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South Dakota Early Hearing Detection and Intervention Program: Using Teleaudiology to Conduct Infant Diagnostic Assessments

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Abstract

Teleaudiology allows patients and providers to bypass several economic and geographic barriers that impede the delivery and accessibility of audiological services. The South Dakota Early Hearing Detection and Intervention (EHDI) program recognized this benefit and created a teleaudiology infrastructure for the diagnostic assessment of infants. Using a hub-and-spoke model, a certified pediatric audiologist at the hub site assesses infants located at two spoke sites in South Dakota. Remote control software applications are used to provide a synchronous method of service delivery. The audiologist's test battery includes video otoscopy, tympanometry, and auditory brainstem response (ABR) testing. Since establishing the teleaudiology program, nine infant assessments have been completed. The South Dakota EHDI program will continue improving the teleaudiology project to ensure all infants in the state have access to pediatric audiological services.

Acronyms: AABR = automated auditory brainstem response; ABR = auditory brainstem response; ASHA = American-Speech-Language-Hearing Association; CDC = Centers for Disease Control and Prevention; DHH = deaf or hard of hearing; DPOAE = distortion product otoacoustic emissions; EHDI = Early Hearing Detection and Intervention; HRSA = Health Resources and Services Administration; LTF/D = lost-to-follow-up/lost-to-documentation; SDDOH = South Dakota Department of Health

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Telepractice enables clinicians to offer health services at a distance by linking clinician and patient or clinician and clinician via technology (American-Speech-Language-Hearing Association [ASHA], 2001). In the mid-1900s, researchers studied the application of telepractice to the field of audiology. Though slow in its initial stages of development, the availability of low-cost web cameras, broad-band connectivity, and highly computerized equipment catalyzed the growth of teleaudiology (Krumm & Syms, 2011).

Teleaudiology allows clinicians and patients to circumvent both geographic and economic barriers. Such barriers include long distances, detrimental weather conditions, travel expenses, and impaired mobility (ASHA, 2005b; Krumm et al., 2002). The challenges these barriers create are heightened by a worldwide shortage of audiologists (Hayes, 2012). Although this shortage disproportionally affects developing countries, rural areas of the United States are not immune to a lack of specialists. In response to these barriers, Swanepoel et al. (2010) said, "The majority of children and adults with hearing loss are isolated from the very services which may improve hearing and communication and reduce the potential negative effects of hearing loss on social interaction, education, and vocational opportunity" (p. 197).

Delayed diagnosis of adults who are deaf or hard of hearing (DHH) may adversely affect their activities of daily living. Within the pediatric population, untreated hearing loss can affect a child's speech, language, cognitive, and social development (ASHA, n.d.). As such, the timely diagnosis of hearing loss and enrollment in intervention services are of paramount importance.

In its position statement on telepractice, ASHA (2005a) stated that telepractice is an appropriate model of service delivery. ASHA subsequently indicated that such services must be of the same quality as face-to-face services. This quality can be achieved through use of a synchronous (real-time) method of service delivery, where a clinician at one location directly tests a patient at a distant location (ASHA, 2005b). A key component of this method is the presence of a facilitator at the patient's location. The facilitator is trained on video otoscopy, electrode and insert placement, and observation of the patient's response patterns (Krumm, 2007). Remote control computing allows the clinician to control equipment at the testing site (Krumm et al., 2002).

Several audiological services have been delivered via telepractice, and research studies validate the accuracy and feasibility of such services. Edwards et al. (2012) summarized the literature pertaining to the use of

telepractice in speech-language pathology and audiology; all studies reviewed in the meta-analysis denoted telepractice as an effective medium for the diagnosis and treatment of children and adults with communication and/or hearing limitations. Another systematic review of teleaudiology validated its use for screening, diagnostic, and intervention services (Swanepoel & Hall, 2010). These systematic reviews cite findings by the following researchers: Lancaster et al. (2008), who found real-time otoscopy and immittance testing to be feasible and reliable; Givens & Elangovan (2003), who used remote control software applications to provide real-time diagnostic audiometry services; and Krumm et al. (2008), who conducted a study with 30 infants and found that results obtained by telemedicine and by conventional face-to-face methods were essentially equal for both distortion product otoacoustic emissions (DPOAEs) and automated auditory brainstem response (AABR) testing.

Teleaudiology applications have also been used by several state Early Hearing Detection and Intervention (EHDI) programs. The Joint Committee on Infant Hearing (JCIH, 2019) endorses the early detection and intervention of children who are DHH to "to maximize [their] language and communication competence, literacy development, and psychosocial well-being" (p. 3). This goal is achieved by following EHDI's 1-3-6 benchmarks: all newborns should be screened for hearing loss no later than one month of age; newborns who refer on their initial screening should receive a diagnostic evaluation no later than three months of age; and infants who are identified as DHH should enroll in early intervention services no later than six months of age (JCIH, 2019). Several projects have demonstrated the success of telehealth's application to the EHDI program. For example, Hayes (2012) reported that Children's Hospital Colorado established connections with Guam's EHDI program 7,000 miles away. Due to a shortage of audiologists on the U.S. island territory, Children's Hospital Colorado worked with professionals in Guam to create a teleaudiology infrastructure for assessing infants. With appropriate technology, acceptable test protocols, and a suitable test environment, the Guam EHDI project demonstrated the viability of using remote control software to conduct infant diagnostic assessments.

As demonstrated by the aforementioned research studies and pilot project, telepractice is an effective medium for the delivery of audiological services. Both increasing internet connectivity and improvements in technology are bridging the gap between patients and providers separated by geographic and economic barriers (Swanepoel & Hall, 2010). Telepractice and its associated benefits will create both global and local improvements in the delivery of audiological services. Givens & Elangovan (2003) argued that teleaudiology is not so much an alternative method for diagnostic testing, as this definition portrays telehealth as an inferior mode of service delivery; rather, teleaudiology has become a wise, cost-effective, and convenient method for both clinicians and patients alike. Recognizing these benefits, researchers and professionals working with the South Dakota EHDI program adopted teleaudiology for the provision of infant diagnostic evaluations.

History of South Dakota EHDI Program

South Dakota's EHDI program was established in 2001 after the state received funding from the Centers for Disease Control and Prevention (CDC). Additional funding was provided by the Health Resources and Services Administration (HRSA) in 2015 as part of a nationwide effort to develop additional EHDI programs; recruit and train staff on EHDI goals; ensure families have accurate information on their child's hearing status; and foster family-to-family support after a child has been identified as DHH (HRSA, 2019). This funding led to the creation of the South Dakota EHDI Collaborative. The Collaborative is a partnership between the University of South Dakota (Department of Communication Sciences and Disorders; Department of Nursing) and the Department of Health's State EHDI program, in addition to other partners, including the South Dakota School for the Deaf.

High Lost-to-Follow-Up/Lost-to-Documentation Rates

South Dakota is one of six states lacking a legislative mandate for a newborn hearing screening program (Messersmith et al., 2014). Despite this fact, South Dakota implements universal newborn hearing screening. In 2016, 98% of newborns in the state were screened for hearing loss (CDC, 2016). However, high lost-to-follow-up/lost-to-documentation (LTF/D) rates remain a priority for the South Dakota EHDI program (HRSA, 2019). These rates are highest among American Indian families and infants born to low-income families living in western and central South Dakota. Several reasons account for the state's high LTF/D rates such as limited pediatric audiological services, rurality/geographic isolation, and high poverty levels.

Limited Pediatric Audiological Services

As is common in other states and countries, South Dakota has a shortage of pediatric audiologists. There are five pediatric diagnostic follow-up sites in South Dakota. Four sites are located in the southeastern corner of the state, and one is located on the far western side of the state. Families located in central and northern South Dakota would need to drive three to four hours to receive testing at one of these follow-up sites.

Rurality/Geographic Isolation

Another challenge facing residents is South Dakota's classification as a frontier state. Of the 66 counties in South Dakota, 34 are considered frontier, having a population density of less than six people per square mile. In addition, geographic isolation prevents many families from seeking services at tertiary healthcare centers due to transportation difficulties and/or financial limitations. Detrimental weather conditions can also hinder a family's ability to travel.

High Poverty Levels

Poverty is a major factor contributing to South Dakota's high LTF/D rates. In 2018, South Dakota's poverty rate

was 13.1% (compared to the national average of 11.8%). This percentage equates to 115,572 individuals living in poverty based on the state's estimated population of 882,235 residents in 2018 (United States Census Bureau, 2018).

Solution to High LTF/D Rates

The South Dakota EHDI program aims to lower these high LTF/D rates and ensure infants who are DHH receive a timely diagnosis and early intervention services. Based on the estimate that three to four of every 1,000 babies are born with some level of hearing loss in the United States, approximately 33 to 44 babies are identified as DHH in South Dakota each year (South Dakota Department of Health, 2019). Determined to diagnose all infants who are DHH and overcome the previously mentioned barriers, the Collaborative established two teleaudiology sites in South Dakota. A description of how South Dakota EHDI created a teleaudiology infrastructure, in addition to the equipment required for synchronous diagnostic evaluations, will be provided in the remainder of this article.

Creation of Teleaudiology Infrastructure

From 2016 to 2017, the Collaborative established two teleaudiology sites in South Dakota. An outside consultant with expertise in teleaudiology assisted the Collaborative in developing the program's infrastructure.

Method

Using a hub-and-spoke paradigm, synchronous (real-time) methods are used to assess infants for hearing loss. A hub-and-spoke model allows healthcare professionals (located at a centralized *hub* site) to assess patients located at distant *spoke* sites via telepractice. The infant and family receive testing at the spoke site location, where trained medical personnel place equipment on the infant (e.g., otoscope speculum, electrodes, insert earphones) and assist the family in preparing the infant for sleep. The pediatric audiologist performs testing and evaluates test results at the hub location via remote control software applications. Routine maintenance and annual calibration of equipment is performed at the spoke site locations.

The University of South Dakota Speech Language and Hearing Clinic, located in Vermillion, South Dakota, serves as the hub site. The first spoke site is located at the Sanford Health Winner Regional Hospital in Winner, South Dakota (approximately 180 miles from the hub location). The second spoke site is located at Avera Saint Luke's Hospital in Aberdeen, South Dakota (approximately 260 miles from the hub location).

At the Aberdeen spoke site, both the initial screen and rescreen are performed prior to diagnostic testing. The protocol for the Winner spoke site is slightly different. If the infant refers on the initial screen, the family is referred to diagnostic testing. The spoke site assistant begins the appointment by performing the rescreen, and the audiologist only moves forward with diagnostic testing if the infant refers on this second screen.

A certified pediatric audiologist at the University of South Dakota clinic (hub site) remotely performs the diagnostic evaluations. The audiologist's test battery includes video otoscopy, tympanometry, and ABR testing. As mentioned in the introduction, completing these assessments via teleaudiology is proven to be a reliable and valid method; results obtained through conventional face-to-face methods and through telemedicine are essentially equal (Krumm & Syms, 2011; Lancaster et al., 2008).

Currently, these services are being provided through the HRSA grant, and no entity (patient or third party) is billed for the diagnostic testing. When the teleaudiology program transitions out of the pilot phase, services will be billed to the responsible entity, which may be the patient and/or a third-party provider (e.g., Medicaid, Medicare, private insurance).

Training

Before teleaudiology appointments were scheduled, medical personnel at the spoke site locations were trained on proper procedures for placing equipment and interacting with family members. Providing this in-person training was necessary to guarantee that spoke site assistants were well prepared.

The South Dakota EHDI Collaborative also created toolkits for personnel at the spoke sites. These toolkits explain how to complete otoscopy, ABR testing, otoacoustic emissions (OAE) testing, and tympanometry. They also include scripts for personnel to use when discussing information with parents.

In addition to toolkits and in-person training, PowerPoint presentations and video trainings were provided to spoke site assistants. Medical personnel can visit the YouTube channel titled "Communication Support through Aids and Technology" to see a list of training videos uploaded by the Collaborative. Such videos offer training on swaddling infants, completing otoscopy, scrubbing for electrode placement, placing electrodes, removing electrodes, placing insert earphones, and preparing the infant for bone conduction testing. An example of a training video can be viewed at https://www.youtube.com/watch?v=P9CltdLNLG4.

Equipment

The spoke site locations must have specific test equipment for assessments to be completed. A list of supplies and additional requirements is shown in Table 1. Necessary equipment made available to the spoke sites' trained personnel included the following items: video otoscope, ABR equipment, OAE equipment, tympanometry equipment, a computer to operate hardware and software programs, web camera, and ancillary supplies (e.g., specula and probe tips). The spoke site must also have an adequate upstream speed (at least 3 megabit) and permissible ambient noise levels.

Two types of software are necessary for completing synchronous testing: 1) software allowing remote access to the spoke site computer and 2) software allowing video and audio connection between the hub site and spoke sites. The South Dakota EHDI Collaborative uses

Table 1
Necessary Supplies for Teleaudiology Infrastructure

Equipment	*Software*	*Additional Requirements*
Video otoscope	Software allowing remote access to spoke site computer	Adequate upstream speed at spoke site (must be at least 3 megabit)
ABR equipment	Software allowing video and audio connection between hub and spoke sites	Permissible ambient noise levels at spoke site
OAE equipment		Internet connection at spoke site
Tympanometry equipment		Trained technicians at spoke site
Computer to run hardware and software programs		
Web camera		
Ancillary supplies (probe tips, specula, etc.)		

Note. Establishing a teleaudiology program requires standard audiology equipment, specific software programs, and additional standards required of the spoke site itself. ABR = auditory brainstem response; OAE = otoacoustic emissions

TeamViewer to obtain remote access to both spoke site computers. For video and audio connection, the Collaborative has tested two types of software programs, with a different program being used at each spoke site.

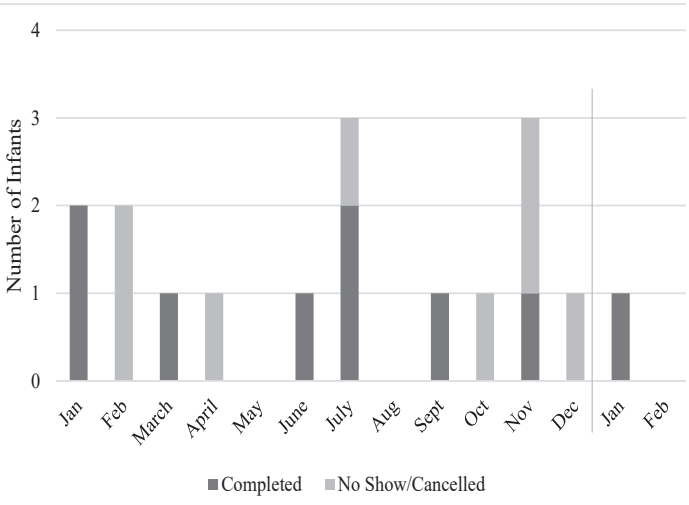
For appointments with Sanford Health Winner Regional Hospital, *Skype for Business* is used for video and audio connection. Although this program is HIPAA compliant, cost effective, and user friendly, it provides a somewhat informal connection between the audiologist and family. For appointments with Avera Saint Luke's Hospital, *Cisco Systems* is being used. Compared to *Skype for Business*, this program offers a more formal connection between the patient and provider. *Cisco Systems* is also HIPAA compliant and allows for clearer imaging. However, *Cisco Systems* is a more expensive software program, and both the hub site and spoke site need to purchase the program. Both *Skype for Business* and *Cisco Systems* have their advantages and disadvantages, and one program is not necessarily superior to the other.

At the time these software programs and equipment items were purchased, the HRSA grant was held by the South Dakota Department of Health (SDDOH). As such, the SDDOH purchased the teleaudiology equipment (subject to HRSA approval) before subcontracting the grant to the University of South Dakota. The EHDI Collaborative, cognizant of decreased funding opportunities and the expense of audiology equipment, did its best to minimize cost by taking advantage of cost-effective or previously-held software programs (e.g., using the *Skype for Business* program with a HIPAA certificate and business affiliation agreement; using a preexisting electronic medical records system for data entry).

Results

Testing at the teleaudiology sites began in January 2019. As of February 2020, a total of nine infants have received diagnostic assessments. Eight additional appointments were classified as *no show* or *cancelled*. See Figure 1 for a timeline of assessments from 2019 to 2020.

Figure 1
Appointments Completed and No Show/Cancelled Appointments at Both Spoke Sites from January 2019 to February 2020



Although one spoke site was consistently referring infants to their teleaudiology location, the other spoke site was facing challenges with its referral process. As a result, assistants with the EHDI Collaborative spread awareness of the teleaudiology program to additional pediatricians, obstetricians/gynecologists, and family care physicians nearest this spoke site through postcards, emails, and presentations. In addition, contact information for the teleaudiology sites was sent to the South Dakota Department of Health, which now lists both the Winner and Aberdeen spoke sites on its website. It is expected that the number of infants tested via teleaudiology will increase as more healthcare providers and families become aware of the program.

Counseling

Following a conventional face-to-face assessment, the audiologist immediately provides the family with results. When testing via teleaudiology, discussing results with parents can differ based upon the audiologist's and family's preferences.

The South Dakota EHDI Collaborative has determined its preferred method for delivering results. When no hearing loss is identified, the audiologist provides the family with results at the time of testing. When a hearing loss is identified, the audiologist either conducts a virtual meeting with the family or determines another appropriate route for conveying these results. Krumm (2007) stressed the need for future research on proper counseling procedures for telehealth appointments. Research should focus on counseling methods in the event that a parent experiences denial upon discovering his or her child has been identified as DHH.

Collecting Feedback from Spoke Sites

After diagnostic testing had been performed at both teleaudiology spoke sites, the Collaborative collected feedback from the spoke sites' trained assistants. The Collaborative wanted to understand the assistants' experience with the teleaudiology program and identify the need for potential improvement in training. Results of the formal feedback survey are displayed in Table 2.

Table 2
Formal Feedback Results from Teleaudiology Spoke Sites

Question	***Winner Regional Hospital*** *Date: 10/09/2019*	***Aberdeen's Avera St. Luke's Hospital*** *Date: 11/11/2019*
1. Has the teleaudiology spoke site been a useful resource since it's been established? Why or why not?	"Yes - it has saved families a lot of driving by allowing them to do the testing closer to home."	Respondent 1: "The training was great when we started but then we didn't have any [additional trainings], so we set up practice trainings a couple different times, but it took 3 hours out of our day."
2. Was the training you received sufficient to prepare you for the teleaudiology sessions? If not, what could be improved?	"Yes, it was sufficient. Additional information about how the testing works would have been helpful."	Respondent 1: "Maybe we should set up a refresher [course] to go through the equipment briefly."
3. Would a refresher training course be beneficial?	"Not for me, but possibly for others who could fill in for me but do not regularly assist with the testing."	Respondent 2: "I think a yearly competency [training] would be good. Step-by-step visuals are great."
4. What improvements could be made to the teleaudiology spoke site?	"None"	Respondent 1: "Trying to get the word out and trying to get more clientele."

Overall, feedback from both spoke sites was positive. The assistants believed the teleaudiology program was a useful resource for families with limited access to audiological services. Two opportunities for improvement were suggested in the formal feedback survey. First, the assistants commented on the need for refresher training courses once or twice a year, especially if new assistants join the teleaudiology team. Second, the personnel recommended that information on the teleaudiology spoke sites be made available to more healthcare providers in their respected locations.

Since the survey was completed, the assistants' suggestions were reviewed by the Collaborative and progress has been made to improve the teleaudiology program. The hub site's pediatric audiologist agreed with the recommendation to present refresher training courses. In addition, the previously mentioned training videos and PowerPoint presentations created by the Collaborative (see "Training") have been placed in the medical facilities' continuing education platforms and are available for review at any time by spoke site personnel. To address the second suggestion, information regarding the

teleaudiology program has been sent to nearby physicians who may contribute to the spoke sites' referral processes.

Conclusion

With technological advances and increasing Internet connectivity, telepractice proves to be an effective avenue for delivering healthcare services. Teleaudiology, though slow in its initial stages of development, has gained increasing attention. Audiological services delivered via technology allow patients and providers to bypass several barriers—both geographic and economic—that too often separate individuals from the very services that could improve their hearing and communication.

The South Dakota EHDI Collaborative's teleaudiology program and its adoption of a hub-and-spoke model has demonstrated the feasibility of using remote control software applications to complete video otoscopy, tympanometry, and ABR testing. Infants born in the western and central portions of South Dakota can now receive diagnostic audiological testing that may have been challenging or nearly impossible to attain prior to the development of the two spoke sites.

Future research on teleaudiology should focus on patient satisfaction with the teleaudiology program. Although feedback from spoke site assistants has been positive, formal feedback should also be collected from families whose children have undergone testing at the spoke sites. Additional research should be conducted on how best to counsel families whose children have been identified as DHH following a teleaudiology evaluation.

Regardless of where children live, whether it be in a rural area of the United States or a developing country, they deserve access to audiological services—services that could largely impact their speech, language, cognitive, and social development. The way in which to broaden their access to these services is no enigma; countless studies (Edwards et al., 2012; Swanepoel & Hall, 2010; Givens & Elangovan, 2003; Krumm et al., 2008) corroborate teleaudiology's status as a valid and reliable method of service delivery. By choosing to welcome the advent of teleaudiology and embrace its benefits, barriers to audiological services will become a challenge of the past.

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