Original Research

Reducing Loss to Follow-Up with Tele-audiology Diagnostic Evaluations

Madan Dharmar, MBBS, PhD,[1,2] Anne Simon, AuD,[3] Candace Sadorra, BS,[2] Gerald Friedland, PhD,[4] Jennifer Sherwood, MA, F-AAA,[5] Hallie Morrow, MD, MPH,[5] Dawn Deines, REEG T, BA,[6] Deborah Nickell, EKG T,[7] David Lucatorta, EEG T,[6] and James P. Marcin, MD, MPH[1,2]

Departments of [1]Pediatrics and [3]Otolaryngology, University of California Davis, Sacramento, California.
[2]Center for Health and Technology, University of California Davis, Sacramento, California.
[4]International Computer Science Institute, University of California Berkeley, Berkeley, California.
[5]Systems of Care Division, California Department of Health Care Services, Sacramento, California.
[6]Neurodiagnostics, Benioff Children's Hospital, University of California San Francisco, San Francisco, California.
[7]Dignity Mercy Medical Center, Redding, California.

Abstract

Background: *Infants who do not pass their newborn hearing screen require diagnostic follow-up visits but often face access barriers such as travel distance and shortage of pediatric audiologists. Telemedicine (tele-audiology) is a potential solution to provide diagnostic hearing evaluations for families of infants facing access barriers. We determined the feasibility and impact of a tele-audiology program that provided comprehensive diagnostic evaluations to a region with a high lost to follow-up rate among newborns who did not pass their newborn hearing screen.* ***Materials and Methods:*** *We evaluated the tele-audiology program using parent and provider surveys to determine the perception of quality and satisfaction of care. We also compared the lost to follow-up rate of the tele-audiology program with the loss to follow-up in the region before the implementation of the program.* ***Results:*** *Twenty-two infants who did not pass their newborn hearing screen were referred to the tele-audiology program for diagnostic evaluation. Among these infants, 59.1% were diagnosed with some form of hearing loss. The mean quality score rated by both parents and providers on the telemedicine interaction was over 6.5 on a 7-point Likert scale. All parents rated the importance of tele-audiology as 7 (extremely important) for their family, whereas the provider rated the mean importance as 6.4 (95% confidence interval, 5.9, 6.9) on a 7-point Likert scale. Almost all parents actively participated or were engaged during history taking and counseling and were comfortable in discussing their child's hearing status remotely over telemedicine. All infants completed their diagnostic evaluation with no loss to follow-up compared with 22% loss to follow-up in the region before the implementation of the program.* ***Conclusions:*** *Tele-audiology is a feasible solution that reduces the loss to follow-up among infants who do not pass their newborn hearing screen and have access barriers to qualified audiologists for diagnostic evaluations.*

Key words: *pediatrics, telemedicine, technology, telecommunications*

Introduction

The Joint Committee on Infant Hearing recommends a diagnostic hearing evaluation by 3 months of age for infants who do not pass their newborn hearing screen.[1] If the diagnostic evaluation confirms hearing loss, the Joint Committee on Infant Hearing further recommends enrollment in intervention and rehabilitation services by 6 months of age.[1] It is expected that if interventions are implemented within this time frame, a child with hearing loss can acquire speech and language skills and have similar cognitive and developmental abilities as his or her hearing peers.[1,2] The language proficiency of a child is considered to be an important predictor of literacy skills and enables individuals to achieve academic and vocational success.[3] It is estimated that when children with hearing loss are not identified early and do not receive early intervention, the additional costs for education is nearly $420,000 with a lifetime societal cost of $1 million per child.[4]

According to data from the National Early Hearing Detection and Intervention Program,[5] the prevalence of hearing loss among newborns is approximately 1.4 per 1,000 births. Unfortunately, some infants who do not pass their newborn hearing screen do not receive the necessary diagnostic hearing evaluation that would determine presence, type, and degree of hearing loss. In the State of California, in 2010, 4.5% of infants who did not pass their outpatient hearing screen were lost to follow-up, not receiving a diagnostic evaluation.[6] In one Northern California region, the loss to follow-up rate was unacceptably high at nearly 22%.[6] Several factors contributed to this high loss to follow-up rate, including a lack of expertise

and shortage of pediatric audiologists and challenges faced by families such as lack of transportation, childcare, and loss of wages.[7]

Remote evaluation of infants identified with possible hearing loss using telemedicine (tele-audiology) is increasingly recognized as a possible solution to improve access to audiology services in less populated areas where the services may not otherwise be available.[8–13] Tele-audiology has the potential to address some of the challenges faced by families by reducing some of the burdens of travel, including travel costs, time away from home, and loss of wages.[10,13,14] As a consequence, the use of tele-audiology can facilitate a timely follow-up evaluation, diagnosis of hearing loss, and enrollment in early intervention services by 6 months of age.

The California Tele-audiology Program (CTP) was established to provide remote diagnostic audiology evaluations for infants who do not pass their newborn hearing screen. Using telemedicine technologies, a pediatric audiologist performs evaluations while the infant remains near his or her home community with a telepresenter who facilitates the session. The Northern California Hearing Coordination Center (HCC) is responsible for facilitating the referral of all infants who do not pass their newborn hearing screen to an appropriate pediatric audiologist. Prior to the tele-audiology program, patients were referred to pediatric audiologists up to 6 hours away from the infant's local community. The CTP provides this clinical service in a centrally located city in rural Northern California where services were previously unavailable. The goal of this study was to determine the feasibility and impact of tele-audiology on the loss to follow-up rate of infants referred to this program and to assess the patient/family centeredness of the program by measuring parent satisfaction.

Materials and Methods

STUDY SETTING AND PARTICIPANTS

This was an observational study describing the infants who did not pass their newborn hearing screen and were referred to the tele-audiology program for diagnostic audiologic evaluation. The Pediatric Telemedicine Program at the University of California Davis Children's Hospital (UCDCH) launched the CTP in December 2011 in partnership with the Systems of Care Division of the California Department of Health Care Services, the Departments of Pediatrics and Otolaryngology at UCDCH, the Center for Health and Technology at UCDCH, and Dignity Health Mercy Medical Center Redding (MMCR), in Redding, CA. We selected MMCR as the originating site (spoke) hospital in Northern California based on its central location within the rural and underserved communities that had a high loss to follow-up rate. MMCR also had an existing telemedicine relationship with the UCDCH.

This study included infants identified by the Northern California HCC who did not pass their newborn hearing screen between December 2011 and December 2013. Typically, these infants, who did not pass inpatient and outpatient hearing screening, receive assistance from the HCC in accessing a qualified pediatric audiologist to complete their diagnostic evaluation. The families of infants who do not pass their newborn hearing screen who live in communities surrounding MMCR are routinely to qualified audiologists outside their community. Once the CTP was established, they were referred to CTP for their diagnostic evaluation.

HUMAN SUBJECTS

The study was approved by the Human Subjects Review Committees at the University of California, Davis.

TELEMEDICINE EQUIPMENT

The tele-audiology program connects the UCDCH pediatric audiologist to the patient at MMCR, the originating (spoke) site. At UCDCH, a telemedicine workstation is used to conduct a live, interactive video consultation with a dedicated laptop that controls the audiology equipment located at MMCR. The telemedicine workstations at the UCDCH and MMCR include a turnkey videoconferencing unit (Cisco, San Jose, CA), a flat-screen high-resolution monitor, and an uninterrupted power supply. The videoconferencing units provided bidirectional video using a high-definition camera capable of pan, tilt, and zoom functions. The dedicated laptop at the UCDCH includes remote desktop software to establish a secure connection from the pediatric audiologist's computer to the computer at the MMCR. This enables the pediatric audiologist to remotely control the audiology equipment and view and interpret the test results instantaneously.

TELE-AUDIOLOGY EVALUATION

The tele-audiology infant diagnostic evaluation is meant to deliver the same quality of care as the in-person diagnostic evaluations with the help of a telepresenter at the originating site. The comprehensive tele-audiology diagnostic hearing evaluation includes the patient history, visualization of external structures, video otoscopy, immittance (including high-frequency tympanometry and middle ear muscle reflexes), distortion product otoacoustic emissions, auditory brainstem response with air and bone conduction, and, when indicated, auditory steady-state response.

The role of the telepresenter is to prepare the infant for the evaluation and to assist the pediatric audiologist at the UCDCH

during the evaluation. The telepresenter prepares the infant's skin, places and connects electrodes, places probes in the infant's ears, and positions the otoscope, under the guidance of the UCDCH audiologist. As needed, the telepresenter assists the parent with attaining a sleep state for the infant. The audiologist at the UCDCH then conducts the diagnostic evaluation controlling the test parameters including the intensity levels, type of stimulus, and filter settings as would be done during an evaluation in the traditional setting.

DATA COLLECTION

For each infant evaluated in the program, we collected data on the infant's age, the presence/absence of hearing loss, the severity of hearing loss (mild, moderate, and severe or profound hearing loss), the type of hearing loss (conductive, sensorineural, or mixed), and the number of encounters needed to complete the diagnostic evaluation.

PARENT/GUARDIAN SATISFACTION

We measured parent/guardian satisfaction with the tele-audiology encounter using a modified version of a previously published survey (the parent tele-audiology survey is given in Supplementary Appendix 1; Supplementary Data are available online at www.liebertpub.com/tmj) used to measure parent satisfaction of care during a telemedicine encounter.[15] The survey included questions regarding various aspects of the telemedicine experience, including quality of the visual images, quality of the audio, and the overall experience with the telemedicine encounter. The survey also included two questions to measure the parent's satisfaction with discussions on his or her child's hearing status over telemedicine and whether the parent was comfortable with discussions on his or her child's hearing status over telemedicine. In addition, the survey included a question on the perceived importance of the tele-audiology service. All survey questions were measured on a 7-point Likert scale except the question on whether the parents were comfortable discussing their child's hearing status using telemedicine, which required a yes/no response.

PROVIDER (AUDIOLOGIST) SURVEY

We also measured the provider's experience during the tele-audiology consultations for quality improvement purposes. Similar to the parent survey, the provider survey (see Supplementary Appendix 2) included questions on various aspects of the telemedicine experience, including quality of the visual images, quality of the audio, and overall experience with tele-audiology. We also assessed if, at the end of the session, a complete diagnostic audiologic evaluation and comprehensive hearing diagnosis were provided. This survey also collected information on parent participation during the history interview and parent participation during counseling. Finally, the clinician rated how important it was for this clinical service to be available over telemedicine. All provider survey questions were measured on a 7-point Likert scale.

STATISTICAL ANALYSIS

We performed all statistical analyses using STATA version 12 software (StataCorp, College Station, TX). For descriptive analysis, mean and standard deviation were calculated for continuous variables, and proportions were calculated for categorical variables.

Results

Twenty-two infants who did not pass their newborn hearing screen were identified by the HCC and were referred to the CTP for diagnostic evaluation during the study period. The CTP completed evaluations for all the 22 (100%) infants with no patients lost to follow-up. The average age of the infants

Table 1. Demographic Characteristics and Clinical Outcomes Among Infants Evaluated in the California Tele-audiology Program

VARIABLE	ALL ($N=22$)
Age in months [mean (SD)]	5.5 (3.8)
Number of infants with a complete evaluation [*n* (%)]	22 (100)
Hearing loss [*n* (%)]	
No	9 (40.9)
Yes	13 (59.1)
Mild	4 (30.8)
Moderate	1 (7.7)
Severe or profound	8 (61.5)
Type of hearing loss [*n* (%)]	
Conductive	6 (46.1)
Sensorineural	4 (30.8)
Mixed	3 (23.1)
Number of encounters [mean (SD)]	1.9 (0.8)
Number of encounters [*n* (%)]	
1	7 (31.8)
2	8 (36.4)
3	7 (31.8)

SD, standard deviation.

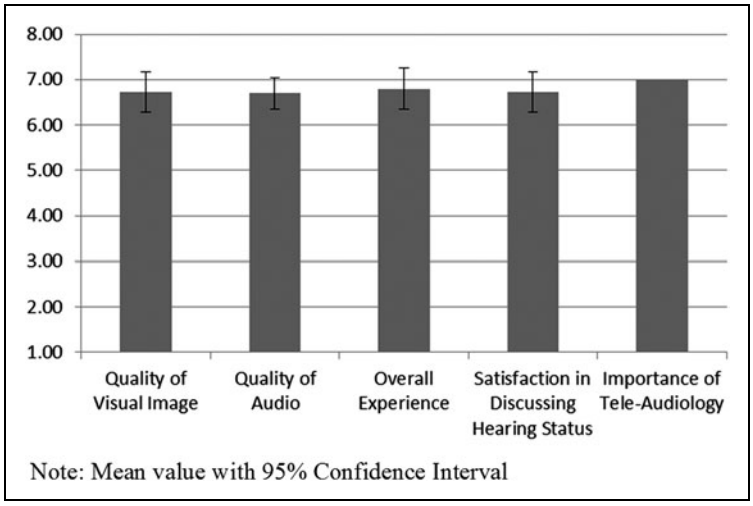

Fig. 1. Parents' perception of tele-audiology consultation. Data are mean values with 95% confidence intervals indicated.

evaluated using the program was 5.5 months (standard deviation, 3.8 months). For a majority of the infants (86.4%), diagnostic evaluations were conducted by 3 months of age as per the recommendations outlined by the Joint Committee on Infant Hearing. The average number of encounters necessary to complete the diagnostic evaluation was 1.9 (range, 1–3), with a majority of the infants (68.2%) requiring more than one encounter to complete the evaluation (*Table 1*). Among these infants, 40.9% had normal hearing, whereas the remaining 59.1% were diagnosed with some form of hearing loss. Among those with hearing loss, 61.5% were found to have severe to profound hearing loss, in at least one ear.

Figure 1 displays the results of the parent satisfaction survey. We received 11 (50.0%) parent surveys. The parents scored the quality of the visual image and the quality of the audio as 6.7 (95% confidence interval [CI], 6.3, 7.0) and 6.7 (95% CI, 6.4, 7.0), respectively, on a 7-point Likert scale. The overall quality for the consultation was scored 6.8 (95% CI, 6.3, 7.0) on a 7-point Likert scale. All parent responses scored the importance of tele-audiology as 7 (extremely important) for their family. A majority of the parents ($n = 10$, 90.9%) said they were comfortable discussing hearing status over telemedicine, and they scored the overall satisfaction in discussing their child's hearing status as 7.

Figure 2 displays the results of the provider survey. We received 12 (54.5%) of the provider surveys. The audiologist scored the quality of visual image and audio quality as 5.9 (95% CI, 4.6, 7.0) and 6.7 (95% CI, 6.4, 7.0), respectively, on a 7-point Likert scale. The overall experience for the consultation and the importance of tele-audiology was scored 5.9 (95% CI, 4.6, 7.0) and 6.4 (95% CI, 5.9, 6.9), respectively, on a 7-point Likert scale.

The loss to follow-up rate in the HCC region served by the tele-audiology program was reported to be 22% in the year before the implementation of the program. The survey reported that all infants (100%) referred to the program received a complete comprehensive diagnostic evaluation through the program. Sixty percent of the infants received a complete diagnostic evaluation during their first visit, and 70% received a comprehensive diagnosis during that first encounter. Some individuals received a diagnosis and returned at a later date for evaluation of more frequencies; therefore these individuals did not receive a complete evaluation during the first visit even though they had received a comprehensive diagnosis. Nearly all surveys reported that the parents actively participated or were engaged during history taking (100%) and counseling (90%).

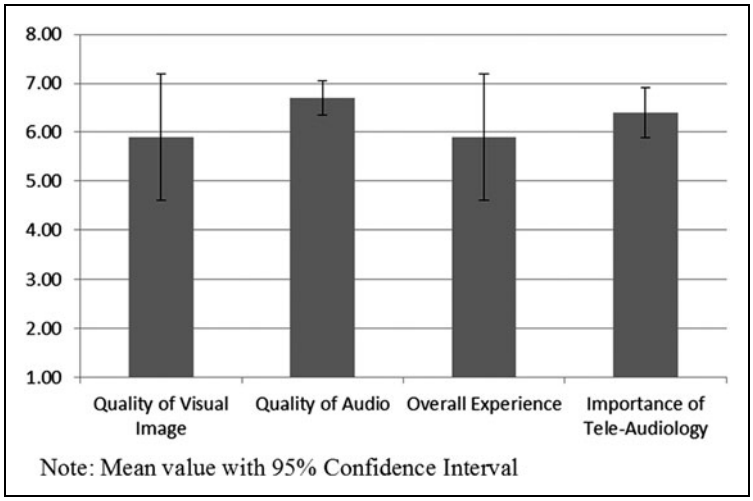

Fig. 2. Originating site providers' perception of tele-audiology consultation. Data are mean values with 95% confidence intervals indicated.

Discussion

In this study, we demonstrated the feasibility of conducting remote comprehensive diagnostic audiologic evaluations with infants who did not pass their newborn hearing screen and considered the impact these evaluations had on eliminating an otherwise unacceptably high loss to follow-up rate. All infants referred to the program by the HCC received an evaluation with no infant lost to follow-up, and the majority of the infants (60%) receiving their diagnosis during their first tele-audiology encounter. Both parents and provider scored the quality of the visual image, audio, and the overall consultation experience at almost 6 or more points on a 7-point Likert scale, proving that it is feasible to conduct a high-quality infant audiologic evaluation over

telemedicine. Finally, we also found that the majority of parents (90.9%) were comfortable discussing the hearing status of their child over telemedicine and were actively engaged in both the history and counseling portions of the session.

Several studies have demonstrated the use of the telemedicine model for providing hearing screens for both adults and children.[9,11,16,17] These studies have shown that screening distortion product otoacoustic emissions and screening auditory brainstem responses, conducted over telemedicine, are equivalent to face-to-face screens conducted among the same patients.[11] Studies that have evaluated the use of telemedicine for diagnostic hearing evaluation have demonstrated the feasibility of conducting auditory brainstem responses, otoacoustic emissions, video otoscopy, and immittance among adults.[9,10,14] Our model is the first to have successfully established a comprehensive infant audiologic evaluation program, where all aspects of the evaluation are completed remotely. This model is consistent with the recommendations by Elangovan et al.[18] and Krumm and Syms,[9] to use interactive video synchronously with the diagnostic test to direct and monitor the telepresenter regarding electrode and ear probe placement, while remotely controlling the tests. In this study, we have been able to show that the infant diagnostic test battery can be successfully completed by a remote pediatric audiologist using the help of a telepresenter.

Our finding of high-quality visual image, audio, and overall consultation experience in using telemedicine to provide diagnostic audiology consultation is similar to studies evaluating the use of telemedicine by other specialties.[15,19–22] Several studies also support our parents' and provider's perception of the importance of providing these consultations remotely. Eikelboom and Atlas,[23] in their 2005 study, found that the most common reasons for patients' willingness to use telemedicine were to reduce the time waiting for an appointment and to reduce the cost of travel. This supports our assertion to use telemedicine to provide infant diagnostic hearing evaluation. This audiology model can potentially address the barriers to diagnostic evaluation, which has resulted in zero loss to follow-up in our program.

This is the first study that has examined parental perception during remote hearing evaluations and found that parents actively engage in the history and counseling portions of the evaluation and are comfortable discussing the hearing status of their child over telemedicine. A limitation of this study is that it only includes the infants referred to our program by the HCC and does not evaluate the loss to follow-up rates of all the infants who did not pass the newborn screening in this region. Another limitation is the additional cost of telemedicine equipment needed at both the sites to conduct the evaluation, but this is a one-time capital cost to establish the program.

In conclusion, we found that tele-audiology can be used to provide remote diagnostic audiologic evaluations for infants resulting in early detection of hearing loss. Our program successfully completed evaluation for all infants referred to the program, resulting in a zero loss to follow-up rate. Not only did we find that parents and provider had a higher perception of quality of the telemedicine interaction, we also found parents were comfortable having their child's hearing evaluated over telemedicine. Further research is needed in this area to better understand the parental interaction with the provider during these tele-audiology consultations and to assess how this remote interaction could impact the psychosocial aspect upon learning that one's child has hearing loss when the provider is not in the same room.

Disclosure Statement

No competing financial interests exist.

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Address correspondence to:
Madan Dharmar, MBBS, PhD
Department of Pediatrics
University of California Davis Children's Hospital
2516 Stockton Boulevard
Sacramento, CA 95817

E-mail: mdharmar@ucdavis.edu

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