login information (i.e. researcher created emails and passwords for the purposes of the current study) to avoid participants using their personal email addresses.

Intervention

6) The online AT programme (intervention) was then completed by all participants at their own convenience over a four-week period; with the researcher monitoring their progress through the LACE Online cloud server. Participants were instructed to complete sessions in a quiet environment while wearing their HAs. The following applied to the intervention period:

    a. Target of 3 AT sessions per week.

    b. Weekly reminders (via WhatsApp) were sent at the beginning of each week, and one additional reminder in the middle of the week (as required).

    c. Weekly progress reports were given to participants as well as highlighting their strengths to encourage continued AT.

Post-Intervention

7) Upon the completion of the programme each participant was booked for the post-intervention assessments using the APHAB and QuickSIN (as with the pre-intervention assessments).
8) At post-intervention sessions, participants AT results were explained and they were also asked to complete:
    a. The System Usability Scale (SUS) (Brooke, 1996), to determine the self-perceived usability of the programme. This was self-administered by the participants.
    b. An Exit Questionnaire which included questions on the self-perceived experience of the programme, accessibility, and device preference. This was self-administered by the participants.
9) After the post-intervention session, Exit Interviews were conducted; and questions were asked about the tele-rehabilitation structure and delivery, clinician support and opinions on AT. The interviews were conducted in a quiet room with the researcher recording (via clinical notes) the participant responses.

Table 4 below outlines and summarises all the data gathered in line with study aim and objectives.

Table 4:

Summary of Data Collection

Objective	Data Collection Method(s)	Data Collection Tool(s)
1) Determine participants' compliance to an online AT programme (LACE Online) with respect to the following:		
a) Number of sessions spent on the LACE Online programme per week.	• Online researcher monitoring	• LACE Online patient cloud-based records
b) Frequency of interactions and contact time between researcher and each participant (orientation and subsequent support as required).	• Researcher record keeping	• WhatsApp messaging records • Telephonic call log
c) Number of participants who complete the prescribed sessions versus any participants who withdraw.	• Researcher record keeping • Participant reporting	• WhatsApp messaging • Telephonic calls

2) Determine participants' AT results and speech perception in noise score (pre- and post- administration of the online AT programme).	• Online AT • Speech perception testing	• LACE Online patient cloud-based records • QuickSIN
3) Assess participants' experience and benefit of tele-rehabilitation documented through self-report questionnaires and interviewing.	• Self-report questionnaires • Participant interviews	• APHAB • SUS • Researcher recordings
4) Estimate the costs around tele-rehabilitation programme implementation (online access/participant data usage/travel costs).	• Researcher record keeping • Manual calculations	• Smartphone data usage estimation software • Calculator

3.6 Data Analysis

3.6.1 Analysis of Quantitative Data

Descriptive statistics were used for the quantitative data. The advantages of using descriptive statistics include, the simple analysis and straight forward interpretation of the data (Mishra et al., 2019). For the current feasibility study, descriptive statistics were also advantageous as they provided meaningful summaries of the findings; which allowed the intervention modality to be analysed from different aspects (Mishra et al., 2019).

3.6.2 Analysis of Qualitative Data

Thematic analysis of the qualitative data was conducted to determine any commonality between participant interviews. The thematic analysis in the current study adopted a systematic phased process outlined by Nowell, Norris, White, and Moules (2017). The analysis process included:

- ***Familiarization with the data**:* Researcher reviewing transcripts.
- ***Generating initial codes:*** Coding of data and researcher reflexive writing of initial thoughts and impressions of the data.
- ***Searching for themes:*** Identification of possible themes based on common participant experiences.
- ***Reviewing themes:*** Determination of link between themes and participant experience.

- ***Defining and naming themes:*** Definition and clarification of themes and sub-themes.
- ***Producing report:*** Write-up of common themes and sub-themes with raw data (participant quotes) embedded within report.

Thematic analysis was appropriate because this analysis method aims to summarise and describe patterns or group similarities in the data, which would allow interpretation of the data in line with the feasibility intent of this study (Clarke, 2015). See below Table 5 for a summary of the data analysis in this study.

Table 5:

Summary of Data Analysis

Data	Analysis Method
• Number of AT sessions completed (compliance) • Contact Time (between the researcher and participant) • Associated costs of the tele-rehabilitation	Frequency and descriptive tables
• QuickSIN scores • APHAB scores • AT (LACE Online) scores	Comparative tables (Used to determine any change between pre- and post-intervention scores)
• SUS results	Bar graph
• Interview responses	Descriptive thematic analysis

<u>*Intended Analysis*</u>

The intended inferential statistics were dependent t-tests and the Wilcoxon signed rank test. Dependent t-tests were supposed to be used to analyse the QuickSIN scores, in order to determine a statistical difference pre- and post- intervention. The Wilcoxon signed rank test was to be used to analyse the findings from the APHAB (the APHAB's Likert scale made the Wilcoxon signed rank test appropriate). However, due to the small sample size in the current study neither inferential statistical test could be used. Although descriptive and inferential statistics are both equally important in the inclusion for data analysis; the lack of inferential statistics due to sample size, limits the generalizability and implications of the findings (Mishra et al., 2019).

3.7 Ethical Considerations

This study was guided by the ethical principles outlined by the World Medical Association (WMA), in the Declaration of Helsinki (World Medical, 2013). These principles serve to guide researchers in protecting the rights, mental well-being and physical health of human participants in medical research (World Medical, 2013). Ethical approval was granted by the Human Research and Ethics Committee (HREC) of UCT. The ethical approval reference number for this study was: 642/2018 (Appendix I).

Autonomy (Informed Consent)

The introduction session as well as the recruitment letter, ensured that the participants understood what the research entailed and thus allowing them to give informed consent. No one was forced to participate. Participants were also able to withdraw from the study, at any time, without being penalised.

Confidentiality

The confidentiality of the participants' identifying information was kept electronically in a password protected cloud. The testing and interviews were conducted in a private room. Furthermore, the results of each participants' assessments were reported back to them (in the same private room) at the end of their training. No identifying information is reported in this thesis.

Non-maleficence

The intervention had no risk of physical or emotional harm and did not hinder the functioning of the participants' HAs. In addition, the speech assessment had no risk of harm and was performed by a qualified clinician (the researcher). To limit participant expenses; the assessments were arranged on days where the participant already had other hospital appointments. In some instances participant travel costs were reimbursed (e.g. train/bus ticket). Furthermore, participants received mobile data at the beginning of the study to complete the online AT programme.

Beneficence

Participants received intervention that would have only improved their listening abilities, and there was no risk of further damage to their hearing.

Justice

All participants received the same intervention and were assessed with the same tests. Each participant received 1.0 – 1.5 gigabytes (GB) (depending on the options provided by their network provider). It was determined that 1.0 GB was more than sufficient to complete the entire programme and could additionally be utilized for regular phone-based support. The data usage required to complete the programme was calculated according to an online session conducted on a smartphone, and also based on data usage estimates from an online article by Legget (2019). The smartphone used had a built-in system function whereby mobile data can be monitored. Each LACE Online session is nearly identical in terms of media content and time, therefore data usage for each session would be similar.

CHAPTER 4: RESULTS

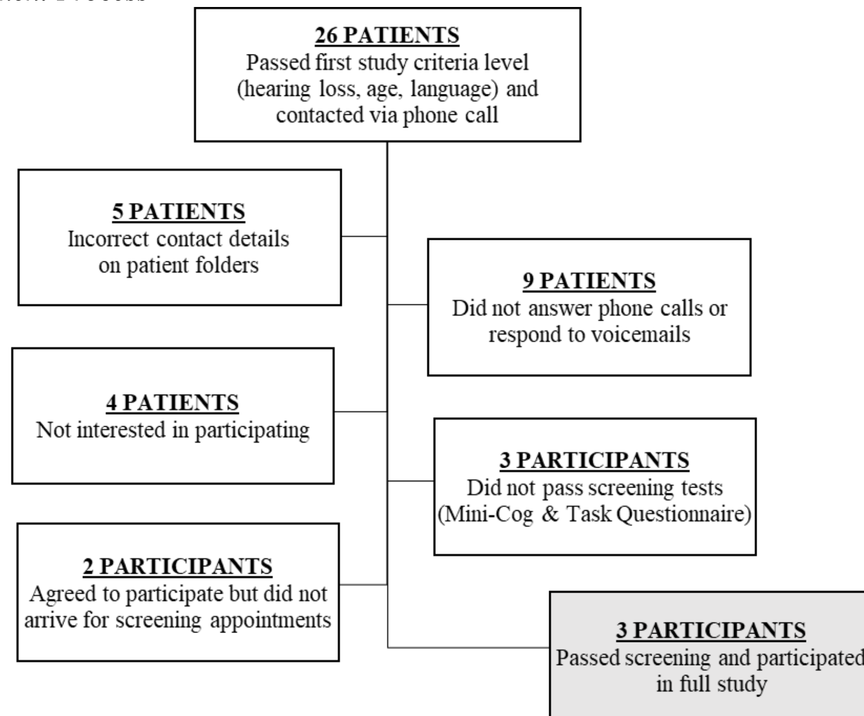
Introduction: This chapter will present the results of this study according to its aim and objectives. Firstly, the chapter will describe the participants. Secondly, it will present the findings regarding participants' compliance to the online AT programme. Thirdly, the outcome of the pre-/post-intervention assessment following the online AT (intervention) will be presented. Fourthly, the participants' experiences and perceived benefit from the online AT programme will be outlined (interviews and questionnaires). Lastly, the costs associated with implementation of the online AT programme will be presented.

4.1 Participant Descriptions

A total of 26 patients were identified and passed initial eligibility criteria for recruitment to this study. After the screening and eligibility determination, there were initially five eligible participants. However, due to two participants not arriving for appointments, three participants were included in this feasibility study (see Figure 2 below). All included participants were female between the ages of 35-55 years; diagnosed with a bilateral hearing loss and fitted monaurally (all on their left ear). The participants' aided period (duration since fitting) ranged from 6-24 months.

Figure 2:

Participant Recruitment Process



Participant Profiles

The following will describe each participant's case history/hearing concerns/technology knowledge (Entrance Interview) and their Entrance Questionnaire responses. Participants were assigned numbers and results correspond with the number (i.e. Participant 1 refers to the same participant throughout dissertation).

PARTICIPANT 1

Case History

Participant 1 was a 53-year-old woman with a moderate to profound sensorineural hearing loss. She was fitted with a Starkey HA on her left ear two years ago, and her home language is English. Participant 1 wanted to participate in the study because she reported having struggles with hearing in background noise. She was enrolled in a Bible and Christianity related diploma programme at her church and attends frequent lectures. She reported being unemployed but manages a university student accommodation house, that she owns with her husband. Participant 1 does not reside with any of her own children currently, however, is often surrounded by many people as a result of the student accommodation. She attended all her face-to-face appointments without a communication partner.

Hearing Concerns

Participant 1 noted the following hearing concerns; distant speakers and hearing in background noise. It was explained by the researcher during the pre-intervention session that these issues were common among HA users (especially the issue of hearing in background noise). She emphasized a specific example of her struggles with hearing in background noise. She stated that during the day, she at times, surrounded by many people occupied with their own endeavours (e.g. moving in and out of the house); which sometimes poses difficulties when concentrating on listening to one speaker.

Technology Knowledge

Participant 1 reported that she had no problems handling technology and had access to both a smartphone and a laptop. Although mobile data was offered to her as a participant in a research study; she preferred to use her own home Wi-Fi data. Participant 1 was optimistic about the potential benefits of online AT and hoped it would improve her hearing in background noise.

Entrance Questionnaire

Participant 1 had not had any form of AT before this feasibility study and was unaware of AT. She reported that she would be able to make time in her schedule to complete the online AT. WhatsApp was indicated as her preferred method of contact with the researcher instead of the other options that included email, SMS and phone-call.

PARTICIPANT 2

Case History

Participant 2 was a 36-year-old woman with a mild to severe sensorineural hearing loss. She was fitted with an AccuQuest M15 CP HA on her left ear one year ago, and her home languages are English and Chichewa (Malawi). Participant 2 wanted to participate in the study because she wanted to improve her hearing in background noise. She is unemployed and reported being a housewife with some part-time jobs. She has three school-aged children, whom she mainly communicates with as her husband works full-time. Participant 2 attended all her face-to-face appointments without a communication partner.

Hearing Concerns

Participant 2 noted the following hearing concerns; hearing in background noise, and discomfort when sounds are too loud (e.g. in a movie theatre). It was explained by the researcher during the pre-intervention session that the concerns with uncomfortably loud sounds, could be remedied by adjusting the HA volume. However, if the concerns continued; a follow-up appointment at the HA clinic at Groote Schuur Hospital should be made. Participant 2 emphasized struggles hearing one-on-one conversations, when people are talking in the background. She expressed enthusiasm and positivity with regards to starting the online AT.

Technology Knowledge

Participant 2 reported that she is able to do simple smartphone tasks (i.e. WhatsApp). When shown how to log-in online and start the training, she needed initial assistance and support. Participant 2 had access to a smartphone to complete the online AT.

Entrance Questionnaire

Participant 2 reported that she had heard of and experienced some type of listening training before, but it was minimal and a while ago. The listening training occurred when she first received a HA from a different hospital; before moving and becoming a Groote Schuur Hospital patient. Participant 2 agreed that she would be able to make time to complete the training at her own convenience; and indicated that WhatsApp was the preferred method of contact with the researcher.

PARTICIPANT 3

Case History

Participant 3 was a 53-year-old woman with a moderate to severe sensorineural hearing loss on her left ear (aided), and a severe to profound hearing loss on her right ear. She was fitted with an Oticon Ino P on her left ear seven months ago; and her home languages are English and Afrikaans. Participant 3 wanted to participate in the study because she wanted to improve her hearing in background noise. She reported being a housewife and lives with her husband and three children; two of the children are high school aged and the eldest is working. Participant 3's husband is a full-time teacher and was present

at all face-to-face appointments. Her husband played a key-role in communicating weekly online AT progress sent by the researcher; as Participant 3 did not have a smartphone at the time of the pre-intervention session. The husband received all of the weekly updates and reminders. Participant 3 opted to use her own home Wi-Fi data.

Hearing Concerns

Participant 3 reported struggles with distant speakers and hearing in background noise. She described that she has issues hearing someone who calls or speaks to her from another room. The limitations of the HA technology in relation to this issue was explained to her by the researcher during the pre-intervention session. It was then suggested that an effort should be made from other people to go to the room she is in, before communicating with her. When the concept of AT and the online programme was explained to Participant 3, she believed it could benefit her because she wished to improve her listening skills.

Technology Knowledge

Participant 3 admitted that she has no interest in technology and she struggles to navigate devices. However, when shown how to navigate the programme, she was positive it was simple enough for her to complete on her own. Participant 3 had access to a laptop and a family member's smartphone. She reported that she would complete the programme on a smartphone but ended up using a laptop; indicating that it was easier to see the instructive texts in the programme. Participant 3 admitted to requiring the assistance of a family member to type in the log-in information for the first session, before becoming more comfortable with the programme.

Entrance Questionnaire

Participant 3 indicated that she had never had AT before, and had also never heard of the concept. She indicated that she believed she would be able to make time to complete the training and indicated WhatsApp (her husband's) was the preferred method of contact.

4.2 Compliance

Objective 1: Determine participants' compliance to an online AT programme (LACE Online) with respect to the following:

(a) Number of sessions spent on the LACE Online programme per week.

The target number of sessions for completion per week was three and the participants for this study averaged at two per week, with the average total completed AT sessions being 9 out of 11 (84.82%).

(b) Frequency of interactions and contact time between researcher (clinician) and each participant (orientation and subsequent support as required).

The number of in-clinic face-to-face interactions per participant came to two (one for pre-intervention assessment and one for post-intervention assessment). The frequency of phone or email interactions varied among the participants, as some participants required more support than others. Most of the interactions during the weeks of online AT, were to communicate and explain their AT progress and results. For the duration of the study there was a total average of 9 online interactions for each participant with an average of once per week per participant.

The average total contact time for each participant was 3 hours and 25 minutes and the weekly average was 22.5 minutes for each participant. The total contact time for all participants for the duration of the study was 10 hours and 15 minutes.

(c) Number of participants who complete the prescribed sessions versus any participants who withdraw.

For this study there was a 100% completion rate and 0% withdrawal rate.

Table 6 on the next page describes the above compliance factors in the current study. This referred to (a) the number of weekly sessions; (b) the frequency of clinician (researcher) contact and clinician-participant contact time (in hours).

Table 6:

Compliance Factors

	(a) Number of AT sessions completed per week						
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Total (out of 11)**		
Participant 1	2	3	3	3	11		
Participant 2	4	3	2	2	11		
Participant 3	0	2	2	2	6		
Mean	**2**	**2.67**	**2.33**	**2.33**	**9.33**		
	(b) Number of online interactions (telephonic/email contact)						
	Pre-intervention	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Post-intervention**	**Total**
Participant 1	1	2	1	2	1	2	9
Participant 2	1	2	1	1	1	2	8
Participant 3	1	2	2	2	1	2	10
Mean	**1**	**2**	**1.33**	**1.67**	**1**	**2**	**9**
	(b) Contact time (face-to-face and telephonic) (in hours)						
	Pre-intervention	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Post-intervention**	**Total**
Participant 1	0.75 (-0.25)*	0.50	0.25	0.25	0.25	0.75 (-0.16)*	2.75 (-0.41)*
Participant 2	1.50 (-0.25)*	0.50	0.25	0.25	0.25	1.00 (-0.16)*	3.75 (-0.41)*
Participant 3	0.75 (-0.25)*	0.50	0.75	0.25	0.50	1.00 (-0.25)*	3.75 (-0.50)*
Mean	**1.00**	**0.50**	**0.42**	**0.25**	**0.33**	**0.92**	**3.42**

**Value in brackets represents study related time*

4.3 Effect of Intervention on Speech Perception

Objective 2: Determine the effect of the online AT programme on participants' speech perception in noise (pre- and post- online AT).

Online AT Results

The results of the AT showed evidence of clinical benefit (according to the LACE Online) with an overall improvement in participants' listening skills in the trained tasks (i.e. Competing Speaker/Rapid Speech/Speech-In-Noise Training/Word Memory Training).

QuickSIN Results - LACE Online Assessment

The LACE Online conducts the QuickSIN three times – during the first, sixth and final session. The QuickSIN assessment done through the AT programme is an estimate and it presents the stimulus and noise through the same speaker. With the QuickSIN test, a decrease in score indicates an improvement. The overall average QuickSIN score (administered by the LACE Online) improved by 5.3 dB for the participants.

QuickSIN Results - Audiometric Booth Assessment

The participants were tested through free field speakers, while wearing their HAs. The test was conducted twice on each participant, with each time one speaker presenting the stimulus (QuickSIN sentence list) and the other presenting the noise (speech noise). The overall average QuickSIN score did not improve for both speakers – it should be noted that Participant 3 could not be included in this calculation (see Table 7 and Table 8 below for details).

Table 7:

Assessment and Intervention Results

PARTICIPANT 1

Pre-Intervention		Intervention	First Session	Final Session	Improvement (Y/N)	Post-Intervention		Improvement (Y/N)
QuickSIN LACE	15.0 dB	**Competing Speaker**	3.8 dB	6.6 dB	**N**	**QuickSIN LACE**	6.5 dB	**Y**
		Rapid Speech	1.2 x	1.5 x	**Y**			
QuickSIN Booth	Left = 1.5 dB	**Speech-In-Noise Training**	16.8 dB	8.1 dB	**Y**	**QuickSIN Booth**	Left = 6.5 dB	**N**
	Right = -2.5 dB	**Word Memory Training**	2.5	4.3	**Y**		Right = 1.5 dB	**N**

PARTICIPANT 2

Pre-Intervention		Intervention	First Session	Final Session	Improvement (Y/N)	Post-Intervention		Improvement (Y/N)
QuickSIN LACE	0.5 dB	**Competing Speaker**	0.0 dB	-11.7 dB	**Y**	**QuickSIN LACE**	9.0 dB	**N**
		Rapid Speech	1.6 x	2.1 x	**Y**			
QuickSIN Booth	Left = 8.5 dB	**Speech-In-Noise Training**	9.3 dB	-0.3 dB	**Y**	**QuickSIN Booth**	Left = 8.5 dB	**N**
	Right = 15.5 dB	**Word Memory Training**	1.8	2.1	**Y**		Right = 13.5 dB	**Y**

PARTICIPANT 3

Pre-Intervention		Intervention	First Session	Final Session	Improvement (Y/N)	Post-Intervention		Improvement (Y/N)
QuickSIN LACE	14.0 dB	**Competing Speaker**	-0.8 dB	-9.9 dB	**Y**	**QuickSIN LACE**	-2.0 dB	**Y**
		Rapid Speech	1.2 x	1.3 x	**Y**			
QuickSIN Booth	Left = 10.5 dB	**Speech-In-Noise Training**	16.0 dB	-1.5 dB	**Y**	**QuickSIN Booth**	Left = ***	***
	Right = 12.5dB	**Word Memory Training**	2.2	3.8	**Y**		Right = ***	***

***** Participant could not be tested – participant did not replace HA battery on the day of assessment*

Table 8:

Assessment and Intervention Results (Overall Average/Mean)

OVERALL AVERAGE/MEAN									
Pre-Intervention		**Intervention**				**Post-Intervention**		
			First Session	Final Session	**Improvement (Y/N)**			**Improvement (Y/N)**
QuickSIN LACE	9.8 dB	**Competing Speaker**	1.0 dB	-5.0 dB	**Y**	**QuickSIN LACE**	4.5 dB	**Y**
		Rapid Speech	1.3 x	1.6 x	**Y**			
QuickSIN Booth	Left = 5.0 dB Right = 6.5 dB	**Speech-In-Noise Training**	14.0 dB	2.1 dB	**Y**	**QuickSIN Booth**	Left = 7.5 dB Right = 7.5 dB	**N** **N**
		Word Memory Training	2.2	3.4	**Y**			

4.4 Participant Experience and Benefit

Objective 3: Assess participants' experience and benefit of online AT documented through interviewing and self-report questionnaires.

4.4.1 Participants' Intervention Period Summaries and Exit Questionnaire Responses

PARTICIPANT 1

Intervention Period

In the four weeks of the online AT, Participant 1 required minimal clinician support (one WhatsApp conversation per week), except for the initial introductory and demonstration session. She completed the target number of sessions each week, and her results indicated an improvement in 3 of the 4 listening tasks in the LACE Online.

Exit Questionnaire

Participant 1 indicated that she mostly used a laptop to complete the online AT. She reported that she found the AT to be beneficial and strongly agreed that it should be included in audiological management. She also found it easy to log-in and had no issues with internet connectivity. Participant 1 indicated that at times the American accent was difficult to follow, but overall, it was not a problem to complete the online AT.

PARTICIPANT 2

Intervention Period

During the pre-intervention session, Participant 2 required more support than Participant 1 and 3. Participants 2's pre-intervention session lasted 90 minutes in comparison to the 45 minutes of the sessions of Participant 1 and 3. This discrepancy is attributable to a temporary access block for the LACE Online website, during Participant 2's pre-intervention session. This was a consequence of email security and safety measures that are automatically put into place. All Participants were signed up for the LACE Online using a predetermined email account (e.g. lacepart01@gmail.com). It created an unforeseen problem with logging in to the LACE Online, from a different device to the original device used to create the email account. This was easily rectified by changing the security setting within the

email address settings. However, it did create a slight struggle in the beginning for Participant 2 to start the programme. She completed the set target sessions each week and showed an improvement in all four listening tasks of the LACE Online.

Exit Questionnaire

Participant 2 reported that she mostly used a smartphone to complete the online AT. She indicated that she found the AT to be beneficial and strongly agreed that it should be included in audiological management. She found it easy to log-in and also had no issues with internet connectivity. Participant 2 indicated that she could follow the American accent without any difficulties.

PARTICIPANT 3

Intervention Period

Participant 3 struggled to meet the required number of sessions each week despite weekly reminders being sent. She only completed 6 out of the 11 sessions. However, Participant 3's AT results did indicate an improvement in all four listening tasks from the first session to her sixth session.

Exit Questionnaire

Participant 3 indicated that she mostly used a laptop to complete the online AT. She found the AT to be beneficial and strongly agreed that it should be included in audiological management, especially for patients who struggle in noise. She found it slightly challenging to log-in at first but became familiar with the programme. Participant 3 indicated that she had no issues with internet connectivity and no problem following the American accent.

4.4.2 Participant Exit Interviews

The following section will describe the responses obtained during the Exit Interviews. The responses gathered formed several categories which could be encapsulated under three different themes as depicted in Table 9 below.

Table 9:

Thematic Analysis

THEME	CATEGORY	DESCRIPTION	EXAMPLE OF PARTICIPANT(S) QUOTE
CLINICIAN CONTACT: HELPFUL AND NEEDED	**Helpful weekly reminders**	All participants found the training enjoyable; however, they did report that they needed the weekly reminders to stay on track to complete the programme. Participant 3 was assisted by her husband with weekly reminders, and he mentioned that it was good to be continually updated; however, he felt pressure to remind her to do her sessions. He concluded by stating that the reminders were a burden, however, very much needed because she struggled to be compliant.	"*The reminders helped me to remember to make time to fit it* [online AT] *in my busy life*". (Participant 1) "*Yes, the reminders were helpful... With that* [weekly reminders], *the burden fell on me.*" (Participant 3 – communication partner)
PROGRAMME STRUCTURE	**Tasks**	There were mixed opinions on the structure of the programme (i.e. task instruction delivery and task order). One participant reported that it was, at times difficult to switch from one task to another without warning (e.g. one session may have included a few *Competing Speaker* tasks and a few *Word Memory* tasks). She went on to explain that once she built confidence in one task, the programme moved onto the next task; and it became frustrating.	"*I would get used to doing one task then the voice would change, and I would have to do something different...I was building confidence in one thing and then it would change... the woman's voice was the easiest*" (Participant 1)
	Good session length	In relation to the individual training session length, participants reported no issues with the length.	"*The sessions were not too long...*" (Participant 2) "*... it* [the length] *was fine*" (Participant 1)
	Helpful communication tips	All participants mentioned, during their interviews, that the communication tips given in the LACE Online were helpful and appreciated.	"*... and I have learnt so much from the tips given in the programme.*" (Participant 1)
OPINIONS TOWARDS AT	**Patient education**	All participants believed AT should be included in audiological rehabilitation of hearing loss. Participants noted that patients should at least be informed about the concept of AT so that they know it exists and that it can help with listening skills.	"*They* [public health patients] *should at least be informed about it* [AT]." (Participant 1) "*Yes* [inclusion of AT in regular audiological management], *especially when they can't hear in noise.*" (Participant 3)
	Enjoyable training	It was apparent from the positive responses given by the participants that they preferred to do the AT sessions in their own time, as there was no pressure to attend regular hospital appointments.	"*I highly recommend this programme...It is a fantastic programme.*" (Participant 1)

4.4.3 Participant Perceived Benefit

APHAB Results

The areas assessed by the APHAB provided complementary information to the Exit Interviews, as the APHAB assessed HA benefit post online AT and the interviews were aimed at the participants' experience of the online AT itself. The APHAB is separated into four sub-scales (areas): Ease of Communication (EC), Reverberation (RV), Background Noise (BN), and Aversiveness (AV). Each statement or item in the APHAB is scored in a percentage (e.g. "Never" = 1%; "Generally" = 75%; "Always" = 99%). In all sub-scales, an increase in percentage score between pre-intervention and post-intervention indicates an improvement in perceived benefit. In this study the results of the APHAB, showed that with all the participants, there was an overall improvement in perceived HA benefit in three of the four sub-scales. The average benefit of the RV items improved by 21.3%, BN items improved by 21.2%, and AV items improved by 16.4%. The EC average benefit decreased by 1.1%. Tables 10 and 11 describe the APHAB results pre- and post- intervention for each participant and the overall average.

Table 10:

APHAB Results

PARTICIPANT 1				
Pre-Intervention		**Post-Intervention**		**Improvement (Y/N)**
APHAB EC	26.9 %	**APHAB EC**	49.5 %	**Y**
APHAB RV	36.7 %	**APHAB RV**	71.8 %	**Y**
APHAB BN	18.3 %	**APHAB BN**	61.7 %	**Y**
APHAB AV	-82.7 %	**APHAB AV**	-90.7 %	**N**
PARTICIPANT 2				
Pre-Intervention		**Post-Intervention**		**Improvement (Y/N)**
APHAB EC	11.5 %	**APHAB EC**	12.4 %	**Y**
APHAB RV	2.1 %	**APHAB RV**	33.0 %	**Y**
APHAB BN	4.2 %	**APHAB BN**	-8.3 %	**N**
APHAB AV	-36.7 %	**APHAB AV**	16.5 %	**Y**
PARTICIPANT 3				
Pre-Intervention		**Post-Intervention**		**Improvement (Y/N)**
APHAB EC	82.0 %	**APHAB EC**	55.2 %	**N**
APHAB RV	65.8 %	**APHAB RV**	63.7 %	**N**
APHAB BN	34.7 %	**APHAB BN**	67.5 %	**Y**
APHAB AV	-36.5 %	**APHAB AV**	-32.5 %	**Y**

Table 11:

APHAB Results (Overall Average/Mean)

OVERALL AVERAGE/MEAN				
Pre-Intervention		**Post-Intervention**		**Improvement (Y/N)**
APHAB EC	40.1 %	**APHAB EC**	39.0 %	**N**
APHAB RV	34.9 %	**APHAB RV**	56.2 %	**Y**
APHAB BN	19.1 %	**APHAB BN**	40.3 %	**Y**
APHAB AV	-52.0 %	**APHAB AV**	-35.6 %	**Y**

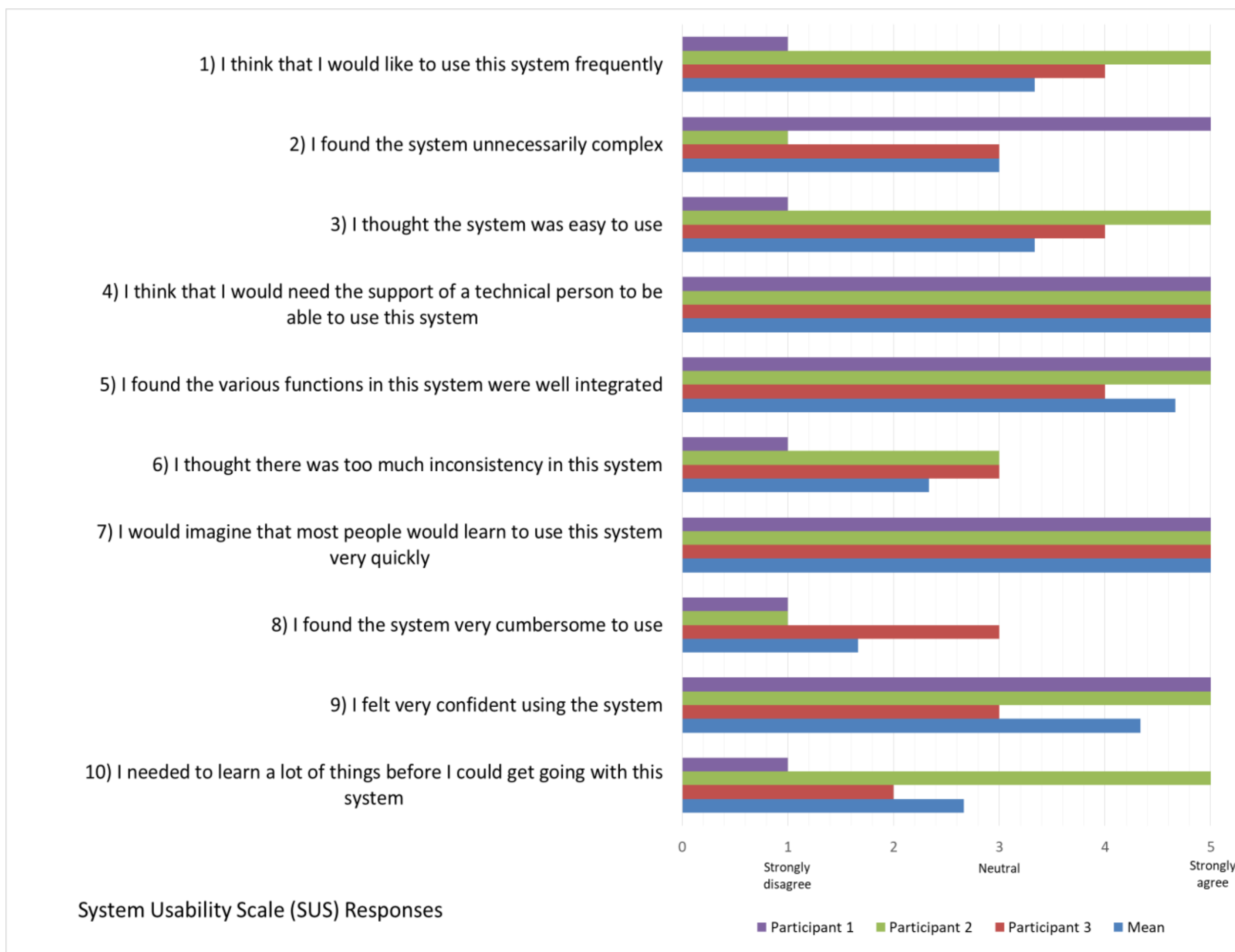
4.4.4 Participant Perceived Usability of Online Programme

SUS Results

The usability of the AT programme was documented through the SUS. The SUS was used as formal means for the participants to assess the usability of the LACE Online platform. All participants indicated that they believed people would need initial technical assistance to be able to learn to use the programme quickly. Figure 3 below depicts the responses received.

Figure 3:

SUS Responses



4.5 Costs Associated with Online AT Implementation

Objective 4: Estimate the costs around online AT programme implementation (online access/participant data usage/travel costs).

The estimated costs of the implementation of the online AT programme were calculated by including the following costs for each participant:

- LACE Online access – $79.00 (R1 200.80 according to the exchange rate on 09/10/2019).
- Mobile data – R80.00 – R100.00.
- Travel – R28.00 – R30.00.

The most expensive factor in the implementation was the cost of the online access to the AT programme itself. At approximately R1 200.80, which could be seen as more affordable than other available online programmes because this cost is once-off whereas some programmes require monthly subscriptions.

The most affordable factor was the cost of travel. This was minimal considering that each participant only had two in-clinic appointments. With regards to the mobile data, this varied depending on the network of the participants and Cell C was found to be the most affordable in terms of mobile data per GB. Table 12 below describes the breakdown in costs of the tele-rehabilitation programme implementation.

Table 12:

Breakdown of Costs

	Breakdown of costs			
	LACE Online (*rands = r*)	**Mobile data (*rands = r*)**	**Travel (*rands = r*)**	**Total (*rands = r*)**
Participant 1	1200.80	80.00	28.00	1308.80
Participant 2	1200.80	80.00	30.00	1310.80
Participant 3	1200.80	100.00	30.00	1330.80
Participant 4	1200.80	***	***	1200.80
Participant 5	1200.80	***	***	1200.80
Total	**6004.00**	**260.00**	**88.00**	**6352.00**

Participants did not arrive for appointments (see Figure 1)* with leading *:

**** Participants did not arrive for appointments (see Figure 1)*

CHAPTER 5: DISCUSSION

Introduction: This chapter will discuss the findings of the current study in relation to existing research literature. Possible implications emanating from the study findings will also be discussed. The chapter will end with a discussion of the strengths and limitations of this study.

5.1 Tele-rehabilitation Feasibility Study

This study set out to investigate if the implementation of a tele-rehabilitation programme for adult HA users is feasible in a South African public health context. Findings from this study may be positive indicators that audiological rehabilitation of disabling hearing loss may be administered using a tele-health model in a South African context. Key findings of this feasibility study include 1) a high compliance rate (84.82%) to tele-rehabilitation with minimal clinician contact time at 3 hours 25 minutes over a 5–6-week period; 2) improvement in participants' perceived HA benefit as well as improvement in their listening skills; 3) reported positive experiences by participants; and 4) minimal programme costs at an average of R1 350.00 per person. These findings will be discussed in detail below.

5.2 Compliance to online AT

The compliance rate of the participants for this feasibility study was 84.82 %. This compliance rate refers to the number of online sessions completed. When taking into account the length of the online intervention (length of sessions and total number of sessions) the compliance rate is high. High compliance rates were also noted in the Saunders et al. (2016) (84%), Chisolm et al. (2013) (84%) and Tye-Murray et al. (2012) (>90%) studies. The high compliance rate in the current study could be attributed to regular clinician support; which included weekly telephonic contact as well as the initial introductory and programme demonstration sessions at the beginning of intervention. It was found during the interviews that all participants mentioned that the weekly reminders helped them to complete sessions each week. A similar finding of clinician contact impacting patient compliance was also concluded from the Chisolm et al. (2013) and Tye-Murray et al. (2012) studies. Regular clinician contact influencing compliance is an important factor to consider; as it implies that tele-rehabilitation

should not fully replace clinician contact, in fact, clinician contact (through a hybrid model of delivery) is pertinent to positive patient compliance.

5.2.1 Clinician Contact

In this feasibility study the average total clinician-participant contact time was 3 hours and 25 minutes. The weekly online contact time as well as the face-to-face contact time were similar in length between the participants. This could indicate a pattern in the amount of clinician support that is required at the different stages of tele-rehabilitation, however the current small sample size limits the validity and reliability of this finding. Clinician contact and its influence on patient compliance was seen in this study and previous studies on AT (Chisolm et al., 2013; Tye-Murray et al., 2012). The current study was conducted over 6 weeks and the amount of contact time was minimal. The participants completed a full AT programme and were provided with weekly clinician support. In a usual audiology clinic, 3 hours would approximately equate to three/four diagnostic tests or initial HA fittings. This shows that a hybrid model of tele-rehabilitation delivery could possibly be introduced into the existing public health patient load and service provision without creating a significant burden on the existing clinicians and daily appointment bookings. Furthermore, the benefits of tele-rehabilitation (i.e. easy modality for patients and professionals, high compliance rate, patient-led) possibly outweigh the addition of the 3 hours 25 minutes over 6 weeks to an existing clinic.

The lack of sufficient HAs and qualified audiologists to provide comprehensive audiological rehabilitation for patients with disabling hearing loss in the South African public health sector resulted in a clinical protocol that generally ends at HA fitting and subsequent device maintenance (Orji et al., 2020; Pienaar et al., 2010). A recent South African large-scale study showed that only 15% of patients, with a moderate to severe hearing loss, were fitted with HAs within the public health sector (Hlayisi & Ramma, 2019). Considering the above challenges; the need to provide rehabilitation to improve these patients' self-perceived HA benefit and satisfaction, is considerable (Hlayisi & Ramma, 2019; Orji et al., 2020).

The findings from this feasibility study could suggest that South African adult HA patients may comply to online AT as it is convenient and does not require regular travel to the hospital. However, further large-scale research should be conducted on the feasibility of tele-rehabilitation in all South African settings (e.g. private health sector, rural areas).

5.3 Participant Benefit

The results of the APHAB showed that the BN (Background Noise) sub-scale was one of the most improved sub-scales overall. This is an important result, as one of the key training tasks of the LACE programme is speech-in-noise training. An improvement in the participants' self-perceived hearing in background noise is a positive indicator of the effectiveness of the skills learned in the LACE Online. However, the results of the two sets of QuickSIN scores assessing listening in noise (LACE administered and in-booth testing) were not consistent. The overall LACE administered QuickSIN scores improved, however the in-booth QuickSIN scores did not. Reasons for this could be a result of inconsistent testing conditions (i.e. LACE administered QuickSIN was performed in an uncontrolled environment) or possible participant ear canal obstruction (otoscopy was not performed on participants). Although participants perceived their listening to have improved in background noise, this did not translate to the clinical testing. It can be argued that because the APHAB items are multi-circumstantial and address real-world situations, the improvement in the self-perceived scores does indicate some form of translation of the LACE-trained skills into real-world listening situations. Stropahl et al. (2020) further states that, a self-perceived benefit scale may be considered the closest representation of real-world benefit. However, it would be expected for improved skills to be further revealed in clinical testing. The APHAB has proved to be a comprehensive and effective assessment of perceived HA benefit not only in this study but in multiple previous studies (Brodie et al., 2018; Cox, Johnson, & Xu, 2014; Santos et al., 2014; Tye-Murray et al., 2012).

Self-report measurements in audiological rehabilitation are important; because the communication skills of HA users are multi-faceted and need comprehensive assessment, which assist in measuring improvements and to establishing communication goals (Sweetow & Henderson-Sabes, 2010). Measuring self-perceived benefit should be considered important when administering AT; as

seen with the other results of the APHAB, which correlate with the LACE training effects. For example, a possible reason for the EC (Ease of Communication) subscale of the APHAB failing to improve post-intervention; could be attributable to the fact that EC items all address quiet situations. Whereas, the other sub-scales present items of complex listening situations. The LACE Online focuses on improving listening in noise skills; therefore, the perceived benefit could have been more perceptible in complex noisy situations. An improvement in listening in noise skills, would then determine how the participants scored their listening skills in noisy environments compared to quiet environments. This finding suggests that the results of an AT programme should be cross-checked with a self-perceived benefit scale, such as the APHAB.

5.4 Participant Experience

Interviews

Participants responded positively to the tele-rehabilitation according to the interview findings which was a promising indicator that South African public health patients may be open and willing to engage in tele-health methods. All participants indicated that AT should be included in audiological rehabilitation. Some stated that patients should, at least, be informed about it; citing that they had never heard of AT before this research. The lack of information and implementation of further hearing rehabilitation could be because public health audiologists are challenged with attending to back-to-back patients and the diagnosing and fitting of patients leaves little time for further services (e.g. AT) (Makhoba & Joseph, 2016; Pienaar et al., 2010). This is reported in the South African study by Makhoba and Joseph (2016), who noted the inclusion of communication strategies was the only form of further audiological rehabilitation after HA fitting; and only reported to be included by 69.8% of their sample (45 audiologists). The lack of inclusion of AT is possibly further corroborated by other international literature which have reported that AT is a vital yet underutilized tool in the field of audiology (Chisolm et al., 2013; Dubno, 2013; Ferguson & Henshaw, 2015; Sweetow & Palmer, 2005). Therefore, the use of online AT whereby the patients receive a self-explanatory document (e.g. pamphlet); may afford public health patients the opportunity to receive AT, without placing a burden on public health audiologists in South Africa. As found in the current study; it would not require a substantial amount

of time, to explain AT and introduce patients to an online programme (approximately 15 minutes) during their first obligatory HA follow-up. The inclusion of AT programmes in audiological practice should be initialized with a detailed introductory session. In addition, it is important to select programmes that are appropriate for the population in terms of language, context and usability.

Self-report Questionnaire

The System Usability Scale (SUS)

The main point revealed from the SUS, was that participants believed most people would learn to use the programme very quickly. However, they also indicated that they would need the support of a technical person to be able to use the programme. This can be associated with the results of the frequency of clinician-participant interaction; which showed that most support is provided in the first week of intervention. Although the AT programme was explained in detail, and participants were given a one-page document summarising how to log-in; patients required further reassurance and support, in week one. This finding is similar to a crucial point made by Nemes (2010); who suggested that tele-audiology methods should be applied, without disregarding duties towards patient support in the form of clinician contact. In addition, Sweetow and Henderson-Sabes (2010) highlighted that compliance of home-based AT has been reported by many audiologists, to have improved with an initial face-to-face introductory session with the clinician. Taking into account these previous findings and the findings of the current study; it can be said that tele-rehabilitation should be implemented using hybrid methods. It has shown to improve 1) compliance, 2) patient trust and 3) patient empowerment (Nemes, 2010; Sweetow & Henderson-Sabes, 2010; Tye-Murray et al., 2012).

5.5 Online AT Costs

The total costs for this feasibility study were R6 352.00, and the average cost per participant was R1 350.00. When considering the estimated budget that the National Department of Health recently spent on healthcare (R222.6 billion) (Treasury, 2019); the tele-rehabilitation cost inclusion of R1 350.00 per HA user may be plausible. A possible manner of cost inclusion could be to combine tele-rehabilitation costs with the costs of a HA per patient (Hlayisi & Ramma, 2019).

A factor in assessing the feasibility of the tele-rehabilitation programme is the determination of associated costs. These costs generally include the costs of resources (e.g. assessments, programme access etc.), health facility costs (e.g. equipment and health professionals) and patient costs (e.g. travel expenses, internet data costs). The current study reviewed the costs of the tele-rehabilitation programme from a health provider perspective and included the costs of: the American product (LACE Online) which was influenced by the dollar to rand exchange rate; mobile internet data and patient travel expenses. The intent on investigating the feasibility of the tele-rehabilitation programme in the context of a health facility was the determining factor in adopting a health provider perspective. This perspective allowed the initial investigation of associated costs on a basic level with the intent of future research in tele-rehabilitation adopting a larger perspective which could incorporate broader factors (e.g. family, societal, government) (Polimeni, Vichansavakul, Iorgulescu, & Chandrasekara, 2013).

One of the initial presumed factors for this study was the possibility that public health patients would not have access to an internet capable device (e.g. smartphone/laptop/tablet). However, it was found that all but one of the screened participants had access to at least one device (mostly smartphones), and already had some form of regular internet access (e.g. home Wi-Fi or phone data contract). This is consistent with the findings from Rutherford and Petersen (2019), who noted that the penetration of the smartphone market in South Africa is 73%. This is arguably significant and holds promise for the available technology to be used for healthcare access and delivery through tele-health. Also, Holst (2019), reports that approximately 22 million South Africans have a smartphone. The fact that so many South Africans have access to an internet capable device; highlights a resource that may make tele-rehabilitation not only feasible, but possibly sustainable, as device access is predicted to increase over time (Holst, 2019).

Instituting tele-rehabilitation programmes for disabling hearing loss in the public health sector, may possibly be more affordable; compared to the cost of training and employing the number of clinicians required to conduct face-to-face AT with the number of patients in need. This would hypothetically involve the utilization of existing audiology resources – i.e. available qualified audiologists, existing equipment, and tele-health related resources. This possibly translates to a cost

benefit for the national budget and patients; as home-based AT, is more affordable than traditional face-to-face AT (Reis, Boisvert, Beedell, & Mumford, 2019).

An Australian cost evaluation study for AT on CI users by Reis et al. (2019), was conducted with private practice audiologists. This study highlighted important positive factors (fewer patient costs and in-clinic appointments) of home-based AT that proved to be potentially relevant in the public health context. A factor to consider was that, compared to traditional face-to-face AT, home-based AT translated into less out of pocket expenses (e.g. travel costs) for the patient (Reis et al., 2019). Furthermore, the CI users in the Reis et al. (2019) study completed more sessions and spent more time on home-based AT; in comparison to other methods of AT delivery. This feasibility study showed similar results; particularly in relation to one of the participants. The participant reported that the online platform allowed her to complete more sessions at any time because, she was able to incorporate it into her schedule and "*busy life*".

Costs remain an issue for access to a reliable online AT programme and is understandably a significant factor affecting AT implementation on both a public and private healthcare level (Reis et al., 2019; Saunders et al., 2016; Sweetow & Henderson-Sabes, 2010). However, in the South African context, inter-sectoral collaboration (e.g. IT/tech sector, mobile networks) may assist in providing cost-effective solutions (e.g. allocated mobile data packages for HA users); in order to dispense online AT and other tele-rehabilitative strategies to a larger HA user population. The need for rehabilitation beyond HA fitting may also be addressed by considering existing, more affordable, and accessible AT options.

<u>Current AT Options</u>

In relation to the South African public health setting; the available free AT smartphone applications may prove to be a valuable tool, as it allows basic skill training at minimal cost. However, it is important to highlight that these applications are not as comprehensive as web-based applications and have not been clinically validated; although some were developed with the assistance of audiologists (e.g. *Hearoes*). Currently, only one free mobile application providing clinician monitoring exists – *Hearoes* (by Games4Heroes). The software is flawed and unreliable which translates to the

failure of syncing some results to the cloud. However, it does involve some basic skill training. Although there are free mobile applications available, these are not clinically validated and provide basic skills training compared to the paid programmes available. The goal for public health audiological rehabilitation would be to develop a contextually relevant (i.e. South African language; South African based normative and rehabilitative data), clinically validated, free AT application, with a stable clinician monitoring feature.

The use of a programme that benefits patients, minimises out of pocket expenses and promotes patient empowerment; are necessary factors to consider (Reis et al., 2019; Sweetow & Henderson-Sabes, 2010; Tye-Murray et al., 2012). Other factors may be inferred from this feasibility study as a whole. See Table 13 below for a detailed outline of each factor.

Table 13:

Factors in a Tele-rehabilitation Programme

Factor	Explanation
Patient Need	Any further rehabilitation beyond HA should be determined according to communication issues and goals of the patient. With HA users, listening in background noise is a common issue (Gygi & Ann Hall, 2016). For this reason it can be said that AT is a well-rounded tool that can be used on a wide range of patients. In addition, with the variation in AT strategies; adjustments can be made according to the patient's needs.
Patient Hearing Loss	Patients with a permanent sensorineural loss, require further auditory compensation because of the neurological changes resulting from auditory nerve damage (Gil & Iorio, 2010; Santos et al., 2014; Sweetow & Henderson-Sabes, 2010). Furthermore, hearing losses with a conductive component fluctuate, and are usually remedied with medical intervention (e.g. medication or surgery).
Patient Language	The majority of adult AT programmes currently available, are in English. All AT programmes available were developed outside of South Africa; which means that some of the vocabulary, from the English spoken in these programmes, may not be familiar to the larger population of South Africa. Furthermore, the majority (91.9%) of South Africa does not speak English as a mother language (Statistics, 2018). The language of the patient currently limits AT options.
Patient Age	In senior adults (>60 years); the possibility of various cognitive challenges and possible struggles with technology may hinder their participation in AT (Huh, 2018). This was also noted in the study by Saunders et al. (2016); which investigated the different modalities of LACE. In addition, adults generally have active communicative lifestyles and therefore have a greater need to improve their speech perception.

Patient Device Access	AT in all modalities generally requires regular training, which makes online AT ideal for patients who have access to internet capable devices (e.g. smartphone). Online AT, which is regularly conducted in the clinic on an available device (e.g. laptop), may unnecessarily book up clinical contact time.
Patient Internet Access	Depending on the programme used, patients may be required to download a mobile application or use regular internet. Downloading a mobile application may be best suited for a public health clinical set-up as it would minimise data costs for the patient.
Audiology Department Patient Load	The implementation of traditional face-to-face AT not only requires substantial regular clinical contact time, but also preparation from the audiologist. In a public health setting, to meet the high demand of hearing healthcare, the majority of the clinical contact is prioritised to conduct diagnostic tests and HA fittings. However, the benefits of AT and other supplementary audiological rehabilitation strategies are significant and should be included in audiological management. The tele-health modality of delivering AT may minimise the burden on a public health audiology clinic's patient load.

5.6 Challenges, Strengths and Limitations

5.6.1 Challenges

Participant Recruitment

The inclusion criteria proved difficult to find in the pool of public health audiology patients made available to the researcher. Table 14 below lists and describes the challenges, which arose during the participant recruitment process. The current study had a participant inclusion rate of 11.5%. This is low, considering the widespread public health need for rehabilitation beyond HA fitting. The inclusion criteria for the current study were sensorineural hearing loss and patients between 19-59 years old. These were the greatest influencers of the number of potential participants who could have been considered for the online AT. However, it was found that 34.6% of potential participants did not respond to communication attempts and 19.2% of potential participants' contact details were incorrect or outdated on their medical folders. This translates to more than half (53.8%) of the potential participants. The possibility of those 53.8% consenting to inclusion and passing the screening remains unknown, due to largely communicative and record keeping issues at this study's data collection site.

Table 14:

Participant Recruitment Challenges

Recruitment challenge	Description
Institutional Approval	The needed tools (QuickSIN) and equipment was only available at two public health hospitals (confirmed through telephonic enquiry). Ultimately institutional approval was only obtained at one of the two hospitals – Groote Schuur Hospital; which was advantageous as Groote Schuur Hospital is the only facility with student audiometric booths. This meant data collection could be conducted without disturbing the regular processes of the main hospital's audiology clinic.
Patient Hearing Loss	Only patients with purely sensorineural hearing losses could be included. AT is designed with the purpose of retraining the auditory nerve and subsequent neural pathways to regain some lost speech understanding skills, which usually occurs with auditory deprivation (Gil & Iorio, 2010; Santos et al., 2014; Sweetow & Henderson-Sabes, 2010). It was observed that the majority of patients at the public hospital had either a mixed or conductive hearing loss. This could be due to a number of reasons such as, a high occurrence of ear related infections in poorer communities; which can be partially attributed to the high prevalence of immuno-compromising diseases such as TB and HIV/AIDS (Avert, 2019).
Patient Language (English)	As outlined in the *Methods* section, the criteria for the current study excluded many possible participants. The greatest challenge was that many patients did not speak English as their first language or were not competent enough in English to use the programme. This was a known factor, as the majority of patients seeking public healthcare in South Africa do not have English as their first language; with only 8.1% of the population speaking it as a home language (Statistics, 2018).

5.6.2 Study Strengths

Original Research

The current study was, to the knowledge of the researcher, the first to investigate the feasibility of implementing tele-rehabilitation through an online AT programme in a South African public health context. With regards to tele-audiology research in South Africa (and globally), the majority of study aims to include screening or diagnostic testing in the scope of hearing healthcare service provision. This feasibility study on tele-rehabilitation presented research on a topic that is not widely researched in the field of audiology and would therefore add value to the larger pool of audiology research.

Relevant Research

With the growing influence of tele-health applications in the global field of audiology, the current feasibility study presents a relevant topic. South Africa is seen as one of the leading countries in tele-audiology research and application; due to the significant need for cost-effective, efficient

solutions for our current public health system. In terms of audiological rehabilitation service provision in South Africa, research efforts need to be directed at looking into methods which can provide more comprehensive services to public health patients; in a manner that would not additionally burden the current patient load.

Mixed Methods

The current study included both quantitative and qualitative measures. It is important to include patient experience when considering the feasibility of a new service delivery model for patients; as the quantitative factors can be limited in its means to show patient satisfaction and self-perceived benefit. Also mixed methods allowed for comprehensive data collection from different aspects of the intervention modalities (e.g. costs).

Fourth Industrial Revolution

The continuous evolution of technology has provided replacements and cost-effective alternatives in many sectors, including healthcare. This current study aimed to investigate the feasibility of providing a beneficial treatment to HA users using tele-health methods. Research into using technology and various technological platforms alongside health professionals, is pertinent to the continued improvement in providing patient service. This is particularly important in the South African public health context; where there are insufficient resources and health professionals to cater for the public health patient population.

5.6.3 Study Limitations

Sample Size

One of the limitations of this feasibility study was the sample size. However, in regard to previous research with AT and given the nature of AT; small sample sizes have also been used (Dubno, 2013; Ferguson & Henshaw, 2015; Santos et al., 2014; Sweetow & Henderson-Sabes, 2004). The sample size in the current study was mostly influenced by the design of previous research, and also the objectives of this feasibility study. However, major factors which prevented a larger sample were previously outlined in Table 14.

Data Analysis

The intention of including inferential statistics alongside the descriptive statistics, could not be accomplished due to the sample size. Statistical inferences would not have been valid with the current sample size. The exclusion of inferential statistics implied a limit on the interpretation of the results and no concrete conclusions could be made to generalize or make inferences on the study findings.

Data Collection at One Facility

The needed equipment for the current study was only available at two public health hospitals in Cape Town. However, data collection at Groote Schuur Hospital proved to be advantageous due to the larger audiology database. Challenges with institutional approval at the other hospital ultimately became a disadvantage to the entire research process. Months were spent attempting to obtain institutional approval from the second potential study site, the only other public hospital which had the needed resources but led to no success. During this period, data collection commenced at Groote Schuur Hospital. The challenges with recruiting participants were quickly noted and it was determined that data collection at one facility should continue; as the feasibility intent of the study would report on these challenges, for the benefit of future larger scaled research.

5.7 Bias, Validity and Reliability in The Current Study

5.7.1 Bias Threats

Selection Bias: Is the bias that results from a sample that is not representative of a specific population (Delgado-Rodríguez & Llorca, 2004). The researcher selected participants with criteria that may not necessarily be representative of the larger HA user population in South Africa. Purposive sampling was needed for the current study as AT programmes are designed for sensorineural hearing losses; therefore, the selected participant criteria was needed. However, according to Pannucci and Wilkins (2010), a way to limit this bias would be to select participants from the same general population. Therefore, all participants from the current study were selected from Cape Town to limit this bias.

Interviewer Bias: Is the influence that an interviewer's words, tone, and personality may have on the participant (Pannucci & Wilkins, 2010). The inclusion of standardised questionnaires alongside

face-to-face interviews were used to collect data that would not have been affected by this bias. In addition, the researcher made efforts to use similar language and manner with each participant (Pannucci & Wilkins, 2010).

Response Bias: Refers to the possibility of participants providing responses that are untrue or not an accurate reflection of their opinions or experiences (Sedgwick, 2014). This bias mostly affected the self-administered questionnaires. Participants may have felt obliged to select positive options during the assessments. To counter this, the researcher was not present in the consultation room when participants filled out their questionnaires, to limit the influence of this bias.

Researcher Bias: Is the bias that refers to the researcher influencing the results to represent data that is inaccurate or reporting an inaccurate representation of the results (Wadams & Park, 2018). All data and study results were reported in the same capacity that they were collected (i.e. AT results, QuickSIN scores, interview, and questionnaire responses) and not fabricated or falsified to give a desirable outcome.

Social Desirability Bias: The inherent need for participants to respond to questions in a manner that they consider as the norm or socially acceptable, is known as social desirability bias; which poses a challenge in research interviews (Kelly, Soler-Hampejsek, Mensch, & Hewett, 2013; Latkin, Edwards, Davey-Rothwell, & Tobin, 2017; Stodel, 2015). The presence and threat of social desirability bias, should be acknowledged from the beginning of the research process and when interpreting interview or self-report results. Bergen and Labonté (2020) outline interviewing techniques which may limit the threat of social desirability bias. For example: comprehensive explanation of confidentiality in the beginning of the interview and asking participants open-ended follow-up questions. These techniques as well as the strategy of asking participants for examples or specific stories about their experience, was used by the researcher in the current study; in an attempt to limit as far as possible this bias (Bergen & Labonté, 2020).

5.7.2 Validity

Threats to Internal Validity

Instrumentation: This threat refers to different measures being used during the pre- and post-intervention assessments, thereby not reflecting an accurate means of comparison (Bhandari, 2020). The instrumentation remained the same in the pre- and post-intervention assessments. Also, all instrumentation (except the Entrance/Exit Questionnaires) had been validated through previous research. This assisted in strengthening the validity of measurements.

Testing: This refers to the possibility of participants' performing better in the post-intervention assessment, due to being familiar with the testing material (Bhandari, 2020). This was controlled by using different QuickSIN wordlists for the pre- and post-intervention assessment. This will not contradict the point made in *Instrumentation,* because the QuickSIN contains different wordlists which are included as testing options, therefore all wordlists were validated.

History: This threat refers to the possibility of an unrelated or unexpected event influencing the results in any way (Bhandari, 2020). Possible threats to validity with regards to unplanned factors during intervention is if a) participants received additional AT, or b) if they had changes to their hearing technology. The first factor (a) was limited because the researcher told the participants during the pre-intervention appointment to not partake in additional AT during the duration of the study, or to notify the researcher if there was a desire to partake in additional AT. The second factor (b) referred to the possibility of a participant either receiving an upgrade on their technology or receiving another HA. It is not ethical to restrict participants' audiological management, therefore participants were asked to notify the researcher if there were any changes to their hearing technology.

Selection: The non-randomization of the sample was a bias threat. However, the current research design used was not suited for participant randomization.

Experimental mortality: The loss of participants has been reported as a significant factor in AT studies (Chisolm et al., 2013; Stacey et al., 2010). A way that this was addressed, was that the duration

and frequency of the intervention sessions were short. Also, the researcher systematically contacted each participant to remind them about their training and provide support.

Hawthorne Effect: This effect refers to the possibility of participants changing their behaviour, compliance, or responses because they are being observed or receiving special attention from being included in research (Wickström & Bendix, 2000). Ways in which the current study limited this effect was by minimising active observation by utilizing the AT programme's online monitoring feature (Harrell, Gladwin, & Hoag, 2013). This allowed the researcher to mostly distance from the participant training except for weekly online interactions to remind participants to complete targeted training sessions. Moreover, the questionnaires were all completed while the researcher was not in the consultation room.

Threats to External Validity

Reactive effects of experimental arrangements: This refers to the possible influence an experimental setting could have on participants' behaviour and performance (Frey, 2018). The intervention in the current study was administered by the participants in their daily life. Therefore, the intervention was administered in the setting of the "real world". This controlled for the concern of an intervention given in a laboratory setting and not being an accurate representation of reality.

Multiple treatment interference: This was not a threat as only one type of intervention was given to the participants. This was ensured by asking the participants if they have had or are currently receiving AT.

5.7.3 Reliability

Researcher error: This would refer to errors during the measurement or observation processes, also known as human errors. The following measures were taken to limit the influence of human error:

- Repeated copying of each participant's AT scores to ensure accuracy. The first copy was hand-written and then it was entered onto a Microsoft Excel spreadsheet.
- Repeated calculation of each participant's APHAB scores to ensure there were no miscalculations. Both manual and computer-based calculations were administered.

- Repeated reviewal of interview transcripts. The nature of thematic analysis allowed the repeated reviewal of the interview transcripts.

Participant changes: This refers to any changes in the participant that may influence results, for example participant fatigue may affect their performance or behaviour. The participant-led nature of the intervention from the current study meant that the researcher had almost no control on when sessions were completed, except for the instances of reminding the patient to complete sessions. However, a way that some of the influences of participant changes were limited by the researcher was to arrange the pre-intervention and post-intervention assessments at the same time of the day (morning) in an attempt to counter the possibility of participant fatigue.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSION

Introduction: This chapter will discuss the recommendations and future research considerations that were determined from the findings of the current feasibility study. The chapter will end with the conclusion of this study.

6.1 Recommendations

The results showed that, for the participants in this study, the use of hybrid tele-health methods was feasible as a modality for the delivery of AT. Therefore larger scale investigations should be carried out, in order to make conclusive inferences on hybrid tele-rehabilitation. The South African public health system is burdened with a high patient load, coupled with few qualified health professionals and resources to meet the need for audiological services (Hlayisi & Ramma, 2019; Swanepoel, 2006). Holst (2019), reports that approximately 22 million South Africans have a smartphone; which accounts for approximately one third of the country's population. This statistic may hold promise for the inclusion of the available technology in tele-health service provision in public health settings, more specifically, the inclusion of tele-rehabilitation with minimal burden on the current patient load.

The result of this study suggests that the inclusion of AT programmes in audiological practice should be initialized with a detailed introductory session, and telephonic follow-ups. In a public health setting, it is unlikely that regular telephonic follow-ups will be accomplished due to most audiology departments being booked with a high patient load (Swanepoel, 2006). However Chisolm et al. (2013) noted that, one follow-up was enough to increase compliance for their study. A suggested tele-rehabilitation guideline (Figure 4 in Appendix J) recommends the use of the mandatory first HA follow-up appointment (to limit extra appointments), and implements a one week telephonic follow-up as well as a one month speech re-assessment.

A recent article outlining principles of a tele-practice framework in audiology, focused mainly on applications in private practice settings; however, the basic foundations of a successful tele-practice are applicable to all settings in which tele-audiology is desired. One of the main principles include having a willing and determined audiology team (Ballachanda, 2019). Successful integration of tele-

audiology methods in public health practice will require a common goal amongst the audiology team. The audiology team includes audiologists and suitably trained support staff, who assist in service provision (Ballachanda, 2019). With regards to the current study, participants were identified using the guidance of the audiologist who conducted the initial hearing test, The audiologist was acquainted with information about the potential participant that the researcher was not aware of; thus making it a combined effort in tele-rehabilitation provision. In a public health context the audiology team should be responsible of identifying potential patients for tele-audiology, providing cost-effective tele-audiology services, and monitoring the clinical standards of these services (Ballachanda, 2019).

The concept of tele-rehabilitation in public health audiology is a topic that has limited evidence-based practice protocols and standards; which makes it difficult to not only implement these services but to enforce and maintain quality control measures. Further in-depth research in tele-rehabilitation is necessary in South Africa.

6.1.1 Future Research Considerations

The sample size of this feasibility study can be noted as a significant limitation. Future research in tele-rehabilitation should make attempts in including a larger scaled research design. A survey for all existing HA patients in an audiology clinic on their knowledge of AT, and if they have a desire to seek supplementary audiological rehabilitation after initial HA fitting, may allow recruitment of larger samples. In addition, the inclusion of CI users in South African AT research, may allow for a larger sample size. The inclusion of an audiology department, with more than one audiologist may also allow for research to be conducted over a longer period.

An additional factor, which influenced the sample size, was the upper age limit of the participants being 59 years old. This was determined largely by the fact that cognitive dysfunction is prevalent in older adults (e.g. memory decline and visual information processing issues,) and minimal technological knowledge (Huh, 2018). However, it can be argued that given the role technology plays in society; there are older adults who are technologically capable of completing a basic AT programme, especially with the inclusion of a comprehensive introductory session. Any AT research including older

participants (>59 years) should include a validated cognition scale, to ensure that no issues with cognitive impairment ensue.

This feasibility study highlighted important factors to consider for future research. These include:

- The use of telephonic follow-ups as a means to boost compliance, and to offer patient support.
- The use of a tele-rehabilitation programme structure that minimises participant out-of-pocket expenses (e.g. travel costs).
- The inclusion of an introductory and demonstration session for participants.
- The use of both behavioural and self-report measurements.

Future research topics could include:

- An exploratory study on South African audiologists' views and experience with online AT.
- The effects of a free AT mobile application on HA users' speech perception from South African public health hospitals.
- Large-scale cost-benefit analysis of tele-rehabilitation in a South African public health context.
- The effects of online AT on HA benefit and return rate in a South African private health context.

6.2 Conclusion

This study was, to the knowledge of the researcher, the first South African study to investigate the feasibility of tele-rehabilitation implementation in a public health context. The inclusion of further hearing rehabilitative services beyond HA fittings, is unfortunately overlooked by many audiologists. Understandably, in a South African public health context, the burden of a large patient load falls on few audiologists who need to prioritise hearing loss diagnosing and HA fitting. However, the results from this feasibility study suggests that a tele-rehabilitative strategy such as online AT, may be implemented with minimal face-to-face clinical contact. South African public health patients are fitted monaurally, and any means to assist with improving HA benefit would not only strengthen their listening skills but also help these patients to compensate better with one HA.

One of the key elements that arose from this research was that in regard to audiological rehabilitation, a tele-health hybrid model (face-to-face contact and online contact) is recommended as a delivery method. The tele-health method of delivery used in this feasibility study, highlighted the importance of clinician contact (both face-to-face and online) in positively influencing compliance to an intervention (AT) programme.

Tele-audiology has predominantly been researched in regard to diagnostic applications. It can be said that tele-audiology methods, for diagnostic assessments, may be normalised to the point of it being included in the majority of clinical practice in the future. This facilitates the need for research and protocol development of tele-rehabilitation strategies beyond diagnostics and HA fitting.

The ethical concerns (e.g. validity of results, patient trust) around tele-audiology cannot be resolved without further research. The development of a contextually relevant, clinically validated AT mobile application, with a stable clinician monitoring feature; would be a valuable tool in public health audiology service provision. Until that is realised, the available device access in the South African population, the available free mobile applications and HA patient need; may allow tele-rehabilitation implementation to be feasible in a South African public health context. However, further larger scaled research is still needed.

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APPENDICES

Appendix A: ***Mini-Cog***

Mini-Cog©

Instructions for Administration & Scoring

ID: __________ Date: ________________

Step 1: Three Word Registration

Look directly at person and say, "Please listen carefully. I am going to say three words that I want you to repeat back to me now and try to remember. The words are [select a list of words from the versions below]. Please say them for me now." If the person is unable to repeat the words after three attempts, move on to Step 2 (clock drawing).

The following and other word lists have been used in one or more clinical studies.[1-3] For repeated administrations, use of an alternative word list is recommended.

Version 1	Version 2	Version 3	Version 4	Version 5	Version 6
Banana	Leader	Village	River	Captain	Daughter
Sunrise	Season	Kitchen	Nation	Garden	Heaven
Chair	Table	Baby	Finger	Picture	Mountain

Step 2: Clock Drawing

Say: "Next, I want you to draw a clock for me. First, put in all of the numbers where they go." When that is completed, say: "Now, set the hands to 10 past 11."

Use preprinted circle (see next page) for this exercise. Repeat instructions as needed as this is not a memory test. Move to Step 3 if the clock is not complete within three minutes.

Step 3: Three Word Recall

Ask the person to recall the three words you stated in Step 1. Say: "What were the three words I asked you to remember?" Record the word list version number and the person's answers below.

Word List Version: ________ Person's Answers: ________________ ________________ ________________

Scoring

Word Recall: ______ (0-3 points)	1 point for each word spontaneously recalled without cueing.
Clock Draw: ______ (0 or 2 points)	Normal clock = 2 points. A normal clock has all numbers placed in the correct sequence and approximately correct position (e.g., 12, 3, 6 and 9 are in anchor positions) with no missing or duplicate numbers. Hands are pointing to the 11 and 2 (11:10). Hand length is not scored. Inability or refusal to draw a clock (abnormal) = 0 points.
Total Score: ______ (0-5 points)	Total score = Word Recall score + Clock Draw score. A cut point of <3 on the Mini-Cog™ has been validated for dementia screening, but many individuals with clinically meaningful cognitive impairment will score higher. When greater sensitivity is desired, a cut point of <4 is recommended as it may indicate a need for further evaluation of cognitive status.

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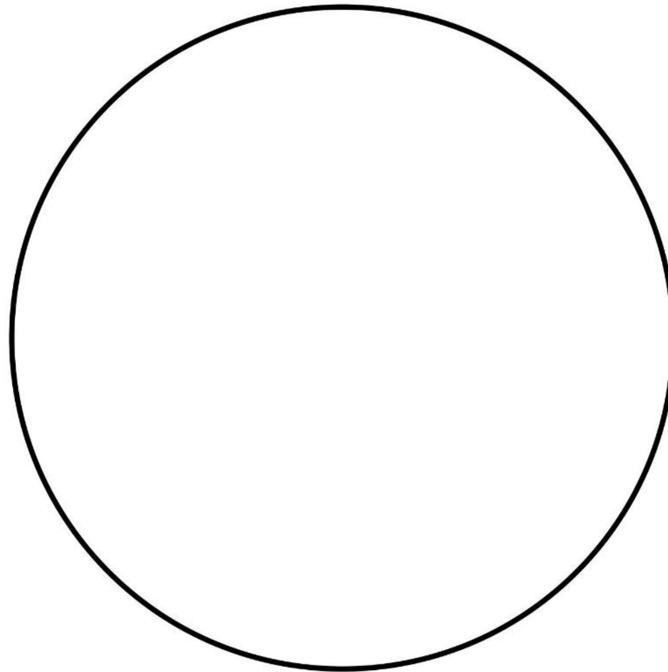
v. 01.19.16

Clock Drawing

ID:__________ Date:______________



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v. 01.19.16

Appendix B: ***Task Questionnaire (Task Ability Checklist)***

PARTICIPANT SCREENER SHEET

Full name: ____

Date of birth: ____

Home language(s): _______________________________________

How many hearing aids do you wear (1 or 2?): _____________________

When did you first get your hearing aid(s)? ______________________

Highest level of education: _________________________________

TASK QUESTIONNAIRE (TASK ABILITY CHECKLIST)		
Are you able to visit a website by yourself?		
Yes	No	Unsure
Are you able to use SMS/WhatsApp?		
Yes	No	Unsure
Are you able to change the volume on your smartphone/laptop/computer/tablet?		
Yes	No	Unsure

Appendix C: ***Entrance Questionnaire***

<table>
<tr><th colspan="60">ENTRANCE QUESTIONNAIRE</th></tr>
<tr><th colspan="60">Have you ever received auditory training before this research study?</th></tr>
<tr><td colspan="20">Yes</td><td colspan="20">No</td><td colspan="20">Unsure</td></tr>
<tr><th colspan="60">Do you think you will benefit from auditory training?</th></tr>
<tr><td colspan="20">Yes</td><td colspan="20">No</td><td colspan="20">Unsure</td></tr>
<tr><th colspan="60">Which of the following do you think you will use the most when accessing the auditory training programme online?</th></tr>
<tr><td colspan="15">Smartphone</td><td colspan="15">Laptop</td><td colspan="15">Tablet</td><td colspan="15">Computer</td></tr>
<tr><th colspan="60">Do you think you will be able to make time each week to complete your auditory training sessions?</th></tr>
<tr><td colspan="12">Strongly Agree</td><td colspan="12">Agree</td><td colspan="12">Neutral</td><td colspan="12">Disagree</td><td colspan="12">Strongly Disagree</td></tr>
<tr><th colspan="60">Select an option as your preferred method of contact:</th></tr>
<tr><td colspan="15">Email</td><td colspan="15">WhatsApp</td><td colspan="15">SMS</td><td colspan="15">Call</td></tr>
</table>

Appendix D: ***Abbreviated Profile of Hearing Aid Benefit (APHAB)***

APP X-A

ABBREVIATED PROFILE OF HEARING AID BENEFIT (APHAB)

(Cox & Alexander, 1995)

Patient:______________________________

Date:______________________________

INSTRUCTIONS: Please circle the answers that come closest to your everyday experience. Notice that each choice includes a percentage. You can use this to help decide on your answer. For example, if a statement is true about 75% of the time, circle C for that item. If you have not experienced the situation we describe, try to think of a similar situation that you have been in and respond for that situation. If you have no idea, leave that item blank.

A Always (99%)
B Almost Always (87%)
C Generally (75%)
D Half the time (50%)
E Occasionally (25%)
F Seldom (12%)
G Never (1%)

STATEMENTS	WITHOUT MY HEARING AID	WITH MY HEARING AID
1. When I am in a crowded grocery store, talking with the cashier, I can follow the conversation.	A B C D E F G	A B C D E F G
2. I miss a lot of information when I'm listening to a lecture.	A B C D E F G	A B C D E F G
3. Unexpected sounds, like a smoke detector or alarm bell, are uncomfortable.	A B C D E F G	A B C D E F G
4. I have difficulty hearing a conversation when I'm with one of my family at home.	A B C D E F G	A B C D E F G
5. I have trouble understanding dialogue in a movie or at the theater.	A B C D E F G	A B C D E F G
6. When I am listening to the news on the car radio, and family members are talking, I have trouble hearing the news.	A B C D E F G	A B C D E F G

1

7. When I am at the dinner table with several people, and am trying to have a conversation with one person, understanding speech is difficult.	A B C D E F G	A B C D E F G
8. Traffic noises are too loud.	A B C D E F G	A B C D E F G
9. When I am talking with someone across a large empty room, I understand the words.	A B C D E F G	A B C D E F G
10. When I am in a small office, interviewing or answering questions, I have difficulty following the conversation.	A B C D E F G	A B C D E F G
11. When I am in a theater watching a movie or play, and the people around me are whispering and rustling paper wrappers, I can still make out the dialogue.	A B C D E F G	A B C D E F G
12. When I am having a quiet conversation with a friend, I have difficulty understanding.	A B C D E F G	A B C D E F G
13. The sounds of running water, such as a toilet or shower, are uncomfortably loud.	A B C D E F G	A B C D E F G
14. When a speaker is addressing a small group, and everyone is listening quietly, I have to strain to understand.	A B C D E F G	A B C D E F G
15. When I'm in a quiet conversation with my doctor in an examination room, it is		

hard to follow the conversation.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
16. I can understand conversations even when several people are talking.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
17. The sounds of construction work are uncomfortably loud.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
18. It's hard for me to understand what is being said at lectures or church services.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
19. I can communicate with others when we are in a crowd.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
20. The sound of a fire engine siren close by is so loud that I need to cover my ears.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
21. I can follow the words of a sermon when listening to a religious service.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
22. The sound of screeching tires is uncomfortably loud.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
23. I have to ask people to repeat themselves in one on one conversation in a quiet room.	A	B	C	D	E	F	G	A	B	C	D	E	F	G
24. I have trouble understanding others when an air conditioner or fan is on.	A	B	C	D	E	F	G	A	B	C	D	E	F	G

NOTES:

Appendix E: ***Exit Questionnaire***

<table>
<tr><th colspan="20">EXIT QUESTIONNAIRE</th></tr>
<tr><td colspan="20">Which of the following did you use the most when accessing the auditory training program online?</td></tr>
<tr><td colspan="5">Smartphone</td><td colspan="5">Laptop</td><td colspan="5">Tablet</td><td colspan="5">Computer</td></tr>
<tr><td colspan="20">Did you find the auditory training to be beneficial?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Did you find it easy to log-in to the programme?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Did you have problems with internet access?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Did you find the American accent easy to follow?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Were you able to make time each week to complete your auditory training sessions?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Did the programme meet your expectations?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Do you believe auditory training should be included in audiological management?</td></tr>
<tr><td colspan="4">Strongly Agree</td><td colspan="4">Agree</td><td colspan="4">Neutral</td><td colspan="4">Disagree</td><td colspan="4">Strongly Disagree</td></tr>
<tr><td colspan="20">Any further comments on your experience/the programme…</td></tr>
<tr><td colspan="20"></td></tr>
<tr><td colspan="20"></td></tr>
<tr><td colspan="20"></td></tr>
</table>

Appendix F: ***System Usability Scale (SUS)***

System Usability Scale

© Digital Equipment Corporation, 1986.

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Appendix G: Letter of Consent

University of Cape Town

Department of Health and Rehabilitation Sciences

Division of Communication Sciences and Disorders

LETTER OF CONSENT FOR RESEARCH

Dear Sir/Madam

By participating in this study, you agree to complete the 11 session online listening training programme, complete the questionnaires, and come for 2 short speech assessment appointments at your hospital (the dates will be confirmed with you at a later stage).

By signing this document, you agree to:

- Participate in the 11 session online auditory training programme, known as LACE Online.
- Allow speech assessment and will complete the questionnaires before and after the programme.
- Participation is completely voluntary and you can withdraw at any time without any consequences.
- Your personal information will be kept confidential.

____ __________________

NAME (*in print*) DATE (*dd/mm/yyyy*)

____

SIGNATURE

Email address: ____

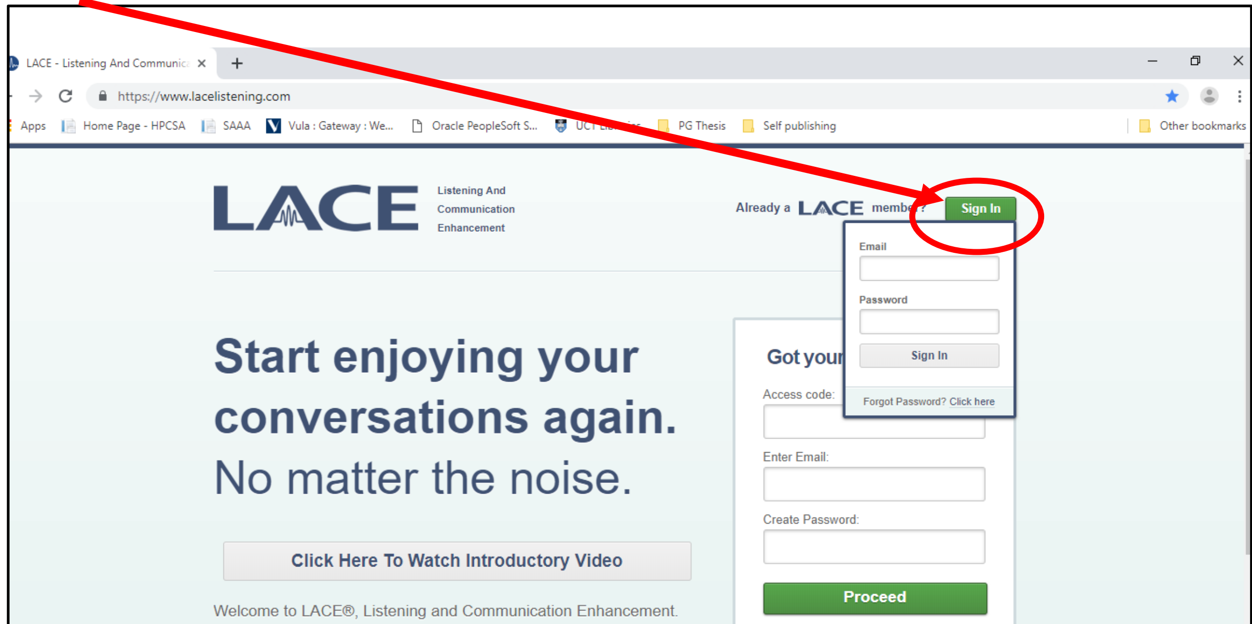
Contact number (s): ____

If you have any questions please contact the researcher: Nuha Khatib (nuhakhatib93@gmail.com or WhatsApp 071 270 6014), the research supervisor: Vera-Genevey Hlayisi (UCT) (vera.hlayisi@uct.ac.za), the research co-supervisor: A/Prof. Lebogang Ramma (UCT) (lebogang.ramma@uct.ac.za), or The University of Cape Town Faculty of Health Sciences Human Research Ethics Committee (HREC) can be contacted on 021 406 6338 in case there are any questions regarding your rights and welfare as a research participant in the study. HREC Ref. No. 642/2018.

Appendix H: ***Log-In Details Summary Page***

HOW TO LOG-IN:

Step 1: Visit https://www.lacelistening.com/ and type in your login information by clicking on the green **Sign In** button. Use the email and password that was given to you.



Step 2: Complete your session by following the instructions for each activity. Don't stress if you don't get everything correct. We want you to just try your best.

Step 3: Once completed with the session exit the programme for the day.

HOW TO POSITION YOURSELF:

- It is important to complete your sessions in a quiet environment.
- Whether using a smartphone/computer/laptop make sure you do not move the device after you are comfortable. (If you sit closer/further it will change the loudness of the programme).

REMEMBER:

- Wear your hearing aid(s) while using the programme.
- The entire programme is 11 sessions and each session is 20-30minutes.
- You complete the programme at your own pace but you must complete at least 3 sessions per week. (You are allowed to complete 1 session per day if you wish.)
- Please do not change your email/password used for the LACE Online.
- I am able to see when you complete your sessions and will help you to stay on track.
- If you struggle with anything please contact me on 071 270 6014 or nuhakhatib93@gmail.com.

Appendix I: ***Ethical Approval Letter***

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: sumayah.ariefdien@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

11 March 2019

HREC REF: 642/2018

Ms VG Hlayisi
Division of Communication Sciences & Disorders
Health & Rehab Sciences
F-45.
OMB

Dear Ms Hlayisi

PROJECT TITLE: BEYOND HEARING AID FITTING: INVESTIGATING THE FEASIBILITY OF PROVIDING TELE-REHABILITATION FOR ADULT HEARING AID USERS IN A SOUTH AFRICAN PUBLIC HEALTH CONTEXT (Masters Candidate - Ms N Khatib)

Thank you for your response, addressing the issues raised by the Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study, subject to obtaining permission form the Western Cape Department of Health.

Approval is granted for one year until the 30 March 2020.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student: Ms Nuha Khatib will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

Signature Removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Appendix J: ***Proposed Tele-rehabilitation Implementation Guideline***

Figure 4:

Proposed Tele-rehabilitation Guideline for Public Health Clinics