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**A TUTORIAL ON THE PRACTICE AND IMPLEMENTATION OF
TELEAUDIOLOGY FOR AUDIOLOGISTS AND HEARING HEALTHCARE
PROFESSIONALS**

by

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THESIS APPROVAL PAGE

This is to certify that the thesis prepared by Eleni Mitoulis, B.S., entitled "A Tutorial on the Practice and Implementation of Teleaudiology for Audiologists and Hearing Health Professionals" has been approved by the thesis committee as satisfactorily completing the thesis requirement for the degree of Doctor of Audiology.

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Abstract

A Tutorial on the Practice and Implementation of Teleaudiology for Audiologists and Hearing Healthcare Professionals

Eleni Mitoulis

Telehealth is a mode of healthcare delivery that has been developed as a result of recent advancements in technology. It has been used to bridge the geographical distance between patients and healthcare providers, as well as increase the efficiency of these services by providing them in a time and cost-effective manner (Swanepoel, 2015). When applied directly to the field of audiology, it is called teleaudiology. Many types of audiological services can be accurately provided via teleaudiology (Swanepoel et al., 2010a). The aim of this thesis project was to offer audiologists and other professionals who deliver hearing healthcare a guide to providing teleaudiology services and implementing them into their practices. This guide would also describe populations that could benefit from teleaudiology, challenges inherent in this delivery model, and professional resources available for those interested in teleaudiology.

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List of Abbreviations

- AAA:** American Academy of Audiology
- AABR:** Automated auditory brainstem response
- ABR:** Auditory brainstem response
- ACA:** Affordable Care Act
- AEP:** Auditory evoked potential
- AJA:** American Journal of Audiology
- ANSI:** American National Standards Academy
- ART:** Acoustic reflex threshold
- ASHA:** American Speech-Language-Hearing Association
- BTNRH:** Boys Town National Research Hospital
- C:** Comfort level
- CEUs:** Continuing Education Units
- CI:** Cochlear implant
- CNC:** Consonant-nucleus-consonant
- CVT:** Clinical Video Telehealth
- DAI:** Direct audio input
- dB:** Decibel
- dB HL:** Decibel hearing level
- dB SPL:** Decibel sound pressure level
- DPOAE:** Distortion product otoacoustic emissions
- DS:** Distance support
- ECAP:** Electrically evoked compound action potential

FDA: Food and Drug Administration

GDP: Gross domestic product

HINT: Hearing in noise test

HIPAA: Health Insurance Portability and Accountability Act

Hz: Hertz

IT: Information technology

MCI: Mild cognitive impairment

MoCA: Montreal Cognitive Assessment

NIHS: Newborn infant hearing screening

NAL-NL1: National Acoustics Laboratories nonlinear fitting procedure 1

NASA: National Aeronautics and Space Administration

OAE: Otoacoustic emissions

RT: Reverberation time

SES: Socioeconomic status

SIG 18: Special Interest Group 18

SNR: Signal to noise ratio

T: Threshold level

VA: Department of Veterans Affairs

WHO: World Health Organization

Chapter 1

Introduction

Throughout the world there are several models of healthcare that are currently being employed. The two primary models being used are often described as either a “socialized” or “government funded model”, or a “privately funded model” (Wallace, 2013). In reality, these healthcare models are much more complex. There can be numerous challenges associated with the delivery of both these types of healthcare models. Some of these challenges include: the cost of healthcare services; the quality of these services provided; and the geographical distance between the patient and healthcare provider (Casey, Call, & Klingner, 2001; Jones, Lopez-Carr, & Dalal, 2011; Lameire, Joffe, & Wiedemann, 1999; Ridic, Gleason, & Ridic, 2012; Van Dis, 2002; Wang & Luo, 2005; Wong & Regan, 2010).

A new healthcare model, known as telehealth, has emerged to address some of these challenges. This model utilizes advances in technology to provide healthcare services to patients in remote areas of the world utilizing the Internet and other electronic devices (Swanepoel, 2015). The main goals of telehealth are to bridge the geographical distance between the patient and the healthcare provider, as well as to provide healthcare in a more time and cost efficient way. This literature review will discuss telehealth and its application in audiology. This specific type of telehealth application is called teleaudiology (Swanepoel, 2015).

In the last two decades, there have been a number of studies which have investigated the accuracy and effectiveness of providing audiological services through teleaudiology (e.g., Campos & Ferrari, 2012; Given & Elangovan, 2003; Krumm,

Huffman, Dick, & Klich, 2008; Lancaster, Krumm, Ribera, & Klich, 2008; Ramos et al., 2009; Swanepoel et al., 2010a; Swanepoel, Koekemoer, & Clark, 2010b; Swanepoel et al., 2014; Thorén, Svensson, Törnqvist, Carlbring, & Lunner, 2011). Collectively, the results of these studies have demonstrated that several types of audiological services and intervention techniques can be successfully provided via teleaudiology, and the results of these screening and diagnostic evaluations delivered via teleaudiology are as accurate as those obtained in a typical face-to-face setting. The audiological services that can be successfully provided via teleaudiology include: hearing screenings, audiological evaluations, hearing aid services, cochlear implant (CI) mapping, electrophysiological testing, rehabilitation services, and counseling. The most common practices that utilize teleaudiology today are government-funded programs such as Veterans Affairs (VA), hospitals, private practices, university settings, and industry (Keimig, 2017).

Despite the initial successes of teleaudiology, not many audiologists are utilizing this option likely due to the challenges associated with the implementation and organization of teleaudiology services (Baker & Bufka, 2011; Burkard, 2004; Cohn & Cason, 2012; Eikelboom, & Swanepoel, 2016; Frailey, 2014; Freeman, 2010; Gladden, 2013; Krumm, 2014; Mitzner et al., 2010; Swanepoel, Olusanya, & Mars, 2010c). These challenges include: the purchase and maintenance of the equipment needed for audiology testing; training the facilitator on how to perform necessary tasks; issues with licensing in different states or countries; scheduling appointments when services are being provided in different time zones; the confidentiality of patient information; reimbursement for audiological services; and the possible challenges of this technology for older clients. The aim of this thesis project is to provide a resource on teleaudiology for audiologists and

other hearing healthcare professionals who are contemplating incorporating teleaudiology into their practices. This tutorial will delve into a discussion of the various modes of healthcare delivery via telehealth, the type of work settings in which teleaudiology is currently being employed, and professional resources available on this topic.

Chapter 2

Literature Review

Models of Healthcare

Healthcare is defined by Merriam-Webster as “Efforts made to maintain or restore physical, mental, or emotional well-being, especially by trained and licensed professionals.” (“Health care,” n.d.). Around the world, countries have different ways of providing healthcare to their citizens. These models can vary in their modes of delivery, in what services are provided, and how citizens and the government provide payment for these services. These health care models are often described as a “socialized” model of healthcare or a “private” model of healthcare. In reality, models of healthcare are much more complex. Healthcare can be government controlled and funded, or more privately funded by insurance plans. Differences in the healthcare models created and implemented in different countries are rooted in their cultural and societal expectations (Lameire et al., 1999). In the following section, the primary models of healthcare will be explained in more detail.

Government-funded models. A form of healthcare, most often referred to as “socialized” medicine, is defined as healthcare provided by the government. One such model, the Beveridge Model, is what most people think of when they refer to socialized medicine (Wallace, 2013). In this model, health care is provided to all citizens by the government, and is funded through taxes. Countries that utilize this model include Great Britain, Spain, and New Zealand (Wallace, 2013). Almost 100% of the citizens in these countries have access to healthcare through a centrally organized National Health Service (Lameire et al., 1999).

The National Health Insurance Model, or the Tommy Douglas Model, is also a government run insurance program funded through taxes (Wallace, 2013). However, instead of individuals receiving healthcare services through the government, private sector providers cover them. This model has a defined set of medical benefits and covers the entire population (Ridic et al., 2012). Reimbursement for healthcare services is negotiated between the government and the medical provider. It is illegal for individuals to have private insurance for medical services that are covered, but most citizens have supplemental insurance for services not covered by the plan, such as dental and prescription drugs. Canada is an example of a country using this National Health Insurance model (Ridic et al., 2012; Wallace, 2013).

Privately-funded models. Other healthcare models are more privately funded. The Bismarck Model of healthcare, for example, is provided through an insurance plan (Wallace, 2013). Both employer and employee contribute through a payroll deduction, and those contributions are then placed into “sickness funds.” All citizens are required by law to have health insurance, and the premiums paid are based on the income of the individual (Ridic et al., 2012). This insurance covers a range of healthcare services, but only offers limited benefits in some areas of health, such as psychiatric services (Ridic et al., 2012). This model of healthcare is used throughout Europe in countries such as Germany, France, Belgium, the Netherlands, Switzerland, and Japan (Wallace, 2013).

Finally, the Out-of-Pocket Model is what is seen in most of the world. This method is used in countries that are too poor or without enough organization to create a national model of healthcare (Wallace, 2013). In this model, people who have enough money to pay for healthcare services can receive them, while citizens who are too poor to

pay for them go without. This method of healthcare can be seen in rural regions of Africa, China, and South America (Wallace, 2013).

The United States. One of the only developed countries in the world without a specific model of healthcare is the United States, where a combination of several models of healthcare is employed. Most citizens in the United States purchase health insurance through their employers in the private market (Ridic et al., 2012). This most closely resembles the Bismark Model seen in countries such as Germany. However, less than 30% of these healthcare plans allow unrestricted access to providers, and reimbursements are based on the cost of the service. About 26% of the population in the United States is covered by public health insurance, also known as Medicare or Medicaid. The government provides these programs to disabled or economically disadvantaged people and it is paid for by citizens through taxes (Lameire et al., 1999; Ridic et al., 2012). Finally, as of 2012 about 16% of United States citizens were uninsured, and either received healthcare through public clinics, charity run providers, government health programs, or pay out of pocket (Ridic et al., 2012).

A recent change to the healthcare model of the United States was the introduction of the Affordable Care Act (ACA), signed into law by President Barack Obama on March 23, 2010 (National Conference of State Legislatures, 2010). The main purpose of this act was to expand healthcare coverage for Americans, and it focused mainly on those individuals who were then uninsured. Several different provisions were included in the document to help achieve this goal. The primary provisions of the ACA include the following: insurers were required to cover all pre-existing health conditions; parents were allowed to keep their children on their insurance plans until they reached 26 years of age;

and uninsured individuals were mandated to sign up to receive insurance through the ACA or face substantial fines for each year without insurance (Blumenthal & Collins, 2014). Additional measures of the ACA included: increasing consumer protections of healthcare; emphasizing prevention and wellness; expanding the workforce involved in the provision of healthcare; and attempting to curb the rising costs of healthcare in the United States (National Conference of State Legislatures, 2010).

Most of these actions set for by the ACA were attempting to provide preventative care for American citizens (Koh & Sebelius, 2010). These services include: a wide variety of preventative care services, such as vaccinations; screenings for numerous cancers and infections; as well as screenings for mental health conditions (Koh & Sebelius, 2010). One of the main goals of the ACA was to provide access to healthcare to as many American citizens as possible. As of May 1st, 2014, 20 million previously uninsured Americans have been insured under the ACA (Blumenthal & Collins, 2014). It was also projected that by 2017, the ACA would decrease the number of uninsured people in the United States by 26 million. While it has obviously benefited many Americans, it is not a foolproof system.

All of these models of healthcare discussed above have both benefits and challenges associated with them. In the next section of this literature review, challenges associated with these existing models, such as the cost of providing healthcare services, quality of care, and access to services will be explored.

Primary Challenges Associated with the Current Healthcare Models

Cost. The cost of healthcare, both for the patients and the government, is a cause for concern in many countries. In the United States healthcare spending is the highest in

the world (Lameire et al., 1999; Ridic et al., 2012). Specifically, Ridic and colleagues (2012) compared healthcare spending in the United States against Germany and Canada in terms of gross domestic product (GDP) per capita and percentage of GDP spent on healthcare. These investigators reported that the United States has the largest health care spending when compared to Germany and Canada, both in GDP per capita (\$30,625 in the United States versus \$22,951 and \$23,368 in Germany and Canada respectively) and as a percentage of GDP spent on healthcare (13.6% in the United States versus 10.6% and 9.5% in Germany and Canada respectively) (Ridic et al., 2012). Due to the private market nature of healthcare in the United States, the costs of procedures and services are not controlled and these costs are rising continuously. This makes it more difficult for individuals to receive healthcare services.

In Canada and Germany government expenditure on healthcare is significantly less than in the United States. However, each of these countries is each facing problems with their healthcare costs. In an attempt to reduce costs, Canada has long waiting lists for routine medical procedures, and it has capped spending on new medical technologies. In Germany, spending by the government on healthcare has been steadily increasing due to an aging population and easy access to medical care (Ridic et al., 2012). Each healthcare model faces its own challenges when attempting to manage costs.

Quality of care. In addition to the rising cost of healthcare around the world, there are also problems in the quality of healthcare citizens are receiving. While spending on healthcare in the United States is the highest in the world, its citizens reported being the least satisfied with their healthcare system in comparison to citizens in Canada and Germany. Ridic and colleagues (2012) reported over 60% of Americans believe that the

healthcare system in place in their country is in need of major changes. Specifically, research has shown that Americans have the lowest life expectancies, highest number of life years lost (or premature mortality rates), and highest number of stillbirths per 100 newborns in comparison to countries such as Canada, Germany, the United Kingdom, France, Switzerland, and Japan (Lameire et al., 1999; Ridic et al., 2012).

Another aspect that detracts from quality of care includes continuity of care for healthcare recipients. Wong and Regan (2010) conducted several focus groups to discuss patient perspectives on the quality of healthcare in rural communities in Canada. Their study had total of 50 participants, of which 62% were female. Their participants ranged in age from 20 to over 65 years and had varying levels education. Several common themes emerged from these discussions. Participants felt that there should be constant communication between the patient and the healthcare professional in order to provide information about services and proper management of care. Researchers found that when this continuity of care was not present, it was difficult to provide effective healthcare services. Specifically, it decreased the efficiency of care and caused problems in providing timely access to medical interventions (Wong & Regan, 2010). Other factors that could cause problems in healthcare could be a lack of access to procedures and healthcare professionals.

Access to services. Access to healthcare services can be limited for several reasons. These reasons include both spatial and non-spatial factors (Wang & Luo, 2005). Spatial factors involve the geographical distance between the patient and the healthcare provider; while non-spatial factors could be related to socioeconomic status (SES), income, ethnicity, primary spoken language, sex, age, and education level (Wang & Luo,

2005). For individuals living in a more rural setting, researchers have found that these individuals are less likely to receive healthcare services than people living in more urban areas (Casey et al., 2001). In more rural counties, the geographical distance covered is much larger than in urban areas. Sometimes there is a lack of healthcare services available in the local community, which forces patients to travel long distances to receive medical care (Casey et al., 2001). There is often a trade off between receiving healthcare, and the safety and cost-efficiency of traveling to receive it (Wong & Regan, 2010).

In addition to these geographical barriers, high percentages of individuals living in rural areas do not have health insurance (Casey et al., 2001). In most cases, seeking out care is determined by how serious patients perceive their health condition to be, if they can manage the problem with the healthcare services available to them, or if they have the time and finances to seek out more specialized care (Wong & Regan, 2010). Furthermore, in some cases cultural principles of individuals living in rural environments may prevent them from seeking out health care services. These principles include a focus on self-reliance and individualism, preferences for more informal support than seeking out medical professionals, and reluctance to seek medical assistance unless there is a significant health problem (Casey et. al, 2001).

Finally, there is a shortage of medical professionals available to individuals living in rural areas (Van Dis, 2002). While most of the United States population (80%) is concentrated in urban areas, the remaining 20% live in more rural areas. Only 9% of physicians in the United States practice in these rural areas (Van Dis, 2002). This disparity in distribution of physicians and healthcare providers causes inequality in access to healthcare services. People living in rural areas have less access to all types of

healthcare services including primary, preventative, prenatal, and emergency care (Jones et al., 2011). Modern healthcare in particular requires expensive machinery and specially trained workers. If a large number of people are in need of these specialized services, then easy access to these services may not be available. This is especially troubling for people in rural areas, as it is not physically or financially possible for many healthcare providers to work there (Jones et al., 2011).

Due to the challenges facing each of these models, healthcare providers have been seeking new and more efficient ways to deliver healthcare services to individuals around the world. Specifically, providers and recipients have been searching for ways to lower costs by making services more accessible and efficient. They have also searched for ways to provide assistance to a greater number of people who would otherwise not have access either due to geographical distance, financial constraints, or other societal barriers. With this goal in mind, as well as the assistance of rapid advancements in technology, a new model of healthcare has emerged: telehealth.

New Healthcare Model: Telehealth

The World Health Organization (2010) defines telehealth as “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment, and prevention of disease and injuries, research and evaluation and for the continuing education of health care providers, all in the interest of advancing the health of individuals and their communities” (p 9). In layman’s terms, telehealth is using recent advancements in technology to provide healthcare to individuals who would otherwise not have access to these services.

Goals and aims of telehealth. There are two primary goals of telehealth. One primary goal is to bridge the geographic distance between the healthcare provider and his/her patients (Swanepoel, 2015). This is true on both a national and an international basis. The second primary goal of telehealth is to provide healthcare services in as time and cost efficient manner as possible. This efficiency applies to both the healthcare providers and the patients (Swanepoel, 2015). Each of these goals/aims will be discussed briefly below.

Delivery of Telehealth. Telehealth requires two separate physical locations to perform these healthcare services: the healthcare provider site and the remote site (Swanepoel, 2015). The healthcare provider site is where the medical professional is located. This is typically their office or site of practice. The remote site, in contrast, is where the patient and a facilitator are located. This remote site could be a local doctor's office, a community health center, or any other area where some type of healthcare screening is being completed. This facilitator is an individual who is trained by the medical professional to complete the necessary tests for the appointment. The facilitator is typically a nurse, technician, or community healthcare worker. The communication between the healthcare provider site and the remote site occurs via some type of technology such as video conferencing. Figure 1 shows an illustration of the two sites involved in telehealth, the healthcare provider site and the remote site.

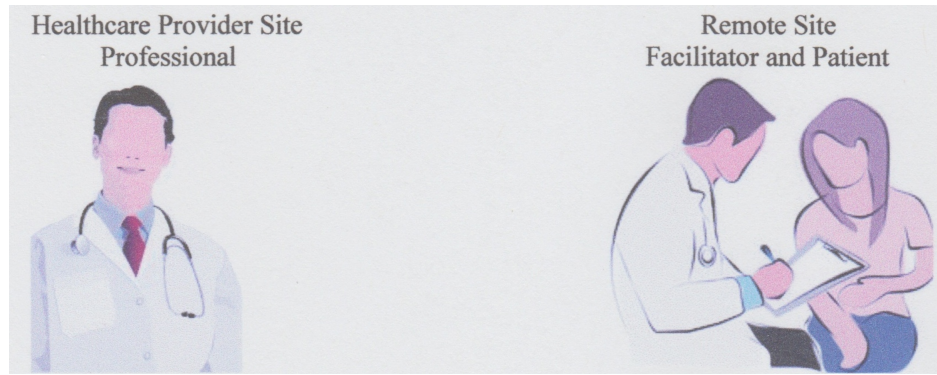


Figure 1. A model of the two sites needed to provide telehealth, the healthcare provider site where the medical professional is located, and the remote site where the patient and facilitator are located.

There are three primary modes of delivery of telehealth services. These are synchronous, asynchronous, and a hybrid model. Each of these delivery models is described below.

Synchronous. The synchronous mode of delivery takes place in “real-time.” The interaction between the patient and the healthcare professional occurs simultaneously, regardless of the geographic distance between them. The technology typically employed in the synchronous mode of delivery includes: videoconferencing; a desktop sharing technology so the medical professional can control the tests; or calling the medical professional to speak to the patient in real-time (Craig & Petterson, 2005; Pan et al., 2008; Swanepoel, 2015). Figure 2 shows an illustration of the synchronous mode of delivery, where the healthcare professional is located in Towson, Maryland, and the patient and facilitator are located in a rural area of West Virginia. The communication between the two separate sites is occurring simultaneously, that is Monday at 9 am, assuming both locations were in the same time zone.

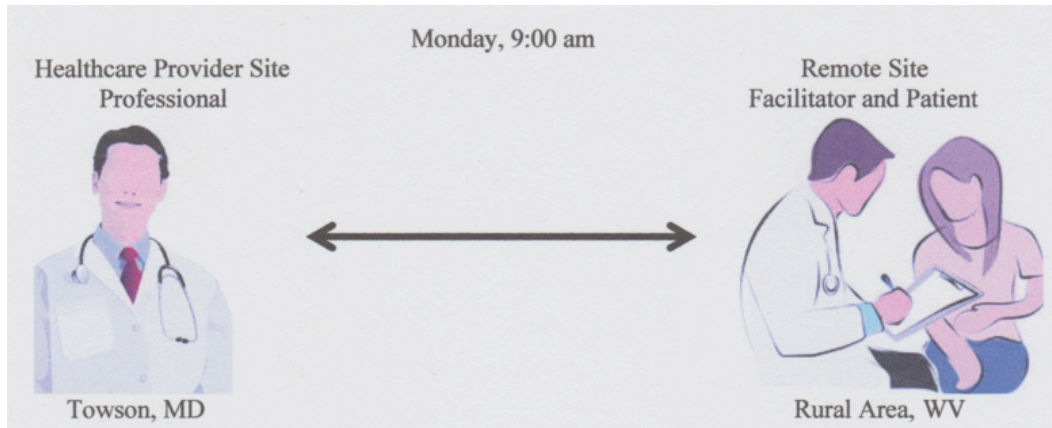


Figure 2. A model of the synchronous mode of delivery, with the medical professional located at the healthcare provider site in Towson, MD, and the remote site where the patient and facilitator are located in rural West Virginia. Note this is taking place in real-time.

Asynchronous. The asynchronous mode of delivery is also referred to as the “store-and-forward” model. As shown in figure 3 below, in this method of delivery the patient and facilitator meet at the remote site at one time (e.g. Monday at 9 am). The facilitator completes the tests and the patient is free to leave. Following the appointment, the facilitator sends the information he/she acquired during the testing to the medical professional located at the healthcare provider site. At a later time (e.g. Monday at 3 pm) the healthcare professional interprets the information, makes their diagnosis and recommendations for the patient, and sends that information back to the facilitator at the remote site. The facilitator then shares this information with the patient at the follow up visit (e.g. Tuesday 9am). Technology used in the asynchronous mode of delivery includes email; still images; postal mail; shared online networks; or web-based patient service sites (Craig & Petterson, 2005; Pan et al., 2008; Swanepoel, 2015).

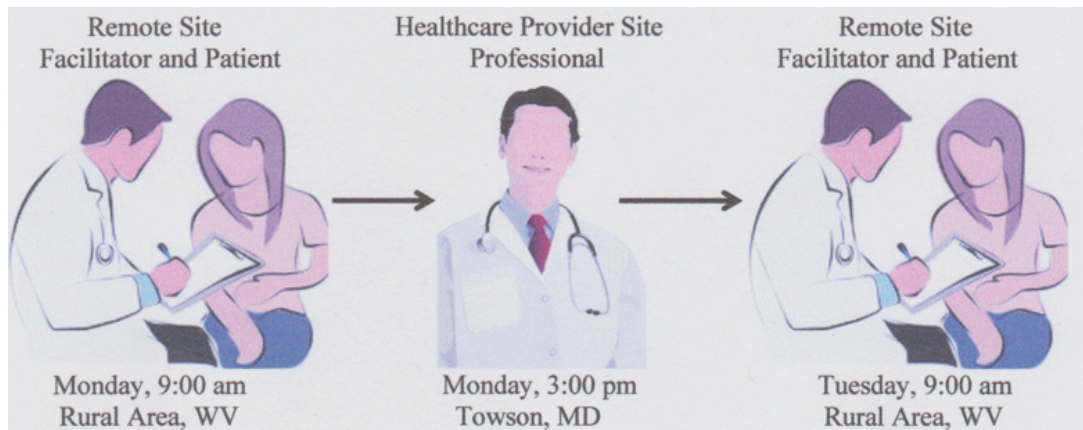


Figure 3. A model of the asynchronous mode of delivery, again with the medical professional located at the healthcare provider site in Towson, MD, and the remote site in West Virginia where the patient and facilitator are located. Note however that in this interaction takes place over several days.

Hybrid. The hybrid model is a combination of both the synchronous and asynchronous models of telehealth delivery. In this model, the patient and medical professional have some interactions in real-time, while some of the information gathered by the facilitator at the remote site is sent to the professional at the healthcare provider site to be reviewed at a later time. With the hybrid model, the technology from both synchronous and asynchronous modes is utilized. Studies have shown that the hybrid mode of delivery is actually the most cost-efficient (Pan et al., 2008).

Given the various advances in communication technology, it is now possible to achieve the two primary goals set forth by telehealth. Medical professionals have the ability to successfully bridge the geographic distance between themselves and their patients, as well as improve the time and cost efficiency of delivering healthcare services. While the goal of bridging the geographic distance has been shown in both Figures 2 and

3, the goal of improving the efficiency of delivering healthcare services can be addressed in other ways. Figure 4 displays an example of conducting hearing screenings for children located at several schools. In this example, facilitators who have been trained by the healthcare provider (e.g. audiologist) are located at these remote sites, while the audiologist is monitoring them all from his/her office.

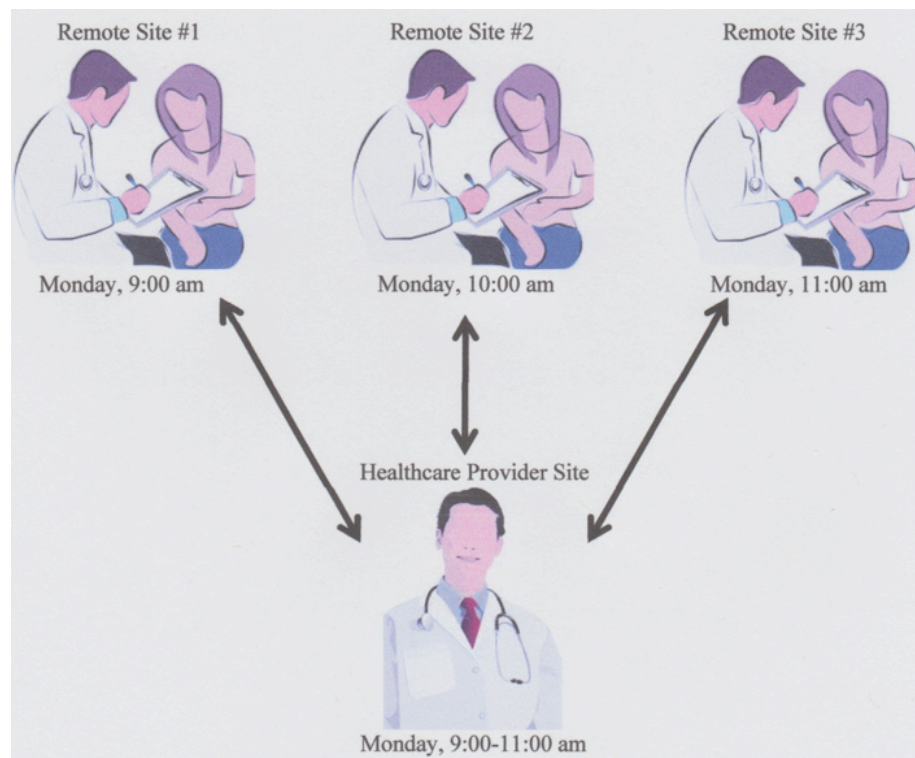


Figure 4. A model of the hybrid mode of telehealth delivery with several facilitators performing hearing screenings, occurring in several different remote locations at different times, while the professional is reviewing the information at the local site at their convenience.

Now that we have examined the goals of telehealth and its three modes of delivery, next we examine how the idea of telehealth came to be, as well as the history of telehealth in the medical field.

History of telehealth. Telehealth has been mentioned in medical literature for the past 20-30 years (Craig & Petterson, 2005). The idea of telehealth, however, has been present since the 19th century. During the civil war, medical professionals would send telegraphs with lists of medical supplies to providers. Later advances in technology allowed technicians to send x-rays of patients to be examined by specialists. The invention of the telephone and radio only helped to increase the use of telehealth (Craig & Petterson, 2005). The National Aeronautics and Space Administration (NASA) was the first agency to use telecommunication technology in the 1960s to monitor astronauts' vital functions, including heart rate, blood pressure, temperature, and respiration during flight (Bashshur, Reardon, & Shannon, 2000). Technology from NASA has led to the widespread use of portable cardiac monitors and resuscitation technology by paramedics. More recently, advances in technology such as the Internet have led to an increased interest in telehealth (Bashshur et al., 2000).

Telehealth is now being performed in most industrialized countries, such as the United States, Canada, Australia, and the United Kingdom (Craig & Petterson, 2005). The types of healthcare services provided via telehealth vary. These services include diagnosis and management of diseases, tele-education, distance management (or tele-surgery), and tele-radiology. The main focus of this thesis project is teleaudiology, which is the application of telehealth to the practice of audiology. Therefore the remainder of this literature review will focus on this application.

Teleaudiology

Need for teleaudiology. First, it is important to realize the need for teleaudiology services, both in the United States and worldwide. According to the World Health Organization (2017), over 5% of the world's population, or about 360 million people worldwide, have a moderate to profound hearing loss. Of this population, 32 million are children. In addition to this number, 1.1 billion young adults (ages 12-25 years) are at risk for noise-induced hearing loss due to recreational and work related noise exposure. Unaddressed hearing loss costs the world a total of 750 billion international dollars. This enormous figure includes the cost of health care, educational support for individuals who have unaddressed hearing loss, the loss of work productivity for these individuals, as well as societal costs (WHO, 2017).

Hearing-impaired children who do not have access to hearing services are at risk for speech and language delays which impacts their reading and academic performance. This could also lead to effects in their social and emotional development. Lack of intervention for children with hearing loss can lead to higher unemployment rates and lower paying jobs (WHO, 2017). All of these children could benefit from early identification of hearing loss and early intervention, whether that be with hearing assistive technologies such as hearing aids or cochlear implants, sign language, or other types of therapy. Teleaudiology provides an effective means for allowing people around the world greater access to various types of audiologic services.

A third group in need of teleaudiology services are individuals who live in rural communities. A recent qualitative survey investigated the opportunities and challenges involved in providing hearing healthcare to adults living in rural environments in the

United States (Chan, Hixon, Adkins, Shinn, & Bush, 2017). Participants included 336 adults: 273 from urban communities and 36 from rural communities. The results of this study revealed that adults in the United States living in more rural areas were more likely to take a greater time to acquire hearing aids than those living in urban areas. On average, the time between the diagnosis of hearing loss and the time of hearing aid purchase was at least 8 years (Chan et al., 2017).

This delay in treatment can be attributed to several factors including: geographic distance to healthcare professionals; lack of hearing healthcare specialists; financial constraints and lack of access to healthcare; and a variety of patient and cultural factors in these rural populations (Chan et al., 2017). On average, these rural populations had lower household incomes, were more likely to have Medicaid insurance, and had much greater travel times to their hearing healthcare specialist in comparison to those individuals living in urban settings (Bush, 2017). This lack of financial resources contributed to the delay in receiving interventions for hearing loss, including the purchase of hearing aids (Bush, 2017). In addition to these difficulties, Chan and colleagues (2017) reported that 60% of all participants felt that their hearing impairment caused them to have difficulty performing their jobs, and over half of rural participants felt that it has inhibited them from completing higher levels of education. Adults in these rural areas have poorer health in general when compared to adults in more urban settings, and a shortage of audiologists further restricts their access to hearing healthcare (Bush, 2017).

Types of services. Many types of audiological services can be successfully provided using teleaudiology. These include hearing screenings, a variety of diagnostic tests including pure tone audiometry (both air and bone conduction), immittance

measures, otoacoustic emissions (OAEs), auditory brainstem response (ABR), fitting hearing aids, activating and mapping CIs, and counseling measures. These services, along with the most effective telehealth models for their delivery, are outlined in Table 1 below (Swanepoel et al., 2010a). Each of the primary applications for teleaudiology will be discussed below.

Table 1. *Scope of application possibilities for telehealth in audiology.*

Field of application	Scope of telehealth applications	
	Synchronous*	Asynchronous**
Education/training		
Health care providers	Real-time interactive videoconference presentations	Interactive online training modules
Paraprofessionals	Telementoring and guidance during assessments or procedures	Posting questions via email or online forums
Parents	Discussing difficult results/cases with experienced clinicians	Requesting 2 nd opinions from experienced clinicians
Screening		
Newborn hearing screening	Real-time screening directed via interactive videoconferencing and application sharing	Automated OAE/ABR screening
School-entry hearing screening	Quality control of screening via interactive videoconferencing	Automated audiometry screening
Adult hearing screening		Internet-based hearing tests may be valuable screening options
Vestibular screening		
Diagnosis		
Case history	Case history via interactive videoconferencing	A case-history can be taken electronically (store-and-forward or electronic patient file)
Otoscopy	Video-otoscopy via interactive videoconferencing and application sharing directed by audiologist	Video-otoscopy (store-and-forward or electronic patient file)
Immittance	Immittance, OAE, AEPs via interactive videoconferencing and application sharing.	Automated test sequences of immittance and OAE completed beforehand and emailed (store-and-forward or electronic patient file)
Otoacoustic Emissions (OAE)	Placement of probe/electrode etc., guided by audiologist and testing conducted via application sharing	Automated audiometry (store-and-forward or electronic patient file)
Auditory Evoked Potentials (AEP)	PC-based audiometers facilitate remote testing via interactive videoconferencing and application sharing	
Audiometry (pure tone & speech)		
Vestibular assessment		
Intra-operative monitoring		
Intervention		
Counseling	Counseling and troubleshooting conducted via interactive videoconferencing	Hearing aids may be pre-selected and pre-programmed based on audiological results
Ear canal management	Ear canal management guided remotely by audiologist via videoconferencing	Counseling sessions via interactive videoconferencing may be preceded by questions and complaints emailed
Hearing aid selection, fitting & verification	Hearing aids fitting guided and programmed via interactive videoconferencing and application sharing	Internet-based audiological counseling programs
Cochlear implant mapping	Verification of hearing aid via application sharing and interactive videoconferencing	Internet-based audiological treatment programs (i.e. tinnitus)
Intervention	Cochlear implant activation and mapping via application sharing and interactive videoconferencing	Internet-based auditory training programs
	Follow-up sessions via interactive videoconferencing	Home-based intervention for infants may be provided by recorded play sessions at home sent through to interventionist for evaluation
	Home-based early intervention services via interactive videoconferencing	

*Usually involves a paraprofessional or trained volunteer to facilitate the telemedicine setup at the remote

location whilst the health care provider (audiologist) is present remotely via interactive videoconferencing.

** Usually involves a paraprofessional or trained volunteer to facilitate the telemedicine setup at the remote location whilst the health care provider (audiologist) is not present or available in real-time via interactive videoconferencing.

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Screening. Many professionals have been developing new methods and technologies to perform hearing screenings around the world using teleaudiology. This includes both the implementation of newborn infant hearing screenings (NIHS) with OAEs and ABR testing, as well as hearing screenings for both adults and children (Krumm et al., 2008; Lancaster et al., 2008). One key question that researchers have been addressing in this area is do the screening measures employed using teleaudiology provide as accurate of results as they would via a face-to-face method?

Specifically, Krumm and colleagues (2008) compared the OAE and automatic auditory brainstem response (AABR) results from a total of 30 infants, ranging in age from 11-45 days old. These two screening procedures were administered using both face-to-face audiology techniques and teleaudiology with an audiologist testing the infants using a computer-sharing system. Krumm and colleagues (2008) reported that distortion product otoacoustic emission (DPOAE) measures obtained from both methods were not significantly different at any test frequency. DPOAE measures were considered present and robust when they were -5 dB signal to noise ratio (SNR) or greater and at least 8 dB above the noise floor. It was considered a pass when these DPOAE criteria were met at three of the five frequencies tested. The AABR results indicated identical screening results for both measures. The pass criteria for the AABR was determined by the

software selected, and a low amplitude electrophysiological activity in response to a click stimuli was considered a refer response in that ear (Krumm et al., 2008).

Based on their teleaudiology experience, Swanepoel and colleagues (2010a) believe that the most effective method of performing NIHS is the asynchronous model of teleaudiology. In this model, technicians in the hospitals can be trained to perform OAE and ABR screenings. They then can send the results of the screenings back to the audiologist for further interpretation if necessary (Swanepoel et al., 2010a).

Pure tone screening for hearing loss can also be done using teleaudiology. Numerous studies have found that the pure tone screening results obtained using teleaudiology are as accurate as face-to-face methods (Krumm et al., 2008; Lancaster et al., 2008; Swanepoel, Myburgh, Howe, Mahomed, & Eikelboom, 2014). For example, Lancaster and colleagues (2008) used teleaudiology to screen hearing in rural elementary schools using otoscopy, pure tone, and immittance measures. These screenings were completed on 32 children in the third grade in a rural elementary school in Utah. Each child was screened once using a traditional face-to-face method and once using teleaudiology practices. Tympanometry was completed using an asynchronous method with the results sent to the healthcare professional supervising the screenings, while otoscopy and pure tone results were completed using the synchronous method. Otoscopy was recorded with a video otoscope, and the healthcare professional obtained children's air conduction thresholds with a remote-operated audiometer. Their results using both methods were compared. The researchers found that there were no significant differences in the results from otoscopy, immittance, and pure tone screening gained in both the teleaudiology and face-to-face method (Lancaster et al., 2008).

Another method of hearing screenings that is becoming more popular for adults is using applications on a cell phone to screen for hearing loss (Swanepoel et al., 2014). The app selected for this study was the hearScreen™ developed at the University of Pretoria in South Africa. This free application provides screening measures for hearing, as well as environmental noise monitoring, automatic testing and interpretation of results, and referrals to hearing health professionals based on location. When calibrated correctly, researchers have found that this application can accurately screen for hearing loss, and the results of this type of hearing screening were not statistically different to results found during conventional screenings (Swanepoel et al., 2014). As stated above, both the synchronous and asynchronous models of teleaudiology can be utilized for these services (Swanepoel et al., 2010a).

Diagnosis. Researchers have also studied the application of teleaudiology for delivering various diagnostic audiological services (Biagio, Swanepoel, Laurent, & Lundberg, 2014; Givens & Elangovan, 2003; Kokesh et al., 2008; Krumm, Ribera, & Klich, 2007; Lundberg, Biagio, Laurent, & Sandström, 2014; Smith, Dowthwaite, Agnew, & Wootton, 2008; Swanepoel, 2015; Swanepoel et al., 2010a; Swanepoel & Hall, 2010; Swanepoel et al., 2010b; Towers, Pisa, Froelich, & Krumm, 2005). These diagnostic services include taking case history, otoscopy, immittance measures, OAEs, ABRs, and pure tone audiometry, including air and bone conduction. Their results have shown that case histories can be accurately recorded using the synchronous model of teleaudiology. This allows the audiologist to speak to the patient directly, or through the asynchronous model by using email to ask the patient questions (Swanepoel et al., 2010a). Similarly, otoscopy can be easily completed using both the synchronous and

asynchronous models using a video otoscope (Biagio et al., 2014; Kokesh et al., 2008; Lundberg et al., 2014).

Immittance measures such as tympanometry and acoustic reflex thresholds (ARTs) can be recorded with similar accuracy using either a face-to-face technique or a teleaudiology technique (Lancaster et al., 2008; Smith et al., 2008; Swanepoel, 2015). As previously stated, Lancaster and colleagues (2008) utilized the asynchronous model of teleaudiology and accurately performed tympanometry measures during hearing screenings. In addition, both OAEs and AABRs can be accurately recorded in patients using teleaudiology (Krumm et al., 2007; Swanepoel & Hall, 2010; Towers et al., 2005).

Pure tone results with air conduction measures can be recorded accurately in patients using teleaudiology (Givens & Elangovan, 2003; Swanepoel et al., 2010a; Swanepoel & Hall, 2010; Swanepoel, et al., 2010b). Swanepoel and colleagues (2010b) explored the possibility of providing diagnostic audiology services from Dallas, Texas to Pretoria, South Africa using an automated audiometer. These researchers tested 30 normal-hearing subjects and 8 hearing-impaired subjects. Each subject's air conduction thresholds were measured from 125-8000 Hz using both manual and automated testing methods. Swanepoel and colleagues (2010b) reported that the difference in air conduction scores between these two testing methods did not exceed 5 dB HL at any test frequency. By using automatic audiometers and videoconferencing, audiologists could accurately measure behavioral hearing thresholds for individuals in Pretoria, South Africa from their office in Dallas, Texas (Swanepoel et al., 2010b). Similarly, Givens and Elangovan (2003) found that bone conduction thresholds could be accurately recorded with teleaudiology methods. Of the 25 participants tested with bone conduction from 250-

4000 Hz, their threshold measures obtained via teleaudiology methods and traditional face-to-face methods varied by no more than 1.2 dB HL. Collectively, the results of these studies have shown that teleaudiology can be used to accurately perform audiological assessments, using both the synchronous and asynchronous modes of delivery (Given & Elangovan, 2003; Swanepoel et al., 2010b).

Intervention. Finally, different intervention strategies such as counseling, hearing aid fittings and verifications, and CI mapping, have been successfully completed using teleaudiology. Counseling and intervention can be completed for newly fit hearing aid users utilizing both the synchronous and asynchronous modes of delivery (Laplanche-Lévesque, Pichora-Fuller, & Gagné, 2006; Thorén et al., 2011). Thorén and colleagues (2011) reported that patients could seek out counseling on their own time by using an online educational program designed for adult hearing aid users. These researchers compared the results of two groups of participants: 29 individuals who had a five-week online rehabilitative course with access to an audiologist, and 30 individuals who belonged to an online discussion forum without access to an audiologist. All participants were experienced hearing aid users ranging in age from 24 to 84 years. At a six-month follow up, results showed that both groups experienced some benefits as self-reported via an online questionnaire. Thorén and colleagues (2011) reported that using both online education tools along with access to an audiologist, as well as online discussion forums, produced better outcomes in hearing aid patients and reduced problems experienced by patients such as symptoms of anxiety and depression (Thorén et al., 2011).

Campos and Ferrari (2012) were interested in determining whether the fitting of hearing aids using teleaudiology techniques was comparable to the results obtained via

traditional face-to-face fittings. In this study, 50 individuals with hearing impairments, ranging in age from 39 to 88 years, were randomly separated into two groups. The two groups consisted of those individuals fit using a traditional face-to-face method, and those individuals fit using synchronous teleaudiology techniques utilizing interactive video communication and remote control of the computer and other devices. Individuals in both groups were fit with one of three different kinds of hearing aids, had their fittings verified using real ear measurements, and were counseled about their hearing aids after their fitting. Campos and Ferrari (2012) reported that both subject groups had similar real ear outcome measures, which verified that all instruments met NAL-NL1 targets, with the exception of only 5 of the 21 targets measures being significantly different between the face-to-face and teleaudiology methods. Secondly, the total amount of time the audiologist spent on the fitting was approximately the same for both groups. Based on these findings, Campos and Ferrari (2012) reported that the synchronous method of teleaudiology was as accurate in hearing aid fittings as the face-to-face method (Campos & Ferrari, 2012).

CI mapping can also be accurately performed using teleaudiology (Hughes et al., 2012; Ramos et al., 2009). The results of these studies have reported no difference in programming and/or outcomes of patients who underwent CI mapping using teleaudiology versus a traditional face-to-face method. Specifically, Ramos and colleagues (2009) programmed CIs in five adults over several sessions, using both traditional face-to-face methods and remote programming utilizing the synchronous method of teleaudiology. They found that over the 12 programming sessions for each method, no significant differences in the programming were found between them when

measuring the most comfortable levels and the qualitative input dynamic range of the devices. This exploratory study has shown promise in using teleaudiology to accurately program CIs. Ramos and colleagues (2009), however, highlighted the importance of local providers in programming these CI devices. Collectively, the results of these studies have shown that common audiological tests and interventions can be provided accurately using both the synchronous and asynchronous methods of teleaudiology.

Common work environments where teleaudiology is utilized. Given that the teleaudiology literature has demonstrated that teleaudiology techniques provide accurate screening and diagnostic results, as well as provide successful intervention strategies for hearing impaired clients, it is important to find out in what type of work settings teleaudiology is regularly being utilized. Keimig (2017) contacted 25 audiologists and hearing healthcare professionals via an online survey and telephone interviews to determine how these individuals are employing teleaudiology in their work settings. Keimig was particularly interested in several topics related to teleaudiology including: 1) determining what patient populations were served by teleaudiology; 2) what diagnostic, rehabilitation, and intervention services were provided; 3) what type of equipment and technology were employed in providing teleaudiology in these environments; and 4) how were the facilitator's identified in each work setting and how were they trained. The following is a discussion of Keimig's findings as a function of each work setting (Keimig, 2017).

Table 2. Summary of Teleaudiology in Work Settings.

Work Setting and N	Services and Patient Population	Equipment and Technology: Hardware and Software	Technician's Title and Training
VA (n = 13)	Diagnostics, hearing aid services, tinnitus management, cochlear implants, aural rehabilitation Adults and geriatrics	Email, remote desktop access, online portals, fax, Titan and OTOflex immittance bridges, Audioscan Verifit, AVTEQ telemedicine carts, messaging, Cisco, video/voice conferencing, Interacoustics, GN Otometrics OTOsuite, and manufacturer programming software	Trained telehealth technician, health technician, audiology assistant, nurse Telehealth trainer, in-person by the audiologist, equipment manuals, manufacturer vendors, audiology systems representatives
Hospital (n = 3)	Diagnostics, cochlear implant services, referrals/consults with other specialty providers Pediatrics and adults	Email, remote desktop access, online portals, Cisco software for voice/video conferencing, messaging, and desktop sharing, and the AFHCAN system. Video otoscopes and an automated tympanometer	Community health worker Telehealth trainer, in-person by the audiologist
Private Practice (n = 3)	Diagnostic services, hearing aid services, tinnitus management, aural rehabilitation Pediatrics and geriatrics	Video/voice conferencing software with a webcam, email, fax, remote desktop access, online portals	Audiology assistant or hearing aid dispenser In-person training by the provider
University (n = 3)	Diagnostics, hearing aid services, tinnitus management, cochlear implants Adults and geriatrics	Video/voice conferencing software, email, remote desktop access, and online portals	Community health worker, trained telehealth technician, an audiologist, audiology student In-person by the provider, training manual, equipment vendor, e-learning online
Manufacturer (n = 2)	Diagnostics, hearing aid services, and counseling post hearing aid fitting Consulting with professionals	Video/voice conferencing software: Polycom or Cisco, remote desktop access, online portals	Audiology assistant, an individual selected by the audiologists In-service training, phone training, webinars
Department of Defense (n = 1)	Diagnostics, hearing aid services, tinnitus management Adults	Video or voice conferencing software, email, remote desktop access	Audiology assistant Online audiology technician training certification, on-site training

VA setting. The VA was the most commonly reported work site for teleaudiology practice, with 13 out of the 25 participants reported using this technology in their work setting (Keimig, 2017). Several researchers in the VA setting reported that the primary goal of utilizing teleaudiology in this environment was to reach patients in the VA system that would otherwise not have access to hearing healthcare services due to geographical distance (Jacobs & Saunders, 2014; Pross, Bourne, & Cheung, 2016). It has been reported that of the 22.6 million veterans enrolled in the VA system, 39% of them live in rural areas (G. Saunders, personal communication, February 13, 2017). For these veterans who live in rural areas, 47% commute greater than two hours to reach a VA hospital. Saunders (2017) reported that approximately 1.6 million veterans are experiencing difficulty with their hearing, and therefore it is important for the VA to provide them with the most efficient care (G. Saunders, personal communication, February 13, 2017).

The VA first started utilizing teleaudiology practices in 2009 (Jacobs & Saunders, 2014). The services that were provided via teleaudiology included diagnostic testing, hearing aid services, tinnitus management, CIs, and aural rehabilitation (Keimig, 2017). Outpatient clinics have been established across the country to assist in providing these services to veterans in rural areas (Jacobs & Saunders, 2014). Nationwide there are currently 168 VA Medical Centers and 1,053 outpatient clinic sites (U.S. Department of Veteran Affairs). These veterans typically receive diagnostic testing and baseline hearing aid fittings at the VA hospital, while their follow-up care and hearing aid checks typically occur at these rural outpatient clinics (Jacobs & Saunders, 2014). In addition, VA hospitals have encouraged their hearing-impaired patients to utilize several smart phone applications to provide self-managed patient care. These cell phone applications include

hearing tests, auditory training, tinnitus management, and hearing aid counseling (Jacobs & Saunders, 2014). A further description of the various cell phone applications used for the purpose of teleaudiology will be discussed later in this literature review.

Pediatric hospitals. Pediatric hospitals, especially those located in more rural areas, have also incorporated teleaudiology practices into their clinical services. The aim of teleaudiology in this setting is to provide parents and teachers of hearing-impaired children with direct access to audiologists to answer any questions they may have about the child's hearing aids and/or amplification system. For example, Cincinnati Children's Hospital Medical Center is utilizing a technology platform called Cisco Jabber™, which allows audiologists to videoconference with parents and/or schools (W. Steuerwald, personal communication, February 3, 2017). This platform allows the audiologists to troubleshoot the amplification device without the need for the family to travel to the hospital. This videoconferencing platform can be downloaded onto a computer or can be accessed as a cell phone application. Cincinnati Children's Hospital Medical Center is also using teleaudiology to perform remote CI mapping internationally from Cincinnati to a physician in the Dominican Republic. The patient's CI is connected to the computer at the remote site with the company's CI mapping software. With a remote access program, the audiologist in Cincinnati can control the computer being used in the Dominican Republic. This way, the audiologist at the healthcare provider site can access the patient's CI at the remote site to make programming changes and adjustments. (W. Steuerwald, personal communication, February 3, 2017).

Manufacturers. Various manufacturers in the hearing healthcare industry have also been using teleaudiology services to provide patients with diagnostic tests, hearing

aid services, and counseling tools post hearing aid fittings (Keimig, 2017). The goals of these teleaudiology programs are to improve the cost and time efficiency in providing services for hearing aid patients, as well as bridge the geographical distance for those patients who cannot always access their audiologist easily. Currently there are six cell phone applications (apps) and software programs from the leading manufacturers in hearing healthcare. These cell phone apps are described in further detail in table 3 below. One example of this type of technology is TeleCare, created by Signia, which is used by patients through an app on their phones called myHearing. This app helps hearing aid patients by providing them with information about their hearing aid devices (how to clean and maintain them) and exercises to improve their listening skills. The myHearing app also contains a portal for their audiologist to monitor their client's progress and see if they are having any problems with their hearing aids. Starkey Hearing Technologies has also created TeleHear, a videoconferencing platform that allows audiologists and patients to communicate. Patients are able to receive hearing tests and hearing aid evaluations at the remote site without having to travel long distances to reach the audiologist.

Table 3. *Summary of Available Teleaudiology Applications*

Manufacturers	Access to Professional	Hearing Aid Information	Adjustments for Hearing Aids	Additional Uses
Signia myHearing	Yes	Yes	VC and program adjustments	Can provide feedback to audiologist about hearing aids Can contact professionals who can respond via text, voice, or CareChat
ReSound Smart 3D	Yes	Yes	Tinnitus management, VC, program adjustments, favorite settings, find my hearing aids	ReSound assist - remote fine-tuning completed by audiologist
Unitron uControl 2.0	No	No	VC and program adjustment	Patients rate listening in different environments, logs information for the professional to access
Oticon ON	No	Yes	VC, program adjustments, find my hearing aids	Can stream directly to hearing aids (only with iOS devices)
Phonak Support App	Yes	Yes	No	Only available through the VA
Starkey TeleHear	Yes	No	No	Can consult online with a remote office to review treatment, recommendations, and follow-up care

International hearing screenings. Audiologists have also been using teleaudiology techniques to perform international hearing screenings in remote areas. For example, a study by Swanepoel and colleagues (2010b) explored the possibility of providing audiology services from Dallas, Texas to Pretoria, South Africa. By using remote controlled audiometers and videoconferencing, audiologists could accurately measure hearing thresholds in individuals in Pretoria from their office in Dallas. Swanepoel and colleagues (2010b) reported that the pure tone results obtained via

teleaudiology were clinically comparable to thresholds obtained via traditional face-to-face measures.

Recently, an exciting new audiometric technology has been developed which allows hearing healthcare providers to perform hearing screenings without the need for a soundproof booth (J. Scotland, personal communication, February 10, 2017). The KUDUwave audiometer is a portable audiometer that allows for hearing screenings and hearing tests to be completed without the need of a sound-attenuating booth. It combines a sound booth, audiometer, and headset into one device that is lightweight and easily transportable (“The future of audiology,” n.d.). The headphones include a pair of insert earphones covered by circumaural earcups (“No patient let behind,” n.d.). These circumaural earcups contain internal and external microphones that monitor the environmental noise to ensure that the noise levels remain within the acceptable limits. This active noise-monitoring technology allows hearing screenings to take place without the need of a sound booth (“No patient let behind,” n.d.).

Scotland (2017) reported that approximately 1200 children can receive hearing screenings in one day using multiple KUDUwave audiometers set up in a school in South Africa, and a hearing healthcare team consisting of one audiologist and four technicians. The results of the hearing screenings can be uploaded to a central server and then reviewed by the audiologist at a later time (J. Scotland, personal communication, February 10, 2017). Scotland reported that when the pure tone air conduction results of 30 participants obtained with the KUDUwave audiometer were compared to traditional face-to-face audiological measures, no significant threshold differences were found across all test frequencies (125-8000 Hz) (“The future of audiology,” n.d.). With this

KUDUwave technology, audiologists have the potential to bridge geographical distances on an international basis and to screen large numbers of children more efficiently than with traditional audiological services, thus achieving the two primary aims of telehealth.

Successes and Challenges of Teleaudiology

As previously stated, teleaudiology can accurately provide a variety of services to patients, both on a national and an international level. However, there are challenges associated with teleaudiology that must be addressed before it can be successfully implemented in a variety of settings. Some of these challenges include: the purchase and maintenance of the equipment needed for audiology testing; training the facilitator on how to perform necessary tasks; issues related to audiology licensing requirements in different states or countries; scheduling appointments when services are being provided in different time zones; the confidentiality of patient information; reimbursement for audiological services; and the possible challenges of this technology for older clients. Each of these areas will be discussed in more detail below.

Equipment. After an audiologist decides they want to implement teleaudiology in their work setting, some of their first purchases are the equipment necessary to perform the audiology services they have chosen to provide. Selecting what types of services, as well as where they will be providing them, will determine what type of equipment is necessary (Krumm, 2014).

Selection of Equipment. For audiologists who are providing services on a national level, it is easier to purchase equipment such as an audiometer, an immittance bridge, and a sound booth for the remote site where the facilitator and the patient would be located. In contrast, for audiologists providing services internationally, this task

becomes more difficult to achieve. For audiologists seeing patients in remote areas of the world, such as in South Africa, installing equipment such as a sound booth is not often feasible (Swanepoel et al., 2010c). When the installation of sound booths is not possible, then environmental noise levels must be closely monitored in the room selected for testing. Access to the Internet is also an important factor when considering where to provide services. While this is not an issue in most countries, some rural areas of China, India, and countries in Africa have large populations without Internet access (Swanepoel et al., 2010c).

Calibration of Equipment. Calibration of the equipment purchased for teleaudiology can also present challenges for the audiologists and facilitators. According to the American National Standards Institute (ANSI), all audiological equipment must be calibrated yearly to maintain the consensus standards outlined by the academy (Burkard, 2004). For professionals providing teleaudiology services nationally this is not a problem, as contracting companies can be hired to perform these yearly calibrations on the equipment. For international services, the audiologists and facilitators have several options. They can have the company fly out to the remote location and calibrate the equipment, or the audiologist themselves can receive the necessary training and certification to perform the calibration (Burkard, 2004). Procedures also need to be in place to ensure that their audiometric equipment is functioning appropriately on a daily basis. Possibly some type of biological calibration, handled by the facilitator, would address this concern.

Training. Another concern for audiologists wishing to begin teleaudiology practices is the training of the facilitator at the remote site (Eikelboom, & Swanepoel,

2016; Givens, 2004; Krumm, 2014). This facilitator, as previously stated, could be a nurse, technician, community healthcare worker, etc. It is important to note that the individual selected is the person in direct contact with the patient at the remote site. This means that the facilitator should be selected wisely by the audiologist to provide patients with the best quality of care (Gladden, 2013). Givens (2004) states that the facilitator providing these services should be comfortable with the audiometric equipment, videoconferencing, and/or technology platform, which requires training on the part of the audiologist. The facilitator also needs to have the means to contact the audiologist if a problem arises (Givens, 2004).

A recent survey conducted by Eikelboom and Swanepoel (2016) revealed that most audiologists who participate in teleaudiology seek to identify personnel already employed by the practice that are currently underutilized, or by using those facilitators already trained in the necessary tasks. These tasks include such things as otoscopy, automated audiometry, and setting up the patient for audiometry provided using synchronous teleaudiology methods (Eikelboom, & Swanepoel, 2016). In addition to these factors, plans must also be in place to train additional personnel if the facilitator leaves the practice.

Licensure. In America there are currently different licensure requirements to practice audiology for each individual state (Frailey, 2014). For those practicing teleaudiology across state lines, this can become an issue. Current practice states that the licensure of the audiologist is based on the location of the client. For example, if the client being seen is located in West Virginia, and the audiologist is located in Maryland, then the audiologist must be licensed in the state of West Virginia, as well as in

Maryland. It can become costly for audiologists to hold licensure in several states (Frailey, 2014). For audiologists providing teleaudiology services internationally, there is even less information about their licensure requirements.

Scheduling. When scheduling appointments for teleaudiology services, audiologists have additional considerations to keep in mind, especially if they are in different time zones from their patients, or those who see patients internationally (Gladden, 2013). Accounting for these time differences as well as determining the amount of time needed to provide teleaudiology services could be challenging. Some practices that are offering teleaudiology services have taken to setting up blocks of times on certain days that patients can make appointments for adjustments and follow-ups (Freeman, 2010). By outlining specific meeting times they can assure that both patient and provider have overlapping business hours to meet, either face-to-face or remotely. These meetings can occur using remote access to customer service or a synchronous adjustment of the device (Freeman, 2010). Audiologists practicing teleaudiology on an international bases can face even more severe scheduling conflicts, as they are generally 16-18 hours off their schedules in comparison to these remote underdeveloped areas (Gladden, 2013).

Confidentiality. Keeping patient records confidential is an important subject for audiologists to consider when they are thinking about practicing teleaudiology. Audiologists must remain in compliance with the Health Insurance Portability and Accountability Act (HIPPA) of 1996 that protects the medical information of the patient (Denton & Gladstone, 2005). Audiologists need to ensure that their patient's teleaudiology records are as private and maintain the same levels of security as if their

patients were being seen for face-to-face testing (Cohn & Cason, 2012). Despite these concerns regarding confidentiality, patients have stated that they have appreciated electronic access to their medical records as it allowed medical professionals to provide continuity of care for both traditional face-to-face testing and teleaudiology (Kokesh, Ferguson, Patricoski, & LeMaster, 2009).

Reimbursement. Another possible reason why teleaudiology is not more widely practiced is challenges related to reimbursement for services (Baker & Bufka, 2011). In the United States, when audiologists bill certain private insurance companies for reimbursement, it is not always required for them to specify whether or not the audiology services were provided via telehealth. However, when Medicare is billed, audiologists are required to specify if services were provided face-to-face or through telehealth (Baker & Bufka, 2011). To date there is very little disseminated knowledge available regarding reimbursement practices for teleaudiology.

Technology Access. Two additional issues that need to be considered regarding the successful implementation of teleaudiology in an audiologist's practice is access to technology for the older adults, as well as their comfort level in utilizing this technology. Recent studies have investigated whether older patients are comfortable using the technology needed to gain access to teleaudiology services (Barnard, Bradley, Hodgson, & Lloyd, 2013; Mitzner et al., 2010). Specifically, Mitzner and colleagues (2010) conducted a focus group that assessed the views of 113 adults from the age of 65 to 85 years on their perception of technology. The researchers found that most of the adults held a positive view of technology. The benefits they reported included: supporting activities (i.e. communication, research, and healthcare management); adding

convenience to their lives; and having useful features. However, several drawbacks were also reported. These drawbacks included security issues, the reliability of technology, and some confusion regarding the various features/selections on the applications. The majority of the participants (about 60%) found that the benefits of technology outweighed the costs and overall they enjoyed using technology (Mitzner et al., 2010).

Teleaudiology often requires the use of equipment such as computers, cell phones, and tablets that have Internet access. Therefore, it is necessary for older adults to be proficient in using these devices to participate in teleaudiology. A systematic review of several studies has assessed the problems faced by older adults when learning how to operate these new technologies (Barnard et al., 2013). It was found that the social environment the adult is in affects their willingness to learn, as well as their own perception of their ability to learn this new information. Next, when they are exploring this new technology, access to additional help and guidance can prevent them from being discouraged. Thirdly, the technology itself and its ease of use can influence how well a person can learn to operate it. Finally, success at learning new technologies leads to more achievements in the future by improving their confidence and increasing to their willingness to learn (Bernard et al., 2013). In summary, in order for older adults to participate in teleaudiology, they need to have access to technology guidance in learning how to use it and a willingness to learn how to operate these new technologies.

Professional Resources for Teleaudiology

There are several teleaudiology resources available for audiologists and other healthcare providers who are looking to acquire more information on this topic. These resources include: professional organizations they can join; surveys and published

research articles; professional development seminars and lectures; and conferences about teleaudiology. The next section of this literature review will briefly review these professional resources.

Professional Organizations. One resource that exists for audiologists is a collaboration group known as Special Interest Group (SIG) 18 – Telepractice, offered by the American Speech-Language-Hearing Association (ASHA) (ASHA, 2016b). This group provides information about telehealth in the fields of telespeech and teleaudiology, as well as a discussion board for its members to allow them to communicate with one another. They serve as the sounding board to ASHA and its members about telespeech and teleaudiology, conduct surveys, and monitor the current events and issues facing telepractice.

In 2016, ASHA developed a survey which assessed audiologists' and speech-language pathologists' attitudes towards telehealth (ASHA, 2016a). A total of 569 individuals participated in this survey. Of this total number of respondents, 45 participants practiced audiology, and only 50% of these individuals (n=26) practiced teleaudiology. Overall findings of this study showed that the audiologists who practiced teleaudiology primarily worked in government agencies such as the VA, or were self-employed. The audiological services they provided via teleaudiology include follow-up care, treatment, consultations, assessments, and screenings. Over half of the audiologists reported having practiced teleaudiology for more than three years. Audiologists also reported receiving their training in teleaudiology primarily from their employer/workplace, networking with colleagues, and ASHA's website (ASHA, 2016a).

Teleaudiology Conferences. There have been several recent conferences for audiologists to stay up-to-date on current issues and practices related to teleaudiology. One of these conferences was the Third International Meeting on Internet and Audiology that was hosted by the University of Louisville from July 27th to the 28th (2017). Four overall themes were addressed at this year's conference including: barriers to implementing telepractice; ethical issues related to internet-based research and service delivery; impact of large scale data on hearing rehabilitation; and the methodology of internet-based research and service delivery. Each theme included several speakers and panel discussions. There is a special issue of the American Journal of Audiology (AJA) that will be published in 2018 detailing the content of this conference. Similarly, the topics discussed from the two previous meetings are available as well from the International Audiology Journal (Andersson, Lunner, Laplante-Lévesque, & Preminger 2015; Laplante-Lévesque, Lunner, Andersson, & Preminger 2016).

Another conference regarding teleaudiology that was held recently was the 24th Annual Appalachian Spring Conference. This national event took place in Mountain Home, Virginia on June 15 (2017). Topics covered during this conference included: teleaudiology in the VA; detection and diagnosis with teleaudiology; fitting hearing aids via teleaudiology; remote applications for hearing aid and cochlear implant users; validation of patient-centered digital telehealth tool; telepractice for cochlear implants; and tinnitus treatment and management with Clinical Video Telehealth (CVT). These lectures are currently available to audiologists to view and gain continuing education units (CEUs) for online (Audiology Online, 2017).

In conclusion, the challenges associated with the current healthcare models worldwide have led to the creation of telehealth to address these shortcomings. Many areas of healthcare, including audiology, have begun to incorporate telehealth techniques in their healthcare delivery models. The application of telehealth in audiology has been termed “teleaudiology.” To date there have been promising results in applying teleaudiology techniques to a variety of audiology practices, including: hearing screenings; diagnostic testing; hearing aid fittings and follow-up appointments; cochlear implant mapping; and counseling techniques. However, there are a number of challenges/issues that audiologists need to consider prior to implementing teleaudiology into their work environments.

Aims of This Study

The primary goal of this study is to develop a tutorial on teleaudiology for audiologists and other hearing healthcare providers who are currently considering incorporating teleaudiology into their work environments. This tutorial will cover the following topics:

- I. The definition of telehealth and its various modes of delivery.
- II. Application of telehealth to audiology.
- III. The primary goals of teleaudiology.
- IV. Type of work settings that currently employ teleaudiology.
- V. Potential challenges associated with the successful implementation of teleaudiology in practice.
- VI. Professional resources available to audiologists wishing to learn more about teleaudiology.

Chapter 3

A Practical Guide to Implementing Teleaudiology

Introduction

During the last decade, there have been dramatic changes in the way people access healthcare services. The introduction and consistent use of smart phones, as well as the use of mobile healthcare apps have produced substantial changes in how healthcare services are delivered and how interventions for chronic diseases are monitored. Given these changes, a new healthcare service-delivery model, known as telehealth or mobile healthcare, has emerged. This model utilizes these advancements in technology to better connect with doctors, increase the efficiency of healthcare delivery, and reduce the geographic distances between the patient and his/her healthcare provider.

One worldwide organization that has been tracking the current as well as future trends in mobile healthcare is the mHealth Economics program (mHealth, 2017). These researchers began this tracking process in 2010, and issue an updated report every year. The mHealth Economics program is the largest digital health research program in the world, with over 15,000 participants. The 2017 report revealed that the majority of digital healthcare practitioners come from Europe (47%); the United States (36%); and the Asia-Pacific region (11%).

The results of their 2017 survey revealed several interesting themes. First, the market for mobile health has grown steadily during the last decade and continues to do so. Specifically, as of 2017 there were 325,000 healthcare apps available for purchase, with 78,000 healthcare apps added to app stores in the last year. It has also been estimated that smart phone users will download 3.7 billion of these applications in 2017.

This number has more than doubled since 2013 (the first year of this survey), in which 1.7 billion apps were downloaded. A second interesting finding was that the best markets for mobile health solutions were the United States, Great Britain and Germany. The reasons app developers rated the United States as the most favorable country for digital healthcare solutions were its large population size, its high GDP, and the high percentage of GDP spent on healthcare. Thirdly, this survey revealed that the top four medical fields that utilized healthcare apps included diabetes, obesity, depression, and hypertension. Patients also reported utilizing these mobile healthcare services for chronic disease management, remote consultations with their doctors, health education, and accessing electronic health records (mHealth, 2017).

Given the dramatic changes in the landscape for the delivery of healthcare services, several professionals involved in hearing healthcare believe that teleaudiology and these mobile apps are “the future of the audiology” (Mazevski, 2018). They have described providing hearing aid support on a remote basis as “the next frontier” (Angle, Schnittker, Tharpe, 2017). Hearing healthcare professionals have noted many benefits to using mobile healthcare apps, such as reduced travel and wait times, smaller problems being addressed quickly and efficiently (sometimes by support staff), and shorter appointments overall for their patients (Mecklenburger, 2018). However, audiologists also have concerns about these apps, such as a reduced face-to-face time with their patients, difficulty reading between the lines of questions, and problems maintaining engagement with their patients during these encounters. A recent online survey of 1,000 Americans over the age of 18 years who reported having some level of hearing loss, found that 86% of these individuals see some value in incorporating teleaudiology into

their hearing healthcare regimen (Mecklenburger, 2018). It was found that 22% of respondents were very to somewhat likely to communicate with their audiologist through telehealth, and this finding was especially prevalent in the 35-54 year old adult group. Approximately 60% of the participants reported already using these mobile apps for purposes such as tracking healthcare goals and medication reminders, and 88% reported they would be willing to share personal information for the sake of improving their treatment options (Mazevski, 2018).

While teleaudiology research has shown that audiologists can provide screening, diagnostics, and rehabilitative services accurately and effectively using telehealth technologies, there is still only a small number of hearing healthcare providers utilizing this mode of service delivery. This can be attributed to a number of challenges that face audiologists when attempting to implement teleaudiology into their practices. These challenges include calibration, licensing, reimbursement, and the training of and communication with the facilitator. The purpose of this manuscript is to provide hearing healthcare professionals with a better understanding of what teleaudiology is, how it is delivered, and the appropriate clinical populations for a teleaudiology service delivery model. This manuscript will also delve into the types of audiology services that can effectively be delivered via teleaudiology; some of the inherent challenges related to this service delivery model; and professional resources that are available on this topic.

What is Telehealth and What are its Primary Goals?

The World Health Organization (2010) defines telehealth as “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information

for diagnosis, treatment, and prevention of disease and injuries, research and evaluation and for the continuing education of health care providers, all in the interest of advancing the health of individuals and their communities” (p 9). In layman’s terms, telehealth is using recent advancements in technology to provide healthcare to individuals who would otherwise not have access to these services.

There are two primary goals of telehealth. One goal is to bridge the geographical distance between the healthcare provider and his/her patients (Swanepoel, 2015). This is true on both a national and an international basis. The second goal of telehealth is to provide healthcare services in as time and cost effective manner as possible. This efficiency applies to both the healthcare providers and the patients (Swanepoel, 2015).

How are Healthcare Services Delivered Via Telehealth?

Telehealth requires two separate physical locations to deliver these healthcare services: the healthcare provider site and the remote site (Swanepoel, 2015). The healthcare provider site is where the medical professional is located, typically their office or site of practice. The remote site, in contrast, is where the patient and sometimes a facilitator are located. This remote site could be the patient’s home, a local doctor’s office, a community health center, or any other area where some type of healthcare screening is being completed. The facilitator is an individual who is trained by the medical professional to complete the necessary tests for the appointment. The facilitator is typically a nurse, technician, or community healthcare worker. The communication between the healthcare provider site and the remote site occurs via some type of technology such as video conferencing. Figure 5 shows an illustration of the two sites involved in telehealth.

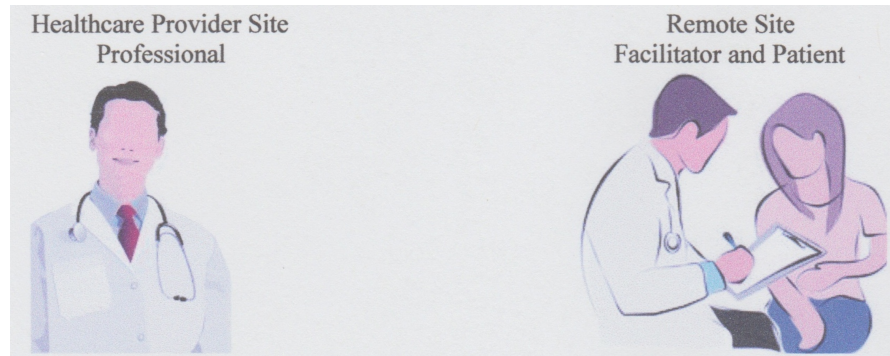


Figure 5. A model of the two sites needed to provide telehealth, the healthcare provider site where the professional is located, and the remote site where the patient and/or facilitator are located.

There are three primary modes of delivery of telehealth services. These are synchronous, asynchronous, and a hybrid model. Each of these delivery models is described briefly below.

Synchronous. The synchronous mode of delivery takes place in “real-time.” The interaction between the patient and the healthcare professional occurs simultaneously, regardless of the geographic distance between them. The technology typically employed in the synchronous mode of delivery includes: videoconferencing; a desktop sharing technology such that the medical professional can control the tests; or calling the medical professional to speak to the patient in real-time (Craig & Petterson, 2005; Pan et al., 2008; Swanepoel, 2015). Figure 6 illustrates the synchronous mode of delivery, where the healthcare professional is located in Towson, Maryland; and the patient and facilitator are located in a rural area of West Virginia. The communication between the two separate sites is occurring simultaneously, that is Monday at 9 am, assuming both locations were in the same time zone.

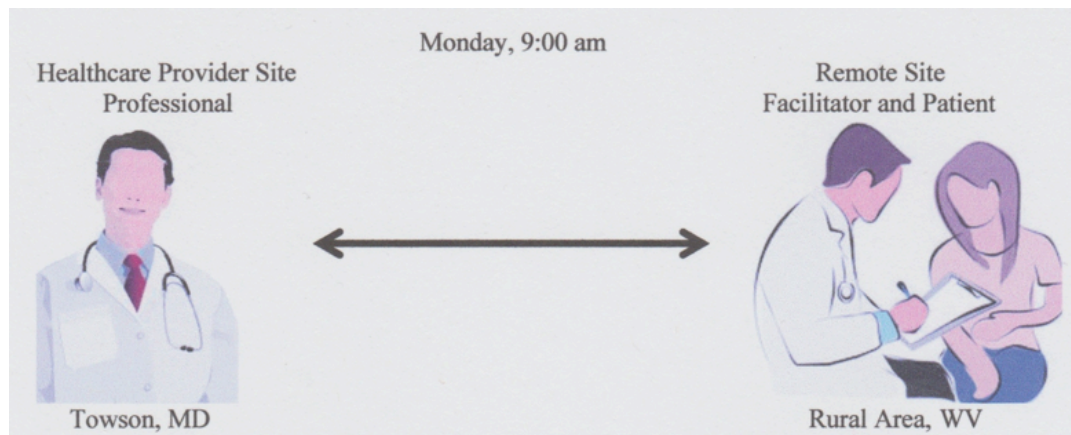


Figure 6. A model of the synchronous mode of delivery where the medical professional is located at the healthcare provider site in Towson, MD, and the remote site where the patient and facilitator are located in rural West Virginia. Note this is taking place in real-time.

Asynchronous. The asynchronous mode of delivery is also referred to as the “store-and-forward” model. In this method of delivery, the patient and facilitator meet at the remote site at one day and time (e.g. Monday at 9 am) as shown in figure 7 below. The facilitator completes the tests and the patient is free to leave. Following the appointment, the facilitator sends the information he/she acquired during the testing to the medical professional located at the healthcare provider site. At a later time that day (e.g. Monday at 3 pm) the healthcare professional interprets the information, makes their diagnosis and recommendations for the patient, and sends that information back to the facilitator at the remote site. The facilitator then shares this information with the patient at the follow up visit (e.g. Tuesday 9am). Another type of asynchronous communication is if the patient contacts a professional with questions or concerns, and the professional responds when their schedule allows. Technology used in the asynchronous mode of

delivery includes email; still images; postal mail; shared online networks; or web-based patient service sites like a patient portal (Craig & Petterson, 2005; Pan et al., 2008; Swanepoel, 2015).

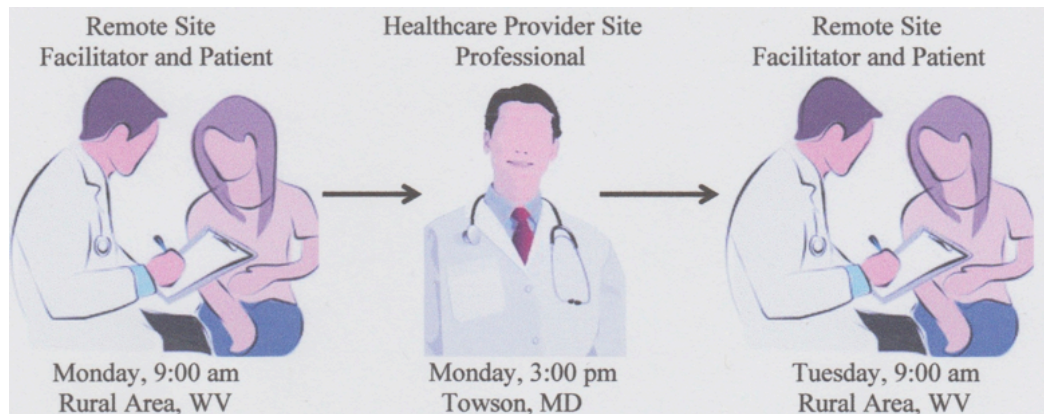


Figure 7. A model of the asynchronous mode of delivery, again with the medical professional located at the healthcare provider site in Towson, MD, and the remote site in West Virginia where the patient and facilitator are located. Note however that in this interaction takes place at different times of the day, or over several days.

Hybrid. The hybrid model is a combination of both the synchronous and asynchronous models of telehealth delivery. In this model, the patient and medical professional have some interactions in real-time, while some of the information gathered by the facilitator at the remote site is sent to the professional at the healthcare provider site to be reviewed at a later time. With the hybrid model, the technology from both synchronous and asynchronous modes is utilized. Studies have shown that the hybrid mode of delivery is actually the most cost-efficient (Pan et al., 2008). The next section of this manuscript will describe how these telehealth principles are applied to the field of audiology. In audiology, this method of service delivery is referred to as teleaudiology.

Who has a Need for Teleaudiology?

It is important for clinicians to realize that there is a considerable need for telehealth services in the field of audiology. This is true on a worldwide level, as well as in the United States. According to the World Health Organization (2017), over 5% of the world's population, or approximately 360 million people, have a moderate to profound hearing loss. However, many of these individuals do not have access to hearing healthcare services. Wang and Luo (2005) found that this lack of access was due to both spatial and non-spatial factors. Spatial factors included the geographical distance between the patient and the healthcare provider, while non-spatial factors were related to SES, ethnicity, primary spoken language, gender, age, and education level (Wang & Luo, 2005). In the United States there are three potential patient populations that are currently being underserved and would likely benefit from teleaudiology. These populations include: 1) individuals living in rural environments; 2) individuals with low SES; and 3) older adults with hearing loss. There is also one group of individuals, the hearing-impaired veteran population, which is currently being successfully served via teleaudiology. Each of these clinical populations will be discussed below.

Several researchers have reported that individuals living in more rural settings in the United States are less likely to receive healthcare services in comparison to people living in urban areas (Bush, 2017; Casey et al., 2001; Wong & Regan, 2010). One reason for this disparity is that the geographical distance needed to reach medical specialists in a rural area is much greater than in urban areas. Therefore, individuals must balance the need for healthcare with the safety and cost-efficiency of traveling to receive it (Wong & Regan, 2010). According to Casey and colleagues (2001), cultural principles of

individuals living in rural environments may also prevent them from seeking out healthcare. These cultural principles include a focus on self-reliance and individualism, preferences for more informal support than seeking out medical professionals, and reluctance to seek medical assistance unless there is a significant health problem, (Casey et. al, 2001). Thirdly, there is a shortage of medical professionals available to individuals living in rural areas (Guilbault & Vinson, 2018; Van Dis, 2002). Van Dis (2002) reported that the majority of the United States population (80%) lives in urban areas, while the remaining 20% live in more rural areas. However, only 9% of physicians in the United States practice in these rural areas. Guilbault and Vinson (2018) found that almost 40% of individuals living in these rural areas lack an appropriate number of health professionals.

Two recent studies investigated the challenges in providing hearing healthcare to adults living in rural environments in the United States as compared to those living in urban communities (Bush, 2017; Chan et al., 2017). Chan and colleagues (2017) reported that hearing impaired adults living in more rural areas were more likely to take a greater time to acquire hearing aids after the diagnosis of hearing loss (about 11 years) compared to those living in urban areas (about 8 years). Bush (2017) also reported that rural populations typically had lower household incomes than urban populations, and were more likely to be on Medicaid or to have no health insurance at all. Bush (2017) speculated that this lack of financial resources contributed to the delay in patients receiving medical interventions, including the purchase of hearing aids.

A second group of individuals impacted by a lack of access to hearing healthcare are adults with low SES. Bainbridge and Ramachandran (2014) reported that hearing-

impaired adults aged 70 years and older ($n = 1,636$) were 28-66% more likely to purchase hearing aids if they were higher on the income-to-poverty ratio than adults with a lower income level. Similarly, Nieman, Marrone, Szanton, Thorpe, and Lin (2016) found hearing-impaired adults ($n = 1,544$) with higher SES were more likely to report using hearing aids than those with a lower SES. Lastly, a recent survey conducted by Helvik, Krokstad, and Tambs (2016) of 11,605 hearing impaired adults aged 65 years and older, revealed that a higher education level, such as a vocational or college degree, was associated with increased use of hearing aids. Collectively, the results of these studies have demonstrated an association between lower SES and poorer healthcare outcomes for audiological services.

Not only is a low SES associated with less access to hearing healthcare, there is also a reverse effect of hearing loss on economic status of individuals in the US (Emmett & Francis, 2015). These researchers conducted a qualitative survey that assessed the hearing thresholds and income levels of hearing-impaired adults ranging in age from 20-69 years ($n = 3,379$). Emmett and Francis (2015) reported that even after controlling for demographic factors such as age, gender, race, and education level, adults with a hearing loss were 1.58 times more likely to have a lower income level and approximately two times as likely to be unemployed or underemployed in comparison to their normal-hearing peers. Hearing loss was also associated with lower educational attainment (Emmett & Francis, 2015). Teleaudiology services could potentially benefit this clinical population of hearing impaired adults who have low SES by allowing them greater flexibility in their access to hearing healthcare services.

The third group of individuals who need access to hearing healthcare services is older hearing-impaired adults. To successfully utilize teleaudiology services, however, patients must have access to the necessary technology and be comfortable operating it. Mitzner and colleagues (2010) assessed the views of 113 older adults ranging in age from 65 to 85 years on their perceptions of technology. These researchers found that most of these older adults held a positive view of technology. They reported benefits such as: supporting their activities (i.e. communication, research, and healthcare management); adding convenience to their lives; and having useful features. However, several drawbacks were also reported. These included security issues, the reliability of technology, and some confusion regarding the various features/selections on the applications. The majority of participants (~60%), however, reported that the benefits of technology outweighed the costs and they overall enjoyed using it (Mitzner et al., 2010).

Teleaudiology requires the use of equipment such as computers, cell phones, and tablets that have Internet access. Barnard and colleagues (2013) conducted a systematic review of the geriatric literature to determine the problems faced by older adults when learning how to operate these new technologies. It was found that the social environment that older adults are living in affects their willingness to learn, as well as their own perception of their ability to learn. Secondly, when older individuals are exploring this new technology, access to additional help and guidance is critical as it can prevent them from being discouraged. Additionally, the technology itself and its ease of use can influence how well an older person can learn to operate it. Finally, success at learning new technologies led to more achievements in the future by improving their confidence and increasing to their willingness to learn (Barnard et al., 2013).

Other researchers have also investigated how well older adults are adapting to the use of these technologies. Wild and colleagues (2012) looked at the differences in self-efficacy and anxiety levels of older adults, both with and without mild cognitive impairment (MCI), in regards to the use of new technologies. The participants (n = 162) ranged from 67 to 92 years of age. They were assessed on their computer self-efficacy and anxiety prior to any training with these technologies for a baseline measurement, and after one year of training on computer use. At the one-year follow-up appointment, participants reported increased self-confidence and decreased anxiety measures in their ability to perform certain tasks on the computer. However, the benefits of this training did seem to vary by task, and often the participants struggled more with tasks involving Internet use. In addition, the results showed older adults without MCI benefited more from the training than did adults with MCI (Wild et al., 2012).

Finally, a work setting in the United States that has successfully been utilizing teleaudiology for several years is the VA. Researchers have reported that the primary goal of utilizing teleaudiology in this environment was to reach veterans that would otherwise not have access to hearing healthcare services due to geographical distance (Jacobs & Saunders, 2014; Pross et al., 2016). It has been reported that of the 22.6 million veterans enrolled in the VA system, 39% of them live in rural areas, and of these patients, 47% commute greater than two hours to reach a VA hospital (Saunders, 2014). These veterans receive diagnostic testing and baseline hearing aid fittings at their local VA hospital; while their follow-up care and hearing aid checks typically occur at rural outpatient clinics via teleaudiology (Jacobs & Saunders, 2014). In 2014, The VA reported that there was about 2,000 teleaudiology encounters which included 920 follow-up visits,

440 hearing aid fittings and 600 hearing tests provided to more than 860 individual veterans (“Teleaudiology in the VA”, 2015). In addition, VA hospitals have encouraged their hearing-impaired patients to utilize several smart phone applications to provide self-managed patient care (Jacobs & Saunders, 2014). These applications will be described in greater detail later in this manuscript. The next section of this manuscript will describe the types of audiological services that can be offered via teleaudiology and recent developments in these areas.

What Types of Audiological Services can be Offered Via Teleaudiology?

Many types of audiological services can be successfully provided using teleaudiology. These include hearing screenings; a variety of diagnostic tests including pure tone audiometry, immittance measures, OAEs, and ABR testing; fitting hearing aids; activating and mapping CIs; and counseling measures. Numerous studies have shown that the results obtained using teleaudiology services are as accurate as those obtained during a typical face-to-face meeting (e.g., Campos & Ferrari, 2012; Givens & Elangovan, 2003; Krumm et al., 2008; Lancaster et al., 2008; Ramos et al., 2009; Swanepoel et al., 2010a; Swanepoel et al., 2010b; Swanepoel et al., 2014; Thorén et al., 2011). This manuscript will highlight recent developments in the application of teleaudiology to the following areas of audiology specialization: 1) hearing screenings and basic diagnostics; 2) hearing aid services for pediatrics and adults; 3) cochlear implant programming and follow-up care; and 4) special populations in need of audiological services.

Hearing screenings. Audiologists wishing to diversify their services/practices could utilize teleaudiology to perform hearing screenings and basic diagnostic evaluations. One recent technological development that could be applicable for this

purpose is known as the KUDUwave audiometer. This is a portable audiometer that allows for hearing screenings and air and bone conduction pure tone testing to be completed without the need of a sound-attenuating booth. It combines a sound booth, audiometer, and headset into one device that is lightweight and easily transportable (“The future of audiology,” n.d.). The headphones include a pair of insert earphones covered by circumaural earcups (“No patient let behind,” n.d.). These circumaural earcups contain internal and external microphones that monitor the environmental noise to ensure that noise levels remain within the acceptable limits of ANSI standards. The active noise-monitoring technology incorporated in this device allows hearing screenings to take place without the need of a sound booth (“No patient let behind,” n.d.). Traditionally, the KUDUwave audiometer has been used to conduct hearing screenings on an international basis. However, audiologists could use this technology within the United States. They could perform hearing screenings in schools, nursing homes, and community centers using a team of technicians or graduate students in audiology while monitoring the results from their office.

Hearing aid services. Teleaudiology techniques can also be successfully utilized with hearing aid patients. Several pediatric hospitals, especially those located in more rural areas of the United States, have incorporated teleaudiology into their clinical services. One way to utilize teleaudiology in this setting is to provide parents and teachers of hearing-impaired children with direct access to audiologists to answer any questions they may have about the child’s hearing aids and/or amplification systems. For example, Cincinnati Children’s Hospital Medical Center is utilizing a technology platform called Cisco Jabber™, which allows audiologists to videoconference with

parents of hearing impaired children and/or their teachers (Steuerwald, 2017). This platform allows the audiologists to provide services such as troubleshooting amplification devices, performing hearing aid evaluations, and completing auditory rehabilitation sessions without the need for families living in rural areas to travel to the hospital. This videoconferencing platform can be downloaded onto a computer or can be accessed as a cell phone application. Another example of teleaudiology services in pediatric hospitals is the University of California Davis Children's Hospital, which is using teleaudiology to provide NIHS and follow up audiological evaluations in more rural areas of the state of California (Satterfield & Sherwood, 2015).

Similarly, there are many teleaudiology applications and services available to assist adult hearing aid wearers. Currently, several leading manufacturers in the hearing healthcare industry have developed cell phone applications and software programs for this clinical population. These programs are described in further detail in table 4 below. One example of this type of technology is TeleCare, created by Signia, which is used by patients through an app on their phones called myHearing. This app helps adult hearing aid patients by providing them with information about their hearing aids (how to clean and maintain them) and exercises to improve their listening skills. The myHearing app also contains a portal for their audiologist to monitor their client's progress and see if they are having any problems with their hearing aids.

Table 4. *Summary of Available Teleaudiology Applications*

Manufacturers	Access to Professional	Hearing Aid Information	Adjustments for Hearing Aids	Additional Uses
Signia myHearing	Yes	Yes	VC and program adjustments	Can provide feedback to audiologist about hearing aids Can contact professionals who can respond via text, voice, or CareChat
ReSound Smart 3D	Yes	Yes	Tinnitus management, VC, program adjustments, favorite settings, find my hearing aids	ReSound assist - remote fine-tuning completed by audiologist
Unitron uControl 2.0	No	No	VC and program adjustment	Patients rate listening in different environments, logs information for the professional to access
Oticon ON	No	Yes	VC, program adjustments, find my hearing aids	Can stream directly to hearing aids (only with iOS devices)
Phonak Support App	Yes	Yes	No	Only available through the VA
Starkey TeleHear	Yes	No	No	Can consult online with a remote office to review treatment, recommendations, and follow-up care

While these manufacturers have embraced the recent changes in the delivery of audiology services, the question of whether adult hearing aid users would be willing and able to access these apps and software programs have been explored. A recent study completed by Angley and colleagues (2017) assessed the feasibility and benefits of hearing aid follow up appointments being provided via teleaudiology. The participants in this study were 50 adults, ranging in age from 32 to 88 years. Of these individuals, 15 were experienced hearing aid users, and 35 were new to wearing hearing aids. The Montreal Cognitive Assessment (MoCA) screening tool was also administered to all

participants to detect any mild cognitive impairments. This study consisted of two phases, an in-clinic phase with all 50 adults participating, and an in-home phase, which included 21 adults from the initial group, as well as one additional participant (Angleley et al., 2017).

During the in-clinic phase of the study, participants were provided with a study laptop and a distance support (DS) software package (Angleley et al., 2017). Each participant received a paper copy of the user's manual that included written steps as well as pictures of instructions needed to install the DS software and set up the required hardware. The audiologist remained in the room with each participant during the installation process but did not provide assistance unless the participant showed signs of confusion. Audiologists also recorded the time needed to successfully complete the installation. Next, the audiologist moved to a different room in the clinic and communicated with the participants using a telephone (either the landline or the participant's cell phone), as well as the laptop with application sharing software that allowed the audiologist to make adjustments to the hearing aids remotely. In contrast, during the in-home phase, a DS package was provided to each participant, along with a paper copy of the user manual with installation instructions for the DS and teleconference software. Each participant was given a hearing aid that was similar to their own, a hearing aid programming device, and a web camera so the audiologists could remotely adjust the participant's hearing aids. All of the in-home appointments occurred approximately 6 months following the in-clinic appointment. All 22 in-home participants were asked to complete the Feelings about Computers questionnaire before software installation began (Angleley et al., 2017).

After the in-clinic phase of this study was completed, each participant was asked to rate his or her overall computer skills level (i.e., beginner, average, advanced, or expert) (Anglely et al., 2017). No significant relationship was seen between the participant's age and their self-rated computer skills level. Eighty two percent of participants in the in-clinic phase were able to successfully install the DS software with no assistance. For the remaining 18% who could not install the software independently, their average MoCA scores suggested the possibility of an MCI in these individuals. On average it took participants eight minutes to successfully install the software and set up the DS equipment, while the older participants (>70 years) took slightly longer (mean = 11 minutes). The vast majority of the in-clinic appointments (86%) had a stable connection between the hearing aids and the DS software. In general, the in-clinic participants reported that the strengths of receiving hearing aid care remotely were saving time, convenience, and the reduction in travel costs. The weaknesses of these remote appointments were a lack of face-to-face time with the provider and possible computer software issues. Both of these weaknesses were only reported by 12-22% of the participants (Anglely et al., 2017).

Similarly, of the 22 participants who completed the in-home phase of the study, 82% were able to install the DS and telecommunication software independently (Anglely et al., 2017). A web camera was successfully used for the majority (77%) of the in-home appointments. All participants who used this arrangement reported that they preferred using a web camera to communicating with the audiologist via telephone. In cases where the web camera did not work it was typically related to the age of the participant's computer and/or operating system, inclement weather, or a poor Internet connection. The

vast majority (86%) of participants in the in-home phase reported a preference for DS appointments under difficult conditions, 90% reported a willingness to recommend DS appointments to others, and 60% would prefer a DS appointment in the future versus a typical face-to-face appointment. Participants specifically enjoyed the time saving aspect of DS appointments (Angleley et al., 2017).

Based on the results of this study, Angleley and colleagues (2017) have suggested that several considerations should be made if audiologists are providing remote hearing aid follow up services. First, the instruction manual provided to patients should be exact, brief, and include only the necessary steps. Inclusion of screenshots of each step could also be helpful to patients. Secondly, if a web camera is being used, then a backup method of communication, such as a telephone, should be available to patients. Lastly, these researchers felt that remote support for hearing aids might be especially helpful to patients when they have first received their amplification devices. Hearing-impaired individuals who have been recently fit are often not as certain in their ability to appropriately manage hearing aids and need frequent support at this initial stage (Angleley et al., 2017).

Cochlear implants. Another audiological service that can be provided via teleaudiology is CI mapping. Once a CI device has been activated, typically several follow up visits to the audiologist are required for adjustments and programming. As of November 2017, the Food and Drug Administration (FDA) has approved the use of teleaudiology to remotely program CI devices. This new ruling allows audiologists to perform CI adjustments without the need for the patient to be physically present, thus reducing the burden on both patients and families who must travel long distances to reach

their audiologist (“FDA Approves”, 2018). Several studies over the past decade have investigated the efficacy of remote mapping of adult CIs users who have used either Cochlear, Advanced Bionics or Med-El devices (Eikelboom, Jayakody, Swanepoel, Chang, & Atlas 2014; Goehring & Hughes, 2017; Hughes et al., 2012; Kuzovkov et al., 2014; McDonald, Sevier, & Hughes, 2018; McElveen et al., 2010; Ramos et al., 2009; Sevier, Choi, & Hughes, 2018; Wesarg et al., 2010).

Hughes and colleagues (2012) assessed the programming of 23 adult and 6 pediatric CI recipients who were implanted with either a Cochlear or an Advanced Bionics device, and had at least one year of CI experience. Each participant took part in three test sessions, the first at the CI lab at Boys Town National Research Hospital (BTNRH), the second at a remote site, and the third at BTNRH. The sessions were spaced out an average of 14 days. The rooms at remote site were small conference rooms equipped with videoconferencing equipment, but no sound treated booths. Background noise levels and reverberation times (RTs) were measured at the remote sites. The personnel at the remote site did not have specific expertise in cochlear implants, as it represented a more realistic application of distant CI programming. The patient’s CI was connected to the computer with the company’s CI mapping software. With a remote access program, the audiologist was able to control the computer being used at the remote site to make programming changes and adjustments. Five measures were taken for each subject: electrode impedance, electrically evoked compound action potential (ECAP) thresholds, psychophysical thresholds, programming levels, and speech perception tests. Results of this study revealed no significant differences in any of these five measures as a function of site (BTNRH versus the remote site). The only exception was speech

perception scores, which were significantly poorer for the remote site condition. The researchers reported that the remote sites had higher background noise levels in the low frequencies and longer RTs in comparison to the CI lab. Hughes and colleagues (2012) speculated that the acoustic differences between sites likely contributed to the poorer speech performance measures at the remote sites.

Wesarg and colleagues (2010) also compared the threshold (T) and comfort (C) levels obtained during local face-to-face test sessions versus remote fitting sessions in 70 CI recipients fitted with Cochlear Nucleus devices. The majority of these participants (n=57) were adults and the remaining 13 were children. These investigators reported no significant difference between the remotely and locally obtained T or C levels. However, no formal speech perception testing was conducted in this study. Wesarg and colleagues (2010) reported that the time needed to program the devices was comparable between the local and remote sites (mean of 20.8 ± 11.3 minutes, and 23.0 ± 12.0 minutes, respectively). Audiologists reported that remote programming provided an acceptable level of performance and the majority of participants reported that remote programming was an efficient alternative to face-to-face programming (Wesarg et al., 2010).

Kuzovkov and colleagues (2014) were interested in evaluating the use of remote CI programming in different countries in order to determine the ease of use, and to explore how CI users and medical professionals felt about the remote programming experience. These CI users were all fit with Med-El devices, and their input was evaluated by questionnaires. The results of this study revealed that 96.9% of the CI users were satisfied with the programming results and 100% stated they would use remote programming again and/or recommend it to others. The length of the remote

programming session was similar to the traditional face-to-face session. Participants reported that the biggest advantages for the remote programming sessions were it saves money and time, allows patients to have sessions at home, and it is possible to have experts from the company involved in the programming session (Kuzovkov et al., 2014).

A recent study has demonstrated that remote mapping of CIs can be successfully completed with the pediatric population. Goehring and Hughes (2017) measured CI behavioral thresholds levels (T levels) in 19 children (mean age 5 years, 3 months) using both teleaudiology and traditional face-to-face techniques. All three CI device manufacturers (Cochlear, Advanced Bionics and Med-El) were represented in the study group, and the average length of CI use was 3 years, 3 months. T levels were measured using conditioned play audiometry. These researchers reported that there were no significant differences in T levels measured in the remote versus face-to-face test conditions. The total testing time for both methods of delivery was very similar. A parent/caregiver survey also revealed that 94% of the parents reported that it could be a hardship to attend all of the clinical CI appointments due to coordinating travel and time off work or school, and 100% of caregivers reported they would take advantage of remote CI programming either some or all of the time (Goehring & Hughes, 2017).

One considerable challenge that has emerged in the use of teleaudiology for CI programming is the finding that speech perception scores of adult CI users were significantly poorer in the remote-programming sessions in comparison to the typical face-to-face programming (Hughes et al., 2012). Researchers have speculated that these differences were due to poor room acoustics at the remote site. In order to address this challenge, Seiver and colleagues (2017) explored the use of direct audio input (DAI) as

an alternative means to assess speech perception performance via teleaudiology. DAI can deliver the speech materials directly to the speech processor on a CI unit. DAI allows the audiologist to bypass the microphone of the CI and thus eliminate the harmful effects of poor room acoustics. When DAI was employed, the speech scores obtained in the remote location were comparable to those measured in the sound proof booth. However, a considerable limitation is that the DAI equipment and the calibration software used in this study are not commercially available (Seiver et al., 2017).

Recently, McDonald and colleagues (2018) have explored the performance of 16 teenager and adult CI users in various RTs and SNR test conditions using DAI to evaluate these individual's performance in simulated acoustical environments typical of those seen in remote locations used for telehealth. The subjects had either a Cochlear or an Advanced Bionics implants. The speech stimuli were the AzBio and hearing in noise test (HINT) sentences, as well as consonant-nucleus-consonant (CNC) words/phonemes, all delivered at 60 dB SPL. Each subject's performance was assessed in a sound proof booth via a loudspeaker (which served as a baseline) and using DAI techniques. Results of this study demonstrated the subjects' speech perception performance significantly decreased in presence of longer RTs and increased SNRs. This finding was true for all of the speech stimuli. McDonald and colleagues (2018) reported that because the acoustics of the test environment in remote locations could negatively impact speech perception scores, their findings demonstrate the need for intentional and purposeful selection of testing locations for the delivery of CI services via teleaudiology to approximate similar outcomes to traditional in-person testing. These researchers also stated that future studies should be conducted to develop correction factors that could be applied at remote sites

that lack a sound booth. Their current data was based on single ear performance and it is unclear whether these potential correction factors would be influenced by bilateral or bimodal listening conditions (McDonald et al., 2018).

Special populations. Lastly, two patient populations that could benefit from teleaudiology services are hearing-impaired older adults, as well as hearing-impaired adult patients who are receiving palliative care. Palliative care is defined as specialized medical care provided to individuals of all ages suffering from serious illnesses (Pacala, 2014). There is often a great need of audiological services among these groups of individuals that is not being met with the current medical models. It is also possible that there may be some overlap between these two clinical populations.

Hearing and communication are necessary in order for the hearing-impaired patient to understand their doctors and other healthcare professionals, as well as to successfully interact with their families and friends (Weinstein, 2015). This is especially important for individuals in palliative care, as they are receiving medical treatments for life-threatening illnesses. A recent survey of 510 individuals involved in providing palliative care services (including physicians, nurses, nurse practitioners, social workers, and chaplains) found that 91% of these individuals believed that hearing loss has impacted the quality of care provided to these patients (Smith, Ritchie, & Wallhagan, 2016). These professionals reported that screening for hearing loss in this population could assist them, but 87% of participants were not able to do so in their work settings. In addition, 31% of these respondents were not familiar with resources for individuals with hearing loss, and 38% had never heard of a pocket talker amplification device (Smith et al., 2016). Providing these palliative care patients with amplification devices can greatly

facilitate communication between patients and professionals about important medical decisions. This in turn fosters patient autonomy and dignity which helps improve their quality of life (Weinstein, 2015).

In contrast to those individuals receiving palliative care, who can be of any age, the geriatric population specifically refers to older adults (Pacala, 2014). Gopinath and colleagues (2011) found that only about 1 in 10 older adults with hearing loss utilize hearing aids. Participants reported that the primary reasons for not purchasing or utilizing hearing aids were the cost of the devices and the belief that hearing aids were not needed (Gopinath et al., 2011). Bainbridge and Ramachandran (2014) found that there was a 22-68% greater likelihood of these older adults utilizing hearing aids if they were of a greater income level.

Many individuals in the geriatric population may be living in nursing homes or retirement communities. Patients living in these environments need to be able to effectively communicate with staff and doctors, as well as their family and friends (Weinstein, 2015). Researchers have found that hearing aid use is low among these older adults with hearing loss (Bainbridge & Ramachandran, 2014; Gopinath et al., 2011). Teleaudiology techniques could be used to counsel the staff in these facilities on optimal strategies to communicate with the hearing-impaired geriatric population (Shaw, 2015). Audiologists could also use teleaudiology techniques to provide hearing screenings to older adults living in these communities. For those with hearing aids, audiologists could communicate with the nurses and healthcare workers to help these professionals troubleshoot basic problems with hearing or amplification devices.

Why are More Professionals not Utilizing Teleaudiology?

Despite the fact that there are several clinical hearing-impaired populations that could be helped with teleaudiology, at present there are only a small percentage of audiologists and hearing health professionals who are offering these services nationwide. This is in part likely due to the uncertainty and a lack of practical information about the day-to-day operations of teleaudiology. The challenges that audiologists face when considering incorporating teleaudiology into their work environments include: purchasing the necessary equipment and training staff to perform these services; the management of state licensure issues; patient scheduling; maintaining patient confidentiality; and reimbursement. This next section of this manuscript will delve into the tools needed for teleaudiology, as well as the challenges facing those who are utilizing this mode of hearing healthcare delivery.

Equipment. Once an audiologist makes the decision to provide teleaudiology services, they must first purchase the necessary equipment. This equipment includes both audiometric devices as well as computer software. With new advances in audiometric equipment, such as the KUDUwave audiometer mentioned previously, hearing screenings and tests could be performed at various locations by facilitators without the need for a sound proof booth, who are being monitored by the audiologist from the office (“The future of audiology,” n.d.). Providing counseling and hearing aid services to patients requires equipment such as computers, cell phones, and various software programs that allow the audiologist to communicate with the facilitator, patient, and their family. Cavitt (2018) has stressed the importance of having an information technology (IT) consultant in the instance that there is a problem with these technologies (Cavitt,

2018). Patient confidentiality must also be maintained with these means of communication, which will be addressed later in this section.

Calibration. Another important issue to keep in mind is the calibration of the audiologic equipment selected to perform teleaudiology services. According to ANSI guidelines, all audiological equipment must be calibrated yearly to maintain the consensus standards outlined by the academy (Burkard, 2004). This has typically created a problem for audiologists offering services internationally. However, the use of teleaudiology on a national basis eliminates many of these problems. Contracting companies can be hired to perform these yearly calibrations on the equipment used in the office, as well as the equipment used to perform teleaudiology services (Burkard, 2004). Procedures also need to be in place to ensure that their audiometric equipment is functioning appropriately on a daily basis. Likely training the facilitator to perform a biological calibration on the audiological equipment would address these concerns.

Personnel. Selecting a facilitator who will perform these audiological services at the remote site is an extremely important part of the success of a teleaudiology program (Eikelboom, & Swanepoel, 2016; Givens, 2004; Krumm, 2014). This facilitator, as previously stated, could be a nurse, technician, community healthcare worker, etc. A recent survey conducted by Eikelboom and Swanepoel (2016) revealed that most audiologists who participate in teleaudiology seek to identify personnel already employed by the practice that are currently underutilized to train as facilitators. Givens (2004) states that the facilitator providing these services should be comfortable with the audiometric equipment and communication technology, which requires training on the part of the audiologist. It is important to note that the individual selected to be the facilitator is the

person in direct contact with the patient at the remote site. Thus the audiologist should wisely select the facilitator in order to provide patients with the best quality of care (Gladden, 2013). In addition to these factors, plans must also be in place to train additional personnel if the facilitator leaves the practice.

Licensure. Currently there are no national standards regarding the licensure requirements for audiologists performing teleaudiology (Cavitt, 2018). The current practice is based at the state level, and it is important to check with an attorney regarding the requirements for that state. Sometimes it is required that audiologists hold a professional license both in the state where their practice is located, as well as in the state where the remote site is located and the patient is being seen. This dual licensure can become costly (Frailey, 2014). Liability insurance is also based on the state level. Cavitt (2018) reported that liability insurance typically is required to be purchased for the state in which the client is being seen. For example, if the client being seen in West Virginia, and the audiologist is located in Maryland, then the audiologist must have liability insurance in West Virginia, as well as in Maryland (Cavitt, 2018).

Scheduling. When scheduling appointments for teleaudiology services, audiologists have additional considerations to keep in mind. This is especially important if the audiologist is in a different time zone than their patients (Gladden, 2013). Accounting for these time differences will help to ease the burden on the audiologists performing these services, as well as the office staff. Some practices who are offering teleaudiology services have taken to setting up blocks of times on certain days that patients can make appointments for remote adjustments and follow-ups (Freeman, 2010). By outlining specific meeting times, audiologists can ensure that both patient and

provider have overlapping business hours to meet, either face-to-face or remotely. These meetings can occur using remote access to customer services or a synchronous adjustment of their device (Freeman, 2010).

Confidentiality. An important matter to keep in mind with the communication methods used to provide teleaudiology is that they must remain in compliance with HIPPA standards forth in 1996 that protect the medical information of the patient (Denton & Gladstone, 2005). Audiologists need to ensure that their patient's teleaudiology records are as private and maintain the same levels of security as if their patients were being seen for face-to-face testing (Cohn & Cason, 2012). This means that programs such as Skype, Facetime, SMS messaging, and unencrypted email cannot be used to provide teleaudiology services, as they do not maintain HIPPA requirements (Cavitt, 2018). It is important that audiologists who wish to participate in teleaudiology purchase encrypted means of communication, such as the Cisco Jabber™ software, to remain in HIPPA compliance.

Reimbursement. Another reason why some audiologists might not be providing teleaudiology services is the uncertainty when it comes to billing and reimbursement. In the United States, when audiologists bill certain private insurance companies for reimbursement, it is not always required for them to specify whether or not the audiology services were provided via telehealth. However, when Medicare is billed, audiologists are required to specify if services were provided face-to-face or through telehealth (Baker & Bufka, 2011). It is important to note, however, that Medicare does not reimburse for teleaudiology services, while some third party insurance coverage might, depending on the policy (Cavitt, 2018).

How Professionals Find Out More Information Regarding Teleaudiology?

As stated above, there are many factors that need to be considered before teleaudiology can be successfully implemented in a practice. Many of these issues do not have a clear-cut solution, and without a national standardization, audiologists must adhere to their local state laws, as well as the laws of the state in which their patients are located. For those looking for additional information and resources regarding teleaudiology, there are several options for audiologists and other hearing health professionals that can assist them.

Professional organizations. Organizations such as ASHA and the American Academy of Audiology (AAA) keep audiologists up-to-date with the latest changes and achievements in our field. Teleaudiology is one such area that these professional organizations offer material on. One specific collaboration group, provided by ASHA, is known as SIG 18 – Telepractice (ASHA, 2016b). This group provides information about telehealth in the fields of telespeech and teleaudiology, as well as a discussion board for its members to allow them to communicate with one another. It serves as the sounding board to ASHA and its members about telespeech and teleaudiology, conducts surveys, and monitors the current events and issues facing telepractice.

Teleaudiology conferences. Many professionals in the field of teleaudiology put on conferences that focus solely on this topic. Several events that have taken place in the past year have been the Third International Meeting on Internet and Audiology and the 24th Annual Appalachian Spring Conference. For professionals who want to learn more about teleaudiology, these resources allow them to access those at the forefront of this field. Special editions of the AJA have been published with the contents of the two

previous meetings of the International Meetings on Internet and Audiology (Issue 24, Volume 3; Issue 25, Volume 3) (Andersson et al., 2015; Laplante-Lévesque et al., 2016). Some of the topics covered at this conference included: barriers to implementing telepractice; ethical issues related to internet-based research and service delivery; impact of large scale data on hearing rehabilitation; and the methodology of internet-based research and service delivery. The contents from the Appalachian Spring Conference are also available for audiologists to view online and gain CEUs. Topics included: teleaudiology in the VA; detection and diagnosis with teleaudiology; fitting hearing aids via teleaudiology; remote applications for hearing aid and cochlear implant users; validation of patient-centered digital telehealth tools; telepractice for cochlear implants; and tinnitus treatment and management with CVT (Audiology Online, 2017).

Teleaudiology consultants. For those audiologists and other hearing health professionals seriously considering implementing teleaudiology into their practice, there are consultants in the field there to assist them. These consultants can assist audiologists with business delivery models, the selection and purchase of teleaudiology equipment, IT infrastructure, analyses of the monetary outcomes, and a comparison of other business competitors in the area (Davis, 2017). This information could mean the difference in the successful implementation of teleaudiology in a practice.

Conclusions and Future Directions for Teleaudiology

Over the past several years there have been many changes in the way healthcare services are being delivered. Many healthcare fields have started to develop applications for their patients to download and access services remotely. Individuals who have downloaded these apps typically use them to connect with their medical professionals and

help manage their healthcare needs. According to the 2017 mHealth survey, this trend of using healthcare apps is increasing, and it is clear that these apps are here to stay (mHealth, 2017). Many healthcare professionals and companies believe these apps are the new frontier in healthcare delivery, and it is no surprise that hearing healthcare is one of these fields.

Audiologists and other professionals in the hearing healthcare field have begun to explore telehealth as a viable option to deliver audiology services. Current research in teleaudiology has focused on hearing screenings, providing remote hearing aid follow up services for adults and children, helpful apps to monitor clients' performance with amplification devices, programming and adjustments to cochlear implants, and servicing under-reached populations. However, there are several considerations that need to be addressed before teleaudiology can be used more widely. It is important for audiologists and lawmakers to come to a consensus regarding the requirements for licensure, insurance, and reimbursement for teleaudiology services. Furthermore, research in this field should continue to be done in areas such as improving speech perception scores of cochlear implant users whose devices are programmed via teleaudiology, the feasibility of using teleaudiology services in the older adult population, and ways to better reach underserved populations to provide them with hearing healthcare.

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Curriculum Vitae

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